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Maria Zlotorzynska Date

Gentrification and Prevalence of Preterm Birth in Atlanta

By

Maria Zlotorzynska

Master of Public Health

Epidemiology

_____

Dr. Michael Kramer

Faculty Thesis Advisor

# Gentrification and Prevalence of Preterm Birth in Atlanta

By

Maria Zlotorzynska

BSc, University of Ottawa, 2006

PhD, University of British Columbia, 2012

Faculty Advisor: Michael Kramer, PhD

An abstract of
A thesis submitted to the Faculty of the Rollins School of Public Health of Emory University
in partial fulfillment of the requirements for the degree of
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in Epidemiology

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# Abstract

Gentrification and Prevalence of Preterm Birth in Atlanta

By Maria Zlotorzynska

**Objective**: To characterize neighborhood gentrification in Atlanta and investigate its association with preterm birth (PTB).

**Methods**: The study examined birth outcomes among singleton, live births to women residing in DeKalb and Fulton counties between 2000 and 2007. PTB was defined as birth occurring before 37 weeks of gestation. Gentrification at the census tract level was characterized using data from the US Census Bureau. Census tracts were first defined as "gentrifiable" at the beginning of the intercensal period on the basis of median household income (MHI) and the proportion of buildings built before 1970. The extent of gentrification in these tracts was then quantified based on the relative change between 1990 and 2000 in five variables: (1) proportion of adults over 25 with a college education; (2) proportion of labor force in professional/managerial occupations; (3) MHI; (4) median house value for all owner-occupied units; (5) median rent. Generalized estimating equations were used to model the association between PTB risk and gentrification, adjusting for individual-level maternal characteristics. The study population was split into two birth cohorts, those occurring in 2000-2003 and those occurring in 2004-2007.

**Results**: Among women residing in gentrifiable areas, gentrification was not significantly associated with PTB in either cohort, after adjusting for covariates. However, among women who gave birth between 2004 and 2007, living in a high gentrification area was protective as compared to living in a low gentrification area for non-Hispanic white women and for women with some college education.

**Conclusion**: While residence in a highly gentrified area was not associated with increased PTB, the beneficial effects of living in such areas were not equitably distributed. These findings may be the result of high population turnover in areas with highest gentrification. More work is needed to characterize residential mobility patterns and to determine the extent to which displacement from gentrifying areas affects health outcomes.

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# Introduction

The influence of place on health has received substantial attention. While there has been considerable research on the extent to which local socioeconomic indicators account for health disparities, few studies have examined neighborhood transitions over time. This is an important consideration as local social and economic characteristics are dynamic and heavily influenced by planning and development policies. In particular, gentrification, the transformation of a predominantly low-value neighborhood to one of higher-value, has emerged as an increasingly common urban phenomenon. Gentrification has the potential to influence community health in a number of ways. Many have argued that the return of a stabilizing middle class to inner cities and deconcentration of poverty could potentially bring benefits to communities with a history of disinvestment. However, increase in housing prices that result from the influx of new, high-status residents can put financial strains on existing low-income residents and may even lead to their displacement from the community. Despite a large body of theoretical work on this subject, there is little empirical evidence to inform the debate. Thus, there is a need to study the implications of gentrification in a public health context and to characterize the populations most vulnerable to its negative consequences.

The present study aims to characterize the extent of gentrification in Atlanta between 1990 and 2000, and investigates its association with preterm birth in a population-based sample of births that occurred between 2000 and 2007. Preterm birth, defined as birth occurring before 37 gestational weeks, is an especially important indicator of population health due its potential for lifelong morbidity and strong association with racial disparities. We operationalize gentrification as a composite

measure of the relative change in several economic, demographic and housing variables, and model the association of this measure with preterm birth in our study population. We also examine effect modification by maternal race/ethnicity and education, in order to assess whether certain populations are differentially affected by gentrification.

# Background and Literature Review

## Preterm Birth as a Public Health Issue

Preterm birth, defined as birth occurring before 37 weeks of gestation, is a significant source of morbidity and the leading cause of perinatal mortality in developed countries (1). Women in the US experience an especially high rate of preterm birth, 12-13%, as compared to women in European and other developed countries, where rates are generally 5-9%. The sequelae of preterm birth can be life-long and include cerebral palsy, developmental delay and vision problems (2). Furthermore, treating premature infants can incur high medical costs, both those related to hospitalization immediately after birth and those associated with treatment of related long-term health problems. There is therefore a critical need to elucidate the mechanisms that cause preterm birth and to develop prevention strategies to reduce the public health and economic burdens of this pregnancy outcome.

Preterm labor is thought to be initiated through multiple mechanisms, including stress, infection and inflammation (1). The determinants of preterm birth are complex and have been the subject of extensive study. Individual level factors that have been identified as risk factors include interpregnancy interval, maternal nutritional status and smoking (3-5). The role of maternal demographic characteristics and contextual factors has also received considerable attention. For example, significant racial disparities in preterm birth rates exist in the United States. Non-Hispanic black women experience rates of preterm birth that are approximately 1.6 times that of those among non-Hispanic white women (6). This disparity persists despite adjustment for behavioral risk factors and other demographic variables. Low socioeconomic status and educational attainment have also

been associated with increased risk for preterm birth. The causal mechanisms by which these demographic factors increase the risk for preterm birth are unclear (1).

## Neighborhood Effects and Health

While maternal risk factors have traditionally been emphasized in research on preterm birth, recently there has been a shift in focus towards ecological and structural factors that can affect maternal health and behaviors. A large, multidisciplinary body of work increasingly supports the hypothesis that the local "socio-spatial" context in which one resides is an important determinant of health and that ecologically-derived variables are more than just a proxy for individual-level attributes (7). Neighborhood effects have been advanced as one possible explanation for racial disparities in preterm birth, as black women are more likely to reside in neighborhoods with more economic deprivation and social disorder, and fewer health-promoting resources (6).

The theoretical frameworks proposed to explain the causal mechanisms between neighborhood-level SES and adverse pregnancy outcomes include many factors. Geographical concentration of disadvantage is tied to many health risks, including overcrowding, dilapidated infrastructure, poor recreational facilities, inadequate municipal services and amenities, and exposure to environmental toxins (8). In addition to these factors, neighborhood disadvantage may produce a stressful living environment through exposure to crime. High levels of crime are detrimental to health not only because of the increased risk of victimization, but also through increased stress and behavioral changes associated with living in dangerous areas. Fear of crime is an especially relevant neighborhood-level variable as people tend to perceive crime in geographic terms (9). Researchers have found that people who perceive more crime and

disorder in their neighborhoods experience a higher risk of stress-related mental health issues, such as anxiety and depression (10). This is especially relevant for pregnancy outcomes due to the strong links between maternal stress and increased risk for preterm birth (11).

Racial residential segregation may also play a large role in the racial disparities in preterm birth. Williams has called segregation a "fundamental cause" of health disparities because of the way in which spatial isolation perpetuates socioeconomic inequalities between whites and blacks (12). Racial segregation is thought to produce unhealthy living environments in a number of ways (13). First, there is a high degree of correlation between racial segregation and concentration of poverty. The reduced educational and employment opportunities available to those living in highly segregated areas limits their socioeconomic mobility and further entrenches racial disparities in socioeconomic status and health. Highly segregated areas also experience higher rates of violent and property crime (14, 15) and have poorer quality of housing and urban infrastructure (12). Finally, segregation may increase psychosocial stress through its interaction with personally mediated racism and chronic "weathering" of immune and endocrine systems (16). The literature documenting poorer pregnancy outcomes for blacks living in segregated areas is relatively consistent and various measures of segregation have been associated with elevated preterm birth rates (13).

While many characteristics of economically deprived or segregated neighborhoods are detrimental to health, the spatial concentration of the poor and racial minorities does not necessarily produce an unhealthy environment. Some aspects of racial or ethnic homogeneity may in fact be protective. For example, Bell *et al* investigated the effect of

two dimensions of segregation, clustering and isolation, on pregnancy outcomes among urban black women (17). Isolation represents the probability that members of the same racial group will encounter each other in a given neighborhood, while clustering measures the spatial grouping of racially similar neighborhoods. Using multilevel modeling, Bell found that higher isolation was associated with lower birth weight and higher rates of preterm birth, after controlling for individual- and area-level socioeconomic variables, but that higher clustering was associated with improved outcomes. Similarly, there is evidence that immigrant women who live in predominantly immigrant communities experience better pregnancy outcomes, including higher birth weights and more term births (18). These associations may be mediated by informal social resources, such as social support and social cohesion, which may buffer against the negative effects of concentrated economic deprivation or segregation.

**Gentrification**

There is now an extensive body of evidence documenting the impact of socio-spatial environment on public health. However, despite extensive work examining the effects of neighborhood-level socioeconomic characteristics on population health, there has been relatively little research on how changes in neighborhood character over time influence health. Neighborhood characteristics are dynamic and are influenced by economic and political forces in broader society. Among neighborhood-level changes, none has been as politically charged as gentrification. Gentrification–the transformation of a predominantly low-value neighborhood to one of higher-value–is a process that has generated much debate among social theorists, business groups, urban planners and political activists (19, 20). While the question of whether neighborhood revitalization

results in benefits for the community at large has been central in discussions about gentrification, the empirical evidence is mixed. Furthermore, very few studies have been undertaken to examine the effect of these rapid neighborhood level changes on public health despite the fact that gentrification appears to influence many of the area characteristics that have an effect on health.

