SOCIOECONOMIC MOVEMENT BETWEEN SUCCESSIVE DELIVERIES: IMPACT ON PRETERM DELIVERY IN A DIVERSE RACIAL AND ETHNIC POPULATION

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ABSTRACT OF THE DISSERTATION

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BACKGROUND: Numerous studies have shown that women who live in more deprived neighborhoods are at higher risk of preterm delivery than those in wealthier neighborhoods, even after controlling for individual socioeconomic status. Since socioeconomic status and personal characteristics affect the choice of neighborhood of residence, these studies are likely to be confounded by unmeasured differences between the woman living in the better and worse neighborhoods. This dissertation has attempted to examine the effect of neighborhood socioeconomic status (NSES) using a better study design by following up women who moved between successive deliveries. METHODS: All newborns to the same mother in the Electronic Birth Certificate database were linked to create a longitudinal dataset. Neighborhood information was obtained from Census 2000 to calculate a neighborhood deprivation score. Quintiles of this score formed the socioeconomic neighborhood strata, the highest score being most deprived. Lowest three quintiles were combined to form one neighborhood stratum the other two quintile formed two more strata. Logistic regression was used to estimate the change in

risk of preterm delivery associated with change in NSES for women who moved between successive pregnancies. Stratified Analysis by race/ethnicity was also done.

RESULTS: Moving to a worse socioeconomic neighborhood increased the risk of preterm delivery but moving to a better neighborhood did not reduce the risk, when comparing women who moved to better or worse neighborhood to those who remained in the same neighborhood. On stratifying by race/ethnicity this was observed for Non-Hispanic (NH) Blacks only. However, when comparing a woman after she relocated to her outcome before relocating, the change of neighborhood made no difference. On stratifying by race/ ethnicity, NH Blacks alone had an increase in risk of preterm delivery for those who moved to a worse neighborhood. Similarly teenagers who moved to worse neighborhoods were also at increased risk of preterm delivery.

CONCLUSION: Neighborhood effect on preterm delivery is very small in this cohort. Improvements in the externalities of neighborhood environments would be unlikely to have a short term effect on preterm birth rates. Nevertheless there is a suggestion in this data that at-risk women may do worse in deprived neighborhoods than they would do in more favorable circumstances.

DEDICATION

To my late husband, David Selvapandian Albert - his untiring encouragement was the inspiration to begin this work.

To my sons, Elias and Kaleb - my pride and joy.

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INTRODUCTION

SIGNIFICANCE OF THE PROBLEM

Preterm delivery, delivery before 37 completed weeks of gestation, is the strongest predictor of perinatal and infant mortality and morbidity [1-12] in the United States (US). In 2012, 11.6% of all deliveries that ended in a live birth and 9.9% of singleton live births in the US were preterm.[13] This rate is substantially higher than in other industrialized nations.[14] Moreover, the Institute of Medicine estimated the cost of maternal, fetal and neonatal care associated with preterm delivery (not including medical care cost beyond early childhood, cost of special education and lost productivity of the care giver) to exceed $26 billion in 2005.[15] Reducing the burden of preterm deliveries has therefore been identified as a public health priority.[16]

For the first time in three decades, the rate of preterm deliveries has begun to decline in the US. For instance, the preterm delivery rate dropped by 15.0% between 2005 (9.1%) and 2012 (7.7%).[17] However, this rate is still high when compared to the rate in 1990, which was 10.6%,[18] and far from the target rate of 7.6% set by Healthy People 2010[16] to be comparable to other industrialized nations. Most of the earlier decline in preterm delivery rate was seen in the late preterm deliveries.[19] This decrease was associated with an increase in infant mortality rate for term deliveries.[20] However, the latest report shows that declines from 2011 to 2012 were observed even among infants born early preterm (less than 34 weeks), from 3.44% to 3.41%. Since 2006, the early preterm rate is down by 7% and the late preterm rate by 11%.[13]Possible reasons for this decline

include shift in the focus from preventing perinatal mortality and morbidity to preventing preterm delivery;[16,21,22] reduction in scheduled labor inductions and cesarean deliveries before 37 weeks;[23-27] reduction in the administration of interventions for deserving medically indicated preterm delivery; [28,29] increase in the accuracy of menstrual dating;[30] or difference in data-editing method for the calculation of gestational age.[31] These changes in obstetric practice or administrative changes cannot bring about a sustained reduction in the rate of preterm delivery. Instead, an understanding of the cause of preterm delivery and the secular changes in associated risk factors, identifying high-risk women at impending risk of delivering preterm, and developing programs and interventions that will address such issues, may help reduce the preterm delivery rate.

The two distinct pathways leading to preterm delivery include spontaneous and indicated preterm delivery.[32] Spontaneous preterm deliveries include both spontaneous onset of contractions and labor for no apparent indication leading to delivery at preterm gestations, or preterm premature rupture of membranes, PROM. Known causes include infection, inflammation, utero-placental ischemia, including pre-eclampsia, intrauterine growth restriction, placental abruption, and uterine over-distension.[33] Whereas, risk factors associated with spontaneous preterm delivery include a previous preterm delivery, black race, periodontal disease, low maternal body-mass index, a short cervical length and a raised cervical-vaginal fetal fibronectin concentration.[33] The major reasons to perform medically indicated preterm deliveries too are fetal compromise and pre-eclampsia and other pregnancy complications.[34-37] However, a comprehensive review

paper indicated that the total population attributable risk, also referred to as etiologic fraction, associated with the well-established biologic causes such as genitourinary tract infection, gestational hypertension, incompetent cervix, abruption placentae, and certain risk factors such as prior preterm birth, multiple births, low body mass index, cigarette smoking, cocaine use and physical work was about 70% in a population in which 25% of the women smoked during pregnancy and non-whites were a substantial minority.[38] This implies that the true population attributable risk of all known causes is much lower since these determinants are not mutually exclusive, that is any given woman may have more than one of these causes or factors. In other words, we still don't know much about the causes and risk factors of preterm delivery.

POTENTIAL SOLUTION

Some psychosocial factors, such as stressful life events, and chronic stressors such as racial discrimination, unwanted pregnancy, poor and crowded housing conditions, unemployment and other financial problems and other interpersonal factors, such as lack of intimate support and domestic violence and other adverse socioeconomic factors have been shown to be associated with increased risk of preterm delivery on one hand and with socioeconomic status of the neighborhood on the other. [38] In other words, these psychosocial factors are in fact mediating factors, in the causal pathway between upstream social determinants and preterm delivery.[38] A paradigm shift focusing on upstream social conditions, such as an individual's neighborhood of residence,[39] that give rise to an individual's health status independent of, or in interaction with individual

characteristics, may provide a better understanding of the risk factors and underlying causes of preterm delivery. [40]

Some of the probable pathways from neighborhood deprivation to preterm delivery involve a woman's response to chronic psychosocial stressors;[38] her response to the lack of availability of essential micronutrients[41] measured as inadequate or excess weight gain during pregnancy; and access to preconception and prenatal care measured as late and/or infrequent prenatal care visits; and increased opportunities to indulge in risky behavior[42] such as smoking, drug and alcohol abuse. All of these could lead to complications of pregnancy and labor which in turn could lead to preterm delivery. Therefore, if indeed socioeconomic status of a neighborhood (NSES) had an effect on preterm delivery; it could be prevented either by blocking any or all of these pathways in a neighborhood or moving an expectant mother to a better neighborhood where these factors don't exist.

The term neighborhood of residence has been interchangeably used to refer to the physical environment, socioeconomic deprivation or residential racial segregation of a specified geographic area. For example, racial composition (proportion black race) one of the markers for residential racial segregation has been used to classify geographic areas into 'neighborhoods' with racial segregation or not. A socioeconomically deprived neighborhood is on the other hand, a geographic area in which the opportunity to be socioeconomically stable is lacking, one of the markers being proportion below poverty line. Although these may overlap, focusing on one type, such as the deprivation status

of the residential neighborhood may help us understand the cause of preterm delivery or may at least help us understand the magnitude of the effect and the mechanism by which such deprivation may have an effect on preterm delivery.[43]

A well designed longitudinal study that includes a diverse racial and ethnic population that compares a woman's risk of preterm delivery before and after movement would help establish the effect of short term exposure to the new neighborhood compared to her being exposed to the old neighborhood. Or comparing the risk of preterm delivery for those who moved to a neighborhood to those who stayed back in the same neighborhood would give the effect of moving to a better (or worse) neighborhood, at the population level. The Electronic Birth Certificate database of New Jersey will help answer both these questions. A race/ethnicity stratified analysis will show further if these effects vary by race. Stratification, rather than adjustment in a regression model is important because of the minimum overlap of NSES between races due to extensive residential racial segregation.[44] The four largest race/ethnicity groups among pregnant women are Non-Hispanic (NH) Whites, NH Blacks, Hispanics and Asians & Pacific Islanders, with the four groups accounting for 98.8% of deliveries in New Jersey in 2012. [13] However since the proportion Asians are growing in New Jersey, describing socioeconomic movement between successive deliveries, for this substantial ethnic group exclusively, (data permitting) rather than combining them with pacific islanders is more informative.

Before attempting such a study, it is important to know the prevalence of socioeconomic movement among pregnant women and describe the characteristics of these women who move both geographically and socioeconomically, that is to a better or to a worse neighborhood. Indeed, a few studies have examined patterns and correlates of residential mobility during pregnancy and postpartum,[45-47] but the profile of socioeconomic mobility or movement remains poorly understood – and forms the basis in this research.

FEASABILITY OF INTERVENTION

The underlying assumption of this study is that if socioeconomic movement helps reduce preterm delivery, an attempt will be made to follow through with this implausible solution of moving people out of their neighborhood of residence to a better one. Surprisingly, it is not all that implausible. The US government has undertaken many social interventions where many families were moved to better neighborhoods. The best known was the randomized trial called the Gautreaux program, implemented by court order, in Chicago where many families were moved either to suburban white neighborhoods or to urban mostly black neighborhoods. While all movers showed improvement in social integration and participation in the labor force, the suburban movers did particularly better.[48-50] Interestingly, the Gautreaux program was instituted because of poor handling of existing programs of the US Department of Housing and Urban Development (HUD). These initiatives to relocate families living in substandard housing exist even today. The largest of these is the Section-8 program (now called the Housing choice vouchers [HCV]), where a family gets

rental assistance and so has to pay only 30% of their income on rent. This financial support enables families to move to better privately owned and managed housing, which may be in a socioeconomically better neighborhood.

Inspired by the success of the Gautreaux program, the HUD conducted a large randomized controlled trial that moved some families from high-poverty to lower-poverty neighborhoods in five US cities between 1994 and 2006, called the 'Moving To Opportunity' (MTO) trial. Briefly, the MTO trial had three arms: the control group who did not move; two case groups, one with extra counseling to choose the right housing and the other without counseling (similar to Section-8). But both case arms moved to neighborhood with lower poverty rate.

Several reports of the MTO trial and the Gautreaux program have been published. However most of the benefit has been assessed in terms of education, employment and integration into the community, both, for the Gautreaux program.[48-50] and the MTO[51-56] trial. Very few health benefits have been assessed so far. These effects too varied from program to program. For example, although, the MTO movers had better housing and neighborhood compared to Section 8 movers because of added housing counseling, they did not do better than the Section 8 movers. In fact, they both showed improvement in labor force participation and employment in a short term compared to those who did not move. However, since a robust economy was sweeping the nation at that time,[57] it is not clear if socioeconomic movement helped. Added counseling didn't make a difference.

In terms of health, however, the few studies which were done show better mental health and survival. [58-62] This is true especially for women and for girls, compared to a matched cohort of those who did not move. Adolescent boys did not do as well as the girls did. However they did not study any other aspect of health. Specifically, they did not study the effect of relocation on pregnant women.

The Gautreaux program movers did much better than both the MTO movers and the Section 8 movers in terms of education and employment.[55,63] It is noteworthy that, compared to Gautreaux, MTO moves were to worse neighborhoods. Specifically, the MTO moves were of shorter distances and to census tracts with higher poverty rates, larger minority populations, worse schools, and lower employment rates than Gautreaux moves. [55,63] Moreover, among the Gautreaux movers themselves, the suburban movers did better than the urban movers.[64] The lower effect seen in MTO compared to Gautreaux and between urban movers and suburban movers, seems to imply that there is a gradient in effect depending on the neighborhood at destination. The benefit seems to increase with increase in neighborhood socioeconomic status at destination.[65]

PRIOR OBSERVATIONAL STUDIES

Neighborhood deprivation (NSES), has been shown to be a predictor of preterm delivery independent of individual level socioeconomic status (SES).[66] For example, numerous studies have shown that women who live in more deprived neighborhoods are at higher risk for adverse birth outcomes (including preterm delivery) than those in wealthier

neighborhoods, after controlling for individual socioeconomic status.[67-76] A systematic review[77] of eleven studies[68-75,78-80] that examined neighborhood disadvantage and used multilevel analysis, showed that eight[68-75] reported significant association with preterm delivery. However, since all of these studies were cross sectional by design, whether neighborhood disadvantage is causally associated with increased risk of preterm delivery remains undetermined.

A comparison of two cohorts in a Chicago study,[81] showed a 30% reduction in risk of preterm delivery after adjusting for maternal characteristics among the upwardly mobile (uppermost quartile) women compared to those who did not move (lowest quartile) in a population of African Americans only, where each quartile comprised of multiple neighborhoods, which was accounted for in a multilevel analysis. The movement considered here was from her place of birth to her place of delivery. However, the reduction was seen only among those who were themself of normal birth weight. Another study showed[82] a 20% reduction in the preterm delivery rate among African American movers (n=4,206) but not among whites, compared to those who did not move (n=36,021)when the movement considered was from urban to suburban. On further dividing each urban and suburban counties into quartiles based on income score, only those who moved from a low urban setting benefitted, but not those who started from a high urban setting. However the resulted was not repeated in another similar comparison (n=994). But this may be due to small study size.

A longitudinal study, conducted in Atlanta, compared the effect of moving from public housing to private housing on preterm delivery, where one delivery was in the public housing and the other in private to those who stayed in public housing. The study showed no difference between those who moved and those who did not, in terms of the risk of preterm low birth weight. However, if the relocation was "forced" (an unfortunate consequence due to the demolition of public housing in preparation for the 1996 Summer Olympic Games in Atlanta) the risk of preterm delivery was increased. Those who were forced to move had 1.7fold (95% CI 1.0, 3.0) increased odds of preterm-low birth weight baby (PT-LBW) as women that moved voluntarily. [83] However, this study was restricted to African American women and was done specifically to evaluate moving from public housing to private housing in a better neighborhood under the Section 8 program of the US department of Housing and Urban Development (HUD) and the effect of policy change affecting only public housing residents and is therefore not generalizable. Moreover, the study did not consider the effect of movement for a woman compared to her prior delivery.

A similar study conducted in Denmark,[84] compared to those who had no social decline, change of residence or change of partner, found that social decline predicted preterm delivery in those who had a prior preterm delivery with OR of 1.22 (95% CI, 1.02, 1.47) but not among those who had a prior term delivery. Residential movement was considered in this study, however since it is not clear if urban rural movement is considered just a geographic movement or a socioeconomic movement, it has not been described here. This study too did not consider effect of social decline on a subject specific level.

THE GAP:

The studies described above indicate that, neighborhood deprivation has a negative effect on birth outcome, specifically on gestational age. The preterm birth rate is higher among socioeconomically deprived neighborhood. However since all the studies that have shown this association are cross sectional, whether it is causally associated with increased risk of preterm delivery remains undetermined. If indeed, they are causally associated then preterm birth rate should reduce in a cohort that has moved to a socioeconomically better neighborhood. Such studies show mixed results. The longitudinal studies did not show a reduced effect of moving. Moreover, subject specific studies that control for all potential confounders, by comparing the rate of preterm delivery before and after socioeconomic movement, has not been done.

Socioeconomic neighborhood has been classified as urban-suburban or based on neighborhood income and residential movement between these types of neighborhood has been considered as socioeconomic movement. However, a description of who moves and a comparison of those who moved to those who did not has not been done before. A clear picture of who moves and who stays will help in better planning of any intervention at the community level. Although residential mobility between deliveries has been described before, socioeconomic movement in a cohort of pregnant women has not been described before.

The following three objectives have been considered to fill the above gap.

SPECIFIC OBJECTIVES AND HYPOTHESES

The specific objectives for the three studies are listed below:

1. To describe geographic movement and socioeconomic movement between two consecutive deliveries among New Jersey residents in the time period 1996 to 2006 in terms of socio-demographic, behavioral characteristics and medical conditions. And examine the above by race/ethnicity.

   HYPOTHESIS: We hypothesize that the healthy, well to do women and those who make healthy choices relocate between deliveries and also move upward to a better social tier. In contrast, those of lower socioeconomic status and those who make unhealthy choices and are sick will not move. But if they move, they will move within the same social tier or relocate downward to a worse neighborhood.

