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ABSTRACT

AMANDA TYLER

Built Environment and Birth Outcomes: Examining the Exposure to the Atlanta Beltline and Its Effects on Community Health

(Under the supervision of Dr. Dora Il'yasova and Professor John Steward)

The Atlanta Beltline is an urban redevelopment project that was designed to increase access to trails, parks, and greenspace in Atlanta, Georgia. Thirty-three miles of new trail will be developed, providing a place for the community to engage in purposeful physical activity and active transport around the city of Atlanta. Because physical activity is associated with improvements in birth outcomes and under the assumption that close proximity to the Atlanta Beltline encourages physical activity, I hypothesize that women residing within 0.5 mile of the Atlanta Beltline will show improvements in birth outcomes, as compared to women residing 1-1.5 miles away from the Beltline. Birth outcomes were measured as rates for low birth weight, premature live birth, and fetal mortality rates. Census tract data for birth outcomes for the time period “pre-Beltline,” 2002 - 2007, and “post-Beltline,” 2008 - 2012, was obtained from Georgia Department of Public Health. 18 census tracts in three areas along the Beltline (Northside, Eastside, West End) were identified as exposed and 17 in the same areas were unexposed. We found the following mean rates (SDs) of the outcomes in the exposed census tracts during the pre-Beltline period: 119.22 (48.39) low birth weight, 154.94 (55.80) premature birth, and 16.17(15.81) fetal death, all per 1,000 live birth. During the post-Beltline period in the exposed area, these measurements were: 107.55 (39.66) low births weight, 131.06 (48.92) premature birth, and 12.28 (13.51) fetal death, all per 1000

live birth. In the unexposed census tracts during the pre-Beltline period, mean rates (SDs) of the outcomes were 110.82 (42.81) low birth weight, 144.88 (46.49) premature birth, and 19.94 (35.45) fetal death, all per 1000 live birth. During the post-Beltline period, these measurements in the unexposed area were: 100.88 (40.76) low births, 134.17 (47.85) premature birth, and 8.06 (6.89) fetal death, all per 1000 live birth.

Overall in both the exposed and unexposed areas, the time trends for the examined measurements of birth outcomes were towards improvement; however, only a decrease in premature live birth in the exposed area ($p=0.2$) and fetal mortality in the unexposed area ($p=0.1$) were of statistically marginal significance. We conclude that currently no significant improvements in birth outcomes, associated with close proximity to the Atlanta Beltline have been detected.

INDEX WORDS: Atlanta Beltline, Low birthweight births, Premature birth, Fetal mortality rate, Physical activity, Greenspace

BUILT ENVIRONMENT AND BIRTH OUTCOMES: EXAMING THE EXPOSURE TO THE
ATLANTA BELTLINE AND ITS EFFECTS ON COMMUNITY HEALTH

BY

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MPH CANIDATE, GEORGIA STATE UNIVERSITY

A Thesis Submitted to the Graduate Faculty
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APPROVAL PAGE

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Acknowledgement

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Thank you!

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- Utilize pivot tables in excel for quantitative data
- Draft study report for the results of the ASPPH Governmental Student Practicum Placement Survey for the Centers for Disease Control and Prevention

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Chapter I

Introduction

Preterm birth is the most common direct cause of newborn mortality (World Health Organization, 2015). Preterm birth is also the reason for low birth weight, which is an important cause of neonatal death (World Health Organization, 2015). The risk of developing infections in early life or having long-term problems with delayed motor, social, or learning development is increased for prematurely born infants weighing less than 2,500 grams (CDC, 2014). In 2012, preterm birth affected more than 450,000 babies born in the United States and accounted for thirty-five percent of all infant deaths, more than any other single cause (CDC, 2014). A developing fetus goes through important growth during the final weeks and months of pregnancy (CDC, 2014). Being born less than thirty-seven weeks of gestation puts many organ systems, including the brain, lungs, and liver, in jeopardy of fully developing (CDC, 2014).

The Atlanta Beltline is currently being developed in Fulton County, Georgia, to revitalize the urban built environment. According to the Community Health Status Indicators published by the Centers for Disease Control and Prevention (CDC), Fulton County, Georgia is in the least favorable quartile for premature births and male and female life expectancy when compared to peer counties (2015). Life expectancy at birth is directly related to fetal mortality rates. In 2012, the fetal mortality rate for Fulton County was 10.3 per 1,000 live births (Georgia Department of Public Health, 2015). In addition, Fulton County also had a reported 13.4 percent

premature live births and 10 percent low birth weight births in 2012 (Georgia Department of Public Health, 2015). Fulton County can reduce premature birth and fetal mortality rates by improving the health and care of mothers (World Health Organization, 2015). An increase in physical activity is associated with a number of improved health outcomes such as a reduced risk of cardiovascular disease and type 2 diabetes and improvements in mental health and mood (CDC, 2015). The CDC currently recommends that healthy women get 150 minutes per week of moderately intense aerobic activity during pregnancy. The Atlanta Beltline can facilitate increases in physical activity for pregnant women in Atlanta, Georgia.

The Atlanta Beltline is a major urban redevelopment project that will transform twenty-two miles of abandoned railroad and surrounding property into trails, parks, transit, residential and commercial development (Atlanta Beltline, 2015). The Atlanta Beltline will increase access to parks and greenspace for people in surrounding communities and the city of Atlanta, as it is expected to generate 2,100 acres of new parks and park improvements and thirty-three miles of new multiuse trails (Atlanta Beltline, 2015). The Beltline has the potential to make trails and parks more connected and conducive to pedestrian access, especially for underserved neighborhoods in Atlanta.

The Atlanta Beltline Project has been developing since 1999 when a graduate student came up with the idea, for his master's thesis, to repurpose the old abandon railroads that encircle the city of Atlanta. Since its inception, the Atlanta Beltline has made significant improvements to the environment of Atlanta residents by redeveloping and remediating discovered brownfields in Beltline communities

and constructing six new Beltline parks and four trails in the city of Atlanta (Atlanta Beltline, 2015). It wasn't until 2006 that the Atlanta Beltline Inc. was created, along with a five-year work plan to see the Beltline become a reality (Atlanta Beltline, 2015). In 2008 the first segment of the Atlanta Beltline West End trail opened to the public, the Atlanta Beltline running series had its first 5k race, and construction began for the Historic Fourth Ward Park (Atlanta Beltline, 2015). In 2010, the Northside trail and phase two of the West End trail opened to the public and construction began on another Beltline park, D.H. Stanton Park (Atlanta Beltline, 2015). In 2011, three Beltline parks opened to the public, more property was acquired to build affordable housing, and the Art on the Beltline exhibit opened, which helps bring the city of Atlanta together to celebrate creativity (Atlanta Beltline, 2015). Finally, in 2012 the Eastside trail opened to the public and remains one of the most active trails on the Beltline today (Atlanta Beltline, 2015). Over the next 15 years the Atlanta Beltline is expected to generate 6,500 acres of redevelopment including new and affordable housing, office, retail, institutional, and industrial space, 30,000 new jobs and much needed sidewalk, streetscape, road and intersection improvements (Atlanta Beltline, 2015).

Figure 1. The Atlanta Beltline trail system

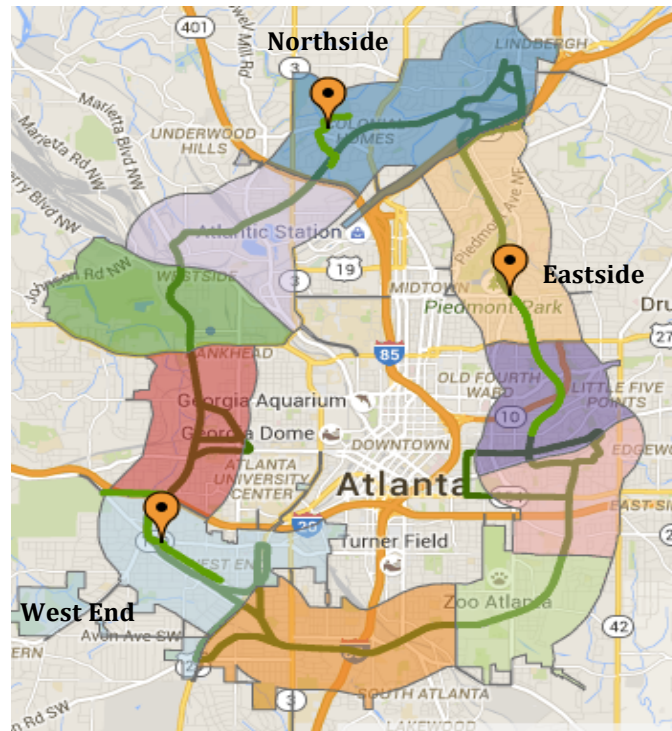


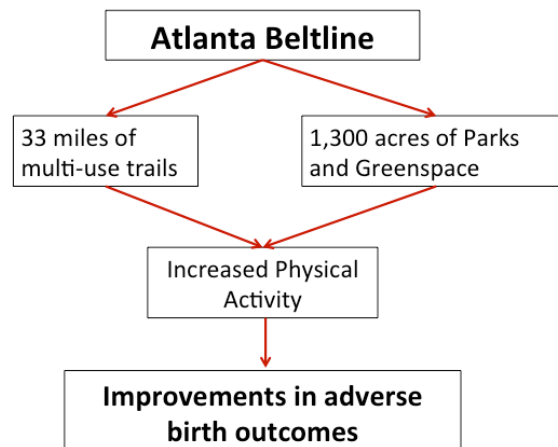
Figure 1 is a map of the Atlanta Beltline identifying the currently paved Beltline trails systems. This figure shows how the Beltline will connect communities from north and south Atlanta. Demographically, there are clear disparities between the north and south communities along the Atlanta Beltline. A health impact assessment, completed in 2007, shows the south side has the highest crude mortality rate for the majority of diseases, highest amount of population below the poverty line, and highest minority population, while the north side has the highest per capita income, highest percentage of non-Hispanic white residents, and lowest percentage of its population below the poverty line (Ross et al., 2012). The Atlanta Beltline will connect 45 different neighborhoods in Atlanta, giving everyone equal access to the same resources offered by residing in close proximity to the Beltline (Atlanta Beltline, 2015). The Atlanta Beltline trail system will provide a place for

residents of Beltline communities to engage easily in leisure time physical activities, like walking, running, or cycling, and active transport (Atlanta Beltline, 2015).