***Drivers of Gentrification***

Since the term "gentrification" was first coined by sociologist Ruth Glass in 1964 (21), there has been considerable debate about the causes of this phenomenon. Most definitions of gentrification include references to the changes in both the physical and social character of a neighborhood. For example, Smith and Williams defined gentrification as "the rehabilitation of working-class and derelict housing and the consequent transformation of an area into a middle-class neighborhood (22)." Thus, research on the drivers of gentrification has focused on both supply-side and demand-side processes, and an understanding of both sets of processes is needed to fully explain this phenomenon.

Supply-side arguments focus on economic forces and the role of urban development as the principal drivers of gentrification. In particular, the "rent gap" theory has received considerable attention. This theory, first introduced by Neil Smith in 1979, posits that the disparity between "the actual capitalized ground rent (land price) of a plot of land given its present use, and the potential ground rent that might be gleaned under a 'higher and better' use" is a principal driver of gentrification (23). In the United States, suburbanization and the outward expansion of cities, driven by availability of cheap land, led to disinvestment in inner city housing. Once the gap between the potential and

capitalized rent on a land parcel becomes sufficiently large, it serves as an incentive for developers and property owners to reinvest in urban properties for a new class of tenants. Local governments, motivated by the reliance on tax revenues, are also involved in producing gentrifiable spaces through rezoning policies and the demolition of public housing (24). While some supply-side theories have been criticized (20, 25), primarily due to the difficulties in operationalizing concepts like the rent gap for empirical hypothesis testing, they remain useful for identifying neighborhoods that are gentrifying or may undergo gentrification in the future.

Demand-side drivers of gentrification are centered on shifts in consumer preferences. There has been considerable scholarship aimed at characterizing "gentrifiers." David Ley, heavily influenced by Daniel Bell's post-industrial thesis (26), identified the shift away from manufacturing and towards service- and knowledge-based economies as a primary reason for a renewed interest in urban living. The "new middle class" that emerged from this shift had "a vocation to enhance the quality of life in pursuits that are not simply economistic," which was manifested in a rejection of suburban living (27). This demand-driven model stresses not only the importance of location, but also the neighborhood amenities, architecture and culture. The increase in the size and purchasing power of this "new middle class," coupled with their desire to minimize commuting time to work and social and cultural attractions in the inner city, intensified the demand on urban housing markets and result in a growth of gentrification in many cities (28). These demand-side theories are reflected in measures of gentrification that include the metrics of the change in college-educated adults and those employed in managerial and professional occupations.

In Atlanta, both supply and demand driven processes have led to the gentrification of inner city neighborhoods. Atlanta experienced mass suburbanization in the latter half of the 20th century (29), leading to disinvestment in the inner city and increased concentrations of minorities and the poor. The central core continued to experience population declines until the 1990s. A number of regional policy initiatives, such as tax abatements for new housing developments, and development for the 1996 Olympic Games led to reinvestment in downtown areas of Atlanta, and there has been substantial growth in in-town housing (30). During the same period, spurred by federal funding through the HOPE VI project, the city also demolished nearly all public housing and replaced it with mixed-income communities (31). Extensive urban sprawl and long commute times in the Atlanta metropolitan area have driven demand for in-city housing by young professionals. New city projects, such as the Beltline, continue to fuel concerns about displacement of low-income residents from potentially gentrifying neighborhoods (32).

***Measurement of Gentrification***

One of the primary methodological challenges in gentrification research has been the operationalization of this multifaceted phenomenon for quantitative measurement. While there is not one agreed upon definition for gentrification in the literature, certain key aspects are shared among most definitions. These include the features of gentrifiable neighborhoods, physical upgrading and rising housing prices, and demographic shifts towards more affluent and educated residents. As a first step, there is a need to define the characteristics of neighborhoods that have the potential to undergo gentrification. Many studies consider inner-city location, a predominantly low-income population at baseline

and a history of disinvestment as prerequisites for gentrification, though the relative thresholds for these measures vary throughout the literature. Areas with a population of low-income residents prior to gentrification are commonly defined as those areas in which the median income falls below the median for the city or metropolitan area (33, 34). Van Criekingen and Decroly used a composite measure, created from principal component analysis of a number of resident socioeconomic status variables such as income, occupation and educational attainment, as proxy for defining "decayed and impoverished urban neighborhoods (35)." Census tracts in Brussels and Montreal were ranked by this measure to determine which had the potential to undergo gentrification. Disinvestment is harder to capture using existing census data. The proportion of older housing stock can be used, as neighborhoods where the majority of housing stock was recently constructed would not seem to be prone to gentrification (33). Again, the definition of this measure varies between studies. For example, Freeman defines this criterion for gentrification as having a proportion of housing built in the past 20 years that is at the $40^{th}$ percentile for the metropolitan area (33). Meligrana and Skaburskis, however, define census tracts as having potential for gentrification if they fall within the highest quartile of proportion of buildings built prior to 1946 (36).

Next, the process of gentrification is quantified in a number of ways, taking into consideration both the changes in housing and the built environment, and the demographics of a neighborhood. Some aspect of housing price appreciation is included in many measures of gentrification. This dimension of gentrification, generally operationalized by changes in median house value and rent (33, 37), is especially important to consider due to the potential for displacement of low-income residents due

to increases in housing prices. Physical upgrading is also associated with gentrification and is sometimes included when attempting to characterize gentrifying areas. For example, Wyly and Hammel conducted detailed qualitative and field surveys to identify visible evidence of reinvestment in four US metropolitan areas (34).

Finally, gentrification measures include changes in the demographics and socioeconomic status of neighborhood residents. Variables that are considered for this measure include mean (or median) income, proportion of those living below the federal poverty line, proportion of adults with college or higher education and proportion of civilians employed in managerial or professional occupations. These characteristics take into account that gentrification is intrinsically a class-driven phenomenon, reflecting the post-industrial thesis and David Ley's theory of "the new middle class" as the primary consumers of gentrifying spaces (27). Variables may be considered individually, usually by comparing the median values at the beginning and end of the study period relative to those of the metropolitan area, or in composite as in the work by van Criekingen and Decroly (35).

As evident from the above discussion, there is a wide range of characteristics that must be captured in measures of gentrification. Many studies of gentrification have been descriptive, and have examined each characteristic individually. However, to make inferences regarding the effects of gentrification, a single measure is most useful. There is considerable heterogeneity in the literature regarding which of the aspects of gentrification previously described should be included. For example, Freeman argues that changes in educational attainment may be better than changes in income as a marker of class and that a measure of gentrification based on income may not capture an influx of

highly educated but poorly paid young professionals (33). In some studies, only variables pertaining to income are included in the final model (38). Methods to combine different variables representing aspects of gentrification into a composite measure also vary between studies. Many use principal component analysis (36, 39) or the sum of *z*-scores of the percent change in a set of variables to construct a single gentrification index (38). Census tracts can also be identified *a priori* as "gentrified" or not based on a set of conditions and outcomes are compared between the two levels of exposure (gentrified vs. not) (33). While this approach is conceptually easier to interpret than those based on composite measures, it may not adequately capture neighborhoods in transition between non-gentrified and gentrified states.

There are a number of limitations to current measures of gentrification. The first is that most measures rely primarily on census data with its inherent limitations, such as the use administrative boundaries to define neighborhoods. These may not adequately capture the full dimensions of a spatial area undergoing neighborhood-level changes. Furthermore, many important aspects of neighborhood character change in the process of gentrification, such as social networks and area amenities, which may not be captured by census data. Arguably, the most considerable limitation is the difficulty in measuring and characterizing displacement of long-time residents from a gentrifying neighborhood. Residential mobility is extremely difficult to track and it is often impossible to determine the extent to which gentrification is responsible for residents moving out of a neighborhood (40). This aspect of gentrification is particularly salient to health researchers as the populations compared throughout the gentrification process may not be exchangeable. As health outcomes are very highly correlated with income and education,

an observation of improvement in the overall health of a community may be due to displacement of a lower SES population with one of higher SES.

### *Consequences of Gentrification and Potential Implications for Health*

Gentrification dramatically changes a neighborhood's character and resources in many ways that may influence community health, especially for the poor. By far the most dominant theme in research on the effects of gentrification is residential displacement. Indeed, some even include displacement of existing residents in the very definition of gentrification (30). The increases in housing costs that result from reinvestment and a subsequent influx of new, high-status residents may force existing residents to move away from the neighborhood. The threat of displacement is a key motivator of anti-gentrification activism. However, the empirical evidence of displacement in gentrifying areas is inconsistent, primarily due to the methodological challenges in measuring this phenomenon. Newman and Wyly summarize this problem as follows:

> In short, it is difficult to find people who have been displaced, particularly if those people are poor… By definition, displaced residents have disappeared from the very places were researchers and census-takers go to look for them (41).