   Additionally, relocation preferences will vary by race, with Caucasians and Asians behaving like the healthy and well to do women and the African Americans and the Hispanics will relocate like the unhealthy and women of lower socioeconomic status.

2. To estimate the risk of preterm delivery in the second pregnancy for those who moved geographically, comparing those who moved to a different socioeconomic neighborhood to those who stayed in the same neighborhood between two consecutive deliveries.

   HYPOTHESIS: We hypothesize that on an average, women's good fortune, as evidenced by relocation to a better neighborhood, is associated with term

delivery compared to other women who do not relocate. In contrast, relocation to a worse neighborhood is associated with increased risk of preterm delivery compared to other women who do not relocate.

- To estimate the risk of preterm delivery in the worse neighborhood, among those who moved geographically between two consecutive deliveries irrespective of the direction of movement, by comparing the risk of preterm delivery before and after movement.

  HYPOTHESIS: We hypothesize that irrespective of the direction of movement, a woman will always have a higher risk of preterm delivery in the worse neighborhood. That is, whether a woman relocated from a good neighborhood to a bad one or vice versa, the risk of preterm delivery will be higher in the worse neighborhood.

METHODS

SOURCE OF DATA

The main data source for this study is the Electronic Birth Certificate (EBC) of New Jersey which contains parental demographic data including race and ethnicity, parental education, parental date and place of birth, residential address at the time of delivery, initiation and duration of prenatal care, and maternal medical and behavioral risk factors for each pregnancy. It also includes complete data on employment, health insurance, enrollment in WIC and social security number, unlike the original birth certificate, an unedited version of the electronic birth certificate. However, it does not

contain the geocodes of the residence of each woman at delivery. The geocodes alone were therefore obtained from the original birth certificate dataset. Since the census tracts associated with these geocodes did not always refer to the same census year, census tracts based on census 2000 were first obtained for these geocodes. The two datasets were then merged to obtain the relevant information. This resulted in a loss of 18,942 (1.6%) records. Of these records 17,123 were lost because of incorrect or missing geocode and 1,819 because of the inconsistency between the EBC database and the original birth certificate database, most of who were born to NJ residents outside NJ. These datasets are maintained by the New Jersey Department of Health and Senior Services (NJDHSS). However, since the geocode (the latitude and longitude) for each residence is available only between 1996 and 2006, the study population has been restricted accordingly. (With additional funds the residential address at delivery for each woman could have been geocoded for more recent years). Since NJ did not adopt the 2003 revision of the birth/death certificates during this period, all variables are consistently ascertained during the entire study period based on the 1989 version of the birth certificates. All newborns to the same mother were linked using six personal identification variables of the mother to create a longitudinal dataset with multiple records per woman. This was done using The Link King v7.1.21, a public domain record linkage software, that has been shown to have high sensitivity of 79% and positive predictive value of 98%.[85,86] The Link King has fashioned a powerful alliance between sophisticated probabilistic record linkage and deterministic record linkage protocols.[87]

GEOCODING

All deliveries were geocoded (assigned a latitude and longitude) by the NJDHSS based on the mother's full address at time of delivery. If the full address was not available, the NJDHSS used the following rule to geocode: If a PO Box was provided instead of a street address, the post office was used to geocode; if only a zip code was available, then the centroid of that zip code was geocoded (the latitude and longitude of the central point of the area covered by the boundaries of a 5-digit ZIP code area). These geocodes were used to determine who moved between deliveries. A difference of 0.001^{o} (about 111 m or 364 ft.) in the latitude and longitude between successive deliveries was considered as geographic movement. A consistency check to verify if this difference actually referred to a move was done using a random sample of 1000 records. Any smaller difference did not refer to a geographic movement. However, this process does not include people who move within the same building, as movers.

Although the NJDHSS also assigned census tracts for each birth, all birth records did not have census 2000 based census tracts. Therefore census tracts based on census 2000 was re-assigned for each birth record using geocodes, with ESRI ArcGIS system (Environmental Systems Research Institute, Inc., USA). The census 2000 census tracts were essential to capture the socioeconomic variables for each census tract from the census 2000 database. As mentioned earlier, some geocodes could not be linked to a census tract as the address referred to a national park or such similar areas that are not assigned a census tract or the geocodes were incorrect or missing. These records were excluded from the study population.

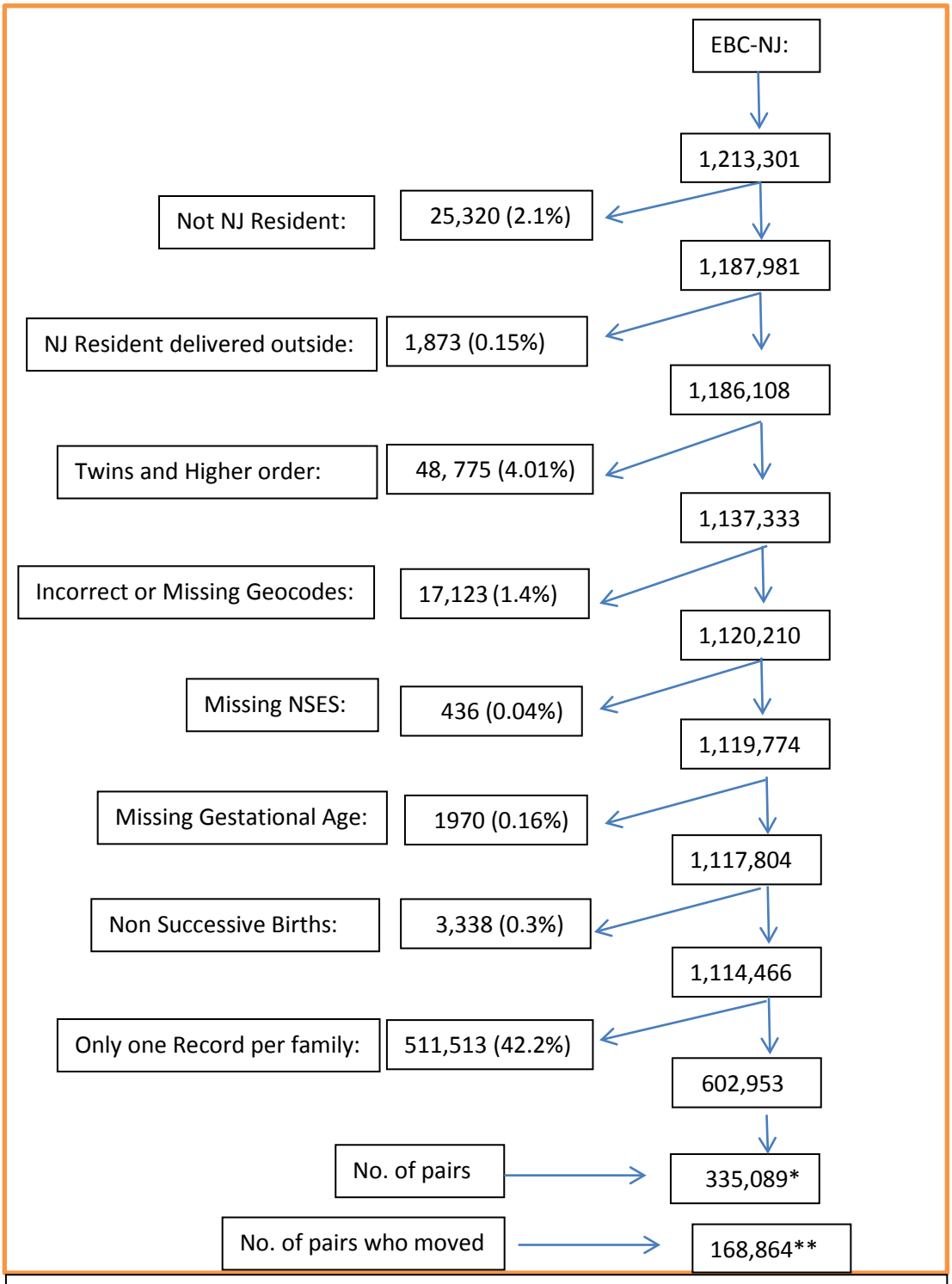
COHORT COMPOSITION

The study population comprised of all New Jersey resident women who delivered in New Jersey between the years 1996 and 2006. Figure 1 below describes the exclusion of records that are not included in the study.

The Electronic Birth Certificate of New Jersey had 1,213,301 deliveries between 1996 and 2006. Of these, 25,320 (2.1%) deliveries were to those who resided outside NJ but delivered in NJ and were excluded. Other exclusions include deliveries to NJ residents who delivered outside NJ: 1,873 (0.15%); twins and higher order births: 48,775 (4.0%); incorrect or missing geocodes: 17,123 (1.4%); unavailable Neighborhood SES: 436 (0.04%) and missing gestational age: 1970 (0.16%).

This resulted in 1,117,804 births. This was further narrowed by excluding 3,338 (0.3%) records of non-successive births; 511,513 (42.2%) that did not have a sibling during the study period. After these exclusions, 335,089 pairs of siblings (602,953 births) remained for the study for manuscript one. The first delivery of a pair was used in manuscript one, where the main objective was to describe socioeconomic movement between successive deliveries. The second and third manuscripts use only 168,864 pairs who moved. The second manuscript used the second delivery of the pair to estimate the impact of socioeconomic movement on preterm delivery when comparing two cohorts; and the third manuscript used the whole pair to compare the effect of the current neighborhood to the previous one.

Figure 1: Flow Chart Showing Exclusions applied to Births between 1996 and 2006 based on the Electronic Birth Certificate database of New Jersey (EBC-NJ)



* No. of pairs of births used in Manuscript I (includes 602,953 births.)

** No. of pairs included in Manuscript II and III

NEIGHBORHOOD SOCIOECONOMIC STATUS (NSES)

Measurement of NSES has remained inconsistent across prior studies. The most common approach to assess NSES is to use variables from the decennial census database. However, the choice of variables selected from the census as a proxy for deprivation varies from study to study. Many studies have considered only a single socioeconomic factor as a determinant of a health condition such as preterm delivery. These include education,[88] income,[82,89-92] occupation,[93] and poverty — all at the aggregated neighborhood level.[93] Other studies have included many of the above factors as independent risk factors in the same model[67,72,93,94] or as a derived composite score.[70,95,96] However, a composite score is preferred because the high correlations between census variables make finding an effect of one census variable difficult to interpret. The disadvantage of a composite score is that the interaction effect of a component of such a score with any other covariate cannot be studied.[96,97] One such derived composite score is based on several variables from the Summary File 3 (SF3) of the US census,[98] which consists of detailed tables related to social, economic and housing characteristics of Census 2000. These tables were compiled from a sample of approximately 19 million housing units (about 1 in 6 households) that received the Census 2000 long-form questionnaire with separate tables for nine major race and Hispanic or Latino groups. This comprehensive score, also known as the Neighborhood Deprivation Index (NDI),[96,49] was modified by excluding the component on housing stability, since the objective of this study was to examine housing and economic

stability. Each quintile of this score forms a "neighborhood" or social tier, irrespective of their geographic location.

Change in quintile in either direction was considered as socioeconomic movement, the primary outcome. The details of the calculations of the NDI are shown below. Certain census tracts could not be assigned a neighborhood deprivation index, as most information needed to calculate the NDI were not available for these census tracts. Therefore all records associated with these census tracts were excluded (n=436; 0.04%).

NEIGHBORHOOD DEPRIVATION INDEX

Messer et al.,[99] identified six domains from previous literature, including indices for education, unemployment, housing, poverty, low occupation and residential stability. These domains have been consistently used to represent socioeconomic position of a neighborhood. In fact, Messer et al.[96] gives a list of articles related to perinatal epidemiology between the year 2000 and 2006 that have used various domains to represent socioeconomic position of a neighborhood. Racial composition was not considered as a domain as the black race and socioeconomic disadvantage are highly correlated in the US. Therefore, using it would probably conflate the effects of racial composition with those of socioeconomic disadvantage.[99] Using various variables from the census database, to represent these domains, the authors created a Neighborhood Deprivation Index. This index has been validated for its effect on preterm delivery and has been used previously in studies of neighborhood deprivation and preterm delivery [73,100,101] Since movement between neighborhoods is the main exposure in our proposed

research, including neighborhood residential stability into the deprivation index may cause biased results. Therefore using Principal Component Analysis (PCA), the weights for each variable that is appropriate to New Jersey after excluding the residential stability domain was obtained.

The variables selected from the SF3 database of US 2000 census are listed below. Note that, prior to PCA, the variables were log-transformed and standardized. This was done because the distribution of each variable was highly skewed and the metric for all variables are not the same. Some variables were reverse coded (indicated by an asterisk) so that a higher code represents higher deprivation.

Education

1. % females 25 years and older with no high school education;
2. % above 25 years and older with bachelors or more education;*

Employment

3. % 16 years and older unemployed (of those in labor Force);
4. % 16 years and older males not in Labor force;

Occupation

5. % males 16 years and older in management/finance occupations; * (of civilian employed)
6. % males 16 years and older in professional occupations; * (of civilian employed)

Housing

7. Median value of owner occupied unit;

8. % occupied houses that are rented;

9. % housing costs more than 35% of monthly income;

10. % occupied houses with >1 person per room;

11. % vacant houses;

Poverty

12. % individuals of all ages below federal poverty level (based on income in year 1999);

13. % families with female-headed household with dependent children;

14. % households with income less than $35,000;

15. % households with public assistance income;

16. % Occupied houses with no vehicle.

Neighborhood Deprivation Score or Index was calculated by adding the above weighted variables for each census tract in New Jersey, where the final communality estimates from PCA formed the weights. The ranked census tracts were then grouped into quintiles so that the highest quintile would represent the most deprived neighborhood. The US census 2000 was chosen to calculate the NDI, since the available dataset includes all women residents of New Jersey (NJ) who delivered in NJ between 1996 and 2006 and straddles the year 2000.

The effect of socioeconomic movement may be confounded because of the presence of the phenomenon called gentrification, which is the improvement of a neighborhood with time. It is possible that either or both neighborhoods may have changed over time,

especially because of a federal grant to many cities including those in New Jersey called the HOPE VI plan to revitalize cities.[102] A comparison of deprivation score calculated based on the average of the years 2005 to 2009 of the American Community Survey (which has the same variables as SF3) and the one based on Census 2000 showed a high correlation (Kendall's Tau was more than 0.80) between the two time periods.

RATIONALE FOR THE CHOICE OF COVARIATES

Certain individual level characteristics are associated with neighborhood deprivation and may vary with socioeconomic movement too. Therefore socioeconomic movement will be described in terms of these covariates, namely: race, maternal age, socio demographic characteristics, behavioral characteristics and complications of pregnancy and labor.

RACE:

Racial/ethnic residential segregation, the degree to which two or more groups live separately from one another in a geographic area,[103] in the US is still common today. Although such segregation is illegal now and has declined considerably, it has not abated even with the passage of time in the Northeastern and Midwestern metropolitan areas like New York City and Milwaukee.[104] The distinct historical, political, and social circumstances of segregation, particularly among blacks, have profoundly shaped individual and community well-being and health.[104] Although, patterns of segregation among blacks in the US remain the highest of all racial/ethnic groups,[105] it is not uncommon among Hispanics and other minor ethnicity groups. These groups tend to live in ethnic enclaves. The effect of such segregation, however, seems to have a

beneficial effect on health. [106-108] Therefore race is an important predictor of the choice of neighborhood of residence.

MATERNAL AGE:

The effect of maternal age on the risk of preterm delivery is well established, with teenage mothers[109-112] and those above the age of thirty five[113,114] being at higher risk.[84] Racial differences in maternal age have also been shown to play a role in preterm delivery.[115] However, although not seen in prior literature, it can be hypothesized that since socioeconomic movement depends on one's improvement or decline in personal economic or social achievement, which is affected by age/time, maternal age is a determinant of socioeconomic movement.

SOCIOECONOMIC CHARACTERISTICS:

Socioeconomic characteristics, sometimes referred to as 'selection' variables may influence the choice of a neighborhood when a woman wants to move. The EBC database however did not have all socioeconomic variables. Information on employment, rather than occupation, and health insurance was available and complete. Although, parental education was available, only the number of years of education with all professional education above a four year college was grouped into one category, was available. Therefore for this study, those who had attained 12 years of education were considered as one group and the rest as a second group. Information on income was not available. Therefore an income score was created with those on Medicaid, WIC or those without any health insurance was considered as 'low income' and the others as

'medium/high income', as eligibility for Medicaid and WIC is income based. Marital status was classified as married and single, where single included all those who were not married, including unmarried, widowed and separated. The effect of health insurance or the effect of WIC was therefore not considered separately.