Studies show that residents living in communities surrounding an established trail system are more likely to utilize the trail for daily physical activity (Gordon, 2014; Merom, 2003; Troped, 2001). Furthermore, communities that were previously without trails increase their daily physical activity once a trail system was put in place (Gusat et al., 2012).

Currently, there are no studies examining the impact the Atlanta Beltline has had on physical activity and the subsequent prevention of adverse birth outcomes in its surrounding communities. Prevention is key when it comes to improving birth outcomes. Looking at the effects of the Beltline on birth outcomes can help identify a low-cost intervention for females in Atlanta to improve maternal and infant health. The social ecology model was utilized as the theoretical base for this study. Globally, the Atlanta Beltline has the potential to decrease CO₂ emission by increasing pedestrian and bicycle traffic in Atlanta. The introduction of the Atlanta Beltline to the built environment can facilitate increases in physical activity in Beltline communities and lead to improvements in birth outcomes. The improvements to the natural environment, such as increased vegetation along the Beltline and in newly developed Beltline parks, can also facilitate increases physical activity and subsequently improve health at the individual level. Based on the presumption that urban trails and greenspace increase physical fitness, Figure 2 presents the proposed mechanism used to formulate this study.

Figure 2: Atlanta Beltline mechanism for improvements in birth outcomes



Compared to women living at a greater distance, calculated as 0.5 miles to 1.5 miles from the Atlanta Beltline, I hypothesize that women living within 0.5 miles of the completed Atlanta Beltline trails will show a significant improvement in birth outcomes, measured as decreases in rates for low birth weight, premature births, and fetal mortality.

Chapter II

Review of the Literature

2.1 Physical Activity and Birth Outcomes

Physical activity during pregnancy is recommended for women with no contraindication to exercise (CDC, 2015). Physical activity can provide a modifiable and cost effective way to reduce the risk of adverse birth outcomes. Researchers Lieferman and Evenson (2003) examined the relationship between physical activity and adverse birth outcomes and found a significant inverse relationship between regular leisure physical activity and birth weight; women who never exercised were more likely to give birth to a very low birth weight infant compared with

conditioned exercisers (OR=1.75, 95% CI: 1.50,2.04) (Lieferman & Evenson, 2003). Similarly, Hegaard et al. (2008) found that light leisure-time physical activity as compared to sedentary lifestyle reduces the risk of preterm birth (OR = 0.76, 95% CI, 0.60-1.02). The inverse association between physical activity and preterm birth is stronger when sedentary women are compared to those engaged in moderate-to-heavy leisure time activity (OR = 0.34, 95% CI, 0.14-0.85). Among African-American women, who experience more preterm death in the United States when compared to non-Hispanic white women, walking for a purpose during pregnancy offers protection against preterm delivery. After adjusting for potential confounders, Sealy-Jefferson et al., (2014) found a significant inverse association between walking for longer than thirty minutes and prevalence of preterm delivery among urban low-income African-American women. (Prevalence Ratio=0.64, 95% CI: 0.43,0.94). Thus, even light physical activity during pregnancy, such as walking, may reduce the existing birth outcome disparity. Domingues, Barros, & Matijasevich (2008) examined the amount of physical activity done over the course of pregnancy. After adjusting for confounders, physical activity in all three trimester, physical activity in the third trimester, and minimum physical activity (greater than or equal to 90 minutes a week) in the third trimester were significantly associated with preterm birth, (Prevalence Ratio=0.55, 95%CI: 0.32,0.96), (Prevalence Ratio=0.50, 95%CI: 0.31,0.80), and (Prevalence Ratio=0.58, 95%CI: 0.34,0.98) respectively (Domingues et al., 2008). Women who engaged in physical activity throughout their pregnancy significantly lowered their chances of having adverse birth outcomes.

2.2 Urban Trails and Physical Activity

The Atlanta Beltline is developing an environment that facilitates an opportunity for healthy and active lifestyles that can potentially increase physical activity throughout the city of Atlanta (Atlanta Beltline, 2015). Even small increases in physical activity have the potential to produce significant health benefits and decrease rates of negative birth outcomes (Atlanta Beltline, 2015; CDC, 2015). Improving the structure of the built environment and building easily accessible trails makes physical activity more attainable. Urban trails encourage walking and other forms of physical activity among both sedentary and active individuals. In West Virginia, Gordon et al., (2014) found the presence of urban trails to be associated with significantly more physical activity. Ninety-eight percent of new exercisers and fifty-two percent of habitual exercisers reported an increase in exercise amounts (Gordon et al., 2014). In Knoxville, Tennessee researchers Fitzhugh, Bassest and Evans (2010) examined the causal relationship between the built environment and physical activity by observing changes over time before and after construction of an urban greenway. They found at follow-up, the count of physical activity was significantly higher in the neighborhood exposed to the greenway with a median increase of eight counts ($p=0.028$)(Fitzhugh et al., 2010). In New Orleans, Louisiana, Researchers Gustat, Rice, Parker, Becker, and Farley (2012) examined the effects of changes in the built environment on physical activity in a low-income African American neighborhood and found self-reported walking for transportation and leisure-time physical activity increased after construction of a community trail, with a significant increase in the proportion of people engaged in

moderate and vigorous activity ($p < 0.001$) (Gusat et al., 2012). Further evidence for urban trails as a potentially important avenue for reaching high-risk population exist for a study conducted in southeast Missouri which found, women, compared to men, were more than twice as likely to report using trails (Prevalence Ratio=2.1, 95%CI=1.0,4.4) and lower income groups were more likely to have increased walking due to trail use when compared to those in higher income groups (Prevalence Ratio=0.9, 95% CI: 0.4, 2) (Brownson et al., 2000). Urban trails systems, like the Atlanta Beltline, may have a greater influence on lifestyle choices to engage in physical activity because outdoor recreation provides a free outlet for leisure time physical activity and trails become permanent fixtures in the community (Brownson et al., 2000).

A key component to a successful urban trail is the ability of residents to have access near their homes and provide connectivity by linking destinations. In 2007, researchers from the Robert Wood Johnson Foundation concluded the presence of sidewalks, community walkability, access to park and open spaces, and proximity to destinations were key features of the built environment associated with physical activity (Goodell & Williams, 2007). Merom et al. (2003) found a significant association between distance to trail and trail use. Approximately twenty-one percent of residents living within 1.5 km of the trail reported regular use, compared to only 3.8 percent of trail users residing between 1.5 km and 5 km from the trail. In Arlington, Massachusetts, Troped et al., (2001) found a significant association between use of the Minutemen trail and distance to the beltway (Troped et al., 2001). There was an inverse relationship, as survey respondents were 0.65 times as

likely to use the trail for every 0.25-mile increase in self-reported distance from the trail (Troped et al., 2001). Furthermore, the GIS road network distance was also inversely associated with beltway use (OR=0.58) (Troped et al., 2001). The research conducted by Gordon et al., (2014) found convenience to be the number one enabler to using newly built urban trails. Urban trails provide a potentially low-cost intervention that may facilitate walking and other forms of physical activity by reducing barriers related to convenience and accessibility. These redeveloped recreational trails have the potential to be powerful vehicles for the promotion of physical activity, especially for inactive individuals.

The Atlanta Beltline is transforming urban health in the city of Atlanta. For women, the promotion of healthy behaviors during the reproductive years can positively increase healthy birth outcomes. The urban trail and park system created by the beltline can allow women to escape the stressors of everyday life and purposefully engage in physical activities. Researcher Kira Krenichyn (2005) conducted a number of qualitative interviews to explore the ways outdoor environments encourage physical activity in urban environments for women. Urban trails and parks offer a more smooth and continuous workout (Krenichyn, 2005). On streets and sidewalks, women often have to negotiate obstacles and the dangers of traffic while parks and trails offer a more controlled environment (Krenichyn, 2005). Contact with nature was also cited as almost essential for women living in hectic city environments (Krenichyn, 2005). Urban parks are a valuable resource for working class women from surrounding neighborhoods because they do not have many other alternatives for outdoor activity (Krenichyn, 2005). The Atlanta Beltline

can provide a more scenic and controlled urban environment for women to engage in leisure-time physical activity and subsequently improve their health and the health of their future offspring.

2.3 Urban Greenness and Birth Outcomes

Physical activity has many benefits and has been identified as an important behavioral health indicator targeted during the preconception period (Vamos et al., 2015). Physical activity during this period can lead to a reduce risk of adverse pregnancy and birth outcomes as well as improve psychological health for preconception women (Vamos et al., 2015). Many studies have linked increased physical activity to the distribution of urban greenspace. Urban greenspace is largely connected with racial and socio-economic patterns, where areas with a lower minority population and high average income tend to have more recreational greenspace. This is important for the existence of health disparities in underserved communities, as greenspace has been linked to improved pregnancy outcome through a decrease in the risk of low birth weight, small for gestational age, and preterm birth (Vamos, 2015; Grazuleviciene, 2015; Hystad, 2014). Hystad et al. hypothesized that residential greenness may influence birth outcomes through the reduction of harmful environmental exposures, providing space for recreational physical activity, increases in social networks and community belonging, and through reducing psychosocial stress and depression (2014). Using satellite-derived normalized difference in vegetation index (NDVI) to obtain a continuous measure of greenness, researchers found that increased residential greenness was inversely associated with very preterm birth (OR=0.91, 95% CI: 0.74, 1.13), moderate

preterm birth (OR=0.95, 95% CI: 0.90, 1.00), and small for gestational age (OR=0.95, 95% CI:0.91, 0.99) (Hystad et al., 2014). Using similar methods, Grazuleviciene et al., (2015) found that women who resided in areas with low surrounding greenness had increased risk for low birth weight (OR=2.23, 95% CI: 1.20,4.15), term low birth weight (OR=2.97, 95% CI: 1.04,8.45), and preterm birth (OR=1.77, 95% CI: 1.10,2.81). They found a significant difference in the characteristics of their NDVI buffer environments as buffer zones with less vegetation had a higher concentration of noise, and higher levels of air pm2.5 and NO² concentration (Grazuleviciene et al., 2015). The evidence for the association between urban greenness and birth outcomes may moderate relationships between increases in physical activity and improved birth outcomes. Urban greenness is an essential aspect of the built environment that facilitates physical activity for women living in cities, and can provide both physical and psychosocial benefits to surrounding communities.