Regardless, there have been a number of longitudinal studies that have documented residential displacement in gentrifying areas (40, 42). The magnitude of this phenomenon is under debate, with some studies finding that displacement is negligible and that poor renters do not appear to be more vulnerable to displacement from gentrifying areas (33). Some have argued that such findings may result from a lack of affordable housing options in increasingly tightening housing markets and that poorly-resourced households may in fact be the least able to move (20, 35). Furthermore, overcrowding may increase in gentrifying areas as a reaction to rising rental prices (43). These pressures may not be

reflected in quantitative data and thus many studies have used qualitative and mixed-methods approaches to document residential displacement (41, 44, 45).

Related to the issue of displacement is the rise in housing costs that precedes it. This has implications for affordable housing and may exert pressure on wider city housing markets. There are a few studies that link homelessness to gentrification *via* the secondary effects of a loss of affordable and public housing or through eviction and harassment of existing tenants (46, 47). Displacement has critical implications for population health as it can be a great source of stress and disrupt social support networks that are protective for health. Furthermore, even if existing residents are not displaced, the financial strains imposed by higher housing costs may negatively affect their health if increased investment in the community does not improve their overall socioeconomic status. The issue of displacement is also problematic methodologically as the populations being compared before and after gentrification takes place may not be exchangeable.

While gentrification is often viewed as a "negative neighborhood process" (48), it has also been touted as the answer to a number of social ills in urban neighborhoods (49). Gentrification could result in an overall benefit to health by reducing the spatial concentration of poverty. As described earlier, there is a considerable body of literature on the associations between neighborhood deprivation and negative health outcomes. Gentrification may bring investment and improvements in housing, neighborhood amenities and infrastructure, as well as increased local tax revenue (49, 50), all of which may have an overall positive effect on health. Furthermore, disinvestment in inner city areas may have created a spatial mismatch between workers and jobs (51, 52). Gentrification represents a recentralization of the labor market, which could potentially

result in more employment opportunities for low-income residents in revitalized inner city neighborhoods. Thus, on its face, gentrification would appear to be beneficial for a community, provided that low-income residents are not displaced. The empirical evidence of these supposed benefits, however, is sparse (53).

Changes in the social character in a gentrified neighborhood may also have positive or negative impacts on community health. Breaking down the social isolation of the poor through the creation of "socially mixed" communities has been one of the dominant themes in contemporary housing policy (20). Many researchers, spurred by Wilson's seminal work *The Truly Disadvantaged* (54), identify the lack of a stabilizing middle class population as a key cause of the decline of urban neighborhoods (55). Browning, Cagney and Wen describe the theorized benefits of neighborhood affluence (55):

> Consonant with Wilson's emphasis on the benefits of economic heterogeneity for urban communities, recent contributions to neighborhood theory and research have stressed the critical role of neighborhood affluence in generating the social conditions that support community social organization and mobilization capacity—described by Sampson and colleagues as ''collective efficacy."

However, there has been considerable debate among theorists about whether gentrification would achieve these goals. The increased social and political capital that comes with an influx of higher socioeconomic status residents may benefit the community by attracting investment and political attention to historically marginalized neighborhoods. However, it is not clear if only the new residents alone would experience the benefits associated with this social capital, while existing, low-income residents face the threat of displacement. Gentrification is often a source of community conflict, and may disrupt social cohesion and existing social networks. Finally, the migration of higher-income residents into a low-income community increases the extent of income inequality on the local level. While the extent of income inequality has been negatively

associated with population health on a societal level, evidence of these associations on smaller spatial scales is mixed (56).

Additionally, gentrification may impact neighborhood health by changing crime rates. Different theories exist regarding the effect of gentrification on crime. Crime may decrease through displacement of criminal elements from gentrifying areas. Conversely, rational actor theories assert that the increased affluence may be a target for crime (53). Indeed, the few studies on changes in crime levels in gentrified neighborhoods have produced mixed findings. One study found that property crime rates remained unchanged and personal crime rates declined (57), while others have observed opposite trends, with property crimes rates declining and rates of aggravated assault and murder rising in gentrified areas (58, 59). These contradictory findings may stem from different operational definitions of gentrification and different study settings.

As evidenced in the above discussion, despite extensive theoretical work, there is not a consensus on whether the net effects of gentrification are positive or negative. This is in part due to the methodological challenges of operationalizing and measuring the complex processes involved in neighborhood change. The weight of empirical evidence seems to suggest an overall negative effect for low-income residents of gentrifying areas, with discussions of the positive effects of gentrification primarily emerging from theory rather than measurable outcomes. However, Atkinson argues that the paucity of research on the benefits of gentrification may result from selectivity on the part of researchers, many of whom are "drawn to the subject because of its relationship to issues of social justice and conflict and this goes back to its Marxist hallmark in the 1960s (53)." Thus,

there is a clear need for further empirical study of the phenomenon of gentrification and its effects on the health of inner city communities.

### *Health Effects of Gentrification*

While it is clear that gentrification could have a number of potentially important impacts on health, either positive or negative, there has been little empirical research on this issue in the public health literature. The few studies that have been undertaken have found negative health impacts for some residents of gentrifying areas.

Barrett and coworkers examined associations between upward socioeconomic neighborhood change (i.e. gentrification) and distant metastasis at time of diagnosis of breast cancer, using cancer registry and census tract data from Cook County, Illinois (39). Their measure of gentrification was created using principal component analysis and consisted of a composite score of percent changes between 1990 and 2000 in owner-occupied housing value, percent of the civilian labor force in professional and managerial occupations and percent of adults with a college education. The odds of distant metastasis at diagnosis were modeled using multilevel logistic regression, controlling for individual-level characteristics such as age and race/ethnicity. The authors found a significant association between upward socioeconomic change and the probability of distant metastasis at diagnosis (adjusted odds ratio [aOR]=1.09, 95% Confidence Interval [CI]: 1.01–1.18). Interestingly, the same analysis also found a significant positive association between the outcome and a measure of concentrated disadvantage (aOR=1.23, 95% CI: 1.12–1.36), as well as a significant measure of concentrated affluence (aOR=0.86, 95% CI: 0.79–0.93). While these results seem to suggest that upward socioeconomic change should decrease the odds of metastasis at diagnosis, the opposite effect was observed.

The authors speculate that the women with distant metastasis in the gentrifying tracts in this study were long-standing residents of these areas, and may have experienced stress and decreased social support that resulted in decreased utilization of preventative or screening services. They cite another study that found that low-income women are less likely to have a mammogram if they reside in areas with higher overall education or income (60). Furthermore, the authors also speculate that gentrification may disrupt access to healthcare if the designation of a deprived area as a medically underserved area changes and the availability of federally qualified health centers serving low-income residents is impacted. The authors conclude that while upward neighborhood change may eventually result in the better health outcomes for residents, the transition period may put women in gentrifying neighborhoods at higher risk of late cancer diagnosis. However, it is not clear from this work whether these effects are temporary or if improved health outcomes in more affluent neighborhoods resulted from displacement of low-income residents.

A recent study by Huynh and Maroko examined the impacts of gentrification on preterm birth in New York City, using community districts as the neighborhood unit of analysis (38). The measure of gentrification used in this study was a composite of the number of college educated adults aged 25 or more, the number of residents living below the federal poverty line and the median household income. A percent change in each of these variables was calculated, using data from the 1990 Census and the 2005/2009 American Community Survey, and the *z*-scores for each were calculated and summed. A five-level variable was constructed using quintiles corresponding to the extent of upward change (very low, low, medium, high, very high), with “very low” serving as the referent

group. District-level 1990 median household income was included in the model to account for past neighborhood socioeconomic status. Individual level covariates that were included in the analysis were maternal age, Medicaid status and marital status, and the results were stratified by maternal race/ethnicity. While gentrification was not found to be significantly associated with increased odds of preterm birth in the overall sample, significant associations were found when the data were stratified by race/ethnicity. Among non-Hispanic black women, residence in a very highly gentrified district was positively associated with preterm birth (aOR=1.16, 95% CI: 1.01–1.33), while among non-Hispanic white women, living in a very highly gentrified district had a protective effect (aOR=0.78, 95% CI: 0.64–0.94). No significant effects were found in an analysis stratified by maternal education.

The authors posit that lower housing costs in gentrifying neighborhood may result in more disposable funds for new residents, but that long-term residents may experience psychosocial stress associated with changes in the neighborhood character and disruption of social networks. The implication of this assessment, in light of the findings, is that non-Hispanic whites were primarily the new residents moving to majority non-Hispanic black neighborhoods in this study setting. However, data on the housing tenure of the study participants was not collected and thus it was not possible to determine whether new and long-term residents were affected differentially by neighborhood change. The measure of gentrification used in this study did not include housing price appreciation, which is an important dimension of gentrification and may have provided some information on the extent to which residents were vulnerable to being displaced. Furthermore, this study did not define which districts were considered “gentrifiable” at

baseline. While the 1990 median household income was included in the model to account for the neighborhood socioeconomic status at baseline, the measure of gentrification in this study does not distinguish between those districts that had a low proportion of college-educated adults and high poverty rate at baseline and remained relatively unchanged, and those districts that had a high proportion of college-educated adults and low poverty rate at the beginning of the intercensal period.

While there has been great amount of interest in the influence of place of residence on health outcomes, neighborhoods are dynamic and there is a paucity of research on the effects of upward socioeconomic changes on public health. Given that gentrification is a widespread phenomenon throughout American urban centers, there is a clear need for more research on the health of gentrifying neighborhoods. There is also a need to further investigate and validate new methods of quantifying gentrification, and to operationalize this complex process in epidemiological research.