BEHAVIORAL FACTORS:

Risky health behavior like smoking, alcohol use and drug use during pregnancy affect preterm delivery. Similarly, preference to not indulge in these risky behavior, may affect the choice of neighborhood, even among pregnant women, as seen in the Gautreaux program and other studies of residential mobility. Prenatal care has been shown to be associated with preterm delivery. It is both a reflection of access to care and a reflection of health seeking behavior. Month of starting prenatal care (PNC) was grouped as those who started in the third trimester as 'late' and those who started before that as 'early/timely'. And 9 visits and more was considered adequate and others as inadequate.[116] Similarly adequate or excess weight gain may be considered both an indicator of access to nutritious food and an indicator of healthy choices. Since body mass index (BMI) was not known, rather than using BMI adjusted cut-offs[117] those who gained less than 15 lbs. was considered to have inadequate weight gain and those who gained more than 40 lbs. was considered to have excess weight gain.

MEDICAL COMPLICATIONS OF PREGNANCY AND LABOR:

While migration studies show that it's the healthy that move, residential mobility studies which are in general over a shorter span of time do not show that. The list of

medical conditions and complications that were considered include placental abruption, hypertensive disorders in pregnancy like chronic hypertension, gestational hypertension, preeclampsia, and eclampsia, gestational [118] and pre-gestational[119] diabetes mellitus, incompetent cervix, and uterine bleeding, placental abruption, placenta previa, premature rupture of membrane (PROM), cord prolapse, fetal distress and prior preterm.

SUMMARY

The goals of this dissertation are to describe socioeconomic movement between deliveries in terms of the covariates associated with it; to examine the effect of socioeconomic movement on preterm delivery in a cohort of pregnant women, comparing both to those who didn't move and to her outcome prior to movement. The dataset used to arrive at the conclusions is the Electronic Birth Certificate Database of New Jersey. Pairs of successive singleton births were extracted for this purpose. The statistical methods required in achieving these goals, the results and the conclusion of each study are described in the following three chapters. The final chapter gives the conclusion of all three studies together.

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PATTERNS AND CORRELATES OF SOCIOECONOMIC MOVEMENT BETWEEN SUCCESSIVE DELIVERIES

By

ALICE DAVID

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ABSTRACT OF MANUSCRIPT 1 OF 3

PATTERNS AND CORRELATES OF SOCIOECONOMIC MOVEMENT OF BETWEEN SUCCESSIVE DELIVERIES

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ABSTRACT

BACKGROUND: Residential mobility is more than just a change in physical location. It is often a reflection of a change in economic and social status. Upward socioeconomic mobility is potentially important contribution to the reduction in socioeconomic disparity and therefore health disparities in a society. However, the capability of an individual or family to move upward is not only a reflection of the inequality in ability and effort at the individual level, but is exacerbated and perpetuated by inequality of opportunity to be economically stable, at the neighborhood level. Therefore, examining the characteristics of those who experience a change in socioeconomic status of the neighborhood of residence (NSES), in a specific period of time, may help us understand the factors that increase socioeconomic mobility, or the capability of individuals or families in a society to move upward between social tiers. This paper examined the characteristics of women who move between two successive deliveries, comparing them to those who did not move at all.

METHODS: The main data source is the Electronic Birth Certificate (EBC) of New Jersey for the years 1996 to 2006. All newborns to the same mother were linked using six personal identification variables of the mother to create a longitudinal dataset with multiple records per woman. Based on the geocodes of the residence at delivery, neighborhood information on 16 variables was obtained from Census 2000 to calculate a neighborhood deprivation score. Quintiles of this score formed the socioeconomic neighborhood stratum. The highest score being most deprived. Lowest three quintiles were combined to form one neighborhood stratum the other two quintile formed two more strata. A descriptive analysis showing the characteristics of those who moved geographically, and those who moved to a socioeconomically better or worse neighborhood between any two successive pregnancies was done. The difference in proportion of movers compared to resident women who stayed was examined using chi-square test. Possible association of the above risk factors with socioeconomic movement after adjusting for maternal age at baseline was examined using log linear models. Separate models were used to study the possible association of each potential risk factor and type of movement: geographic movement, upward socioeconomic movement and downward socioeconomic movement. The only confounder considered for each of these models was maternal age. Since more than one pair of consecutive births per woman may be included in the study, generalized estimating equations (GEE) was used to control for the correlation between the responses per subject and to obtain robust standard errors.

RESULTS: Geographic movement between pregnancies was 55.3% but upward socioeconomic mobility was only 28.5% of those who moved. Non-whites, singles, teens, unemployed and having low education or low income and those who indulged in risky health behavior were more likely to move and more likely to move to a worse neighborhood. However, most medical conditions, including those with prior preterm delivery 18% higher risk (95% CI, 1.14, 1.21) of geographic movement but were not likely to move to a worse neighborhood. All racial/ethnic groups moved. However, NH Blacks 90% (95% CI: 1.86, 1.94) higher risk of moving to a worse neighborhood.

CONCLUSIONS: Socioeconomic movement that was observed in this cohort of pregnant women is reflection of residential instability rather than the capability of individuals or families in a society to move upward between social tiers.

PATTERNS AND CORRELATES OF SOCIOECONOMIC MOVEMENT BETWEEN SUCCESSIVE PREGNANCIES

BACKGROUND

For the first time, the 'Healthy People 2020' objectives have included social determinants of health as one of the four overarching goals for the decade. This goal to create social and physical environments that promote good health for all is shared by the World Health Organization[1] and certain US health initiatives such as National Partnership for Action to End Health Disparities[2] and the National Prevention and Health Promotion Strategy.[3] One of the key areas to achieve this goal is economic stability with housing stability being a key component of economic stability.[4]

Residential mobility is more than just a change in physical location. It is often a reflection of a change in economic and social status as was seen in a longitudinal study that considered the reasons for residential movement during pregnancy.[5] By increasing the upward socioeconomic mobility, socioeconomic disparity and therefore health disparities in a society can be reduced. [6] However, the capability of an individual or family to move upward is not only a reflection of the inequality in ability and effort at the individual level, but is exacerbated and perpetuated by inequality of opportunity to be economically stable, at the neighborhood level.[6] Therefore, examining the characteristics of those who experience a change in socioeconomic status (NSES) of the neighborhood of residence, in a specific period of time, may help us understand the factors that increase socioeconomic mobility, or the capability of individuals or families

in a society to move upward between social tiers. Or, examining the characteristics of those who move downward to worse socioeconomic neighborhood stratum can help prevent health disparities.

Residential mobility in relation to health has been studied extensively for various groups of people such as children, adolescents, and adults, as well as women during their pregnancies.[7] Most studies of pregnant women have focused on residential mobility from her place of birth to her place at delivery based on the birth record of her child, [8-15] (often referred to as migration rather than residential mobility). Other studies have examined the effect of residential movement during pregnancy.[7,16-24] And one study examined a birth cohort prospectively both during pregnancy up to the first year post-partum.[5] All these studies, did not consider change of NSES. However other studies have examined the effect of residential movement of pregnant women on preterm delivery, where the movement can be considered as change in NSES. One examined residential movement from public to private housing,[25] another study considered movement from urban to suburban[10] and a third used census tracts to determine the NSES for each woman. [26] Other studies include randomized social intervention trials that moved families from high-poverty to lower-poverty neighborhoods, called 'Moving To Opportunity' (MTO) trial[27,28] and 'Gautreaux program'.[29] However all but one of these studies were restricted to Blacks. One study included Whites.[10] Moreover the residential movement was in only one direction.

This paper examined the characteristics of women who move between two successive deliveries, comparing them to those who did not move at all. This type of movement is referred to as 'Geographic' movement. Characteristics of women who moved to a better or worse socioeconomic neighborhood stratum than the neighborhood recorded at their first delivery were also examined. This type of movement is referred to as 'Socioeconomic' movement. Some of the factors considered to be associated with each type of movement are demographic, socioeconomic status, health behavior and medical conditions at the time of the delivery before their relocation from the residence at origin. A race/ ethnic specific description, which includes the four major race/ethnic groups, Non-Hispanic (NH) Whites, NH Blacks, Hispanics and Asians, and all others grouped as one category, is also shown.

METHODS

SOURCE OF DATA

The main data source for this study is the Electronic Birth Certificate (EBC) of New Jersey. The EBC contains parental demographic data including race and ethnicity, parental education, parental date and place of birth, residential address at the time of delivery, initiation and duration of prenatal care, and maternal medical and behavioral risk factors. The EBC also includes data on employment, health insurance, enrollment in WIC and social security number. Since the geocodes of residence at delivery were not available in the EBC file, these alone were obtained from the original birth certificate dataset. Census tracts associated with these geocodes did not always refer to the same census year. Therefore census tracts based on census 2000 were first obtained for these

geocodes using ESRI ArcGIS system (Environmental Systems Research Institute, Inc., USA). The two datasets were then merged to obtain the geocodes and census tracts based on census 2000. These datasets are maintained by the New Jersey Department of Health and Senior Services (NJDHSS). The years included in the study were 1996 to 2006. They were selected because 1996 was the first year that EBC was in widespread use and 2006 was the last year that geocoding was available. It should be noted that, NJ did not adopt the 2003 revision of the birth/death certificates during this period, all variables are consistently ascertained during the entire study period based on the 1989 version of the birth certificates. All newborns to the same mother were linked using six personal identification variables of the mother, namely first name, middle name, maiden name, last name, date of birth and social security number of the mother to create a longitudinal dataset with multiple records per woman. This was done using The Link King v7.1.21, a public domain record linkage software, that has been shown to have a sensitivity of 79% and positive predictive value of 98%.[30,31] The Link King uses both a probabilistic record linkage and deterministic record linkage protocols.[32] On examining 100 random mothers, the linking seemed to be correct for all 100 records. Some last names were different, but all other five personal identifications, including date of birth and social security number (SSN) were the same. Therefore it was assumed that it was the same mother with a different spouse. SSN was missing for some. However all other five identifiers matched and so it was assumed that it is the same person.

GEOCODING

All deliveries were geocoded (assigned a latitude and longitude) by the NJDHSS based on the mother's full address at time of delivery. Using these geocodes, a census tract was assigned to each birth record, using ESRI ArcGIS system (Environmental Systems Research Institute, Inc., USA). If the full address was not available, the NJDHSS used the following rule: If a PO Box was provided instead of a street address, the post office was used to geocode; if only a zip code was available, then the centroid of that zip code was geocoded (the latitude and longitude of the central point of the area covered by the boundaries of a 5-digit ZIP code area). The assigned census tract would therefore be imprecise too. Some geocodes could not be linked to a census tract as the address referred to a national park or such similar areas that are not assigned a census tract or the geocodes were incorrect or missing. These records were excluded from the study population. A difference of 0.001^{o} (about 111 m or 364 ft.) in both, the latitude and longitude between successive pregnancies was considered as evidence of geographic movement. Smaller differences were not interpreted as evidence of a change in residence. However, this definition will not include people who move within the same building, as movers.

A validation to verify if this difference actually referred to a move was done using a random sample of 1000 pairs. Of the 500 pairs who were supposed to have moved based on the above specification, the manual verification showed that 13.8% had not

moved. And of the 500 pairs who did not move according to the above specification, 9.8% actually moved. That is sensitivity is 89.8% and specificity is 86.7%.

NEIGHBORHOOD SOCIOECONOMIC STATUS (NSES)

Measurement of NSES has remained inconsistent across prior studies. The most common approach to assess NSES is to use variables from the decennial census database. However, the choice of variables selected from the census as a proxy for deprivation varies from study to study. Many studies have considered only a single socioeconomic factor as a determinant of a health condition such as preterm delivery. These include education,[33] income,[10,34-37] occupation,[38] and poverty — all at the aggregated neighborhood level.[38] Other studies have included many of the above factors as independent risk factors in the same model[38-41] or as a derived composite score.[42-44] A composite score is preferred because the high correlations between census variables make finding an effect of one census variable difficult to interpret. The disadvantage of a composite score is that the interaction effect of a component of such a score with any other covariate cannot be studied.[44,45] One such derived composite score is based on several variables from the Summary File 3 (SF3) of the US census,[46] which includes detailed tables related to social, economic and housing characteristics from the decennial census. These tables were compiled for the year 2000, from a sample of approximately 19 million housing units (about 1 in 6 households) that received the long-form questionnaire with separate tables for nine major race and Hispanic or Latino groups. This comprehensive score, also known as the Neighborhood

Deprivation Index (NDI),[44,49] was modified by excluding the component on housing stability, since the objective of this study was to examine housing and economic stability. Each quintile of this score forms a "neighborhood" or social tier, irrespective of their geographic location. From these quintiles we defined three social strata, quintile I to III were considered 'GOOD'; quintile IV was labeled 'BAD'; and quintile V was labeled 'WORST'. For this study change in quintile in either direction was considered as socioeconomic movement, the primary outcome and maternal characteristics the independent variables of interest. The details of the calculations of the NDI are shown below. Certain census tracts could not be assigned a neighborhood index, as most information needed to calculate the NDI were not available for these census tracts. Therefore all records associated with these census tracts were excluded (n=436; 0.04%). The details of the calculation of the NDI are given in the 'Introduction' chapter.

The US census 2000 was chosen to calculate the NDI, since it provides a metric for nearly every residential census tract and is roughly mid-way through the 1996-2006 study period. A comparison of deprivation score calculated based on the average of the years 2005 to 2009 of the American Community Survey and the one based on Census 2000 showed a high correlation (Kendall's Tau ≥0.80) between the two time periods. Although the NJDHSS also assigned census tracts for each birth, all birth records did not have census 2000 based census tracts. Therefore census tracts based on census 2000 was re-assigned for each birth record using geocodes, with ESRI ArcGIS system (Environmental Systems Research Institute, Inc., USA). The census 2000 census tracts

were essential to capture the socioeconomic variables for each census tract from the census 2000 database.

COHORT COMPOSITION

The study population is made up of all New Jersey resident women who delivered at least two consecutive singleton births in New Jersey between 1996 and 2006. If the residential address of a woman at the time of delivery belonged to a census tract for which NSES could not be calculated, that delivery was excluded. Similarly if a census tract could not be assigned either because it did not belong to the unedited original birth file or because the address was a forest or similar area that did not have a census tract, that delivery was excluded too. Deliveries for which the gestational age was missing were also excluded. After these exclusions, women who did not have two qualifying deliveries during the study period were excluded. The details of exclusion are given in the introductory chapter. After the exclusions there were 335,085 pairs of siblings delivered by 280, 060 women. For women with more than two deliveries in the dataset we used all successive delivery pairs available. If she moved between one pair and did not for another pair, she was considered as mover for baseline characteristics only.

RISK FACTORS

Potential risk factors of socioeconomic movement considered were classified as:

1. Socio-Demographic: maternal age, educational attainment, employment status, marital status, income level at delivery and foreign origin (born) status were included. Paternal educational attainment and employment status were also included. Since the birth certificate database does not have information on income, those eligible for WIC, MEDICAID and those who did not have health insurance were considered 'low income'. Maternal age was categorized as below 20, 20 to 34 and 35 and above. Marital Status was classified as single and married, where single includes unmarried, legally separated, divorced, widowed, marriage annulled and unknown and married includes married, common law and Indian marriage.
2. Health Behaviors: adequate prenatal care, time of initiation of prenatal care, drug abuse, alcohol and tobacco use during pregnancy were considered as risk factors of preterm delivery. These factors vary by race/ethnicity and by NSES. Weight gain during pregnancy, an indicator for nutritional status was also considered as a health behavior. Those who gained less than 15 lbs. were considered to have inadequate weight gain and those who gained 40 lbs. or more as excess weight gain. Further, although WIC is an indicator for nutritional status, it was not included separately as it was already included as a proxy for income.
3. Medical Conditions: prior preterm delivery, hypertensive disorders in pregnancy including chronic hypertension, gestational hypertension, preeclampsia and eclampsia, pre-existing diabetes mellitus type I and II, gestational diabetes,

incompetent cervix, uterine bleeding, placenta previa, placental abruption, premature rupture of membrane (PROM), cord prolapse and non-reassuring fetal status were included.

STATISTICAL ANALYSIS

A descriptive analysis showing the characteristics of those who moved geographically, and those who moved to a socioeconomically better or worse neighborhood between any two successive pregnancies was done. The difference in proportion of movers compared to resident women who stayed was examined using chi-square test. Possible association of the above risk factors with socioeconomic movement after adjusting for maternal age at baseline was examined using log linear models. Separate models were used to study the possible association of each potential risk factor and type of movement: geographic movement, upward socioeconomic movement and downward socioeconomic movement. The only confounder considered for each of these models was maternal age. Since more than one pair of consecutive births per woman may be included in the study, generalized estimating equations (GEE) was used to control for the correlation between the responses per subject and to obtain robust standard errors.