2.4 Rationale for the study

The Atlanta Beltline project is expected to improve the health of residents nearby. The Atlanta Beltline trail system will connect multiple neighborhoods, increase urban greenspace, and facilitate physical activity. The previous studies have provided evidence for increased trail use and physical activity among those residing within a close proximity to trails and greenspace. Furthermore, there is an abundant amount of evidence for improvements in birth outcomes for women who engage in physical activity and reside in areas characterized by vast amounts of greenness and vegetation. The Atlanta Beltline project will be developing for the next 15 years, through 2030, and there is potential for more research to be done to

examine how it will improve health for the city of Atlanta. Currently, there is no other study exclusively looking at how the Beltline will affect birth outcomes. The objective of this study is to examine the presence of an association between the Atlanta Beltline and birth outcomes in the surrounding communities.

Chapter III

Methods

The study population is females aged 10 to 44 who resided within one of the 46 designated census tracts surrounding the Atlanta beltline.

3.1 Data Source

Data on birth outcomes in Atlanta, Georgia were requested from the Georgia Department of Public Health's Office of Health Indicators for Planning (OHIP). OHIP leads the population health assessment component of Georgia Department of Public Health and provides valid and reliable evidence about the health status of the population of Georgia. Birth outcomes data were requested at the census tracts level for the area surrounding completed Northside, Eastside and West End Beltline trails. Geographic information system (GIS) software was used to identify the census tracts that corresponded to each exposure level around the Atlanta Beltline trails. The mean center was used to differentiate exposed and unexposed buffer zones around the Atlanta Beltline trails.

3.2 Independent Variables

The two main independent variables for this study are time period and proximity to the Atlanta Beltline.

The independent variable of time period has two levels, with the first level representing the years 2002 - 2007 and the second level representing the years 2008 - 2012. The time period was chosen to represent a time before and after the completion of the initial Atlanta Beltline trails. The first trail to be completed was the West End trail, which currently runs 2.4 miles from Rose Circle Park to Westview Cemetery. The West End trail was completed in two parts with the first opening in 2008 and the second in 2010. The Northside trail, which runs through the Collier Hills neighborhoods and extends a 1-mile distance connecting Ardmore Park to Bobby Jones Golf Course, opened to the public in 2010. Lastly, the Eastside trail, which was completed in 2012, is a 2.25 mile long paved trail running from 10th Street and Monroe to Irwin Street.

The second independent variable was distance from the mother's residence, at birth, to the Atlanta Beltline. Distance to the Beltline has three levels:

Exposed: mothers residing within 0.5 mile buffer of the Atlanta Beltline, at time of birth,

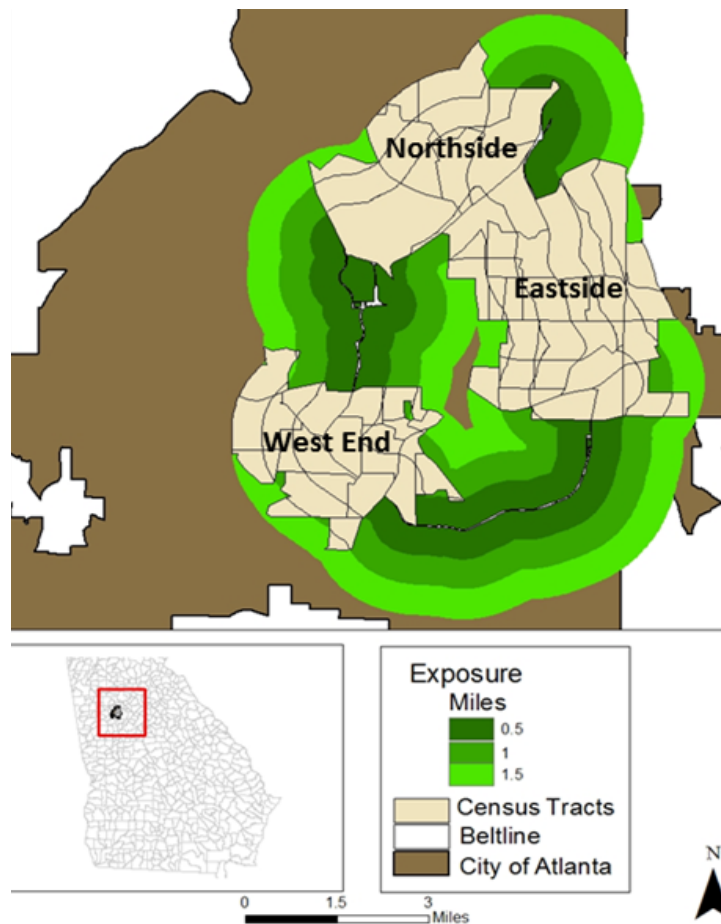
Unexposed level 1: mothers residing within 0.5 mile to 1 mile buffer from the Atlanta Beltline, at time of birth,

Unexposed level 2: mothers residing within the 1 mile to 1.5 mile buffer around the Atlanta Beltline at time of birth.

Distance to the Atlanta Beltline was derived using ArcGIS software. Figure 3 is a map derived using ArcGIS showing the Atlanta Beltline and 0.5 mile buffers used to identify exposure levels for this study. Exposed and unexposed census tracts for the Northside, Eastside and West End trails are also present in Figure 3. The 0.5-

mile buffer exposure level was used to correspond with the Atlanta Beltline planning framework. The Atlanta Beltline planning committees are using a 0.5-mile on each side of the Beltline to create a suitable framework for future population growth and Beltline usage (Atlanta Beltline, 2015). Furthermore, the literature for urban trail usage often uses distances at approximately 0.5-mile from trails to classify an area in close proximity to the trail (Merom, 2013; Troped, 2001). The 0.5-mile distance is often considered walkable and more likely to increase active transport to destinations.

Figure 3: Atlanta Beltline Exposure and Census Tracts



3.3 Dependent Variables

The three main birth outcomes are low birthweight births, premature live births, and fetal death. These variables were expressed as rates per 1,000 live births

Low Birthweight Births was defined as live births of a birthweight less than 2,500 grams (5lbs. 8oz.). *Premature Live Births* was defined as gestational age less than 37 weeks. *Fetal Mortality Rate* was defined as death prior to the complete expulsion or extraction from its mother of a product of human conception, regardless of the duration of pregnancy; the death is indicated by the fact that after such expulsion or extraction the fetus does not breathe or show any other evidence of life such as beating of the heart, pulsation of the umbilical cord, or definite movement of voluntary muscles. The value shown is of fetal mortality at 20 weeks or higher gestation. Fetal mortality rate is calculated as $\text{Number of fetal deaths (at or greater than 20 weeks gestation)} / [\text{Number of fetal deaths (at or greater than 20 weeks gestation)} + \text{Number of live births}] * 1,000$.

Social indicators: Birth outcome data for social indicator variables was requested to examine the change of social and cultural norms over time. The social trends included were the following; 1) number of first births, 2) births to females with less than a 12th grade education, 3) births to unmarried females defined as, number of live births to females who are not legally married at the time of conception and did not marry during the time between conception and delivery, and 4) number of births reported by women who use tobacco during pregnancy.

3.4 Statistical Analysis

SAS 9.4 software was used for all analysis.

The *proc univariate* statement was used to summarize the data distribution for each dependent outcome variable. Outcomes were dichotomized by year. Histograms and probability plots were also plotted to visually assess the normality of data. None of the outcome variables were normally distributed. As a result, a Wilcoxon-Mann-Whitney test (*proc npar1way*) was performed to compare exposure levels for each birth outcome (low birth weight, premature births, and fetal deaths) for the years 2002-2007 and 2008-2012 at each exposure level. Similarly, the Wilcoxon-Mann-Whitney test was also used to examine time changes in social trends variables. In addition to the test statistic, box plots were plotted to visually compare the medians for each outcome. To look at the distribution of outcomes between exposure levels, the Wilcoxon-Mann-Whitney test ranks the data used to determine if there is any difference between exposed and unexposed areas. The Wilcoxon-Mann-Whitney test also ranks the data looking at time changes for each variable to determine if there is any difference between time period 2002-2007 and 2008-2012. Rank scores are indicated on the y-axis of the box plots.

Chapter IV

Results

4.1 Comparison of Birth Outcomes between Trails

Descriptive statistics for the primary outcome variables of low birth weight birth, premature live birth, fetal mortality rate, and social indicator variables are presented in Table 1. Table 1 shows a trend of improvement in birth outcome

variables among communities associated with all trails and each individual trail: Northside, Eastside, and West End. Among the completed Beltline trails, the Northside Beltline community comprised the most homogenous population in the 2002-2007 time-period as there is smaller variability between the minimum and maximum values for each birth outcome and social indicators, compared to the Eastside trail, which consisted of the most heterogeneous population. For low birth weight births, the Northside Beltline communities had a range of 60 while Eastside Beltline communities had a more than 2-fold increase with a range of 148. For premature live births, the same trend occurred with the range for Northside trail communities, 75, being approximately half of the Eastside trail communities, 147. Similarly, for fetal mortality rate, Northside trail communities had a range of 22 while the Eastside trail communities had a range of 48. Furthermore, the West End trail communities have greater mean and median rates for each birth outcome, for each time period, compared to the outcomes for both the Northside and Eastside trail communities. Just looking at the rates for low birth weight births for the time period 2008-2012, the census tracts corresponding to the West End trail have a median of 156 while the Eastside trail communities have a median of 88 and the Northside trail communities have a two-fold decrease with a median of 76(*Table 1*). We can also see that the change in mean values from time periods 2002-2007 and 2008-2012 for social indicators show some improvement, with the greatest mean difference for births to females with less than a 12th grade education for all trails.

4.2 Comparison of Birth Outcomes between Exposure Levels

I compared distributions of birth outcomes between exposure areas at each time

period.

Figure 4 shows the box plot comparing low birth weight birth between exposure levels 0(exposed) and 2(unexposed) for the pre-Beltline time period, 2002-2007 and post-Beltline time period, 2008 - 2012. No exposure level differences were observed for low birth weight birth for the time period 2002-2007 or time period 2008-2012.

Figure 5 shows the box plot comparing premature live births between exposure levels 0(exposed) and 2 (unexposed) for the pre-Beltline time period, 2002-2007, and post-Beltline time period, 2008-2012. No exposure level differences were observed for premature live birth for the time period 2002-2007 or time period 2008-2012.

Figure 6 shows the box plot comparing fetal mortality rates between exposure levels 0 (exposed) and 2 (unexposed) for the pre-Beltline time period, 2002-2007 and the post-Beltline time period, 2008 - 2012. No exposure level differences were observed for fetal mortality rates for the time period 2002-2007 or time period 2008-2012.