The present study investigated the association between living in a gentrified neighborhood and preterm birth in a population-based sample of births in Atlanta, Georgia, and whether there was a differential effect by race and education. We developed a measure that aimed to capture economic, housing and social changes associated with gentrification between 1990 and 2000, and modeled its association with birth outcomes in the three years immediately following this period. Further, we examined whether continuing neighborhood changes had an impact on the local risk profile by examining outcomes in a cohort of births from 2004 to 2007.

# Methods

## Data Sources

Data on birth outcomes and maternal demographics, including census tract of residence, were abstracted from vital records files provided by the Office of Health Indicators for Planning (OHIP) of the Georgia Department of Public Health. Data on all neighborhood-level characteristics were obtained from the US Census Bureau.

This study was reviewed and approved by the Emory University IRB (protocol # IRB00070088).

## Study Sample

Our study population was comprised of singleton live births to women who were residents of DeKalb and Fulton counties, Georgia between 2000 and 2007. The study sample was limited to births occurring after 2000 as neighborhood gentrification was evaluated by examining changes between 1990 and 2000. Only records with complete information on maternal ethnicity, maternal marital status and maternal education were included in the analysis.

## Definition of Exposure

The primary exposure of interest is residence in a gentrified census tract, as determined using data from the 1990 and 2000 Decennial Censuses. There were a total of 282 census tracts in DeKalb and Fulton counties in 2000. As a first step, these tracts were categorized as "gentrifiable" and "non-gentrifiable" at baseline, using 1990 census data normalized to 2000 tract boundaries (61). This was done in order to distinguish between disinvested tracts that remained ungentrified and those tracts already gentrified at the beginning of the intercensal period. Census tracts were classified as "gentrifiable" if they

had a median household income (MHI) less than the median for all census tracts, and if the proportion of housing units built before 1970 was higher than the median for all census tracts. These criteria were adapted from Freeman (33). A total of 105 census tracts were classified as "gentrifiable" using these criteria.

Among the gentrifiable tracts, the extent of gentrification between 1990 and 2000 was determined using the change in the following variables: (1) proportion of adults over 25 with a college education; (2) proportion of labor force in professional/managerial occupations; (3) MHI; (4) median house value for all owner-occupied units; (5) median rent. The 1990 MHI, median house values and median rents were adjusted for inflation utilizing the Consumer Price Index prior to calculating change (62). These variables were chosen to reflect the housing, economic and social changes involved in gentrification. The percent change during the intercensal period was calculated for all variables, and *z*-scores were calculated for each. For tracts in which the percent change could not be calculated for a variable because the value at baseline was zero, a *z*-score of zero was assigned for that variable. The *z*-scores were then summed, with lower *z*-scores corresponding to less gentrification. Finally, a three-level gentrification variable was constructed using tertiles of the summed *z*-scores (low, medium and high). After each census tract was categorized by gentrification status, these data were merged with the birth outcomes dataset using the census tract FIPS codes.

**Definition of Outcome**

Preterm birth is the primary outcome of interest and is defined as a birth occurring prior to 37 gestational weeks. Births were excluded if they occurred before 22 weeks of gestation or had a birthweight of less than 500 grams.

**Additional Covariates**

The present analysis adjusted for a number of maternal covariates that are relevant to birth outcomes. These were maternal age (continuous), race/ethnicity, educational status, Medicaid status (yes vs. no) and marital status (married vs. not married). Maternal race/ethnicity was categorized as non-Hispanic white, non-Hispanic black, Hispanic, non-Hispanic Asian, non-Hispanic American Indian/Alaska Native, non-Hispanic Hawaiian/Pacific Islander and non-Hispanic multi-racial. Maternal education was categorized as less than $9^{th}$ grade, $9^{th}$ through $11^{th}$ grade, completed high school or GED, and some college or higher.

**Statistical Analysis**

The total sample of births was characterized using descriptive statistics. Additionally, descriptive statistics were calculated separately for births that occurred between 2000 and 2003, and those that occurred between 2004 and 2007. The study sample was split into two cohorts as it is likely that the areas that underwent gentrification between 1990 and 2000 continued to undergo neighborhood-level changes past this time, and throughout the duration of data collection on birth outcomes. Thus, we wished to assess the effects of continued gentrification in our study. The distribution of maternal demographics by neighborhood gentrification status was calculated for the total sample, as well as for the two cohorts.

A descriptive analysis of neighborhood-level variables was also performed, stratifying the census tracts by gentrification status (non-gentrifiable, low, medium, high gentrification). These data were obtained from the 1990 and 2000 Decennial Censuses and the 2005-2009 American Community Survey. For all proportions, tract population-

weighted averages for each stratum of gentrification status are presented. For median household income, rent and house value variables, the median for all census tracts in each stratum is presented.

The association between extent of gentrification and preterm birth was modeled using generalized estimating equation modeling, to account for the clustered nature of the data. We used the GENMOD procedure and the REPEATED option with binomial distribution and logit link (SAS version 9.3, Cary, NC). Race/ethnicity, maternal education, Medicaid status and birth year were assessed individually as effect modifiers using two-way interaction terms with gentrification status. The statistical significance of overall interaction terms was evaluated by the generalized score test.

For models that included race/ethnicity interaction terms, the data were restricted to those identified as non-Hispanic white, non-Hispanic black and Hispanic, to avoid convergence errors in the model. Statistical significance was evaluated at $p<0.05$.

# Results

## Descriptive Statistics

Our study population consisted of 179,447 singleton live births to women who were residents of DeKalb and Fulton counties, Georgia between 2000 and 2007. We excluded 0.2% of the births (n=312) because they occurred before 22 weeks of gestation and/or had a birthweight of less than 500 grams. Additionally, we excluded 2.8% of births (n=5,090) that were missing information about maternal ethnicity, 0.04% (n=69) that were missing information about maternal marital status and 3.6% (n=6,398) that were missing information about maternal education. After exclusions, 167,578 eligible births remained, of which 84,330 occurred between 2000 and 2003 and 83,248 occurred between 2004 and 2007.

Descriptive statistics for all 167,578 births included in the present analysis are presented in Table 1. These statistics were further stratified for the 2000-2003 and 2004-2007 cohorts. This was done in order to assess whether ongoing gentrification after the 1990-2000 intercensal period had an impact on preterm birth risk in our study sample. The distribution of demographic characteristics was similar between the two cohorts. The overall preterm birth rate for the total study population was 11.9%. The overall preterm birth rate was slightly higher in the later birth cohort (12.7%) than in the earlier cohort (11.1%). As observed in previous studies, the preterm birth rate for black women was higher than for white women. In the total study population, 15.0% of births to black women were preterm as compared to only 7.8% for births to white women. However, Hawaiian/Pacific Islander women had the highest preterm birth rate (20.0%) of all race/ethnicity groups, though the overall number of these women was very small. In all

cohorts, women residing in non-gentrifiable census tracts experienced the lowest preterm birth rate. Among those women residing in gentrifiable census tracts, preterm birth rates were inversely related to the extent of gentrification, with women residing in the highest gentrification tracts experiencing the lowest preterm birth rates.

We next examined the distribution of maternal demographics by neighborhood gentrification status (Table 2). In total 127,651 (76.2%) women resided in non-gentrifiable tracts, 16,732 (10.0%) women resided in low gentrification tracts, 14,902 (8.9%) women resided in medium gentrification tracts and 8,293 (4.9%) women resided in high gentrification tracts. Low gentrification tracts had by far the highest proportion of black women (82.8%) as compared to all other tracts, while non-gentrifiable tracts had the lowest proportion of black women (45.9%). Low gentrification tracts also had the lowest proportion of married women (20.7%), lowest proportion of women who had some college education or higher (20.6%) and the lowest mean maternal age at birth (24.3, SD=5.87). Maternal demographics by gentrification status were also assessed separately for the 2000-2003 and 2004-2007 birth cohorts (Table 3, Table 4). While the distribution of maternal race/ethnicity between the two cohorts was similar for non-gentrifiable and low gentrification areas, the proportion of non-Hispanic black women in medium and high gentrification areas decreased in the later cohort relative to the earlier cohort. Furthermore, in medium and high gentrification areas, the distribution of educational attainment shifted towards higher education levels in the later cohort. Finally, the prevalence of Medicaid receipt was much higher in the earlier cohort than in the later cohort for all areas. Regardless, in both cohorts the proportion of women receiving

Medicaid was highest for those living in low gentrification tracts, while those residing in non-gentrifiable tracts had lowest prevalence of Medicaid receipt.

We next assessed gentrification in Atlanta at the census tract level. The changes in a number of neighborhood-level characteristics between 1990 and 2000 were assessed by gentrification status. Tract population-weighted averages and median values for all census tracts are presented in Table 5. Interestingly, the combined population of high gentrification tracts decreased from 98,519 in 1990 to 92,585 in 2000, while all other areas experienced population increases during this period. As expected, the high gentrification tracts had the most dramatic increase in the proportion of college educated adults, proportion of civilians employed in professional occupations, median household income and house values. Despite these increases, the values for these variables in high gentrification tracts remained below those in the non-gentrifiable tracts. Non-gentrifiable tracts had a lower weighted average proportion of non-Hispanic black residents in both census years than gentrifying areas. However, the proportion of non-Hispanic black residents declined the most in the intercensal period in high gentrification tracts. Home ownership rates increased slightly from 33.8% to 39.3% in high gentrification areas while declining from 47.9% to 42.9% for low gentrification areas.