RESULTS

Of the 280,060 residents of NJ who had two or more successive pregnancies, 154,763(55.3%) women moved geographically between the two deliveries. Of these 83,133 (53.7%) women remained in the same socioeconomic stratum while 44,107 (28.5%) moved to a better and only 27,523 (17.8%) moved to a worse stratum

The baseline characteristics of those who moved from their initial address between deliveries and those who stayed in the same residence are shown in table 1. Those who moved differed in many respects from those who did not. Differences included greater mobility with: younger age, black and Hispanic race/ethnicity, single marital status, low income, limited education, and street drug use during pregnancy. In contrast to these differences, medical conditions and complications associated with pregnancy were not much associated with moving house, although moving was a little more common among those with a prior preterm birth and eclampsia.

Table 2 shows the socioeconomic direction of the moves by baseline characteristics. Overall, 54% of moves were within the same socioeconomic stratum while 18% were downward and 28% were upward. The excess of upward moves over downward moves is consistent with the timing of the study years before the great recession and with the gains in income that would be expected in a substantial fraction of these young families as a result of breadwinner career development. The frequency of downward moves was fairly uniform according to baseline characteristics, occurring in 15-20% of nearly every category. Upward moves between pregnancies were less common among women who, at their first delivery, were under age 20, of black race, single, unemployed, late to prenatal care, or used street drugs.

Age-adjusted relative risks of moving to worse or better neighborhoods are shown in Table 3. Women in the bottom neighborhood stratum at the first pregnancy are excluded from the calculation of risk for moving down (which was not possible for them)

and, likewise, women in the top stratum were excluded from moving up. The associations described above are largely reproduced after age-adjustment, and it is notable that, given the large numbers of women in the study, the great majority of associations are statistically significant.

As shown in Table 4, white women were the least likely to move between deliveries, and black and Hispanic women were the groups most likely to move down and least likely to move up. Asians were more likely to relocate compared to NH Whites and were more likely to move to a better socioeconomic neighborhood or to a worse one than the one they lived in earlier.

DISCUSSION

At their baseline delivery, most women, in this cohort, were primiparous (67.4%), between the age 20-34 years (80.4%), married (68.7%) , US born (73.6%), having mid/high level of income (58.7%), employed (67.3%) and had more than 12 years of education (55.8%).

This study shows more than half (55.3%) of all women with two or more successive pregnancies moved from their initial residence between their deliveries, and of these, a little over half (53.7%) stayed in the same NSES stratum. Almost a third of the movers (28.5%) went to a better neighborhood and only about a sixth (17.8%) to a worse neighborhood.

The residential mobility observed in this study (55.3%) is more than another study[5] that observed residential movement in pregnant women prospectively who observed that 28.5% moved in the first year post-partum. This is probably due to a longer period of observation. Upward socioeconomic movement was observed only in about a third of those who moved. That is only 15.8% moved upward between deliveries and 9.8% downward. That is 16.9% of NH Whites and 12.2% of NH Blacks moved upward between deliveries. Although this is lower than the lifetime upward movement to suburban counties of about 70% among NH Whites, it was similar to the lifetime upward movement of 13% among African Americans in a Chicago based study.[10] Upward socioeconomic mobility for Hispanics, Asians and all other races were not examined in any other study. Neither was downward socioeconomic movement for any race.

A notable finding is that socioeconomic mobility differed by race/ethnicity. That is, while in every race there were more women who moved than those who stayed, the proportion of NH Blacks and Hispanics who moved were much higher than those who stayed. Moreover, while every race was more likely to move than NH Whites, NH Blacks were least likely to move to a better socioeconomic neighborhood stratum and most likely to move to a worse stratum from their initial place of residence, followed by Hispanics and other races, compared to NH Whites. Asians were likely to move to both better and worse socioeconomic neighborhood stratum than their initial place of residence, compared to NH Whites.

Another interesting result of the study that was not examined in any other study of pregnant women is that while most medical conditions during pregnancy were

associated with residential movement, they were not associated with moving to worse socioeconomic neighborhood strata and were less likely to move to better socioeconomic neighborhood than those who were healthy. This goes against the hypothesis that there is selective residential mobility of the unhealthy to worse neighborhoods. [47]

This study is one of the first to characterize patterns of socioeconomic movement for a racially/ ethnically diverse cohort of women between two consecutive singleton births considering various social, demographic and clinical determinants. Residential mobility was higher among teenagers, singles, those with low income level, unemployed and those who had less than 12 years of education. Those who moved were highly likely to move to a worse neighborhood and less likely to move to a better neighborhood. However the characteristics of the women who moved between deliveries were similar to those who moved during pregnancy. [5]

Socioeconomic mobility, during the child bearing years of a woman's life is important to consider as it sets the stage not only for an individual's opportunity for health and material success but also for subsequent generations. Moreover, since the child bearing years also coincide with the most productive years in terms of socioeconomic achievement, it may reflect the ability of the whole society that they represent to be socioeconomically mobile.

This study shows that upward socioeconomic mobility during child bearing years, particularly after the birth the first child is less common. The movement seen in this

cohort reflects forces other than socioeconomic growth in the society, as more than 50% of the women who moved remained in the same socioeconomic stratum and about a third of those who moved out, moved to a worse neighborhood stratum. That is, only about 15% were upwardly mobile in this cohort. The long-standing ideology in the US that upward social mobility is available to all is not seen here. This may be a reflection of the stagnant or declining socioeconomic mobility seen throughout the US.[48] A stagnant or declining socioeconomic mobility will not only increase the income inequality but also increase the disease burden of the society.[6] Improving the socioeconomic status of the women, educating them to have better health related behavior may prevent the downward socioeconomic mobility in pregnant women.

STRENGTHS AND LIMITATIONS

The strengths of this study are:

(i) A large database and representing a diverse racial and ethnic population was used for this study. Most studies on residential mobility in pregnant women have considered only Blacks or a comparison of Blacks to Whites only. This study includes four major racial/ethnic groups

(ii) All residential addresses socioeconomic and demographic variables and certain behavioral variables like prenatal care initiation and usage, use of drug alcohol and smoking during pregnancy, medical risk factors and complications of pregnancy and labor were verified by the NJDOH's State Health Assessment Data (NJSHAD) system. Of which only drug, alcohol use

and smoking during pregnancy is self-reported by the patient. The error margin is below 2%.

(iii) Study based on longitudinal study design, following a woman from one delivery. Most studies have examined residential mobility, especially the ones related to birth defect using case control design. Recall bias, the major problem with case control studies was therefore avoided

(iv) Both geographic movement and socioeconomic movement were studied, unlike other studies that only considered geographic movement.

The limitations of this study are:

(i) The unavailability of information before the first delivery for any woman. The address was collected at the time of delivery and therefore we do not know if she moved before delivery. Since a prior study showed that those who move during prenatal period are twice as likely to move after delivery,[5] the absence of such information may be insignificant.

(ii) The exact date of relocation is not available. Therefore any relocation that would have occurred between two pregnancies cannot be ascertained and exact duration of stay in that neighborhood is not known. However, since this study only examines potential predictors of socioeconomic movement, not the effect of residential movement on health, the lack of this information does not affect the results of the study.

(iii) Using a difference of 0.001^{o} as cut off to determine who moved and who did not caused misclassification of the outcome. However since the misclassification is non-differential the observed risk will not be lower than what is observed in this study.

CONCUSION:

The main conclusions of this study are:

(i) Geographic movement between pregnancies is very high but upward socioeconomic mobility is low in this cohort;

(ii) Non-whites, singles, teens, unemployed and having low education or low income and those who indulged in risky health behavior were more likely to move and more likely to move to a worse neighborhood. However, most medical conditions, including prior preterm delivery were associated with geographic movement but were not likely to move to a worse neighborhood;

(iii) All racial/ethnic groups moved. However, NH Blacks were most likely to move to a worse neighborhood after the study birth than they were in at the time of delivery. Hispanics and women of other races followed closely in a similar pattern. Asians on the other hand were more likely to relocate compared to NH Whites and moved to both better and worse socioeconomic neighborhood stratum than their neighborhood of residence at delivery of the first child. .

TABLES:

Table 1: Baseline Characteristics of Women who moved between Successive Deliveries*

CHARACTERISTICS	ALL WOMEN	MOVED	
AGE :			
< 20	30,957	21,775	70.3%
20-34	225,124	123,318	54.8%
≥35	23,972	9,667	40.3%
RACE/ETHNICITY			
NH White	159,187	81,479	51.2%
NH Black	42,692	27,607	64.7%
Hispanic	55,640	33,356	59.9%
Asian	18,733	10,253	54.7%
Others	3,808	2,068	54.3%
MARITAL STATUS			
Single	87,683	58,837	67.1%
Married	192,377	95,926	49.9%
PLACE OF BIRTH			
Foreign Born	72,995	40,456	55.4%
US Born	206,104	113,765	55.2%
INCOME STATUS			
Low	115,637	70,305	60.8%
Mid/ High	164,423	84,458	51.4%
EMPLOYMENT STATUS			
Unemployed	88,996	54,076	60.8%
Employed	188,481	99,151	52.6%
EDUCATION ATTAINED			
≤ 12 years	117,964	72,537	61.5%
> 12 years	156,337	78,690	50.3%
SPOUSE/PARTNER EMPLOYMENT			
Unemployed	27,308	16,383	60.0%
Employed	227,783	121,176	53.2%
SPOUSE/PARTNER EDUCATION			
≤ 12 years	107,588	63,110	58.7%
> 12 years	144,020	72,326	50.2%
WEIGHT GAIN DURING PREGNANCY			
> 40 lbs.	47,467	26,520	55.9%
15-40 lbs.	196,760	107,349	54.6%
< 15 lbs.	24,212	14,074	58.1%

PRENATAL CARE: FREQUENCY			
≤ 9 times	**85,993**	**49,968**	**58.1%**
> 9 times	**182,928**	**98,646**	**53.9%**
PRENATAL CARE: INITIATION			
After 6 months	**9,264**	**5,992**	**64.7%**
Before 6 months	**262,326**	**143,929**	**54.9%**
SMOKING DURING PREGNANCY			
Yes	**27,092**	**17,601**	**65.0%**
No	**251,371**	**136,095**	**54.1%**
DRUG USE DURING PREGNANCY			
Yes	**5,169**	**3,714**	**71.9%**
No	**273,147**	**149,887**	**54.9%**
ALCOHOL USE DURING PREGNANCY			
Yes	**4,647**	**2,955**	**63.6%**
No	**273,350**	**150,411**	**55.0%**
PARITY AFTER FIRST STUDY BIRTH			
One	**188,767**	**100,549**	**53.3%**
Two	**91,161**	**54,128**	**59.4%**
MEDICAL CONDITIONS[+]			
DIABETES TYPE 1	**852**	**466**	**54.7%**
DIABETES TYPE 2	**314**	**174**	**55.4%**
GESTATIONAL DIABETES	**8,309**	**4,292**	**51.7%**
HYPERTENSION	**1,642**	**901**	**54.9%**
PREGNENCY INDUCED HTN	**8,418**	**4,498**	**53.4%**
PRE-ECLAMPSIA	**4,013**	**2,250**	**56.1%**
ECLAMPSIA	**185**	**115**	**62.2%**
INCOMPETENT CERVIX	**1,000**	**513**	**51.3%**
PRIOR PT	**2,515**	**1,588**	**63.1%**
EXCESS BLEEDING	**6,601**	**3,749**	**56.8%**
PROM	**6,064**	**3,355**	**55.3%**
PLACENTAL ABRUPTION	**1,819**	**1,015**	**55.8%**
PLACENTA PRIVIA	**820**	**428**	**52.2%**
CORD PROLAPSE	**651**	**353**	**54.2%**
FETAL DISTRESS	**7,244**	**3,905**	**53.9%**
ALL WOMEN	**280,060**	**154,763**	**55.3%**

*** Missing values are not shown**

[+] Missing values considered as absent

Table 2:Baseline Characteristics by Socioeconomic Movement*

CHARACTERISTICS	ALL MOVERS	SOCIOECONOMIC MOVEMENT					
		WORSE		SAME		BETTER	
AGE							
< 20	21,775	4,483	20.6%	12,614	57.9%	4,678	21.5%
20-34	123,318	21,734	17.6%	64,885	52.6%	36,699	29.8%
≥ 35	9,667	1,306	13.5%	5,632	58.3%	2,729	28.2%
RACE/ETHNICITY							
NH Whites	81,479	14,565	17.9%	42,099	51.7%	24,815	30.5%
NH Blacks	27,607	4,849	17.6%	16,655	60.3%	6,103	22.1%
Hispanics	33,356	5,901	17.7%	18,978	56.9%	8,477	25.4%
Asians	10,253	1,769	17.3%	4,429	43.2%	4,055	39.5%
Others	2,068	439	21.2%	972	47.0%	657	31.8%
MARITAL STATUS							
Single	58,837	12,021	20.4%	33,217	56.5%	13,599	23.1%
Married	95,926	15,502	16.2%	49,916	52.0%	30,508	31.8%
PLACE OF BIRTH							
Foreign Born	40,456	7,011	17.3%	20,898	51.7%	12,547	31.0%
US Born	113,765	20,415	17.9%	61,940	54.4%	31,410	27.6%
INCOME STATUS							
Low	70,305	12,675	18.0%	40,104	57.0%	17,526	24.9%
Mid/High	84,458	14,848	17.6%	43,029	50.9%	26,581	31.5%
EMPLOYMENT STATUS							
Unemployed	54,076	9,351	17.3%	31,188	57.7%	13,537	25.0%
Employed	99,151	17,868	18.0%	51,076	51.5%	30,207	30.5%
EDUCATION ATTAINED							
≤ 12 Years	72,537	14,048	19.4%	40,522	55.9%	17,967	24.8%
> 12 Years	78,690	12,839	16.3%	40,519	51.5%	25,332	32.2%

SPOUSE/PARTNER EMPLOYMENT							
Unemployed	**16,383**	**2,473**	**15.1%**	**10,073**	**61.5%**	**3,837**	**23.4%**
Employed	**121,176**	**21,604**	**17.8%**	**62,832**	**51.9%**	**36,740**	**30.3%**
SPOUSE/ PARTNER EDUCATION							
≤ 12 Years	**63,110**	**12,097**	**19.2%**	**34,334**	**54.4%**	**16,679**	**26.4%**
> 12 Years	**72,326**	**11,611**	**16.1%**	**37,303**	**51.6%**	**23,412**	**32.4%**
WEIGHT GAIN DURING PREGNANCY							
> 40 lbs.	**26,520**	**5,157**	**19.4%**	**13,657**	**51.5%**	**7,706**	**29.1%**
15-40 lbs.	**107349**	**18604**	**17.3%**	**57763**	**53.8%**	**30982**	**28.9%**
< 15 lbs.	**14,074**	**2,514**	**17.9%**	**7,986**	**56.7%**	**3,574**	**25.4%**
PRENATAL CARE: FREQUENCY							
≤ 9 times	**49,968**	**8,990**	**18.0%**	**27,745**	**55.5%**	**13,233**	**26.5%**
> 9 times	**98,646**	**17,487**	**17.7%**	**52,106**	**52.8%**	**29,053**	**29.5%**
PRENATAL CARE: INITIATION							
After 6 months	**5,992**	**1,239**	**20.7%**	**3,393**	**56.6%**	**1,360**	**22.7%**
Before 6 months	**143,929**	**25,415**	**17.7%**	**77,146**	**53.6%**	**41,368**	**28.7%**
SMOKING DURING PREGNANCY							
Yes	**17601**	**3875**	**22.0%**	**9328**	**53.0%**	**4398**	**25.0%**
No	**136,095**	**23,435**	**17.2%**	**73,220**	**53.8%**	**39,440**	**29.0%**
DRUG USE DURING PREGNANCY							
Yes	**3,714**	**713**	**19.2%**	**2,220**	**59.8%**	**781**	**21.0%**
No	**149,887**	**26,586**	**17.7%**	**80,275**	**53.6%**	**43,026**	**28.7%**
ALCOHOL USE DURING PREGNANCY							
Yes	**2,955**	**552**	**18.7%**	**1,681**	**56.9%**	**722**	**24.4%**
No	**150,411**	**26,694**	**17.7%**	**80,699**	**53.7%**	**43,018**	**28.6%**
PARITY AFTER FIRST STUDY BIRTH							
One	**100,549**	**18,888**	**18.8%**	**51,720**	**51.4%**	**29,941**	**29.8%**
Two or More	**54,128**	**8,616**	**15.9%**	**31,377**	**58.0%**	**14,135**	**26.1%**