4.3 Comparison of Social Indicators between Exposure Levels

Figure 7 shows the box plot comparing first births between exposure levels 0(exposed) and 2(unexposed) for the pre-Beltline time period, 2002-2007 and post-Beltline time period, 2008 - 2012. No exposure level differences were observed for first births for the time period 2002-2007 or time period 2008-2012.

Figure 8 shows the box plot comparing births to female with less than a 12th grade education between exposure levels 0(exposed) and 2 (unexposed) for the pre-

Beltline time period, 2002-2007, and post-Beltline time period, 2008-2012. No exposure level differences were observed for births to females with less than a 12th grade education for the time period 2002-2007 or time period 2008-2012.

Figure 9 shows the box plot comparing births to unmarried mothers between exposure levels 0(exposed) and 2(unexposed) for the pre-Beltline time period, 2002-2007 and post-Beltline time period, 2008-2012. No exposure level differences were observed for births to unmarried mothers for the time period 2002-2007 or time period 2008-2012.

Figure 10 shows the box plot comparing births to mothers that used tobacco during pregnancy between exposure levels 0(exposed) and 2 (unexposed) for the pre-Beltline time period, 2002-2007, and post-Beltline time period, 2008-2012. No exposure level differences were observed for births to women who smoked tobacco during pregnancy for the time period 2002-2007 or time period 2008-2012.

4.4 Time Changes of Birth Outcomes within Exposed and Unexposed Levels

I compared changes in birth outcomes and social indicators between the time periods. Here I expected that after the construction of beltline, improvement in birth outcomes would be seen in the exposed but not in the unexposed area.

Figure 11 shows the box plot comparing low birth weight birth between time period 1(2002 - 2007) and 2 (2008 - 2012) for those exposed and unexposed to the Atlanta Beltline. No time-related differences were observed for low birthweight births in both the exposed and unexposed areas.

Figure 12 shows the box plot comparing premature live birth between time period 1(2002 - 2007) and 2 (2008 - 2012) for those exposed and unexposed to the

Atlanta Beltline. There is a marginally significant decrease in the rate of premature live birth between time periods among those exposed to the Beltline, $p=0.2$ and no change observed in the unexposed area.

Figure 13 shows the box plot comparing fetal mortality rates between time period 1(2002 - 2007) and 2 (2008 - 2012) for those exposed and unexposed to the Atlanta Beltline. No time-related differences were observed for fetal mortality rate in the exposed area. There is a marginally significant decrease for fetal mortality rate in the unexposed area, $p=0.1$.

4.5 Time Changes of Social Indicators within Exposed and Unexposed Areas

Figure 14 shows the box plot comparing first births between time period 1(2002 - 2007) and 2 (2008 - 2012) for those exposed and unexposed to the Atlanta Beltline. There were no time-related differences observed for both the exposed and unexposed areas.

Figure 15 shows the box plot comparing births to female with less than a 12th grade education between time period 1(2002 - 2007) and 2 (2008 - 2012) for those exposed and unexposed to the Atlanta Beltline. There is a marginally significant decrease in the rate of births to female with less than a 12th grade education in the exposed area, $p=0.2$, and in the unexposed area, $p=0.2$.

Figure 16 shows the box plot comparing births to unmarried mothers between time period 1(2002 - 2007) and 2 (2008 - 2012) for those exposed and unexposed to the Atlanta Beltline. No time-related differences were observed in both exposed and unexposed areas.

Figure 17 shows the box plot comparing births to mothers that used tobacco

during pregnancy between time period 1(2002 - 2007) and 2 (2008 - 2012) for those exposed and unexposed to the Atlanta Beltline. No time-related differences were observed in both exposed and unexposed areas.

Chapter V

Discussion and Conclusion

The data for the birth outcome and social indicator variables show improvements for each examined Beltline trail (*Table 1*). The birth outcome data corresponding to the Atlanta Beltline communities was consistent with Fulton County as over time birth outcomes in Fulton County Georgia have also improved. In 2007, the percentage of low birth weight births was 10.9, while in 2012 the percentage dropped to 10. Similarly, premature live births and fetal mortality rate also decreased from 2007 to 2012: from 15.6 percent to 13.4 percent for premature live births and 11 percent to 10 percent for fetal mortality rates.

Using census tract data for birth outcomes, in communities surrounding the Atlanta Beltline, this study did not find a significant association between living near the Beltline and improvements in birth outcomes. The results of the Wilcoxon-Mann-Whitney test to compare birth outcomes between the exposed and unexposed to the Atlanta Beltline areas did not show statistical significance at a $p < 0.05$ level. Thus, the study did not detect significant effects of the Atlanta Beltline. However, given the small sample size, it is possible that the effect of the beltline could not be detected due to low statistical power. The results were not as expected given the substantial amount of literature that supported the connection between improved

birth outcomes, physical activity, and proximity to urban trails.

To ensure improvements in birth outcomes over time were associated with the introduction of the Beltline to the built environment, the buffer level representing exposed to the Beltline was 0.5 mile. Previous studies provided evidence that proximity to trail systems was associated with trail use (Merom, 2003; Troped, 2001). Living in an urban environment, we predicted that a 0.5-mile buffer would be walkable for those in the Beltline communities. However, we did not take into account the factors that influence walkability besides distance. Currently, Atlanta is not a pedestrian friendly city. Atlanta's current walk score is 46, classifying the city as car-dependent, with most errands requiring a car, but within our completed beltline communities, walk scores varied from very walkable to car dependent (Walk Score, 2015). The Northside trail, consistent with the city of Atlanta, has a walk score of 45 making the Northside community car dependent (Walk Score, 2015). On the other hand, both Eastside and West End Beltline trail communities had a high walk score of 80 and 81 making them very walkable communities within the city of Atlanta (Walk Score, 2015). The built environment is not constant and evident by the competing walk scores, variable even within a small area. Despite being the least walkable community in this cohort, descriptive statistics from Table 1 show that the Northside Beltline community has the lowest mean rates for low birth weight births, 77.38, premature live births, 108.13, and fetal mortality rates, 4.63 for 2008 - 2012. Atlanta is making strides in the right direction with the Beltline and improvements in pedestrian infrastructure, but these changes take time. Future studies should examine the factors associated with walkability within

each completed beltline community.

Although not statistically significant, the Wilcoxon-Mann-Whitney test did show a decrease over time for all primary birth outcomes examined in this study. A closer look at the medians for each outcome shows that low birth weight decreased from 106.5 to 94.5, premature live birth from 140.0 to 139.5, and fetal mortality rate from 10.5 to 8.0. Birth outcomes improved across each exposure level, indicating there is something occurring in the populations surrounding the Atlanta Beltline. Given the size of our sample, no valid conclusions could be drawn. Increasing the sample size is necessary to obtain reliable result for our research question, does being exposed to the Atlanta Beltline improve birth outcomes.

We observed two marginally statistically significant result for time-related changes: premature live birth in the exposed area dropped an average 4.39 per 1,000 live births and fetal mortality rates in the unexposed area dropped on average 5.59 fetal deaths per 1,000. The decreases in premature live births among those exposed to the Beltline is important because the rate of premature lives births is greater than low birth weight births and fetal mortality in all trails (*Table 1*). The marginally significant decrease of premature live births, as a result of being exposed to the Beltline, could potentially have the greatest impact for improvements in birth outcomes for women in the city of Atlanta. On the other hand, the marginally significant decrease for fetal mortality rates among those unexposed to the Beltline could be related to the changes in the socioeconomic status indicators. Our social trend variables served as a representation of socioeconomic status for each trail and exposure. The health impact assessment completed for the Atlanta Beltline in 2007

shows apparent health disparities between the Northside and West End trails of the Beltline (Ross et al., 2012). In our data set, West End trail had the highest number of births to women with less than a 12th-grade education, a proxy for educational level within the community, and the highest rates for low birth weight birth, premature live birth, and fetal mortality. The Atlanta Beltline has intentions to decrease the disparities that exist between Beltline neighborhoods by providing affordable housing, but there is already evidence of gentrification associated with the presence of the Atlanta Beltline (Immergluck, 2009). For this study, we were not able to account for whether or not residents relocated between the examined time periods. Without statistical significance for exposure to Beltline, the mechanism for improvements in birth outcomes over time is unclear. The population as a whole could be healthier due to additional public health efforts or changes to the built environment unrelated to the Atlanta Beltline, or healthy women could have relocated over the years into Beltline neighborhoods. Future studies should examine built environment and socioeconomic changes over time as the Atlanta Beltline develops.

Strengths and Limitations

We initially requested census tract level data because being in proximity of the completed trail systems of the Atlanta Beltline was our primary exposure of interest, but using census tracts as our unit of analysis was our main limitation. We used count data for each census tract instead of individual frequencies. Since this was a secondary data analysis, it would not have been feasible to use individual level data in each census tract, for our requested time periods, and exposure levels

from the Georgia Department of Public Health. This method gave us a total sample size of 46 census tracts surrounding the completed Atlanta Beltline trails.

Comparing the distribution of the birth outcomes between exposure levels decreased the sample size even smaller, 18 for those exposed to the Beltline and 17 for those unexposed to the Beltline. The small sample size may be hiding the actual relationship between exposure to the Beltline and birth outcomes. Even with the small sample size, we observed changes over time in the exposed area for each one of our primary outcome variables with marginal significance: p-values were 0.21 for low birth weight, 0.11 for premature birth, and 0.16 for fetal mortality. With a larger sample size, we possibly could observe significant differences in the exposed area over time.

There were many benefits to using census tract data for this study. First, it is a valid and reliable data source for our birth outcomes from the Georgia Department of Public Health. The downside was the fact that the shape of each census tract did not exactly match our exposure buffer levels. For census tracts that overlapped into another buffer, the mean center was derived to determine what exposure level the census tract would be classified. With the shapes of census tract data, there was no way to avoid overlap between exposure levels, which could have lowered the significance of the results. Furthermore, I hypothesized that women residing within 0.5 miles of the Atlanta Beltline would show improvements in birth outcomes when compared to women residing 1-1.5 miles away from the Beltline but failed to account for other trail system in Atlanta, in close proximity to our unexposed areas 1-1.5 miles away from the Beltline. The Freedom Park PATH Trail system is located

near the unexposed Eastside trail and would give women in the unexposed communities better access to the Beltline. This also could have lessened potentially significant results when looking at the distribution of birth outcomes between exposure levels. To address this issue and provide more accurate geographic results, individual level data should be collected for residents of childbearing age within each 0.5-mile exposure level. Local hospitals could also provide de-identified information on residence in the completed Beltline communities. Intercept surveys and physical activity assessments can be collected at various entry points to the Atlanta Beltline to obtain a better understanding of who is using the trails and for what purpose.