Finally, we examined the residential mobility by gentrification status using data from the 1990 and 2000 decennial censuses, as well as estimates from the 2005-2009 American Community Survey. Proportions of occupied household units in which the householder moved within the past 5 years are presented in Table 6. While recent mobility was the highest in non-gentrifiable areas in 1990, it remained relatively stable in these areas throughout the study period while it increased in gentrifying areas. High

gentrification areas experienced the most dramatic increase in mobility between 1990 and the 2005-2009 estimate (54.8% to 76.2%).

**Modeling**

Odds ratios (ORs) for the association between preterm birth and tract-level gentrification status were estimated using generalized estimating equation modeling. The first set of models examined this association among gentrifiable areas only, with women residing in low gentrification areas serving as the reference group. Crude ORs were computed for the full study population, as well as separately for the 2000-2003 and 2004-2007 birth cohorts (Table 7). Living in a high gentrification area was protective and statistically significant as compared to living in a low gentrification area for both cohorts. However, after controlling for race/ethnicity, marital status, education, age and Medicaid status, no statistically significant associations were observed.

Next, we examined effect modification by various maternal characteristics. Effect modification by education was evaluated in a model that included interaction terms between education and the exposure variable (gentrification), while controlling for marital status, race/ethnicity, age and Medicaid status. The overall interaction term was not significant for the 2000-2003 cohort ($p$=0.84) and associations between gentrification and preterm birth were null for all strata of education below "some college or higher" (Table 8). The overall interaction was significant, however, for the later cohort ($p$=0.04). For women with some college education who gave birth between 2004 and 2007, living in a high gentrification area was protective (aOR: 0.75, 95% CI: 0.59–0.94). No significant associations between gentrification and preterm birth were observed when interaction with Medicaid status was evaluated (Table 9).

Next, effect modification by maternal race/ethnicity was evaluated in a model that included interaction terms with gentrification, while controlling for marital status, education, age and Medicaid status (Table 10). In the 2000-2003 cohort, the interaction terms between the exposure and race/ethnicity variables were not statistically significant ($p$=0.34). However, some differences in the estimated aORs were observed between race/ethnicity groups within this cohort. As compared to living in a low gentrification area, living in a medium (aOR: 0.70, 95% CI: 0.45–1.09) or high (aOR: 0.71, 95% CI: 0.44–1.12) gentrification area was protective for non-Hispanic white women. These associations were null for non-Hispanic black and Hispanic women. A model with a two-way interaction term between race/ethnicity and gentrification was evaluated for the 2004-2007 cohort. As was observed in the model of the early cohort, the overall interaction term was not statistically significant ($p$=0.18) but there was modest evidence of racial differences in the estimated aORs. The magnitude of the protective effect among non-Hispanic white women was even greater and statistically significant in this cohort (aOR: 0.47, 95% CI: 0.31–0.71), while the associations remained null for both non-Hispanic black and Hispanic women.

Given the differences observed between the early and late cohorts when examining interaction with race/ethnicity, we next evaluated a model that contained two-way interaction terms between gentrification and race/ethnicity, as well as the gentrification and birth year, while controlling for marital status, education, age and Medicaid status. Adjusted ORs by race/ethnicity for 2000 births and 2007 births are presented in Table 11. Neither the race/ethnicity interaction terms nor the birth year interaction terms were significant. As observed in previous models that only included

race/ethnicity interaction terms, a significant protective effect was observed for non-Hispanic white women living in medium (aOR: 0.64, 95% CI: 0.45–0.92) and high (aOR: 0.59, 95% CI: 0.41–0.86) gentrification areas, in 2000. The magnitude of this effect slightly increased in 2007 for both those residing in medium (aOR: 0.59, 95% CI: 0.40–0.87) and in high (aOR: 0.55, 95% CI: 0.36–0.83) gentrification areas. These associations were not significant for non-Hispanic black and Hispanic women.

Finally, we evaluated the association between gentrification and preterm birth with women residing in non-gentrifiable census tracts as the reference group. Crude and adjusted ORs, by birth cohort, are presented in Table 12. All crude ORs were significant and indicated higher odds of preterm birth for women living in gentrifying areas as compared to those living in non-gentrifiable areas. The crude ORs were highest for women living in low gentrification areas and lowest for those living in high gentrification areas. After adjusting for race/ethnicity, marital status, education, age and Medicaid status, most of the associations remained statistically significant. The magnitude of the association was higher in the later cohort than in the early cohort. The association was highest for infants born in low gentrification areas between 2004 and 2007 (aOR: 1.29, 95% CI: 1.20–1.40).

## Discussion

For the present analysis, we developed a measure of gentrification that considered both baseline measures and the relative change between 1990 and 2000. We chose to first define areas that could be considered "gentrifiable" using residents' income and the median age of housing units as a proxy for disinvestment. At the beginning of the intercensal period, areas that we considered as potentially gentrifiable had populations that were less educated and had a lower proportion of those employed in professional occupations than did non-gentrifiable areas. Housing values and rents were also substantially lower in these areas. This suggests that our measure adequately captured neighborhoods that are commonly thought as potentially gentrifying.

Between 1990 and 2000, high gentrification neighborhoods experienced the most substantial increases in the proportion of college-educated adults, the proportion employed in professional occupations and housing prices. This was not surprising given that the change in these variables was used to define our measure of gentrification. Also as expected, the values of these variables remained stable in low gentrification areas. Further, the proportion of non-Hispanic black residents in high gentrification areas declined in high and medium gentrification areas, while the proportion of non-Hispanic white residents increased. This change was more pronounced in highly gentrified neighborhoods. As new residents in gentrifying areas are more commonly expected to be white, this demographic change is consistent with what would be expected in gentrifying areas. Interestingly, high gentrification tracts were the only area that experienced a population decline between 1990 and 2000. Given that these areas also experienced

increases in the numbers of educated, professionally employed and white residents, a high proportion of existing residents moved away from these areas during this time.

While we did not evaluate the extent of neighborhood change after 2000, there is evidence to suggest that the areas we considered to be highly gentrified continued to gentrify past this time. When examining the distribution of maternal demographics by neighborhood gentrification status for the 2000-2003 and 2004-2007 birth cohorts, we observed a shift towards higher educational attainment among women in high gentrification areas over time. Further, the proportion of births to non-Hispanic black in the later cohort was lower than that of the early cohort in medium and high gentrification areas, while the racial composition of women in low gentrification and non-gentrifiable areas remained similar over time. Similar trends were observed at the census tract level between 1990 and 2000, with a substantial decline in the proportion of non-Hispanic black residents in high gentrification areas. These observations, in addition to the finding of increased residential mobility in these areas, have important implications for evaluating the potential influence of displacement in our study.

Among women residing in gentrifiable areas, no significant association was observed between preterm birth and extent of gentrification, after controlling for race/ethnicity, education, Medicaid status and maternal age. This is consistent with a previous study on preterm birth and gentrification in New York City. Also consistent with this earlier work was our finding of a differential effect by maternal race. For non-Hispanic white women, living in a highly gentrified area was protective as compared to those living in less gentrified areas. The magnitude of this protective effect appeared to increase for the later birth cohort, though the overall interaction terms between

gentrification and race/ethnicity were not statistically significant. In contrast to Huynh and Maroko's findings, we did not observe any significant associations between preterm birth and gentrification for non-Hispanic black women. Furthermore, residence in highly gentrified areas was protective for the most educated women in the later cohort of our study sample.

To the extent that gentrification is driven by an influx of white, educated residents of higher socioeconomic status, the finding of decreased odds of preterm birth for non-Hispanic white women in high gentrification areas may have resulted from unmeasured socioeconomic confounders. While the present analysis controlled for education and Medicaid status, the populations in low and high gentrification areas may not be exchangeable. As displacement is often cited as a consequence of gentrification, existing low-income residents in highly gentrified areas may have been replaced with a generally healthier population. Indeed, existing residents of high gentrification areas may have been displaced into low gentrification areas, thus increasing the disparities between these two populations. The observed increase in the magnitude of the protective effect in the later birth cohort is likely a product of continued upward neighborhood change between 2000 and 2007. It is also possible that moving into a gentrifying neighborhood may impart some health benefits for new residents. Gentrifiable areas are attractive to new residents due to lower housing costs and thus moving into such an area may result in more disposable income. Furthermore, recentralizing labor markets may result in shorter commute times to work for new residents. The differential effect by race and education level suggests that any putative benefits of gentrification are not equitably distributed.

When women residing in non-gentrifiable areas were included in the analysis as the referent group, living in a gentrifiable area was adversely associated with preterm birth regardless of the extent of gentrification. While a number of socioeconomic measures increased in high gentrification areas, non-gentrifiable areas were still predominantly higher income and more educated. Thus, the neighborhood-level characteristics that increase preterm birth risk in these areas likely persisted despite upward neighborhood change.