MEDICAL CONDITIONS[+]							
DIABETES TYPE 1	466	73	15.7%	270	57.9%	123	26.4%
DIABETES TYPE 2	174	35	20.1%	81	46.6%	58	33.3%
GESTATIONAL DIABETES	4,292	826	19.2%	2,213	51.6%	1,253	29.2%
HYPERTENSION	901	157	17.4%	488	54.2%	256	28.4%
GESTATIONAL HYPERTEN	4,498	849	18.9%	2,397	53.3%	1,252	27.8%
PRE-ECLAMPSIA	2,250	406	18.0%	1,283	57.0%	561	24.9%
ECLAMPSIA	115	23	20.0%	59	51.3%	33	28.7%
INCOMPETENT CERVIX	513	83	16.2%	290	56.5%	140	27.3%
PRIOR PRETERM	1,588	242	15.2%	925	58.2%	421	26.5%
EXCESS BLEEDING	3,749	659	17.6%	2,061	55.0%	1,029	27.4%
PROM	3,355	581	17.3%	1,818	54.2%	956	28.5%
PLACENTAL ABRUPTION	1,015	187	18.4%	573	56.5%	255	25.1%
PLACENTA PRIVIA	428	83	19.4%	219	51.2%	126	29.4%
CORD PROLAPSE	353	64	18.1%	191	54.1%	98	27.8%
FETAL DISTRESS	3,905	689	17.6%	2,074	53.1%	1,142	29.2%
ALL MOVERS	154,763	27,523	17.8%	83,133	53.7%	44,107	28.5%

*** Missing values are not shown**

[+] Missing is considered as absent

Table 3: Age Adjusted Relative Risk of Residential Movement

CHARACTERISTICS	GEOGRAPHIC	SOCIOECONOMIC	
	MOVED	WORSE*	BETTER@
	RR (95% CI)	RR (95% CI)	RR (95% CI)
SINGLE	1.39 (1.38, 1.40)	1.83 (1.80, 1.87)	0.65 (0.64, 0.66)
FOREIGN BORN	1.02 (1.02, 1.03)	1.21 (1.18, 1.23)	1.01 (0.99, 1.02)
LOW INCOME	1.13 (1.12, 1.13)	1.41 (1.38, 1.43)	0.72 (0.71, 0.73)
UNEMPLOYED	1.05 (1.04, 1.05)	1.17 (1.15, 1.19)	0.79 (0.78, 0.80)
≤ 12 YEARS EDUCATION	1.17 (1.16, 1.18)	1.53 (1.50, 1.56)	0.67 (0.66, 0.68)
SPOUSE/ PARTNER UNEMPLOYED	1.03 (1.02, 1.04)	1.43 (1.38, 1.47)	0.67 (0.65, 0.68)
SPOUSE/ PARTNER ≤ 12 YEARS EDU	1.13 (1.12, 1.14)	1.46 (1.43, 1.49)	0.70 (0.69, 0.71)
PARITY AFTER FIRST STUDY BIRTH: ONE	1.00 (0.99, 1.01)	0.81 (0.79, 0.84)	1.52 (1.48, 1.55)
INADEQUATE WT GAIN	1.03 (1.02, 1.04)	1.20 (1.17, 1.24)	0.81 (0.79, 0.83)
EXCESS WT GAIN	1.03 (1.02, 1.04)	1.03 (1.01, 1.05)	1.04 (1.02, 1.06)
INADEQUATE PRENATAL CARE	1.04 (1.03, 1.05)	1.24 (1.22, 1.27)	0.84 (0.83, 0.85)
LATE INITIATION OF PRENATAL CARE	1.11 (1.09, 1.12)	1.33 (1.28, 1.38)	0.77 (0.74, 0.80)
SMOKING	1.19 (1.18, 1.20)	1.18 (1.15, 1.21)	0.83 (0.81, 0.86)
DRUG USE	1.26 (1.24, 1.28)	1.42 (1.35, 1.50)	0.68 (0.64, 0.72)
ALCOHOL USE	1.18 (1.15, 1.21)	1.11 (1.04, 1.18)	0.83 (0.79, 0.88)
MEDICAL CONDITIONS			
DIABETES TYPE 1	1.13 (1.06, 1.20)	0.85 (0.71, 1.02)	0.79 (0.69, 0.91)
DIABETES TYPE 2	1.17 (1.06, 1.29)	1.23 (0.96, 1.58)	1.01 (0.84, 1.21)

GESTATIONAL DM	**1.06 (1.04, 1.09)**	**0.97 (0.91, 1.02)**	**0.95 (0.91, 0.99)**
HYPERTENSION	**1.12 (1.07, 1.17)**	**1.02 (0.90, 1.15)**	**0.84 (0.76, 0.93)**
GESTATIONAL HTN	**1.08 (1.05, 1.10)**	**0.94 (0.89, 0.99)**	**0.94 (0.90, 0.99)**
PRE-ECLAMPSIA	**1.09 (1.06, 1.12)**	**1.06 (0.98, 1.14)**	**0.83 (0.78, 0.89)**
ECLAMPSIA	**1.12 (0.99, 1.26)**	**1.42 (1.19, 1.69)**	**0.89 (0.68, 1.17)**
INCOMPETENT CERVIX	**1.02 (0.96, 1.08)**	**0.94 (0.79, 1.11)**	**0.88 (0.78, 1.00)**
PRIOR PRETERM	**1.18 (1.14, 1.21)**	**1.07 (0.99, 1.17)**	**0.79 (0.74, 0.85)**
EXCESS BLEEDING	**1.14 (1.12, 1.17)**	**0.90 (0.85, 0.96)**	**0.92 (0.88, 0.97)**
PROM	**1.13 (1.10, 1.15)**	**0.87 (0.82, 0.93)**	**0.96 (0.92, 1.01)**
ABRUPTIO P	**1.11 (1.06, 1.15)**	**1.04 (0.93, 1.15)**	**0.82 (0.74, 0.90)**
PLACENTA PREVIA	**1.08 (1.02, 1.16)**	**0.98 (0.82, 1.16)**	**1.00 (0.88, 1.13)**
CORD PROLAPSE	**1.07 (1.00, 1.15)**	**0.97 (0.81, 1.16)**	**0.95 (0.82, 1.10)**
FETAL DISTRESS	**1.10 (1.07, 1.12)**	**0.89 (0.84, 0.95)**	**1.01 (0.97, 1.06)**

***Excludes all from the lowest quintile @ Excludes all from the highest quintile**

Table 4: Relative Risk of Residential Movement by Race/ Ethnicity

RACE/ ETHNICITY	GEOGRAPHIC	SOCIOECONOMIC	
	MOVED	WORSE*	BETTER@
	RR (95% CI)	RR (95% CI)	RR (95% CI)
NH WHITE	REFERENCE	REFERENCE	REFERENCE
NH BLACK	1.19 (1.18, 1.20)	1.90 (1.86, 1.94)	0.59 (0.58, 0.61)
HISPANIC	1.14 (1.13, 1.15)	1.73 (1.69, 1.77)	0.69 (0.67, 0.70)
ASIAN	1.12 (1.10, 1.13)	1.12 (1.08, 1.17)	1.22 (1.19, 1.25)
OTHER	1.03 (1.00, 1.06)	1.46 (1.37, 1.57)	0.90 (0.85, 0.95)

*Excludes all from the lowest quintile @ Excludes all from the highest quintile

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THE EFFECT OF SOCIOECONOMIC MOVEMENT ON PRETERM DELIVERY: A COHORT STUDY

By

ALICE DAVID

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Written under the direction of

George G. Rhoads, MD MPH

ABSTRACT OF MANUSCRIPT 2 OF 3

THE EFFECT OF SOCIOECONOMIC MOVEMENT ON PRETERM DELIVERY: A COHORT STUDY

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ABSTRACT

BACKGROUND: Comparison of cohorts of pregnant women in two different socioeconomic neighborhoods has shown a reduction of the risk of preterm delivery in the better neighborhood in certain subsets of pregnant women. Others have shown no effect. However these cohorts mostly included only African Americans, very few of whom moved and the movement was only to better neighborhoods. This study followed a large multi-ethnic population of pregnant women who moved between successive pregnancies to a better or worse socioeconomic neighborhood to examine the effect of movement on preterm delivery.

METHODS: The main data source is the Electronic Birth Certificate (EBC) of New Jersey for the years 1996 to 2006. All newborns to the same mother were linked using six personal identification variables of the mother to create a longitudinal dataset with multiple records per woman. Based on the geocodes of the residence at delivery, neighborhood information on 16 variables was obtained from Census 2000 to calculate

a neighborhood deprivation score. Quintiles of this score formed the socioeconomic neighborhood stratum. The highest score being most deprived. Lowest three quintiles were combined to form one neighborhood stratum the other two quintile formed two more strata. The relative risk of preterm delivery among the upwardly or downwardly mobile women, compared to those who moved in the same socioeconomic neighborhood, was estimated using log-linear models using generalized estimating equations (GEE) based on a Poisson distribution. Robust standard errors were estimated after correcting for clustering effect of multiple deliveries per woman. Since nesting was broken due to socioeconomic movement, correction for the clustering of census tracts in a neighborhood was not required. Modeling was based on DAG theory followed by backward elimination. Stratified analysis by race/ethnicity was done. All models were done separately for the upward movement and for the downward movement as the risk of preterm delivery is expected to be in opposite directions.

RESULTS: Those who moved to worse neighborhoods compared to those who stayed back in the same neighborhood had a significant increase in the risk of preterm delivery, after adjusting for all maternal characteristics. A decrease in the risk of preterm delivery for those who moved to a better neighborhood compared to those who stayed back in the same neighborhood was also seen but was not significant. On stratifying by race/ethnicity, the same result bore out only for NH Blacks. Moving to a better or worse neighborhood made no difference to Hispanics and only borderline difference to NH Whites.

CONCLUSIONS: This study shows that neighborhood socioeconomic status, after accounting for maternal characteristics, is associated with preterm delivery only among NH Blacks. However the risk of preterm birth did not reduce even among NH Black women who moved to a better neighborhood.

THE EFFECT OF SOCIOECONOMIC MOVEMENT ON PRETERM DELIVERY:

A COHORT STUDY

BACKGROUND

Neighborhood deprivation (NSES), has been shown to be a predictor of preterm delivery independent of individual level socioeconomic status (SES).[1] For example, numerous studies have shown that women who live in more deprived neighborhoods are at higher risk for adverse birth outcomes (including preterm delivery) than those in wealthier neighborhoods, after controlling for individual socioeconomic status.[2-11] A systematic review[12] of eleven studies[3-10,13-15] that examined neighborhood disadvantage and used multilevel analysis, showed that eight[3-10] reported significant association with preterm delivery. However, since all of these studies were cross sectional by design, whether neighborhood disadvantage is causally associated with increased risk of preterm delivery remains undetermined.

Randomized social intervention trials that moved families from high-poverty to lower-poverty neighborhoods in five US cities between 1994 and 2006, called the 'Moving To Opportunity' (MTO) trial[16] and the Gautreaux program,[17] also a randomized controlled trial that preceded the MTO did not study the effect of residential movement in pregnant women.

A comparison of two cohorts in a Chicago study,[18] showed a 30% reduction in risk of preterm delivery after adjusting for maternal characteristics among the upwardly mobile (uppermost quartile) women compared to those who did not move (lowest quartile) in a population of African Americans only, where each quartile comprised of multiple neighborhoods, which was accounted for in a multilevel analysis. The movement considered here was from her place of birth to her place of delivery. However, the reduction was seen only among those who were themselves of normal birth weight. Another study showed[19] a 20% reduction in the preterm delivery rate among African American movers (n=4,206) but not among whites, compared to those who did not move (n=36,021)when the movement considered was from urban to suburban. On further dividing each urban and suburban counties into quartiles based on income score, only those who moved from a low urban setting benefitted, but not those who started from a high urban setting. However the resulted was not repeated in another similar comparison (n=994). But this may be due to small study size.

A longitudinal study, conducted in Atlanta, compared the effect of moving from public housing to private housing on preterm delivery, where one delivery was in the public housing and the other in private to those who stayed in public housing. The study showed no difference between those who moved and those who did not, in terms of the risk of preterm low birth weight. However, if the relocation was “forced” (an unfortunate consequence due to the demolition of public housing in preparation for the 1996 Summer Olympic Games in Atlanta) the risk of preterm delivery was increased.

Those who were forced to move had 1.7fold (95% CI 1.0, 3.0) increased odds of preterm-low birth weight baby (PT-LBW) as women that moved voluntarily. [20] However, this study was restricted to African American women and was done specifically to evaluate moving from public housing to private housing in a better neighborhood under the Section 8 program of the US department of Housing and Urban Development (HUD) and the effect of policy change affecting only public housing residents and is therefore not generalizable. Moreover, the study did not consider the effect of movement for a woman compared to her prior delivery.

Some of the probable pathways from neighborhood deprivation to preterm delivery involve a woman's response to chronic psychosocial stressors;[21] her response to the lack of availability of essential micronutrients[22] measured as inadequate or excess weight gain during pregnancy; and increased opportunities to indulge in risky behavior[23] such as smoking, drug and alcohol abuse, and/or late and infrequent prenatal care visits. All of these could lead to complications of pregnancy and labor, which in turn could lead to preterm delivery. Therefore, if indeed NSES had an effect on preterm delivery, it is likely preventable by blocking any of these pathways in a neighborhood or moving an expectant woman to a better neighborhood where these factors don't exist, as in the MTO trial.[16] A longitudinal study would answer the question, if NSES does truly have an effect on preterm delivery or not, better.

We hypothesize that women that relocate to a poor neighborhood from a good neighborhood between successive pregnancies (i.e., "downward" relocation) will be at increased risk of preterm delivery in the second pregnancy. We test this hypothesis in a large, population-based longitudinal cohort study of 602,953 births to residents in New Jersey.

METHODS

SOURCE OF DATA

The main data source for this study is the Electronic Birth Certificate (EBC) of New Jersey which contains parents' demographic data including race and ethnicity, date and place of birth and residential address at the time of delivery, their socioeconomic characteristics including education, employment, health insurance, enrollment in WIC, social security number, and maternal medical and behavioral risk factors including but not restricted to initiation and duration of prenatal care for each pregnancy, . However, it does not contain the geocodes of the residence of each woman at delivery. The geocodes alone were therefore obtained from the original birth certificate dataset. Since the census tracts associated with these geocodes did not always refer to the same census year, census tracts based on census 2000 were first obtained for these geocodes. The two datasets were then merged to obtain geocodes and the census tracts based on census 2000. These datasets are maintained by the New Jersey Department of Health and Senior Services (NJDHSS). The study period was 1996-2006. This was because

widespread use of EBC began in 1996 and geocodes were available only till 2006. Since NJ did not adopt the 2003 revision of the birth/death certificates during this period, all variables are consistently ascertained during the entire study period based on the 1989 version of the birth certificates. All newborns to the same mother were linked using six personal identification variables of the mother to create a longitudinal dataset with multiple records per woman. This was done using The Link King v7.1.21, a public domain record linkage software, that has been shown to have a sensitivity of 79% and a high positive predictive value of 98%.[24,25] The Link King uses both a sophisticated probabilistic record linkage and deterministic record linkage protocols.[26]

GEOCODING

All deliveries were geocoded (assigned a latitude and longitude) by the NJDHSS based on the mother's full address at time of delivery. Using these geocodes, a census tract was assigned to each birth record, using ESRI ArcGIS system (Environmental Systems Research Institute, Inc., USA). If the full address was not available, the NJDHSS used the following rule to geocode: If a PO Box was provided instead of a street address, the post office was used to geocode; if only a zip code was available, then the centroid of that zip code was geocoded (the latitude and longitude of the central point of the area covered by the boundaries of a 5-digit ZIP code area). These geocodes were used to determine who moved between deliveries. A difference of 0.001^{o} (about 111 m or 364 ft.) in the latitude and longitude between successive pregnancies was considered as evidence of geographic movement. Any smaller difference was not interpreted as residential

movement. However, this definition does not include people who move within the same building, as movers. A validation to verify if this difference actually referred to a move was done using a random sample of 1000 records. This definition of 'residential movement' had a sensitivity is 89.8% and specificity is 86.7%.

NEIGHBORHOOD SOCIOECONOMIC STATUS (NSES)

A derived composite score based on several variables from the Summary File 3 (SF3) of the US census,[27] which consists of detailed tables related to social, economic and housing characteristics of Census 2000. These tables were compiled from a sample of approximately 19 million housing units (about 1 in 6 households) that received the Census 2000 long-form questionnaire with separate tables for nine major race and Hispanic or Latino groups. This comprehensive score, also known as the Neighborhood Deprivation Index (NDI),[28,49] was modified by excluding the component on housing stability, since the objective of this study was to examine housing and economic stability. Each quintile of this score forms a "neighborhood" or social tier, irrespective of their geographic location. From these quintiles we defined three social strata, quintile I to III were considered 'GOOD'; quintile IV was labeled 'BAD'; and quintile V was labeled 'WORST'. Change in quintile in either direction was considered as socioeconomic movement, the primary exposure. The details of the calculations of the NDI are shown in the Introduction chapter.