An additional aspect of the Atlanta Beltline to consider that may have affected the results of this study was the construction that took place in conjunction with the Atlanta Beltline. Along with increasing access to trails, parks, and greenspace, the Beltline is also adding new housing and moving in new businesses for the city of Atlanta. Construction projects often take time and may have initially hindered women from fully utilizing the Beltline. The built environment is modifiable which gives it great potential when it comes to various public health interventions, but as the Atlanta Beltline continues to be developed, construction may influence women's decision to utilize other avenues for physical fitness unrelated to the Atlanta Beltline. Furthermore, the ten-year time period for our study, 2002-2012, may not have been long enough to obtain the most accurate picture for how the Beltline is affecting birth outcomes in the surrounding communities. For our study period, the West End trail had been in place for five

years, the Northside trail for two years, and the Eastside trail for only one year. The constantly changing nature of Atlanta's built environment and short study period could have lessened the statistical effects of the Atlanta Beltline on birth outcome improvements in the surrounding communities.

Another limitation of this study was the lack of adjustment for confounding or moderating variables. Socioeconomic status is often associated with health. Including education, median household income, and demographic characteristics like race, ethnicity, and age for the Beltline communities could provide a better picture of what changes in the community are mediating improvements in birth outcomes over time. Because of the small sample size (n=46), we could not obtain a valid statistical association across multiple levels for our primary outcomes. Besides increasing the sample size, future studies should run a regression model to account for potential confounding from our social indicator variables of percent first births, births to females with less than a 12th grade education level, births to unmarried mothers, and births to mothers who smoked tobacco during pregnancy. There is an abundant amount of evidence showing an association between smoking tobacco while pregnant and an increased risk of low birth weight births and preterm birth (Andriani & Hsien Wen, 2014). Education level is also often associated with overall health status. Researchers Parker, Schoendorf, & Kiely (1994) found maternal and paternal occupation, education, and family income to be associated with low birth weight births for both white and black women. Including social trends in a model with the primary birth outcome variables would provide a more valid statistical observation for exposure to the Atlanta Beltline and birth outcomes.

The main outcomes focused on for this study as a result of the Atlanta Beltline's introduction to the built environment was physical fitness and increased urban greenspace, but there are many aspects of the built environment that can influence birth outcomes in the city of Atlanta. The improvements in road, streetscape, housing, and economic advantages of having shops and restaurants along the beltline have the potential to increase social capital in Beltline neighborhoods. Improvements in neighborhood characteristic, such as decrease litter and less vacant housing can lead to improvements in mental health for women in Beltline neighborhoods. On the other hand, increasing property taxes may force some of the residents in disadvantaged neighborhoods to relocate. As the Atlanta Beltline continues to develop, it will be easier to see the effects it has on the surrounding neighborhoods and the city of Atlanta.

Conclusions

For this sample of birth outcomes in Atlanta Georgia, proximity to the Atlanta Beltline was not associated with improvements in birth outcomes using statistical methods. The small sample size at the census tract level provided additional challenges to obtaining statistically significant results. There is some evidence of a decrease in the proportion of low birth weight births, premature live birth, and fetal mortality rate between the time periods 2002 - 2007 and 2008 - 2012. Continuing research should examine further what mechanisms are contributing to the improvement of birth outcomes over time.

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Tables and Figures

Table 1. Descriptive Statistics for Outcome and Socioeconomic Variables

Variable name	MIN value	Max Value	Mean	Median	Mode	Std. Deviation
ALL TRAILS						
+Low Birth Weight	¹ 23	196	113.5	106.5	86	47.01
	² 12	177	105	94	89	39.66
+Premature Live Birth	¹ 67	264	151.30	140.00	156.00	52.43
	² 42	265	133.26	139.50	93	45.54
+Fetal Mortality Rate	¹ 0	155	16.98	10.50	0	25.00
	² 0	48	10.52	8.00	0	11.33
First Births	¹ 306	788	484.07	461.00	321.00	128.47
	² 263	744	477.43	479.50	383.00	124.46
Births to Female <12th Grade Education	¹ 0	479	175.48	155.00	12.00	161.21
	² 0	432	110.24	48.5	0	119.93
Births to Unmarried Mothers	¹ 5	927	454.37	413.50	156.00	328.06
	² 17	941	429.04	329.00	78.00	342.74
Births to Mothers that Used Tobacco During Pregnancy	¹ 0	100	27.83	18.00	0.00	25.33
	² 0	147	27.74	14.50	0.00	33.01
NORTHSIDE						
+Low Birth Weight	¹ 49	109	80.88	81.50	.	23.42
	² 12	127	77.38	76.00	.	35.42
+Premature Live Birth	¹ 77	152	112.63	108.50	.	29.83
	² 89	143	108.13	99	93	19.91
+Fetal Mortality Rate	¹ 0	22	7.63	5.00	5.00	7.23
	² 0	21	4.63	2.00	0	7.23
First Births	¹ 321	664	498.5	517.50	.	131.43
	² 311	593	477.5	504.0	.	100.19
Births to Female <12th Grade Education	¹ 0	102	23.88	12.00	12.00	33.74
	² 0	31	9.25	5.50	0	10.44
Births to Unmarried Mothers	¹ 17	271	119.13	117.0	.	88.31
	² 5	257	118.25	119.5	.	96.36
Births to Mothers that Used Tobacco During Pregnancy	¹ 0	27	8.25	8.0	0	9.19
	² 0	11	4.13	4.5	0	4.05
EASTSIDE						
+Low Birth Weight	¹ 23	171	93.09	88.0	.	39.33
	² 32	133	88.91	88.00	89	25.23
+Premature Live Birth	¹ 67	214	129.87	131.0	100	36.06
	² 42	162	110.96	115	.	34.80

+Fetal Mortality Rate	¹ 0	48	9.61	7.00	0	11.09
	² 0	36	10.30	9.00	0	10.70
First Births	¹ 306	788	551.30	558	598	119.17
	² 383	744	557.74	546	.	102.16
Births to Female <12th Grade Education	¹ 0	472	129.43	92	7	139.10
	² 0	238	53.34	17	0	68.00
Births to Unmarried Mothers	¹ 46	832	328	225	156	247.50
	² 34	750	263.35	157	78	222.66
Births to Mothers that Used Tobacco During Pregnancy	¹ 0	63	20.61	13	0	18.95
	² 0	48	11.65	5	0	14.27
WEST END						
+Low Birth Weight	¹ 121	196	162.2	166	161	23.73
	² 89	177	147.01	156	156	25.94
+Premature Live Birth	¹ 138	264	204.80	214	.	40.90
	² 153	265	180.87	168	156	30.95
+Fetal Mortality Rate	¹ 10	155	33.27	21	10	36.97
	² 0	48	14	12	0	13.17
First Births	¹ 321	446	373.27	370	.	37.38
	² 263	422	354.27	354	385	39.06
Births to Female <12th Grade Education	¹ 149	479	326.93	315	.	106.63
	² 129	432	251.33	261	289	80.20
Births to Unmarried Mothers	¹ 661	927	826.87	835.0	.	77.05
	² 673	941	848.87	869	904	81.49
Births to Mothers that Used Tobacco During Pregnancy	¹ 15	100	49.3	47.0	.	25.67
	² 18	147	65	56	96	30.74
*All number represent rates per 1,000						
+Primary Outcome Variable						
¹ represents the distribution for the years 2002 - 2007						
² represents the distribution for the years 2008 - 2012						

Figure 4. Box plot for the distribution of low birth weight birth, among time periods 1 (2002-2007) and 2 (2008-2012) for the areas that are exposed and unexposed to the Atlanta Beltline

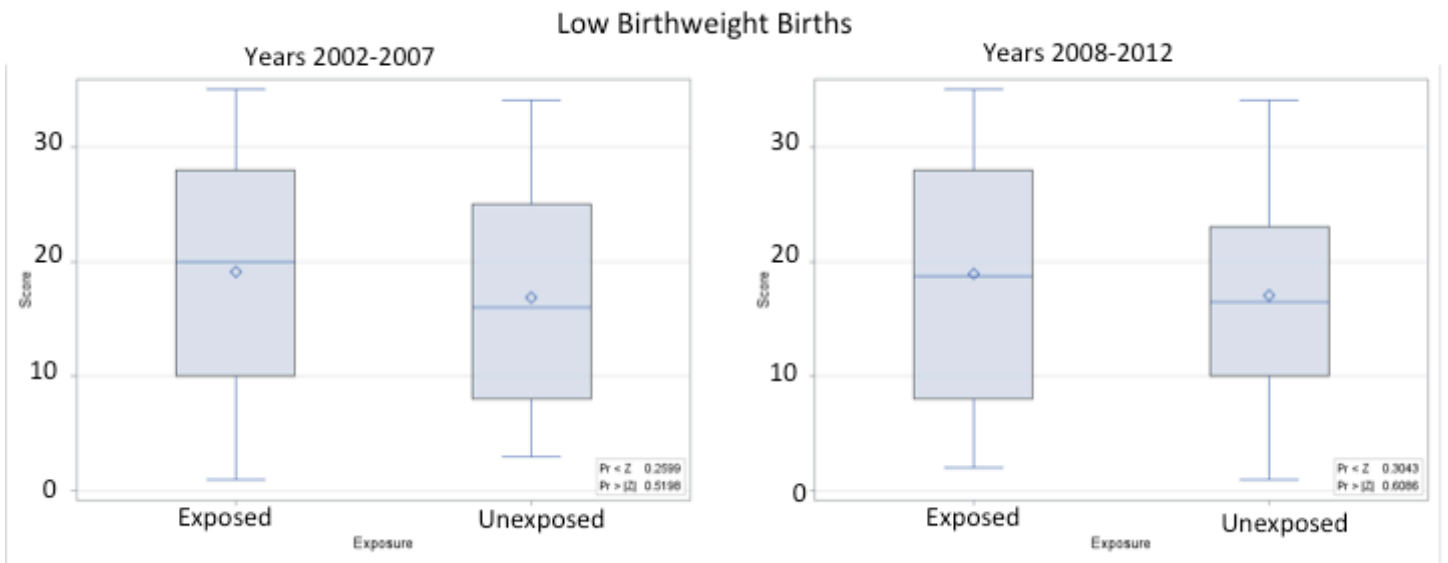


Figure 5. Box plot for the distribution of premature live births, among time periods 1 (2002-2007) and 2 (2008-2012) for the areas that are exposed and unexposed to the Atlanta Beltline