The present study has several notable limitations. First, as in any study of gentrification, measuring residential turnover in gentrifying neighborhoods represents a substantial methodological challenge. We did not have information on the housing tenure of the women in our study. Thus, our ability to make inferences on differential impacts for new and existing residents of gentrifying areas is limited. Furthermore, we could not assess the extent of displacement of existing residents. While we observed only null and protective effects for women residing in high gentrification areas, we could not assess whether this phenomenon had a detrimental impact on health for those who moved out of these communities. Second, the measure of gentrification developed for this study was determined on the basis of five different variables that captured social, housing and economic changes involved in gentrification. However, these variables were drawn from census data, which has inherent limitations. The boundaries that define census tracts may not adequately capture true neighborhood boundaries, and information on the changes in social character and amenities may not be captured by our measure of gentrification. Finally, we assumed that all census tracts defined as gentrifiable at baseline were relatively homogenous before the gentrification process. As we did not assess birth

outcomes in these areas before gentrification, it may be that the risk for preterm birth may have already been differentially distributed prior to the intercensal period.

The present study adds to the literature on gentrification by characterizing demographic and economic changes in Atlanta's neighborhoods, and investigating their association with health. Though deconcentration of poverty through urban renewal is often recommended as a remedy for many factors associated with poor health, we did not find evidence of this in our study. While living in a highly gentrified area was not associated with higher preterm birth, as compared to areas with similar baseline characteristics that did not undergo gentrification, it appears that potential benefits were only experienced by gentrifying populations. A protective effect of living in a gentrified neighborhood was only observed among non-Hispanic white women and those with higher education. Thus, interventions beyond spatial deconcentration of poverty are needed to address socio-spatial determinants of health disparities.

In addition to these findings related specifically to birth outcomes, we also observed a high degree of population turnover in the areas with highest gentrification. While it is not possible to know from our study the reasons why existing residents moved, given the concurrent increases in rent and housing prices in these areas, displacement due to economic pressures is a real concern. More research is needed to characterize these residential mobility patterns and their influence on health outcomes. Future work could focus on longitudinal studies of gentrifying areas to determine the extent and effects of displacement in these areas. Such studies may also be able to distinguish between changes in health in existing residents *versus* those resulting from a turnover in population. Additionally, more work is needed to more fully describe the

health impact of specific social and economic neighborhood-level changes. The gentrification measure employed in the present study was a composite of a number of social and economic changes present in gentrifying neighborhoods. While this allowed us to characterize neighborhood change in a multi-dimensional fashion, future work could focus on the effects of individual markers of gentrification. For example, it could be that rising housing prices have more of a negative impact on health outcomes than do changes in demographic characteristics. Obtaining a more nuanced understanding of gentrification could have important implications for policies, such as rent control measures, that mitigate potential negative effects of neighborhood change. As gentrification is a phenomenon ongoing in Atlanta and other urban metropolitan areas, there is a need for continued investigation of its impact on community health.

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# Tables

**Table 1. Distribution of maternal demographic characteristics by birth cohort.**

| | All births (N) | % Preterm | 2000-2003 births (N) | % Preterm | 2004-2007 births (N) | % Preterm |
|---|---|---|---|---|---|---|
| Total | 167,578 | 11.9 | 84,330 | 11.1 | 83,248 | 12.7 |
| Maternal Race/Ethnicity | | | | | | |
| NH[1] white | 45,448 | 7.8 | 23,862 | 7.7 | 21,586 | 7.8 |
| NH black | 86,570 | 15.0 | 43,961 | 13.8 | 42,609 | 16.3 |
| NH Asian | 8,023 | 7.8 | 3,775 | 7.6 | 4,248 | 8.0 |
| NH American Indian/Alaska Native | 230 | 8.3 | 134 | 8.2 | 96 | 8.3 |
| NH Hawaiian/Pacific Islander | 50 | 20.0 | 20 | 20.0 | 30 | 20.0 |
| NH Multi-racial | 1,041 | 12.9 | 213 | 11.7 | 828 | 13.2 |
| Hispanic | 26,216 | 10.0 | 12,365 | 9.2 | 13,851 | 10.7 |
| Marital Status | | | | | | |
| Married | 89,529 | 9.3 | 46,746 | 9.1 | 42,783 | 9.6 |
| Not married | 78,049 | 14.8 | 37,584 | 13.5 | 40,465 | 16.0 |
| Maternal Education | | | | | | |
| Less than 9th grade | 12,727 | 11.6 | 6,512 | 10.4 | 6,215 | 12.9 |
| 9th through 11th grade | 25,455 | 14.9 | 13,199 | 13.7 | 12,256 | 16.3 |
| High School/GED | 43,273 | 14.0 | 20,890 | 13.0 | 22,383 | 15.0 |
| Some college or higher | 86,123 | 9.9 | 43,729 | 9.5 | 42,394 | 10.4 |
| Maternal age (years) | | | | | | |
| <20 | 18,235 | 14.3 | 9,534 | 13.2 | 8,701 | 15.5 |
| 20-24 | 40,021 | 12.8 | 20,399 | 11.5 | 19,622 | 14.1 |
| 25-29 | 41,013 | 11.4 | 20,154 | 10.5 | 20,859 | 12.2 |
| 30-34 | 41,180 | 10.4 | 20,954 | 9.8 | 20,226 | 11.1 |
| 35+ | 27,129 | 12.0 | 13,289 | 11.9 | 13,840 | 12.0 |
| Mean (SD) | 27.7 (6.39) | | 27.6 (6.40) | | 27.8 (6.38) | |
| Medicaid Status | | | | | | |
| Medicaid | 51742 | 12.7 | 38691 | 12.4 | 13,051 | 13.6 |
| No Medicaid | 115836 | 11.5 | 45639 | 10.0 | 70,197 | 12.5 |
| Gentrification Status | | | | | | |
| Non-gentrifiable | 127651 | 10.9 | 63,509 | 10.3 | 64,142 | 11.5 |
| Low | 16732 | 16.3 | 8,982 | 14.1 | 7,750 | 18.8 |
| Medium | 14902 | 14.0 | 7,669 | 12.9 | 7,233 | 15.2 |
| High | 8293 | 13.5 | 4,170 | 12.7 | 4,123 | 14.4 |

[1]Non-Hispanic

**Table 2. Distribution of maternal demographics by gentrification status, all births (2000-2007).**

| | Non-gentrifiable | | Low | | Medium | | High | |
|---|---|---|---|---|---|---|---|---|
| | N | % | N | % | N | % | N | % |
| Maternal Race/Ethnicity | 127,651 | 100 | 16,732 | 100 | 14,902 | 100 | 8,293 | 100 |
| NH white | 39,429 | 30.9 | 706 | 4.2 | 3,022 | 20.3 | 2,291 | 27.6 |
| NH black | 58,551 | 45.9 | 13,852 | 82.8 | 8,719 | 58.5 | 5,448 | 65.7 |
| NH Asian | 7,381 | 5.8 | 120 | 0.7 | 306 | 2.05 | 216 | 2.6 |
| NH American Indian/Alaska Native | 199 | 0.2 | 15 | 0.1 | 10 | 0.07 | 6 | 0.07 |
| NH Hawaiian/Pacific Islander | 43 | 0.03 | 2 | 0.01 | 2 | 0.01 | 3 | 0.04 |
| NH Multi-racial | 867 | 0.7 | 62 | 0.4 | 54 | 0.36 | 58 | 0.7 |
| Hispanic | 21,181 | 16.6 | 1,975 | 11.8 | 2,789 | 18.7 | 271 | 3.27 |
| Marital Status | | | | | | | | |
| Married | 77,146 | 60.4 | 3,459 | 20.7 | 5,777 | 38.8 | 3,147 | 38.0 |
| Not married | 50,505 | 39.6 | 13,273 | 79.3 | 9,125 | 61.2 | 5,146 | 62.1 |
| Maternal Education | | | | | | | | |
| Less than 9th grade | 9,133 | 7.2 | 1,593 | 9.5 | 1,796 | 12.1 | 205 | 2.5 |
| 9th through 11th grade | 14,287 | 11.2 | 5,515 | 33.0 | 3,638 | 24.4 | 2,015 | 24.3 |
| High School/GED | 30,549 | 23.9 | 6,170 | 36.9 | 4,316 | 29.0 | 2,238 | 27.0 |
| Some college or higher | 73,682 | 57.7 | 3,454 | 20.6 | 5,152 | 34.6 | 3,835 | 46.2 |
| Maternal age (years) | | | | | | | | |
| <20 | 11,032 | 8.6 | 3,689 | 22.1 | 2,343 | 15.7 | 1,171 | 14.1 |
| 20-24 | 27,176 | 21.3 | 6,054 | 36.2 | 4,482 | 30.1 | 2,309 | 27.8 |
| 25-29 | 31,860 | 25.0 | 3,874 | 23.2 | 3,416 | 22.9 | 1,863 | 22.5 |
| 30-34 | 34,545 | 27.1 | 1,962 | 11.7 | 2,863 | 19.2 | 1,810 | 21.8 |
| 35+ | 23,038 | 18.1 | 1,153 | 6.9 | 1,798 | 12.1 | 1,140 | 13.8 |
| Mean (SD) | 28.4 (6.27) | | 24.3 (5.87) | | 26.2 (6.39) | | 26.8 (6.48) | |
| Medicaid Status | | | | | | | | |
| Recipient | 33,607 | 26.3 | 8,654 | 51.7 | 6,306 | 42.3 | 3,175 | 38.3 |
| Non-recipient | 94,044 | 73.7 | 8,078 | 48.3 | 8,596 | 57.7 | 5,118 | 61.7 |