The U.S. census 2000 was chosen to calculate the NDI, since the available dataset which includes all women residents of New Jersey (NJ) who delivered in NJ between 1996 and 2006, straddles the year 2000. A comparison of deprivation score calculated based on the average of the years 2005 to 2009 of the American Community Survey (which has the same variables as SF3) and the one based on Census 2000 showed a high correlation (Kendall's Tau was more than 0.80) between the two time periods. Hence proving that, the neighborhood itself did not change much over time. That is, the scores based on census 2000, applies even to years much later than the year 2000.

Although the NJDHSS also assigned census tracts for each birth, all birth records did not have census 2000 based census tracts. Therefore census tracts based on census 2000 was re-assigned for each birth record using geocodes, with ESRI ArcGIS system (Environmental Systems Research Institute, Inc., USA). The census 2000 census tracts were essential to capture the socioeconomic variables for each census tract from the census 2000 database.

COHORT COMPOSITION

The study population comprised of all New Jersey resident women who delivered in New Jersey between the years 1996 and 2006. A Figure describing the exclusion of records that are not included in the study is shown in the chapter on Introduction

Briefly, the Electronic Birth Certificate of New Jersey had 1,213,301 deliveries between 1996 and 2006. Of these, 25,320 (2.1%) deliveries were to those who resided outside

NJ but delivered in NJ and were excluded. Other exclusion include deliveries to NJ residents who delivered outside NJ: (1,873 0.15%); twins and higher order births: 48,775 (4.0%)); incorrect or missing geocodes: 17,123 (1.4%); unavailable Neighborhood SES: 436 (0.04%) and missing gestational age: 1970 (0.16%). This resulted in 1,117,804 births. This was further narrowed by excluding 3,338 (0.3%) records of non-successive births; 511,513 (42.2%) that did not have a sibling during the study period. After these exclusions, 335,089 pairs of siblings (602,953 births) remained for the study for manuscript one. Of these, 168,864 pairs moved. These pairs formed the cohort for this study.

RISK FACTORS

Potential risk factors under consideration were classified as:

1. Socio-Demographic (race/ethnicity, education, employment status, income, foreign born status, marital status and parity)
2. Health Seeking Behaviors (teenage pregnancy, inadequate or late prenatal care, smoking status, alcohol use, drug abuse and excess or inadequate weight gain) and
3. Medical Conditions (prior preterm, hypertensive disorders in pregnancy like chronic hypertension, pregnancy-induced hypertension, and eclampsia, chronic diabetes mellitus, incompetent cervix, uterine bleeding, placenta previa,

placental abruption, Premature Rupture of Membrane (PROM), cord prolapse and fetal distress).

PRETERM DELIVERY

The primary outcome is preterm delivery of the second pregnancy. Preterm delivery is defined as pregnancy that ended prior to 37 weeks of gestation. Since the EBC database has only live born births, all live born deliveries prior to 37 weeks were included. The clinical estimate of gestational age was used to identify preterm delivery as there is considerable misclassification if the gestational age is calculated based on last menstrual period (LMP).[29]

STATISTICAL ANALYSIS

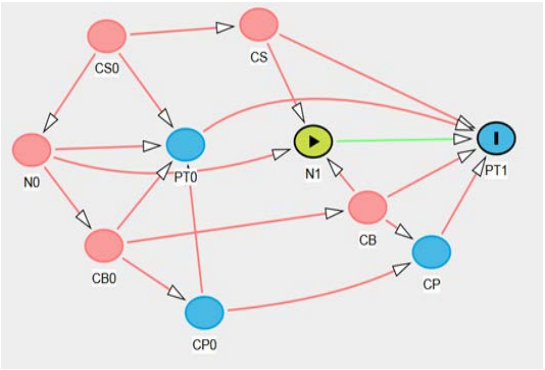
The relative risk of preterm delivery among the upwardly or downwardly mobile women, compared to those who moved in the same socioeconomic neighborhood, was estimated using log-linear models using generalized estimating equations (GEE) based on a Poisson distribution. Robust standard errors were estimated after correcting for clustering effect of multiple deliveries per woman. Since nesting was broken due to socioeconomic movement, correction for the clustering of census tracts in a neighborhood was not required. Modeling was based on DAG theory followed by backward elimination. Stratified analysis by race/ethnicity was done only for NH Whites, NH Blacks and Hispanics. All models were done separately for the upward movement

and for the downward movement as the risk of preterm delivery is expected to be in opposite directions.

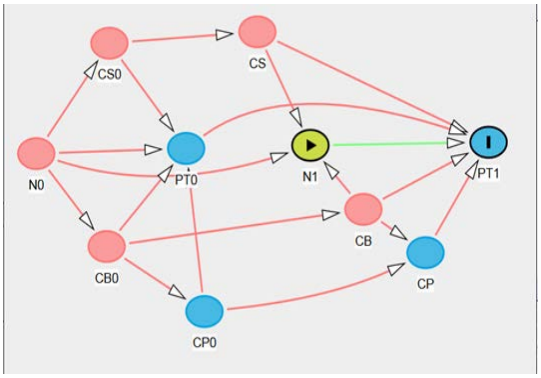
CONCEPTUAL PROCESS

The following two DAGs were conceptualized to estimate the effect of the neighborhood (N1) on preterm delivery (PT1) after moving from the previous neighborhood (N0). The covariates considered are individual level socioeconomic related variables shown as CS and behavior related variables shown as CB. All medical conditions related to complications of pregnancy and labor is shown as CP. The two DAGs differ only because of the path from CS0 to N0. This was drawn in this manner as it was conceptualized that unlike the rich, the socioeconomic status (CS) of the poor is determined to a large extend by the resources available in that neighborhood rather than by personal resources.

DAG1: RICH TO POOR



DAG2: POOR TO RICH



For all other paths the assumptions are as follows: current socioeconomic status is determined by previous socioeconomic status and it determines the current neighborhood; behavior at previous neighborhood is influenced by the neighborhood but the new neighborhood is chosen because of the type of behavior; behavior causes complications of pregnancy and labor; behavior and complication influence birth outcome; prior preterm delivery is highly associated with current preterm delivery status according to prior literature; and the choice of either neighborhood is associated because of residential racial segregation. Although the models were built separately for each DAGs, the potential confounders included in the model were the same.

RESULTS

Table 1 gives a description of the women included in the study at the time of her second study delivery by socioeconomic movement. The socioeconomic and behavioral characteristics of these women remained almost the same for the two pregnancies considered, except of course for maternal age.

The overall rate of preterm delivery and by race/ethnicity is shown in Table 2. Interestingly, the preterm birth rate varies by neighborhood for each ethnic group. As the deprivation of a neighborhood increases the rate of preterm rate also increases. However this monotonicity is not seen for NH Whites. A gradient in risk, at a cross sectional level, is seen for NH Blacks and Hispanics but not for NH Whites who had a reverse gradient before adjusting for potential confounders. The adjusted relative risk

continues to be significant even after all socioeconomic and behavioral characteristics of the woman was adjusted for. However on examining by race/ ethnicity, maternal socioeconomic and behavioral characteristics completely explains the variation in the BAD neighborhood and even in the WORST neighborhood for Hispanics. However there continues to be a 19% increase in risk of preterm delivery for NH Blacks in the WORST neighborhood and a 17% decrease in the risk of preterm delivery for NH Whites in WORST neighborhood.

Table 3 shows that a majority of those who are in the WORST neighborhood stratum and those in the GOOD neighborhood stratum do not move. On stratifying by race/ethnicity this becomes clearer. Almost all of the NH Whites who start in a GOOD neighborhood remain in a GOOD neighborhood and more than half of the NH Whites who start in a WORST neighborhood stratum move upward. Whereas only a little over half of the NH Blacks who start in a GOOD stratum remain in the GOOD stratum. The rest moved downward. Hispanics are slightly better than NH Blacks. Similarly almost all the NH Blacks in the WORST neighborhood continue to stay in the WORST stratum and only a few have moved upward. Again Hispanics are only slightly better than NH Blacks.

Table 4 clearly shows a significant increase in the risk of preterm delivery for those who moved to worse neighborhoods compared to those who stayed back in the same neighborhood. A decrease in the risk of preterm delivery for those who moved to a better neighborhood compared to those who stayed back in the same neighborhood

was also seen but was not significant. This was especially true for NH Blacks. However for Hispanics, moving to a worse or to a better neighborhood made no difference and for NH Whites it was the opposite. The risk of preterm delivery improved for those who moved to the worst neighborhood and increased if they moved to a slightly better neighborhood, but they were only of borderline significance. Neighborhood deprivation had an effect only on those who were relocating downward rather than those who relocated to a better neighborhood.

DISCUSSION

This analysis shows that neighborhood deprivation remains an independent risk factor for preterm delivery, after adjusting for all maternal socioeconomic and behavior characteristics. This is consistent with many cross sectional studies.[3-10] The aim of this study was to compare those who moved out of their neighborhood to those who stayed back to see if that helped improve the risk of preterm delivery. The results show that moving to a better neighborhood did not have an effect on preterm delivery but moving to a worse neighborhood increased the risk of preterm delivery. However on stratifying by race/ethnicity this was found to be true only for NH Blacks. For Hispanics, those who moved to a better or worse neighborhood did not have a higher risk than those who stayed. For NH Whites the effect was reversed. Those who moved to better neighborhoods had higher risk of preterm delivery than those who stayed and those

moved to a worse neighborhood had lower risk of preterm delivery than those who stayed back. This is contrary to expectation and has to be studied further.

Since NH Blacks were the only ones who were affected by neighborhood deprivation, but moving them out of the neighborhood did not really improve the rate of preterm delivery, deprivation of the neighborhood should be reduced without actually moving them out of their neighborhood. Further research is required to see how this can be done. Although socioeconomically similar, the neighborhoods where the NH Whites and Hispanics live and the neighborhoods where the NH Blacks live may be different in other ways than has been captured by the NDI. An examination of the two neighborhoods including more domains that characterize the neighborhood may help pin point the detrimental factor that is truly causing the neighborhood effect. The preterm delivery rate can then be reduced by removing that factor. Some authors have suggested that it could be neighborhood violence[5] or neighborhood social capital.[30]

From the first manuscript it is clear that prior preterm delivery, although associated with residential movement is not associated with socioeconomic movement. That is prior preterm does not cause movement to a worse socioeconomic neighborhood (RR 1.17, 95% CI (0.99, 1.17)). However, since the confidence limits is on the borderline, and since the risk of preterm is very high among those with prior preterm delivery, further analysis stratifying on prior preterm status may add to our current understanding.

More importantly, this study only compares those who moved to those who stayed back in the same neighborhood. However the woman who moves may be inherently different from the woman who stays back. Response to chronic stressors like a deprived neighborhood or just personality may vary from woman to woman. Further research must therefore examine the difference in preterm delivery rate for same woman in the two neighborhoods.

CONCLUSION

In conclusion, this study shows that neighborhood deprivation, after accounting for maternal characteristics, is associated with preterm delivery only among NH Blacks. However NH Black women who moved to a better neighborhood did not reduce their risk of preterm birth. This result is based on a relatively short duration of residence in the new neighborhood, and it is possible that longer residence might be more beneficial.

TABLES:

Table 1: Characteristics of Women recorded at Second Delivery by Socioeconomic Movement

CHARACTERISTICS	ALL MOVERS	SOCIOECONOMIC MOVEMENT					
		WORSE		SAME		BETTER	
ALL MOVERS	154,763	27,523	17.8%	83,133	53.7%	44,107	28.5%
AGE							
< 20	5,108	944	18.5%	3,210	62.8%	954	18.7%
20-34	118,971	22,250	18.7%	63,048	53.0%	33,673	28.3%
≥ 35	30,683	4,328	14.1%	16,875	55.0%	9,480	30.9%
RACE/ETHNICITY							
NH Whites	81,479	14,565	17.9%	42,099	51.7%	24,815	30.5%
NH Blacks	27,607	4,849	17.6%	16,655	60.3%	6,103	22.1%
Hispanics	33,356	5,901	17.7%	18,978	56.9%	8,477	25.4%
Asians	10,253	1,769	17.3%	4,429	43.2%	4,055	39.5%
Others	2,068	439	21.2%	972	47.0%	657	31.8%
MARITAL STATUS							
Single	46,856	9,195	19.6%	27,639	59.0%	10,022	21.4%
Married	107,907	18,328	17.0%	55,494	51.4%	34,085	31.6%
PLACE OF BIRTH							
Foreign Born	40,521	7,037	17.4%	20,903	51.6%	12,581	31.0%
US Born	113,804	20,414	17.9%	61,965	54.4%	31,425	27.6%
INCOME STATUS							
Low	67,261	12,193	18.1%	38,681	57.5%	16,387	24.4%
Mid/High	87,502	15,330	17.5%	44,452	50.8%	27,720	31.7%

EMPLOYMENT STATUS							
Unemployed	**65,083**	**11,305**	**17.4%**	**36,501**	**56.1%**	**17,277**	**26.5%**
Employed	**88,440**	**16,006**	**18.1%**	**45,907**	**51.9%**	**26,527**	**30.0%**
EDUCATION ATTAINED							
≤ 12 Years	**69,570**	**13,383**	**19.2%**	**39,267**	**56.4%**	**16,920**	**24.3%**
> 12 Years	**82,816**	**13,754**	**16.6%**	**42,395**	**51.2%**	**26,667**	**32.2%**
SPOUSE/PARTNER EMPLOYMENT							
Unemployed	**14,035**	**2,212**	**15.8%**	**8,847**	**63.0%**	**2,976**	**21.2%**
Employed	**128,086**	**23,008**	**18.0%**	**66,481**	**51.9%**	**38,597**	**30.1%**
SPOUSE/ PARTNER EDUCATION							
≤ 12 Years	**65,296**	**12,721**	**19.5%**	**35,800**	**54.8%**	**16,775**	**25.7%**
> 12 Years	**75,469**	**12,303**	**16.3%**	**38,678**	**51.3%**	**24,488**	**32.4%**
WEIGHT GAIN DURING PREGNANCY							
> 40 lbs.	**19,836**	**3,666**	**18.5%**	**10,449**	**52.7%**	**5,721**	**28.8%**
15-40 lbs.	**111,175**	**19,347**	**17.4%**	**59,458**	**53.5%**	**32,370**	**29.1%**
< 15 lbs.	**19,109**	**3,725**	**19.5%**	**10,498**	**54.9%**	**4,886**	**25.6%**

PRENATAL CARE: FREQUENCY							
≤ 9 times	**55,441**	**10,151**	**18.3%**	**30,821**	**55.6%**	**14,469**	**26.1%**
> 9 times	**95,068**	**16,670**	**17.5%**	**49,887**	**52.5%**	**28,511**	**30.0%**
PRENATAL CARE: INITIATION							
After 6 months	**5,850**	**1,138**	**19.5%**	**3,431**	**58.6%**	**1,281**	**21.9%**
Before 6 months	**148,913**	**26,385**	**17.7%**	**79,702**	**53.5%**	**42,826**	**28.8%**
SMOKING DURING PREGNANCY							
Yes	**16,307**	**3,574**	**21.9%**	**8,826**	**54.1%**	**3,907**	**24.0%**
No	**137,848**	**23,841**	**17.3%**	**73,986**	**53.7%**	**40,021**	**29.0%**
DRUG USE DURING PREGNANCY							
Yes	**3,309**	**628**	**19.0%**	**2,019**	**61.0%**	**662**	**20.0%**
No	**150,814**	**26,780**	**17.8%**	**80,771**	**53.6%**	**43,263**	**28.7%**
ALCOHOL USE DURING PREGNANCY							
Yes	**2,024**	**346**	**17.1%**	**1,163**	**57.5%**	**515**	**25.4%**
No	**151,900**	**27,024**	**17.8%**	**81,519**	**53.7%**	**43,357**	**28.5%**
PARITY AFTER SECOND STUDY BIRTH							
Two	**98,653**	**18,499**	**18.8%**	**50,785**	**51.5%**	**29,369**	**29.8%**
Three or more	**55,007**	**8,792**	**16.0%**	**31,797**	**57.8%**	**14,418**	**26.2%**

Table 2: Preterm Delivery by Race/Ethnicity and Type of Neighborhood at Second Delivery