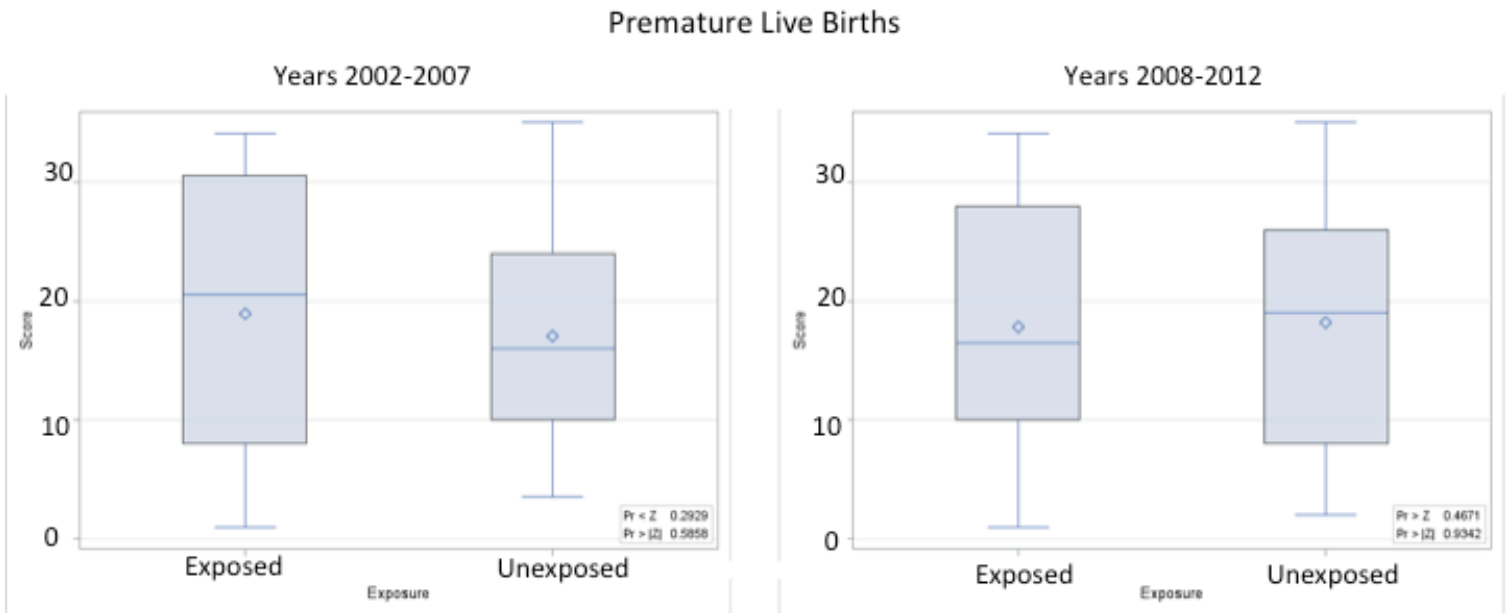


Figure 6. Box plot for the distribution of fetal mortality rates, among time periods 1 (2002-2007) and 2 (2008-2012) for the areas that are exposed and unexposed to the Atlanta Beltline

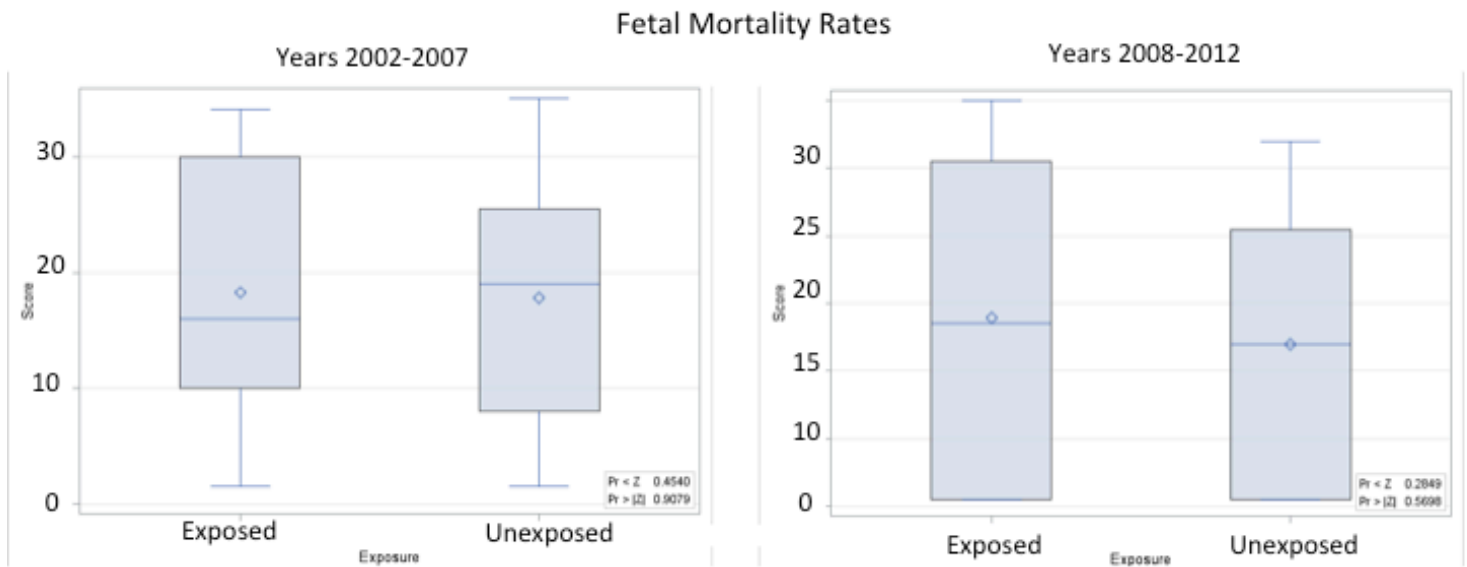


Figure 7. Box plot for the distribution of first births, among time periods 1 (2002-2007) and 2 (2008-2012) for the areas that are exposed and unexposed to the Atlanta Beltline

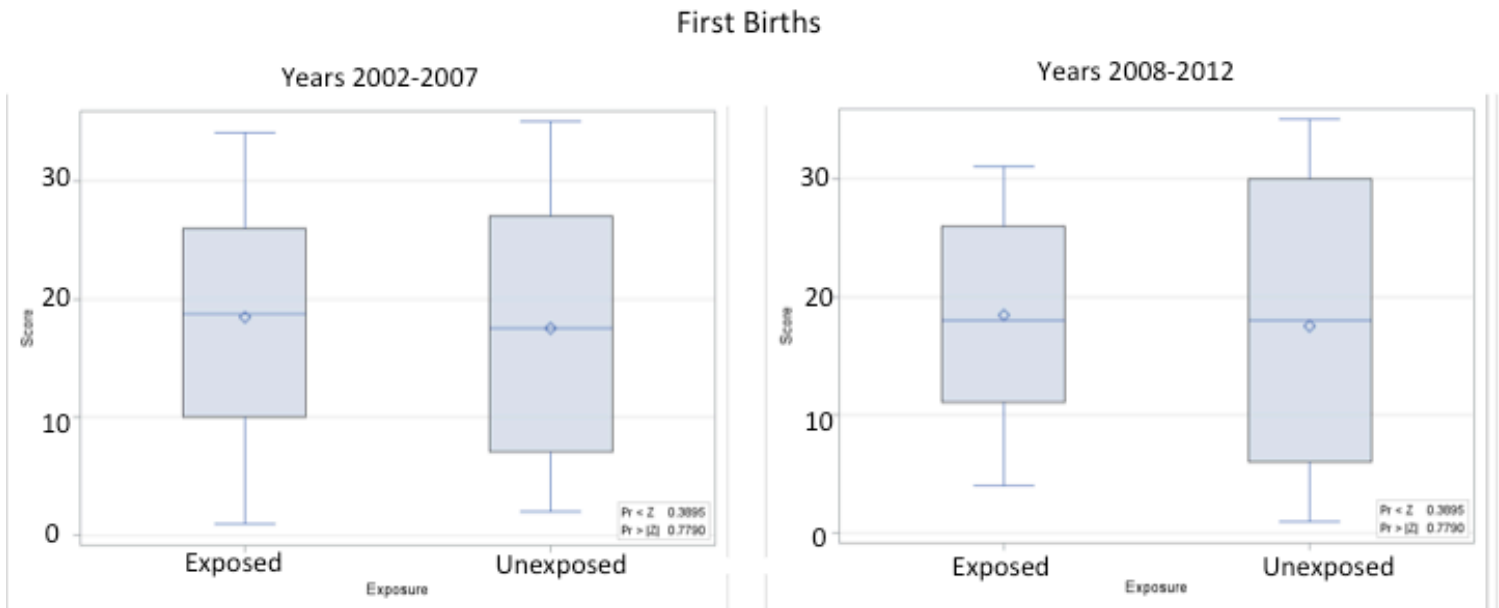


Figure 8. Box plot for the distribution of births to females with <12th grade education, among time periods 1 (2002-2007) and 2 (2008-2012) for the areas that are exposed and unexposed to the Atlanta Beltline