**Table 3. Distribution of maternal demographics by gentrification status, 2000-2003 births.**

| | Non-gentrifiable | | Low | | Medium | | High | |
|---|---|---|---|---|---|---|---|---|
| | N | % | N | % | N | % | N | % |
| Maternal Race/Ethnicity | 63,509 | 100.0 | 8,982 | 100.0 | 7,669 | 100.0 | 4,170 | 100.0 |
| NH white | 21,104 | 33.2 | 346 | 3.9 | 1,418 | 18.5 | 994 | 23.8 |
| NH black | 28,925 | 45.5 | 7,418 | 82.6 | 4,690 | 61.2 | 2,928 | 70.2 |
| NH Asian | 3,459 | 5.5 | 88 | 1.0 | 134 | 1.8 | 94 | 2.3 |
| NH American Indian/Alaska Native | 116 | 0.2 | 11 | 0.1 | 3 | 0.04 | 4 | 0.1 |
| NH Hawaiian/Pacific Islander | 18 | 0.03 | 1 | 0.01 | 1 | 0.01 | 0 | 0 |
| NH Multi-racial | 179 | 0.3 | 12 | 0.1 | 11 | 0.1 | 11 | 0.3 |
| Hispanic | 9,708 | 15.3 | 1,106 | 12.3 | 1,412 | 18.4 | 139 | 3.3 |
| Marital Status | | | | | | | | |
| Married | 40,387 | 63.6 | 2,028 | 22.6 | 2,913 | 38.0 | 1,418 | 34.0 |
| Not married | 23,122 | 36.4 | 6,954 | 77.4 | 4,756 | 62.0 | 2,752 | 66.0 |
| Maternal Education | | | | | | | | |
| Less than 9th grade | 4,504 | 7.1 | 941 | 10.5 | 937 | 12.2 | 130 | 3.1 |
| 9th through 11th grade | 6,869 | 10.8 | 3,038 | 33.8 | 2,087 | 27.2 | 1,205 | 28.9 |
| High School/GED | 14,226 | 22.4 | 3,258 | 36.3 | 2,222 | 29.0 | 1,184 | 28.4 |
| Some college or higher | 37,910 | 59.7 | 1,745 | 19.4 | 2,423 | 31.6 | 1,651 | 39.6 |
| Maternal age (years) | | | | | | | | |
| <20 | 5,399 | 8.5 | 2,107 | 23.5 | 1,327 | 17.3 | 701 | 16.8 |
| 20-24 | 13,414 | 21.1 | 3,268 | 36.4 | 2,437 | 31.8 | 1,280 | 30.7 |
| 25-29 | 15,616 | 24.6 | 1,935 | 21.5 | 1,711 | 22.3 | 892 | 21.4 |
| 30-34 | 17,655 | 27.8 | 1,068 | 11.9 | 1,409 | 18.4 | 822 | 19.7 |
| 35+ | 11,425 | 18.0 | 604 | 6.7 | 785 | 10.2 | 475 | 11.4 |
| Mean (SD) | 28.4 (6.25) | | 24.2 (5.89) | | 25.7 (6.29) | | 26.0 (6.42) | |
| Medicaid Status | | | | | | | | |
| Recipient | 24,498 | 38.6 | 6,782 | 75.5 | 4,904 | 64.0 | 2,507 | 60.1 |
| Non-recipient | 39,011 | 61.4 | 2,200 | 24.5 | 2,765 | 36.1 | 1,663 | 39.9 |

**Table 4. Distribution of maternal demographics by gentrification status, 2004-2007 births.**

| | Non-gentrifiable | | Low | | Medium | | High | |
|---|---|---|---|---|---|---|---|---|
| | N | % | N | % | N | % | N | % |
| Maternal Race/Ethnicity | 64,142 | 100 | 7,750 | 100 | 7,233 | 100 | 4,123 | 100 |
| NH white | 18,325 | 28.6 | 360 | 4.7 | 1,604 | 22.2 | 1,297 | 31.5 |
| NH black | 29,626 | 46.2 | 6,434 | 83.0 | 4,029 | 55.7 | 2,520 | 61.1 |
| NH Asian | 3,922 | 6.1 | 32 | 0.4 | 172 | 2.4 | 122 | 3.0 |
| NH American Indian/Alaska Native | 83 | 0.1 | 4 | 0.1 | 7 | 0.1 | 2 | 0.1 |
| NH Hawaiian/Pacific Islander | 25 | 0.04 | 1 | 0.01 | 1 | 0.01 | 3 | 0.1 |
| NH Multi-racial | 688 | 1.1 | 50 | 0.7 | 43 | 0.6 | 47 | 1.1 |
| Hispanic | 11,473 | 17.9 | 869 | 11.2 | 1,377 | 19.0 | 132 | 3.2 |
| Marital Status | | | | | | | | |
| Married | 36,759 | 57.3 | 1,431 | 18.5 | 2,864 | 39.6 | 1,729 | 41.9 |
| Not married | 27,383 | 42.7 | 6,319 | 81.5 | 4,369 | 60.4 | 2,394 | 58.1 |
| Maternal Education | | | | | | | | |
| Less than 9th grade | 4,629 | 7.2 | 652 | 8.4 | 859 | 11.9 | 75 | 1.8 |
| 9th through 11th grade | 7,418 | 11.6 | 2,477 | 32.0 | 1,551 | 21.4 | 810 | 19.7 |
| High School/GED | 16,323 | 25.5 | 2,912 | 37.6 | 2,094 | 29.0 | 1,054 | 25.6 |
| Some college or higher | 35,772 | 55.8 | 1,709 | 22.1 | 2,729 | 37.7 | 2,184 | 53.0 |
| Maternal age (years) | | | | | | | | |
| <20 | 5,633 | 8.8 | 1,582 | 20.4 | 1,016 | 14.1 | 470 | 11.4 |
| 20-24 | 13,762 | 21.5 | 2,786 | 36.0 | 2,045 | 28.3 | 1,029 | 25.0 |
| 25-29 | 16,244 | 25.3 | 1,939 | 25.0 | 1,705 | 23.6 | 971 | 23.6 |
| 30-34 | 16,890 | 26.3 | 894 | 11.5 | 1,454 | 20.1 | 988 | 24.0 |
| 35+ | 11,613 | 18.1 | 549 | 7.1 | 1,013 | 14.0 | 665 | 16.1 |
| Mean (SD) | 28.3 (6.29) | | 24.5 (5.84) | | 26.7 (6.46) | | 27.5 (6.44) | |
| Medicaid Status | | | | | | | | |
| Recipient | 9,109 | 14.2 | 1,872 | 24.2 | 1,402 | 19.4 | 668 | 16.2 |
| Non-recipient | 55,033 | 85.8 | 5,878 | 75.9 | 5,831 | 80.6 | 3,455 | 83.8 |

**Table 5. Neighborhood characteristics by gentrification status and census year.**

| | High gentrification tracts (N=35) | | Medium gentrification tracts (N=35) | | Low gentrification tracts (N=35) | | Non-gentrifiable tracts (N=177) | |
|---|---|---|---|---|---|---|---|---|
| | **1990** | **2000** | **1990** | **2000** | **1990** | **2000** | **1990** | **2000** |
| Total population | 98,519 | 92,585 | 118,825 | 130,412 | 133,272 | 137,420 | 844,586 | 1,121,454 |
| Median MHI ($) | 18,888 | 29,162 | 26,851 | 28,007 | 25,558 | 25,286 | 53,249 | 54,080 |
| College educated adults (%) | 15.3 | 29.5 | 22.6 | 29.5 | 10.5 | 10.0 | 38.1 | 44.1 |
| Professional occupations (%) | 25.5 | 41.6 | 28.2 | 36.5 | 17.4 | 17.2 | 40.0 | 44.2 |
| Non-Hispanic white (%) | 22.1 | 30.1 | 34.7 | 29.8 | 12.1 | 6.4 | 60.3 | 45.4 |
| Non-Hispanic black (%) | 75.2 | 62.6 | 60.7 | 57.4 | 85.8 | 86.1 | 34.5 | 41.8 |
| Hispanic (%) | 1.4 | 3.0 | 2.6 | 8.2 | 1.2 | 5.1 | 2.6 | 7.1 |
| Median rent ($) | 415 | 530 | 568 | 592 | 560 | 533 | 756 | 789 |
| Median housing price ($) | 54,940 | 106,100 | 71,277 | 84,500 | 65,480 | 68,400 | 122,923 | 148,100 |
| Owner-occupied housing units (%) | 33.8 | 39.3 | 39.4 | 40.8 | 47.9 | 42.9 | 57.9 | 59.0 |

**Table 6. Proportion (%) of occupied household units in which householder moved in within past 5 years, by census year and neighborhood gentrification status.**

| | **1990** | **2000** | **2005-2009** |
|---|---|---|---|
| Non-gentrifiable | 61.1 | 61.3 | 65.0 |
| Low | 46.5 | 51.3 | 61.6 |
| Medium | 56.3 | 59.9 | 73.0 |
| High | 54.8 | 64.8 | 76.2 |