RACE/ ETHNICITY	RATE of PTD	TYPE OF NBHD	TOTAL Number of Deliveries	% OF DELIVERIES BY NBHD	Number of Preterm Delivery	RATE OF PTD BY NBHD	UNADJUSTED RR (95% CI)	ADJUSTED RR (95% CI)
OVERALL	7.9%	WORST	43,919	26.0%	5,189	11.6%	1.89 (1.82, 1.96)	1.22 (1.16, 1.29)
		BAD	31,664	18.8%	2,753	8.7%	1.41(1.35, 1.47)	1.13 (1.07, 1.20)
		GOOD	93,281	55.2%	5,667	6.1%	REFERENCE	REFERENCE
NH WHITES	5.9%	WORST	5,386	6.1%	354	6.6%	1.19 (1.07, 1.32)	0.83 (0.72, 0.95)
		BAD	12,961	14.8%	947	7.3%	1.29 (1.20, 1.38)	1.08 (1.00, 1.17)
		GOOD	69,490	79.1%	3,845	5.5%	REFERENCE	REFERENCE
NH BLACKS	14.3%	WORST	18,388	58.6%	2,964	16.1%	1.50 (1.38, 1.63)	1.19 (1.08, 1.32)
		BAD	6,889	22.0%	861	12.5%	1.18 (1.07, 1.30)	1.07 (0.95, 1.20)
		GOOD	6,081	19.4%	651	10.7%	REFERENCE	REFERENCE
HISPANICS	8.6%	WORST	18,850	51.4%	1,740	9.2%	1.19 (1.09, 1.30)	1.07 (0.97, 1.19)
		BAD	9,491	25.9%	791	8.3%	1.09 (0.98, 1.20)	1.07 (0.96, 1.19)
		GOOD	8,354	22.8%	634	7.6%	REFERENCE	REFERENCE

PTD = Preterm Delivery NBHD= Neighborhood

Table 3: Distribution of Socioeconomic Movement Between Successive Pregnancies by Race/ Ethnicity

NEIGHBORHOOD AT ORIGIN		NEIGHBORHOOD AT DESTINATION							
		WORST		BAD		GOOD		TOTAL	
OVERALL	WORST	29,800	67.3%	8,661	19.6%	5,793	13.1%	44,254	100.0%
	BAD	6,362	20.3%	12,353	39.3%	12,698	40.4%	31,413	100.0%
	GOOD	2,909	3.7%	7,848	9.9%	68,339	86.4%	79,096	100.0%
	TOTAL	39,071	25.2%	28,862	18.6%	86,830	56.1%	154,763	100.0%
NH WHITES		WORST		BAD		GOOD		TOTAL	
	WORST	3,063	45.4%	1,453	21.5%	2,236	33.1%	6,752	100.0%
	BAD	980	6.7%	5,656	38.7%	7,986	54.6%	14,622	100.0%
	GOOD	830	1.4%	4,769	7.9%	54,506	90.7%	60,105	100.0%
	TOTAL	4,873	6.0%	11,878	14.6%	64,728	79.4%	81,479	100.0%
NH BLACKS		WORST		BAD		GOOD		TOTAL	
	WORST	12,858	75.8%	2,709	16.0%	1,400	8.3%	16,967	100.0%
	BAD	2,225	37.8%	2,283	38.8%	1,378	23.4%	5,886	100.0%
	GOOD	952	20.0%	1,113	23.4%	2,689	56.6%	4,754	100.0%
	TOTAL	16,035	58.1%	6,105	22.1%	5,467	19.8%	27,607	100.0%
HISPANICS		WORST		BAD		GOOD		TOTAL	
	WORST	13,164	70.2%	3,970	21.2%	1,629	8.7%	18,763	100.0%
	BAD	2,855	35.2%	3,420	42.2%	1,832	22.6%	8,107	100.0%
	GOOD	965	14.9%	1,293	19.9%	4,228	65.2%	6,486	100.0%
	TOTAL	16,984	50.9%	8,683	26.0%	7,689	23.1%	33,356	100.0%

Table 4a: The Relative Risk of Preterm Delivery due to Socioeconomic Movement by Neighborhood of Origin and Destination

	NEIGHBORHOOD AT ORIGIN	NEIGHBORHOOD AT DESTINATION		
		GOOD	BAD	WORST
		RR (95% CI)	RR (95% CI)	RR (95% CI)
OVERALL UNADJUSTED *	GOOD	REFERENCE	1.43 (1.33, 1.55)	1.94 (1.76, 2.15)
	BAD	0.86 (0.79, 0.94)	REFERENCE	1.32 (1.21, 1.44)
	WORST	0.72 (0.66, 0.79)	0.83 (0.77, 0.88)	REFERENCE
OVERALL ADJUSTED*	GOOD	REFERENCE	1.17 (1.07, 1.28)	1.27 (1.12, 1.45)
	BAD	1.00 (0.91, 1.10)	REFERENCE	1.17 (1.05, 1.30)
	WORST	0.91 (0.82, 1.01)	1.04 (0.96, 1.13)	REFERENCE

*RR (Relative risk displayed horizontally)

Table 4b: The adjusted Relative Risk of Preterm Delivery due to Socioeconomic Movement by Neighborhood of Origin and Destination among NH Whites Only

	NEIGHBORHOOD AT ORIGIN	NEIGHBORHOOD AT DESTINATION		
		GOOD	BAD	WORST
		RR (95% CI)	RR (95% CI)	RR (95% CI)
NH WHITES UNADJUSTED*	GOOD	REFERENCE	1.35 (1.22, 1.50)	1.24 (0.98, 1.58)
	BAD	0.90 (0.79, 1.01)	REFERENCE	1.17 (0.94, 1.45)
	WORST	0.96 (0.77, 1.18)	1.31 (1.05, 1.63)	REFERENCE
NH WHITES ADJUSTED*	GOOD	REFERENCE	1.08 (0.96, 1.21)	0.73 (0.54, 0.99)
	BAD	1.03 (0.90, 1.18)	REFERENCE	0.93 (0.73, 1.20)
	WORST	1.21 (0.95, 1.54)	1.60 (1.25, 2.04)	REFERENCE

*RR (Relative risk displayed horizontally)

Table 4c: The adjusted Relative Risk of Preterm Delivery due to Socioeconomic Movement by Neighborhood of Origin and Destination among NH Blacks Only

	NEIGHBORHOOD AT ORIGIN	NEIGHBORHOOD AT DESTINATION		
		GOOD	BAD	WORST
		RR (95% CI)	RR (95% CI)	RR (95% CI)
NH BLACKS UNADJUSTED*	GOOD	REFERENCE	1.35 (1.13, 1.62)	1.68 (1.41, 2.00)
	BAD	0.84 (0.70, 1.02)	REFERENCE	1.29 (1.11, 1.49)
	WORST	0.85 (0.75, 0.97)	0.82 (0.74, 0.90)	REFERENCE
NH BLACKS ADJUSTED*	GOOD	REFERENCE	1.33 (1.06, 1.66)	1.51 (1.20, 1.90)
	BAD	1.10 (0.88, 1.39)	REFERENCE	1.35 (1.11, 1.64)
	WORST	1.01 (0.86, 1.19)	0.96 (0.84, 1.09)	REFERENCE

*RR (Relative risk displayed horizontally)

Table 4d: The adjusted Relative Risk of Preterm Delivery due to Socioeconomic Movement by Neighborhood of Origin and Destination among Hispanics Only

	NEIGHBORHOOD AT ORIGIN	NEIGHBORHOOD AT DESTINATION		
		GOOD	BAD	WORST
		RR (95% CI)	RR (95% CI)	RR (95% CI)
HISPANICS UNADJUSTED*	GOOD	REFERENCE	1.23 (1.00, 1.50)	1.44 (1.16, 1.78)
	BAD	1.05 (0.88, 1.26)	REFERENCE	1.12 (0.95, 1.31)
	WORST	0.94 (0.80, 1.10)	0.94(0.84, 1.04)	REFERENCE
HISPANICS ADJUSTED*	GOOD	REFERENCE	1.11 (0.89, 1.39)	1.12 (0.87, 1.43)
	BAD	1.03 (0.83, 1.27)	REFERENCE	1.04 (0.87, 1.24)
	WORST	0.96 (0.80, 1.16)	1.08 (0.95, 1.21)	REFERENCE

*RR (Relative risk displayed horizontally)

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THE EFFECT OF SOCIOECONOMIC MOVEMENT ON PRETERM DELIVERY: A PAIRED STUDY

By

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Written under the direction of

George G. Rhoads, MD MPH

ABSTRACT OF MANUSCRIPT 3 OF 3

THE EFFECT OF SOCIOECONOMIC MOVEMENT ON PRETERM DELIVERY: A PAIRED STUDY

By

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Dissertation Director:

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ABSTRACT

BACKGROUND: Numerous studies have shown that women who live in more deprived neighborhoods are at higher risk for adverse birth outcomes (including preterm delivery) than those in wealthier neighborhoods, even after controlling for individual socioeconomic status. Since socioeconomic status and personal characteristics affect the choice of neighborhood of residence, these studies are likely to be confounded by unmeasured differences between the woman living in the better and worse neighborhoods. This study has attempted to examine the effect of neighborhood socioeconomic status using a better study design by following up women who moved between successive deliveries and comparing a woman to her own experience before she relocated to a better or worse neighborhood.

METHODS: The main data source is the Electronic Birth Certificate (EBC) of New Jersey for the years 1996 to 2006. All newborns to the same mother were linked using six personal identification variables of the mother to create a longitudinal dataset. Based on the geocodes of the residence at delivery, neighborhood information on 16 variables

was obtained from Census 2000 to calculate a neighborhood deprivation score. Quintiles of this score formed the socioeconomic neighborhood strata, the highest score being most deprived. Lowest three quintiles were combined to form one neighborhood stratum the other two quintile formed two more strata. Conditional logistic regression was used to estimate the risk of preterm delivery in a poor socioeconomic neighborhood for a woman who moved between successive pregnancies. Stratified Analysis by race/ethnicity and by maternal age was also done.

RESULTS: Overall, movement to a neighborhood of better (or worse) socioeconomic characteristics between pregnancies did not make much difference to the risk of preterm delivery, although there were more term babies in the better neighborhood. On stratifying by race/ ethnicity, this lack of association of NSES with preterm birth was seen in both NH Whites and Hispanics. However for NH Blacks alone, there is 15% increased risk (95% CI: 1.01, 1.30) of preterm delivery for the WORST neighborhood deliveries compared to BAD neighborhood deliveries. Similarly teenagers had a 17% increased risk (95% CI: 1.0, 1.37) for WORST neighborhood deliveries compared to BAD neighborhood deliveries and 40% (95% CI: 1.1, 1.81) increased risk for WORST neighborhood deliveries compared to GOOD neighborhood deliveries.

CONCLUSION: In summary, this paired analysis is consistent with much of the prior literature that suggests that a substantial part of neighborhood effects on preterm birth is likely due to the individual characteristics of women living in different neighborhood social strata, and that improvements in the externalities of neighborhood environments

would be unlikely to have a short term effect on preterm birth rates. Nevertheless there is a suggestion in this data that at-risk women may do worse in deprived neighborhoods than they would do in more favorable circumstances.

THE EFFECT OF SOCIOECONOMIC MOVEMENT ON PRETERM DELIVERY: A PAIRED STUDY

BACKGROUND

Numerous studies have shown that women who live in more deprived neighborhoods are at higher risk for adverse birth outcomes (including preterm delivery) than those in wealthier neighborhoods, after controlling for individual socioeconomic status.[1-12] A systematic review[13] of eleven studies[3-5,7,8,10-12,14-16] that examined neighborhood disadvantage and used multilevel analysis, showed that eight[3-5,7,8,10-12] reported significant association with preterm delivery. However, since all of these studies were cross sectional by design, whether neighborhood disadvantage is causally associated with increased risk of preterm delivery remains undetermined.

Cohort studies that have compared those who moved to those who did not move, found a decrease in the risk of preterm birth only for certain subsets of each population. For example, a study conducted in Chicago among African American women,[17] showed a 30% reduction in the risk of preterm only for women who were of normal weight at the time of their own birth but not among those who were themselves born low birth weight. Another study showed[18] a 20% reduction in the risk of preterm delivery only among African Americans from the lowest quartile of neighborhood income but not among Caucasians or among African Americans who moved from other quartiles. A third study showed no effect of moving on preterm-low birth weight (PT-LBW) compared to those who stayed. [19]

A study conducted in Denmark,[20] found that social decline predicted preterm delivery in those who had a prior preterm delivery but not among those who had a prior term delivery, when compared to those who had no social decline, change of residence or change of partner.

There have been at least two US based randomized social intervention trials that moved families from high-poverty to better neighborhoods. One of which, called the 'Moving To Opportunity' (MTO) trial[21] moved families in five US cities between 1994 and 2006. The other one, known as the Gautreaux program,[22] that preceded the MTO moved families from high poverty area in Chicago. Unfortunately, neither of these studies examined the effect of residential movement on outcomes of pregnancy.

The cohort studies mentioned above have established appropriate temporality and are suggestive of a causal effect of neighborhood quality on birth outcome. However there still might be important differences between women who moved to a better (or worse) neighborhood and those who did not. Large randomized controlled trials could have removed the effect of these differences. However, as mentioned above, pregnancy outcomes were not considered in these trials. Therefore, we reasoned that such differences could be avoided by comparing birth outcomes to the same woman when she was living in neighborhoods of different quality. The New Jersey vital statistics database includes thousands of such women who moved to better or worse census tracts between successive deliveries. If neighborhood, per se, has an independent effect, then a given woman should have a higher chance of having a preterm delivery

when living in a poor neighborhood than she does when living in better circumstances. In this chapter we examine this hypothesis using a standard paired analysis that completely controls the large majority of maternal characteristics.

We hypothesize that women that relocate to a poor neighborhood from a good neighborhood between successive pregnancies (i.e., "downward" relocation) will be at increased risk of preterm delivery in the second pregnancy, compared to her risk while she was at the previous neighborhood. Similarly women that relocate to a good neighborhood from a bad neighborhood between successive pregnancies (i.e., "upward" relocation) will be at decreased risk of preterm delivery in the second pregnancy, compared to her risk while she was at the previous neighborhood. We test this hypothesis in a large, population-based longitudinal study of 168,864 pairs of births to residents in New Jersey who moved between pregnancies.

METHODS

SOURCE OF DATA

The birth records used for this study are maintained by the New Jersey Department of Health and Senior Services (NJDHSS). The main data source is the Electronic Birth Certificate (EBC) of New Jersey which contains parental demographic data including race and ethnicity, parental education, parental date and place of birth, residential address at the time of delivery, initiation and duration of prenatal care, and maternal medical and behavioral risk factors for each pregnancy. The EBC also includes data on employment, health insurance, enrollment in WIC and social security number. However,

the electronic birth certificate files do not contain the geocodes of the residence of each woman at delivery but were available for the years 1996-2006 in the original birth certificate dataset. Since the census tracts associated with these geocodes did not always refer to the same census year, census tracts based on census 2000 were first obtained for these geocodes using ESRI ArcGIS system (Environmental Systems Research Institute, Inc., USA). Since NJ did not adopt the 2003 revision of the birth/death certificates during this period, all variables are consistently ascertained during the entire study period based on the 1989 version of the birth certificates. All newborns to the same mother were linked using six personal identification variables of the mother to create a longitudinal dataset with multiple records per woman. This was done using The Link King v7.1.21, a public domain record linkage software, that has been reported to have a sensitivity of 79% and high positive predictive value of 98%.[23,24] The Link King has fashioned a powerful alliance between sophisticated probabilistic record linkage and deterministic record linkage protocols.[25]

GEOCODING

All deliveries were geocoded (assigned a latitude and longitude) by the NJDHSS based on the mother's full address at time of delivery. Using these geocodes, (although the full address of residence was also available), a census tract was assigned to each birth record, using ESRI ArcGIS system (Environmental Systems Research Institute, Inc., USA). If the full address was not available, the NJDHSS used the following rule: If a PO Box was

provided instead of a street address, the post office was used to geocode; if only a zip code was available, then the centroid of that zip code was geocoded (the latitude and longitude of the central point of the area covered by the boundaries of a 5-digit ZIP code area). The assigned census tract would therefore be imprecise too. As mentioned earlier, some geocodes could not be linked to a census tract as the address referred to a national park or such similar areas that are not assigned a census tract or the geocodes were incorrect or missing. These records were excluded from the study population. A difference of 0.001^{o} (about 111 m or 364 ft.) in the latitude and longitude between successive pregnancies was considered as evidence of geographic movement. Smaller differences were not interpreted as evidence of a change in residence. However, this definition does not include people who move within the same building, as movers. A validation to verify if this difference actually referred to a move was done using a random sample of 1000 pairs, of which 500 pairs moved and another 500 pairs did not according to the above specification. On manual verification this definition had a sensitivity of 89.8% and specificity of 86.7%.

COHORT COMPOSITION

The study population comprised of all New Jersey resident women who delivered in the state between the years 1996- 2006.

The Electronic Birth Certificate database had 1,213,301 deliveries between 1996 and 2006. Of these, 25,320 (2.1%) deliveries were by those who were non-residents and were excluded. Other exclusions include deliveries to NJ residents who delivered

outside NJ: 1,873 (0.15%); twins and higher order births: 48,775 (4.0%); incorrect or missing geocodes: 17,123 (1.4%); unavailable Neighborhood SES: 436 (0.04%) and missing gestational age: 1970 (0.16%).