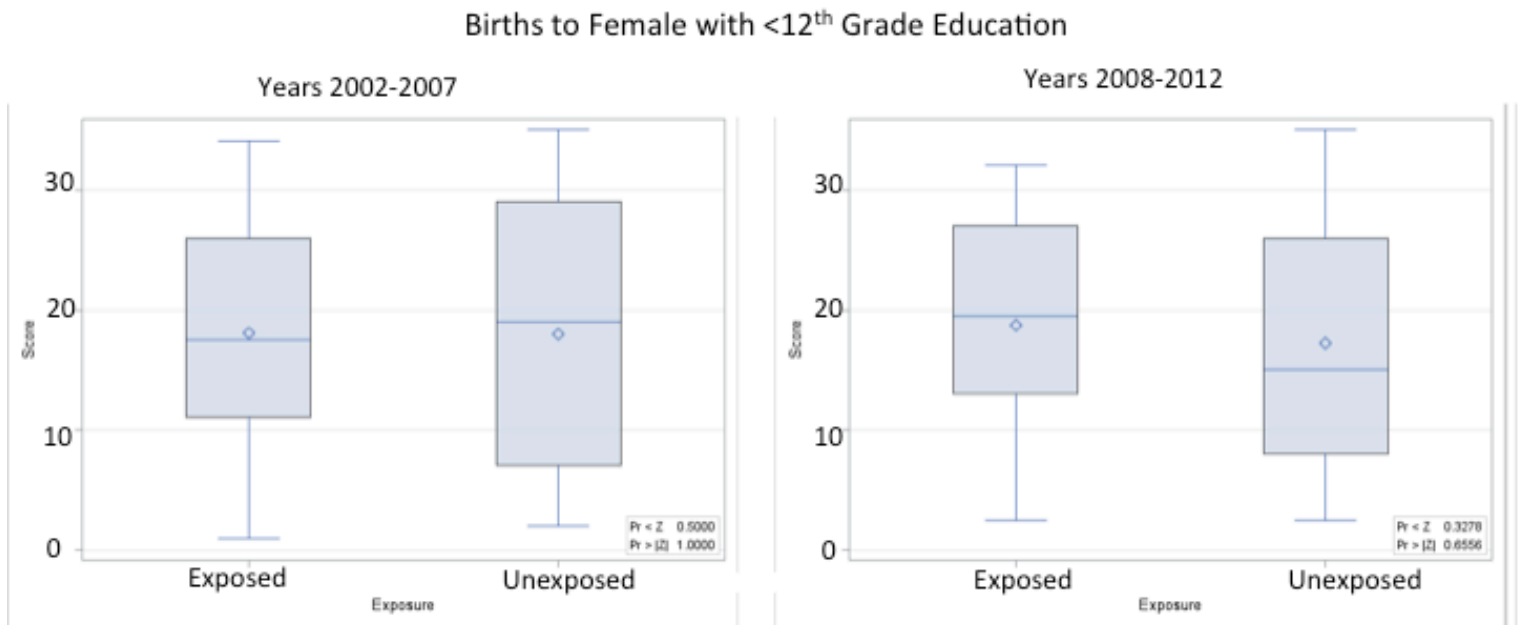


Figure 9. Box plot for the distribution of births to unmarried mothers, among time periods 1 (2002-2007) and 2 (2008-2012) for the areas that are exposed and unexposed to the Atlanta Beltline

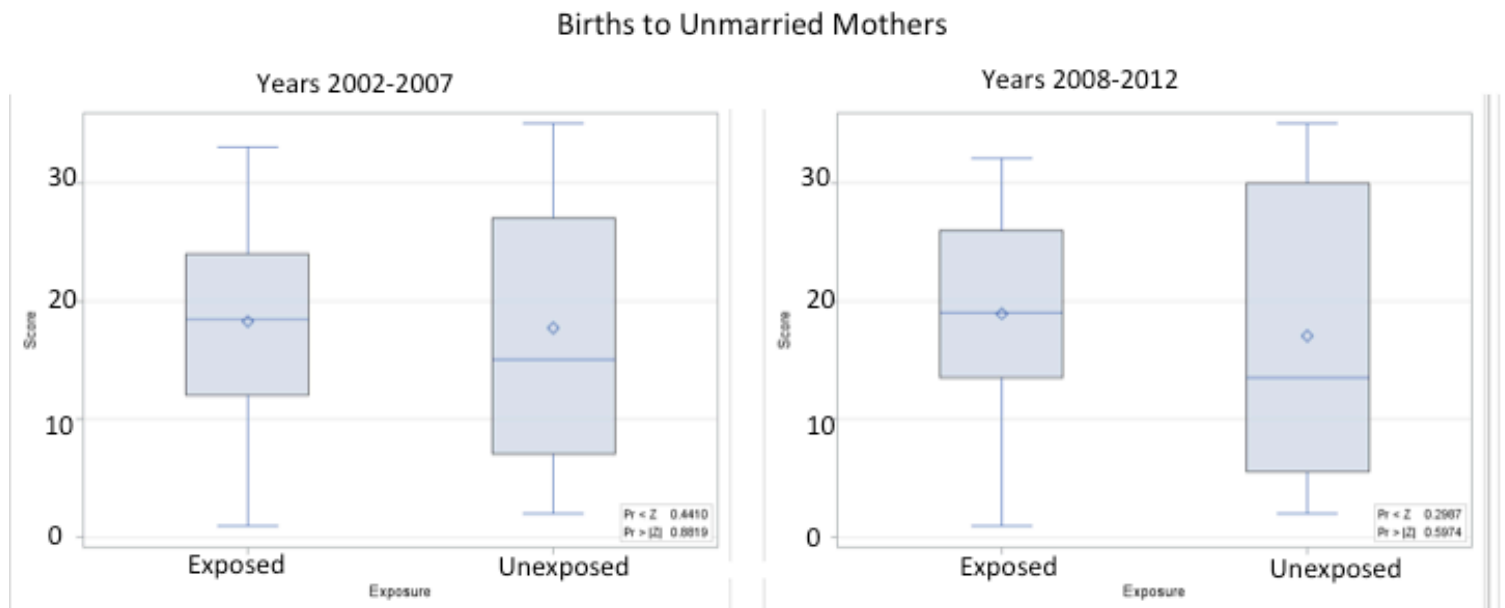


Figure 10. Box plot for the distribution of births to mothers that used tobacco during pregnancy, among time periods 1 (2002-2007) and 2 (2008-2012) for the areas that are exposed and unexposed to the Atlanta Beltline

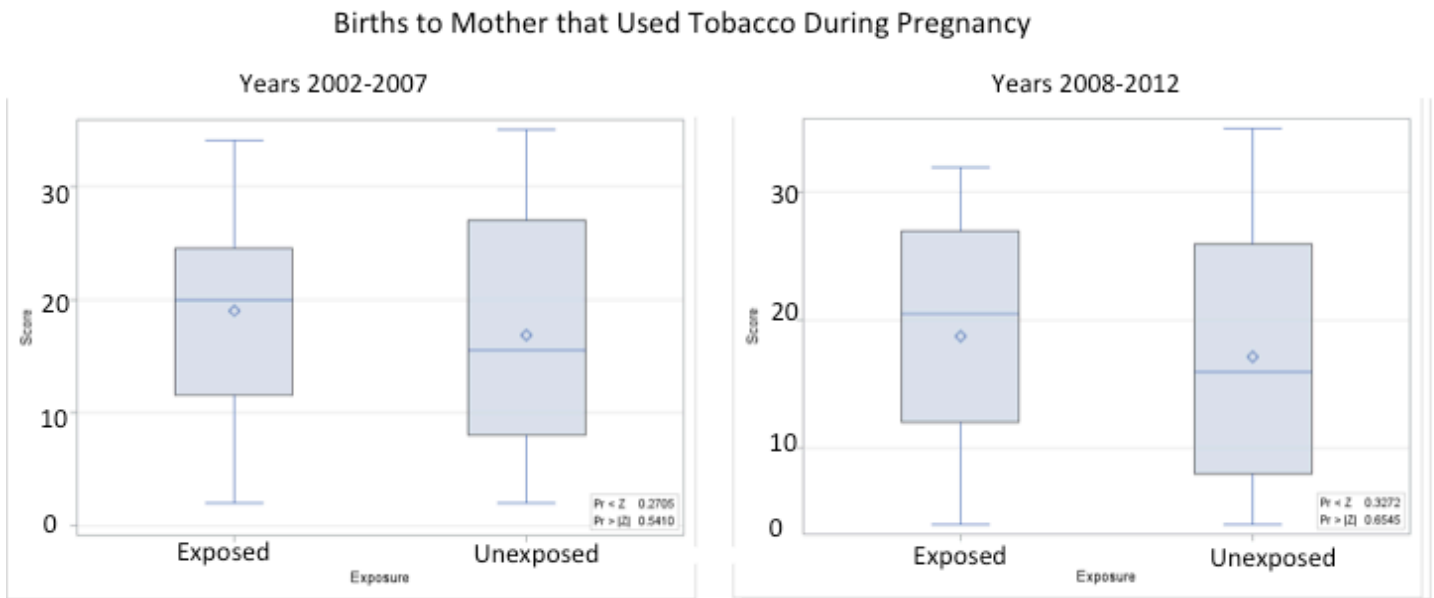


Figure 11. Box plot for the distribution between time period 1 (2002 - 2007) and time period 2 (2008 - 2012) for low birth weight birth among those exposed and unexposed to the Atlanta Beltline.



Figure 12. Box plot for the distribution between time period 1 (2002 - 2007) and time period 2 (2008 - 2012) for premature live birth among those exposed and unexposed to the Atlanta Beltline.

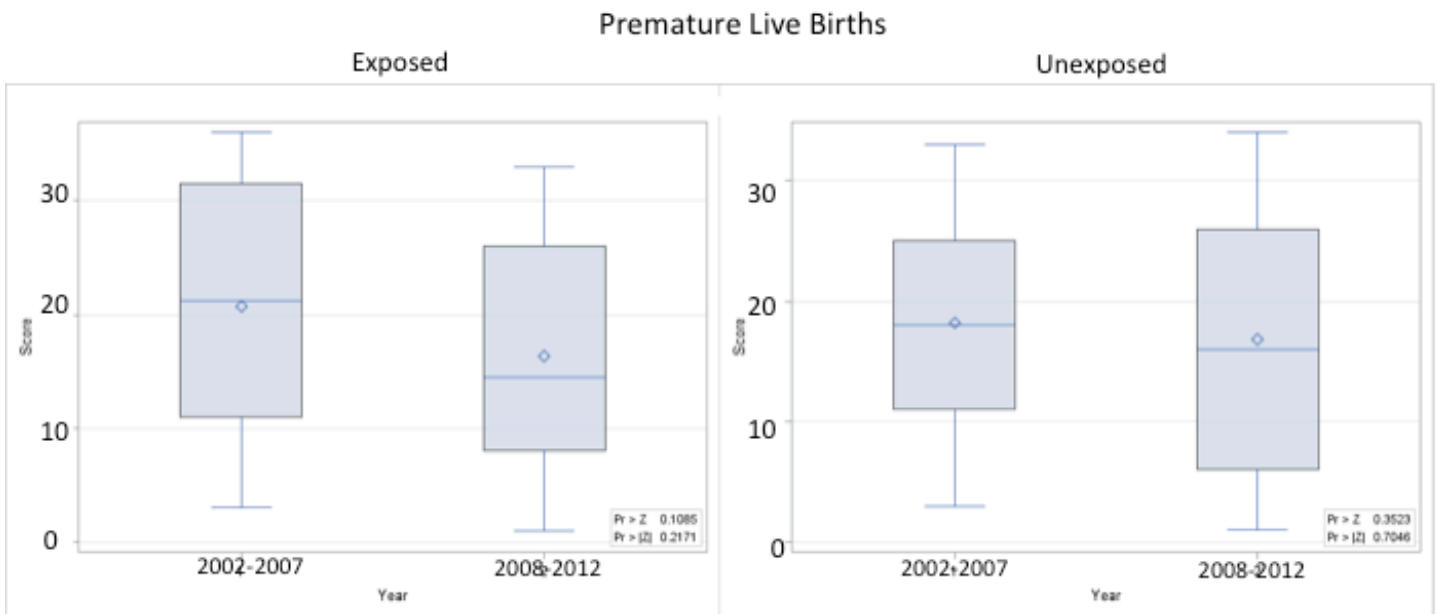


Figure 13. Box plot for the distribution between time period 1 (2002 - 2007) and time period 2 (2008 - 2012) for fetal mortality rate among those exposed and unexposed to the Atlanta Beltline.