**Table 7. Crude and adjusted odds ratios for preterm birth and gentrification, stratified by birth cohort.**

| | Crude OR | 95% CI | aOR | 95% CI |
|---|---|---|---|---|
| All births | | | | |
| Low | Ref | | Ref | |
| Medium | 0.84 | 0.74–0.95 | 0.98 | 0.92–1.06 |
| High | 0.81 | 0.69–0.94 | 0.94 | 0.84–1.04 |
| 2000-2003 births | | | | |
| Low | Ref | | Ref | |
| Medium | 0.90 | 0.80–1.01 | 1.01 | 0.94–1.10 |
| High | 0.89 | 0.76–1.04 | 0.98 | 0.87–1.10 |
| 2004-2007 births | | | | |
| Low | Ref | | Ref | |
| Medium | 0.78 | 0.66–0.91 | 0.95 | 0.86–1.06 |
| High | 0.73 | 0.60–0.88 | 0.90 | 0.79–1.04 |

**Table 8. Adjusted odds ratios for preterm birth and gentrification, stratified by maternal education level and birth cohort.**

| | 2000-2003 Births | | 2004-2007 Births | |
|---|---|---|---|---|
| | aOR | 95% CI | aOR | 95% CI |
| Overall | | | | |
| Low | Ref | | Ref | |
| Medium | 1.01 | 0.94–1.10 | 0.95 | 0.86–1.06 |
| High | 0.98 | 0.87–1.10 | 0.90 | 0.79–1.04 |
| Less than 9th grade | | | | |
| Low | Ref | | Ref | |
| Medium | 0.99 | 0.80–1.22 | 0.87 | 0.69–1.11 |
| High | 0.81 | 0.52–1.26 | 0.90 | 0.46–1.76 |
| 9th through 11th grade | | | | |
| Low | Ref | | Ref | |
| Medium | 1.10 | 0.96–1.26 | 1.07 | 0.90–1.27 |
| High | 0.98 | 0.84–1.15 | 1.16 | 0.96–1.41 |
| High school/GED | | | | |
| Low | Ref | | Ref | |
| Medium | 0.95 | 0.82–1.10 | 0.96 | 0.85–1.10 |
| High | 1.02 | 0.78–1.33 | 0.83 | 0.69–1.00 |
| Some college or more | | | | |
| Low | Ref | | Ref | |
| Medium | 0.99 | 0.79–1.24 | 0.80 | 0.64–1.00 |
| High | 0.94 | 0.74–1.20 | 0.75 | 0.59–0.94 |

**Table 9. Adjusted odds ratios for preterm birth and gentrification, stratified by maternal Medicaid status and birth cohort.**

| | 2000-2003 Births | | 2004-2007 Births | |
|---|---|---|---|---|
| | **aOR** | **95% CI** | **aOR** | **95% CI** |
| Overall | | | | |
| Low | Ref | | Ref | |
| Medium | 1.01 | 0.94–1.10 | 0.95 | 0.86–1.06 |
| High | 0.98 | 0.87–1.10 | 0.90 | 0.79–1.04 |
| Medicaid recipient | | | | |
| Low | Ref | | Ref | |
| Medium | 1.00 | 0.93–1.07 | 1.11 | 0.90–1.37 |
| High | 0.91 | 0.80–1.04 | 1.02 | 0.81–1.28 |
| Non-recipient | | | | |
| Low | Ref | | Ref | |
| Medium | 1.09 | 0.92–1.28 | 0.91 | 0.82–1.02 |
| High | 1.17 | 0.96–1.43 | 0.87 | 0.75–1.01 |

**Table 10. Adjusted odds ratios for preterm birth and gentrification, stratified by maternal race/ethnicity and birth cohort.**

| | 2000-2003 Births | | 2004-2007 Births | |
|---|---|---|---|---|
| | **aOR** | **95% CI** | **aOR** | **95% CI** |
| Overall | | | | |
| Low | Ref | | Ref | |
| Medium | 1.01 | 0.94–1.10 | 0.95 | 0.86–1.06 |
| High | 0.98 | 0.87–1.10 | 0.90 | 0.79–1.04 |
| NH white | | | | |
| Low | Ref | | Ref | |
| Medium | 0.70 | 0.45–1.09 | 0.55 | 0.35–0.85 |
| High | 0.71 | 0.44–1.12 | 0.47 | 0.31–0.71 |
| NH black | | | | |
| Low | Ref | | Ref | |
| Medium | 1.06 | 0.97–1.17 | 0.99 | 0.88–1.12 |
| High | 1.01 | 0.87–1.16 | 0.96 | 0.83–1.11 |
| Hispanic | | | | |
| Low | Ref | | Ref | |
| Medium | 0.90 | 0.73–1.12 | 0.90 | 0.71–1.13 |
| High | 1.07 | 0.71–1.60 | 1.14 | 0.61–2.11 |

**Table 11. Adjusted odds ratios for preterm birth and gentrification, stratified by maternal race/ethnicity and birth year.**

| | 2000 | | 2007 | |
|---|---|---|---|---|
| | **aOR** | **95% CI** | **aOR** | **95% CI** |
| Overall | | | | |
| Low | Ref | | Ref | |
| Medium | 1.03 | 0.93–1.14 | 0.94 | 0.83–1.06 |
| High | 0.99 | 0.85–1.15 | 0.89 | 0.76–1.05 |
| NH white | | | | |
| Low | Ref | | Ref | |
| Medium | 0.64 | 0.45–0.92 | 0.59 | 0.40–0.87 |
| High | 0.59 | 0.41–0.86 | 0.55 | 0.36–0.83 |
| NH black | | | | |
| Low | Ref | | Ref | |
| Medium | 1.07 | 0.96–1.19 | 0.99 | 0.87–1.12 |
| High | 0.98 | 0.77–1.27 | 0.91 | 0.68–1.22 |
| Hispanic | | | | |
| Low | Ref | | Ref | |
| Medium | 0.93 | 0.78–1.11 | 0.86 | 0.72–1.03 |
| High | 0.86 | 0.64–1.16 | 0.80 | 0.58–1.10 |

**Table 12. Crude and adjusted odds ratios for preterm birth and gentrification, stratified by birth cohort.**

| | **Crude OR** | **95% CI** | **aOR** | **95% CI** |
|---|---|---|---|---|
| Overall | | | | |
| Non-gentrifiable | Ref | | Ref | |
| Low | 1.58 | 1.47–1.70 | 1.19 | 1.13–1.26 |
| Medium | 1.33 | 1.17–1.51 | 1.16 | 1.09–1.23 |
| High | 1.27 | 1.09–1.49 | 1.09 | 1.00–1.20 |
| 2000-2003 births | | | | |
| Non-gentrifiable | Ref | | Ref | |
| Low | 1.42 | 1.32–1.53 | 1.09 | 1.02–1.17 |
| Medium | 1.28 | 1.14–1.44 | 1.11 | 1.03–1.19 |
| High | 1.26 | 1.08–1.48 | 1.06 | 0.95–1.18 |
| 2004-2007 births | | | | |
| Non-gentrifiable | Ref | | Ref | |
| Low | 1.77 | 1.62–1.94 | 1.29 | 1.20–1.40 |
| Medium | 1.38 | 1.18–1.60 | 1.21 | 1.12–1.32 |
| High | 1.28 | 1.07–1.54 | 1.13 | 1.01–1.28 |

# Appendix: IRB Approval Letter

EMORY UNIVERSITY

Institutional Review Board

TO: Maria Zlotorzynska,
Principal Investigator
Public Health

DATE: December 7, 2013

RE: **Expedited Approval**
IRB00070088
Gentrification and Prevalence of Preterm Birth in Atlanta, Georgia

Thank you for submitting a new application for this protocol. This research is eligible for expedited review under 45 CFR.46.110 and/or 21 CFR 56.110 because it poses minimal risk and fits the regulatory category F5 as set forth in the Federal Register. The Emory IRB reviewed it by expedited process on 12/6/2013 and granted approval effective from **12/6/2013** through **12/5/2014**. Thereafter, continuation of human subjects research activities requires the submission of a renewal application, which must be reviewed and approved by the IRB prior to the expiration date noted above. Please note carefully the following items with respect to this approval:

- Gentrification and PreTerm Birth Protocol, 11/13/2013
- A complete HIPAA waiver is granted for the conduct of this study.
- A waiver of informed consent is granted for the conduct of this study.
- Subpart D: Title 45 CFR 46.404/50.51.
- A waiver of parental consent is granted for the conduct of this study.

Any reportable events (e.g., unanticipated problems involving risk to subjects or others, noncompliance, breaches of confidentiality, HIPAA violations, protocol deviations) must be reported to the IRB according to our Policies & Procedures at www.irb.emory.edu, immediately, promptly, or periodically. Be sure to check the reporting guidance and contact us if you have questions. Terms and conditions of sponsors, if any, also apply to reporting.

Before implementing any change to this protocol (including but not limited to sample size, informed consent, study design), you must submit an amendment request and secure IRB approval. In future correspondence about this matter, please refer to the IRB file ID, name of the Principal Investigator, and study title. Thank you

Regina Drake, M.Div, CIP
Senior Research Protocol Analyst
*This letter has been digitally signed*

CC: Kramer Michael Epidemiology