This resulted in 1,117,804 births. This was further narrowed by excluding 3,338 (0.3%) records of non-successive births; 511,513 (42.2%) that did not have a sibling during the study period. Women who had more than two deliveries in the study period contributed as many pairs of successive births as were available in the dataset. After exclusions mentioned above, 335,089 pairs of siblings (602,953 births) remained. Pairs who did not relocate as per the above definition were then excluded. The final count of pairs that were included in this study was 168,864 pairs.

NEIGHBORHOOD SOCIOECONOMIC STATUS (NSES)

The main exposure of interest is the socioeconomic neighborhood of residence. All census tracts in New Jersey were assigned a score based on a slightly modified version of the Neighborhood Deprivation Index (NDI), created by Messer et al. [26] The details of the modifications are given in the Introductory chapter. Each quintile of this score formed a socioeconomic neighborhood stratum. The lower three quintiles were combined to form one stratum called GOOD neighborhood. The other two quintiles are called BAD and WORST.

STATISTICAL ANALYSIS

Conditional logistic regression was used to estimate the risk of preterm delivery in a poor socioeconomic neighborhood for a woman who moved between successive

pregnancies. Separate analysis was done for three possible movements: (i) between WORST and BAD neighborhood strata; (ii) between WORST and GOOD neighborhood strata; and (iii) between BAD and GOOD neighborhood strata. Each was further stratified by race/ethnicity, where only the three major ethnic groups: NH Whites, NH Blacks and Hispanic were considered to examine if the risk varied by race/ ethnicity. Similarly, stratified analysis was done on women by maternal age, looking specifically at pairs where the first delivery was to a teenage mother.

RESULTS

Overall, movement to a neighborhood of better (or worse) socioeconomic characteristics between pregnancies did not make much difference to the risk of preterm delivery. This was true whether the move was between WORST and BAD, WORST and GOOD, and BAD and GOOD neighborhoods. As shown in Table 1a, 1b and 1c, the odds ratios for those moves ranged from 1.04-1.06. On stratifying by race/ ethnicity, this lack of association of NSES with preterm birth was seen in both NH Whites and Hispanics. However for NH Blacks alone, we see that there is 15% increased risk of preterm delivery for the WORST neighborhood deliveries compared to BAD neighborhood deliveries. See Table 3a. Similarly among teenagers, a 17% increased risk was seen for WORST neighborhood deliveries compared to BAD neighborhood deliveries and 40% increased risk for WORST neighborhood deliveries compared to GOOD neighborhood deliveries. This increased risk between WORST and GOOD neighborhoods was seen irrespective of the direction of movement. That is there were

more term deliveries in the better neighborhood irrespective of whether the teen moved from the WORST to a GOOD neighborhood or GOOD to a WORST neighborhood. See Tables 5a, 5a.1, 5a.2.

DISCUSSION

This paired analysis shows that although there are more term deliveries when a woman was in a better neighborhood than when the same woman was in a worse one, the overall difference was small and not statistically significant. Our approach differs from nearly all the previous work on neighborhood effects on birth outcomes which mostly have compared women in poor neighborhoods to women living in more fortunate circumstances. Those studies are subject to confounding by individual level differences between the women. However these differences are almost completely controlled when outcomes are compared within the same mother. The results of this tight control suggest that much of the apparent neighborhood effect is in fact due to differences between the groups of women living in neighborhoods.

A number of previous studies have reported that known risk factors completely explained the difference between women of high and low socioeconomic neighborhood.[3,8,9,14,15,27-29] Still other studies have shown that controlling for known differences between women living in high and low SES neighborhoods substantially reduces the differences in risk of preterm birth,[3-5,7,8,10-12] which also suggests that individual differences between the residents themselves explain much of the different risks in birth outcomes.

An important consideration in interpretation of our results is the relatively short time that women in the current study have presumably lived in their destination neighborhood. The average (± SD) inter-pregnancy interval in this study was 2.9 (± 1.6) years, and if one supposes that the average woman moved halfway through the inter-pregnancy interval, her residence in the new neighborhood would be only 1.5 years. It is certainly possible that a better neighborhood could have a long-term effect on birth and other health outcomes that is not apparent in the first few years. To examine this possibility we did a sensitivity analysis looking only at women whose inter-pregnancy interval was six or more years to see whether there was any effect of presumed longer duration in the destination neighborhood. However the results were not different. That is, although there are more term deliveries when a woman was in a better neighborhood than when the same woman was in a worse one, the overall difference was small and not statistically significant even among those whose inter-pregnancy interval was six or more years.

Given the overall absence of significant changes in preterm birth rates with changing neighborhood socioeconomic status, it may be viewed as controversial to examine subgroups. Nevertheless, we thought it appropriate to look more carefully at a few subgroups that are known to be at increased risk of preterm birth in case a favorable change in neighborhood environment might have an effect on them. While it would be of great interest to do this for women with a prior preterm birth, that is not possible within the structure of this paired analysis because the outcome in one member of the pair would be fixed. However, it is possible to look separately at outcomes in black

women and in teenagers, and in both of these groups we found a suggestion of modestly lower risk when these mothers delivered in better neighborhood environments. For teenagers, the improvement increased with the improvement in NSES. That is the risk of preterm delivery was higher in the WORST–GOOD comparison than the WORST-BAD comparison. However no improvement in risk was seen in the BAD-GOOD comparison. For the NH Blacks, on the other hand, the benefit was seen only if the movement was to one tier higher. At least one other study[18] has shown that the health benefit of better socioeconomic neighborhood is only for NH Blacks. Thus, our results are compatible with the possibility that changing environments for particularly high risk women may be helpful.

This study has limitations that should be kept in mind. Only women with two or more deliveries were able to be included making it uncertain as to its generalizability to one child families. Moreover as mentioned above the short time period of residence in the destination neighborhood makes it impossible to assess long-term effects. In addition to these issues, our quality check on the geocoding which underlies this analysis suggested a sensitivity of 89.8%. The false-negative assessments would include moves that were within the same building or otherwise very local and are likely to have missed women who remained in the same neighborhood stratum. There also were limits on the specificity of the residential moves inferred from the geocoded addresses which was - 86.7%. The false positives that contributed to these errors are likely due to geocoding problems that would not be tied to maternal risk factors except through geography. It

seems likely that these geocoding errors would tend to bias the odds ratios toward the null and might contribute modestly to the unimpressive odds ratios that were found.

CONCLUSSION

In summary, this paired analysis is consistent with much of the prior literature that suggests that a substantial part of neighborhood effects on preterm birth is likely due to the individual characteristics of women living in different neighborhood social strata, and that improvements in the externalities of neighborhood environments would be unlikely to have a short term effect on preterm birth rates. Nevertheless there is a suggestion in this data that at-risk women may do worse in deprived neighborhoods then they would do in more favorable circumstances.

TABLES

Table 1a. Distribution of pairs of deliveries occurring in WORST and BAD neighborhoods

		UNEXPOSED	
		BAD	
		PT	T
EXPOSED			
WORST	PT	587	1346
	T	1285	9284

OR: 1.06 (95% CI: 0.98,1.15)

Table 1b. Distribution of pairs of deliveries occurring in WORST and GOOD neighborhoods

		UNEXPOSED	
		GOOD	
		PT	T
EXPOSED			
WORST	PT	266	693
	T	662	8242

OR: 1.04 (95% CI: 0.93,1.17)

Table 1c. Distribution of pairs of deliveries occurring in BAD and GOOD neighborhoods

		UNEXPOSED	
		GOOD	
		PT	T
EXPOSED			
BAD	PT	266	693
	T	662	8242

OR: 1.04 (95% CI: 0.96,1.13)

Table 2a. Distribution of pairs of deliveries occurring in WORST and BAD neighborhoods among NH Whites

		UNEXPOSED	
		BAD	
		PT	T
EXPOSED WORST	PT	66	187
	T	173	2572

OR: 1.10 (95% CI: 0.88,1.38)

Table 2b. Distribution of pairs of deliveries occurring in WORST and GOOD neighborhoods among NH Whites

		UNEXPOSED	
		GOOD	
		PT	T
EXPOSED WORST	PT	44	152
	T	177	3169

OR: 0.86 (95% CI: 0.69,1.08)

Table 2c. Distribution of pairs of deliveries occurring in BAD and GOOD neighborhoods among NH Whites

		UNEXPOSED	
		GOOD	
		PT	T
EXPOSED BAD	PT	234	742
	T	729	12763

OR: 1.04 (95% CI: 0.94,1.16)

Table 3a. Distribution of pairs of deliveries occurring in WORST and BAD neighborhoods among NH Blacks

EXPOSED \ UNEXPOSED		BAD	
		PT	T
WORST	PT	293	584
	T	529	4679

OR: 1.15 (95% CI: 1.01,1.30)

Table 3a.1. Distribution of pairs of deliveries occurring in WORST and BAD neighborhoods among Nh Blacks who moved upward

EXPOSED \ UNEXPOSED		BAD	
		PT	T
WORST	PT	161	317
	T	293	2552

McNemar's OR: 1.08; χ^2_1: 0.94

Table 3a.2 Distribution of pairs of deliveries occurring in WORST and BAD neighborhoods among NH Blacks who moved downward

EXPOSED \ UNEXPOSED		BAD	
		PT	T
WORST	PT	132	267
	T	236	2127

McNemar's OR: 1.13; χ^2_1: 1.91

Table 3b. Distribution of pairs of deliveries occurring in WORST and GOOD neighborhoods among NH Blacks

EXPOSED \ UNEXPOSED		GOOD	
		PT	T
WORST	PT	140	269
	T	246	2140

OR: 1.11 (95% CI: 0.92,1.33)

Table 3c. Distribution of pairs of deliveries occurring in BAD and GOOD neighborhoods among NH Blacks

EXPOSED \ UNEXPOSED		GOOD	
		PT	T
BAD	PT	99	236
	T	196	2389

OR: 1.21 (95% CI: 0.99,1.46)

Table 3c.1. Distribution of pairs of deliveries occurring in BAD and GOOD neighborhoods among NH Blacks who moved upward

EXPOSED \ UNEXPOSED		GOOD	
		PT	T
BAD	PT	47	124
	T	108	1344

McNemar's OR: 1.14; χ^2_1: 1.10

Table 3a.2 Distribution of pairs of deliveries occurring in BAD and GOOD neighborhoods among NH Blacks who moved downward

EXPOSED \ UNEXPOSED		GOOD	
		PT	T
BAD	PT	52	112
	T	90	1045

McNemar's OR: 1.24; χ^2_1: 2.40

Table 4a. Distribution of pairs of deliveries occurring in WORST and BAD neighborhoods among Hispanics

		UNEXPOSED	
		BAD	
		PT	T
EXPOSED WORST	PT	206	507
	T	520	7096

OR: 0.97 (95% CI: 0.85,1.10)

Table 4b. Distribution of pairs of deliveries occurring in WORST and GOOD neighborhoods among Hispanics

		UNEXPOSED	
		GOOD	
		PT	T
EXPOSED WORST	PT	70	211
	T	197	2481

OR: 1.10 (95% CI: 0.90,1.35)

Table 4c. Distribution of pairs of deliveries occurring in BAD and GOOD neighborhoods among Hispanics

		UNEXPOSED	
		GOOD	
		PT	T
EXPOSED BAD	PT	76	212
	T	228	3095

OR: 0.96 (95% CI: 0.80,1.17)

Table 5a. Distribution of pairs of deliveries occurring in WORST and BAD neighborhoods among Teenagers

EXPOSED \ UNEXPOSED		BAD	
		PT	T
WORST	PT	134	381
	T	345	3673

OR: 1.17 (95% CI:1.0,1.37)

Table 5a.1. Distribution of pairs of deliveries occurring in WORST and BAD neighborhoods among Teenagers who moved upward

EXPOSED \ UNEXPOSED		BAD	
		PT	T
WORST	PT	74	224
	T	176	1948

McNemar's OR: 1.3; χ^2_1 5.76

Table 5a.2 Distribution of pairs of deliveries occurring in WORST and BAD neighborhoods among Teenagers who moved downward

EXPOSED \ UNEXPOSED		BAD	
		PT	T
WORST	PT	60	152
	T	169	1725

McNemar's OR: 0.9; χ^2_1 0.9

Table 5b. Distribution of pairs of deliveries occurring in WORST and GOOD neighborhoods among Teenagers

EXPOSED \ UNEXPOSED		GOOD	
		PT	T
WORST	PT	46	164
	T	118	1428

OR: 1.40 (95% CI:1.1,1.81)

Table 5b.1 Distribution of pairs of deliveries occurring in WORST and GOOD neighborhoods among Teenagers who moved upward

EXPOSED \ UNEXPOSED		GOOD	
		PT	T
WORST	PT	24	83
	T	65	731

McNemar's OR: 1.3; χ^2_1 2.18

Table 5b.2 Distribution of pairs of deliveries occurring in WORST and GOOD neighborhoods among Teenagers who moved downward

EXPOSED \ UNEXPOSED		GOOD	
		PT	T
WORST	PT	22	81
	T	53	697

McNemar's OR: 1.5; χ^2_1 5.85

Table 5c. Distribution of pairs of deliveries occurring in BAD and GOOD neighborhoods among Teenagers

EXPOSED \ UNEXPOSED		GOOD	
		PT	T
BAD	PT	69	184
	T	167	2319

OR: 1.09 (95% CI: 0.88,1.35)

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CONCLUSION

The etiology of preterm delivery is unclear for about 50% of all preterm deliveries. However there are many factors that have been associated with preterm delivery, one of them being maternal socioeconomic status. Moreover, the socioeconomic status of the neighborhood of residence has also been shown to be associated with preterm delivery, even after accounting for maternal socioeconomic status. Such an association was observed in this cohort too. There have been other studies that showed that individual socioeconomic status explained all the difference in preterm delivery rate between high and low neighborhood socioeconomic status. All prior studies of the effect association of neighborhood characteristics on preterm delivery used a cross sectional study design. Since we know that socioeconomic status and personal characteristics affect the choice of neighborhood of residence, these studies are likely to be confounded by unmeasured differences between the woman living in the better and worse neighborhoods. This study has attempted to examine the effect of neighborhood socioeconomic status using a better study design, following up women who moved between successive deliveries: first comparing a cohort of women who did not move between successive deliveries to those who did and then comparing a woman to her own experience before she relocated to a better or worse neighborhood. The conclusions are as follows:

1. Geographic movement between pregnancies is very high but upward socioeconomic mobility is low in this cohort;

2. Non-whites, singles, teens, unemployed and having low education or low income and those who indulged in risky health behavior were more likely to move and more likely to move to a worse neighborhood. However, most medical conditions, including prior preterm delivery were associated with geographic movement but not with moves to a worse neighborhood;
3. All racial/ethnic groups moved between successive deliveries. However, NH Blacks were most likely to move to a worse neighborhood. Hispanics and women of other races were also more likely to move downward. Asians on the other hand moved to both better and worse socioeconomic neighborhood strata than did NH Whites who were the most residentially stable group.
4. Overall, compared to those who stayed in the same socioeconomic neighborhood, those who relocated downward to a worse neighborhood stratum had a higher rate of preterm delivery, after adjusting for individual level socioeconomic variables. However, those who relocated to a better socioeconomic neighborhood did not benefit from their relocation. That is, the rate of preterm delivery was similar to those who did not move out to a better neighborhood.
5. Due to racial residential segregation in this cohort, the analysis was repeated after stratifying by race/ethnicity with three major race/ethnic groups. The results varied by race. The above results were borne out for NH Blacks. However for Hispanics, there was no difference in preterm delivery rate for those who moved to a better or to a worse neighborhood compared to those who

remained in the same socioeconomic neighborhood. And for NH Whites the results were reversed after adjusting for confounders: relocating downward to a worse neighborhood decreased the risk of preterm delivery and relocating upward to a better neighborhood increased the risk of preterm delivery, although these differences were, at best, of borderline significance.

6. On comparing a woman to her own past experience, it was found that although there were more term deliveries in the better neighborhood than when she was in the worse neighborhood, the difference was not significant.
7. On stratifying this difference was observed only for NH Blacks and teenagers.

Strengths and Limitations:

The major strength of the studies done here is the study design which adjusts for nearly all confounding factors at the design stage. The other strength is that birth records from the whole state were used rather than restricting to a city or to a metropolitan area. And finally multiple race/ethnic groups were examined in these studies.

Limitations include:

(i) It is unclear if the residence at the first delivery was of long or short duration since we have no information about moves before the first delivery.

(ii) The exact date of relocation is not available. Therefore any relocation that would have occurred between two pregnancies cannot be ascertained and exact duration of stay in the second neighborhood is not known.

(iii) Using a difference of 0.001^{o} as cut off to determine who moved and who did not caused misclassification. However the misclassification was modest.

The above conclusions should be considered in the light of these strengths and limitations.