Figure 14. Box plot for the distribution between time period 1 (2002 - 2007) and time period 2 (2008 - 2012) for first births among those exposed and unexposed to the Atlanta Beltline.

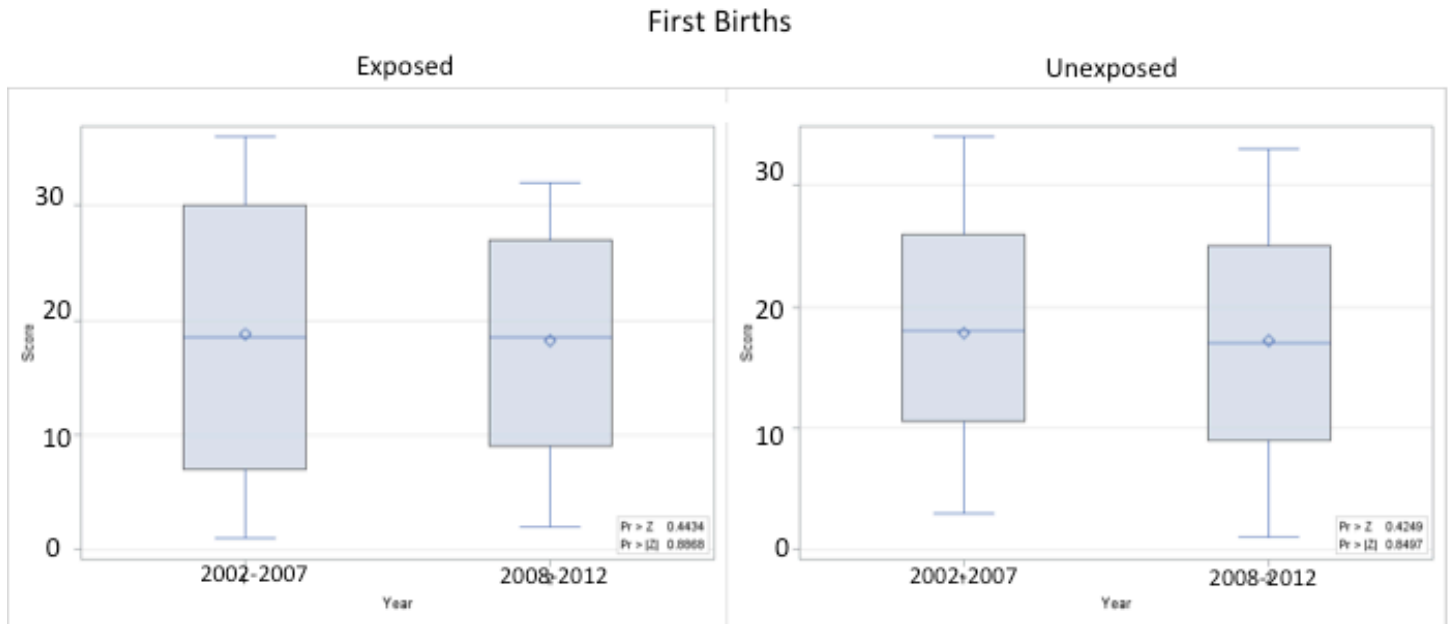


Figure 15. Box plot for the distribution between time period 1 (2002 - 2007) and time period 2 (2008 - 2012) for births to females <12th grade education among those exposed and unexposed to the Atlanta Beltline.

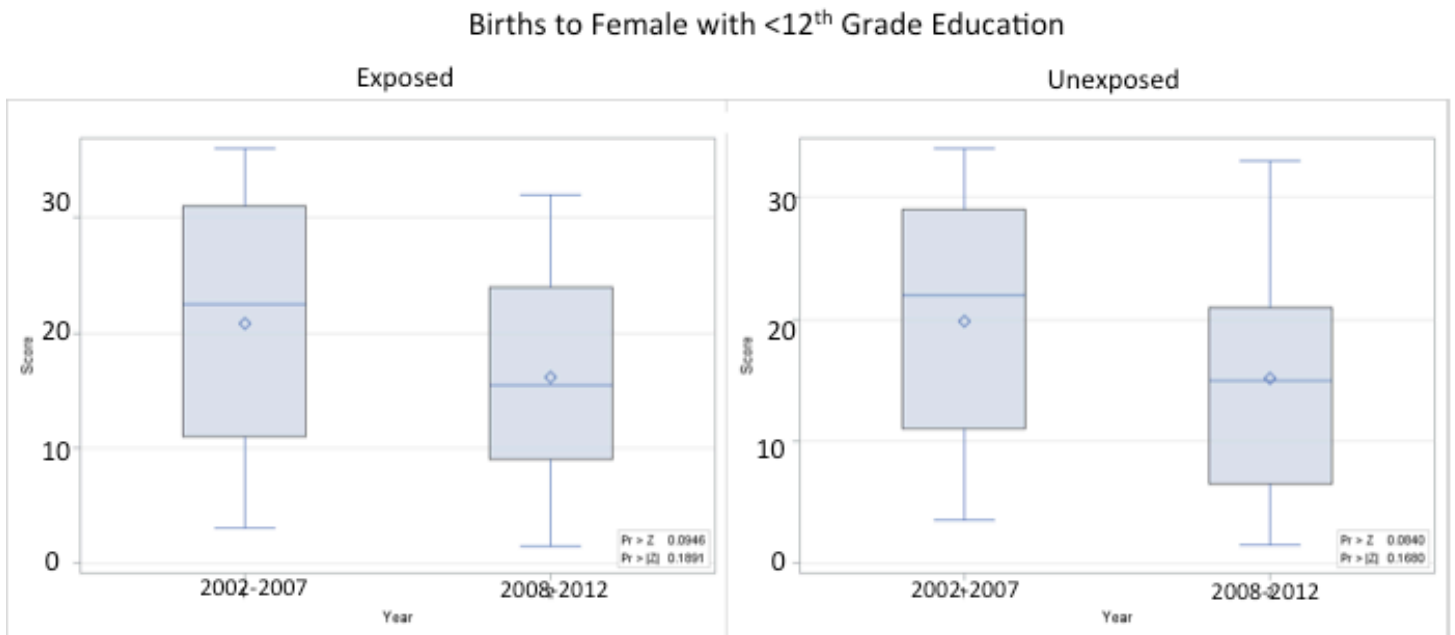


Figure 16. Box plot for the distribution between time period 1 (2002 - 2007) and time period 2 (2008 - 2012) for births to unmarried mothers among those exposed and unexposed to the Atlanta Beltline.

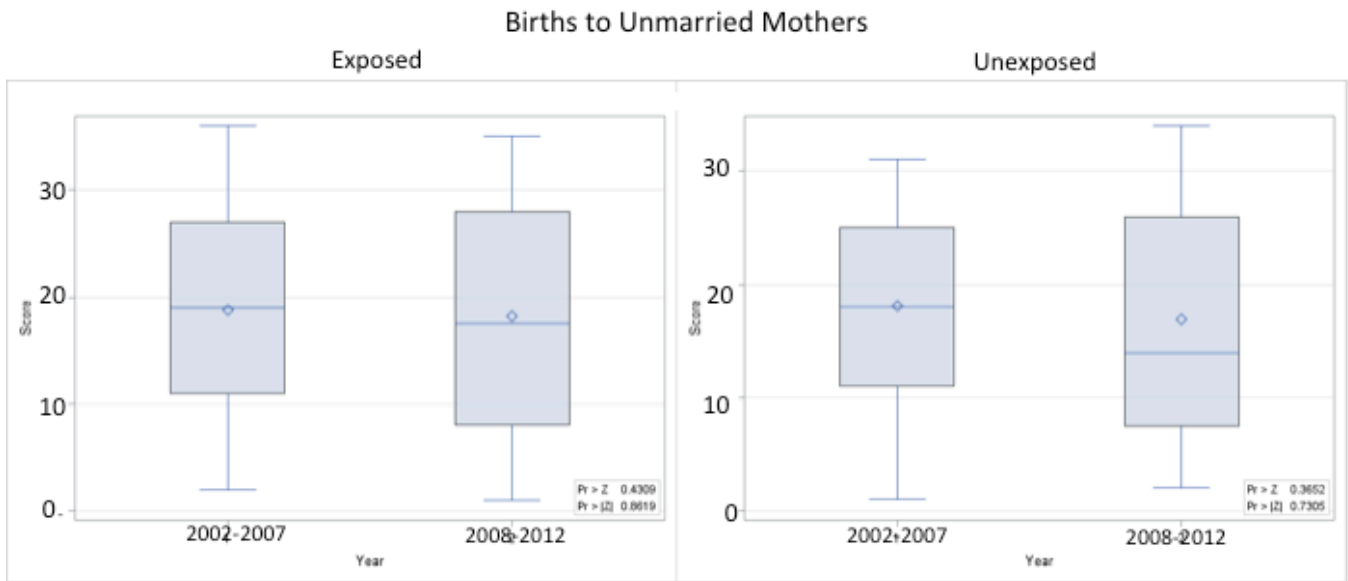


Figure 17. Box plot for the distribution between time period 1 (2002 - 2007) and time period 2 (2008 - 2012) for births to mothers that used tobacco during pregnancy among those exposed and unexposed to the Atlanta Beltline.

