Intergenerational Change in Maternal Education and Risk of Preterm Birth and Small-For-Gestational Age in White Non-Hispanic, Black Non-Hispanic and Hispanic Women in New Jersey

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ABSTRACT OF THE DISSERTATION

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Dissertation Director: George Rhoads, MD, MPH

Aims

In this thesis we examine the effect of grandmother's education on the risk of preterm birth (PTB) and small-for-gestational (SGA) in her grandchildren after accounting for mother's education.

Background

Maternal lifelong socioeconomic status (SES) is believed to affect reproductive health. There are many studies that have shown strong association of mother's current SES with adverse birth outcomes. However, few studies have investigated associations with mother's childhood SES or grandparents' education. In U.S. blacks, previous data suggest that improvement in SES from childhood to adulthood is associated with improved social and mental health outcomes, but perinatal outcomes have rarely been assessed.

Methods

We created a transgenerational dataset to examine the effect of grandmother's education, a dimension of SES, on risk of PTB and SGA in grandchildren. Using Link King Software we matched female infants listed on NJ birth certificates in 1979-1983 to mothers listed on NJ birth certificates for the years 1999-2011. Thus grandmothers were the women delivering in 1979-1983, and mothers were those born to the grandmothers who in turn delivered grandchildren in 1999-2011. We performed descriptive tabulations and multivariate logistic regression to create risk estimates using Statistical Analysis System (SAS) software.

Results

In total we linked 107,347 grandmother and mother pairs. After exclusions (multiple births, gestational age of less than 20 weeks and greater than 47 weeks and other races) there were 99,463 pairs available for analysis. Overall, maternal education was associated inversely with PTB and SGA births in each of the largest demographic groups (non-Hispanic whites and blacks and Hispanics). There was a substantial inter-generational increase in education between grandmothers and mothers in each group, but it was most striking in Hispanics. SGA was more common in 1979-83 births than in 1999-2011. After adjusting for potential confounders, grandmother's education was as strongly associated with PTB of grandchildren as was mother's education. SGA in grandchildren was more common among low-education mothers, but grandmother's education had little effect. Although the overall SGA rates were higher in blacks and Hispanics as compared to whites, the effect of lower maternal education on risk of SGA was strongest in whites, and after adjusting for confounders it lost significance in blacks and Hispanics especially in the 1999-2011 births. Father's education was inversely related to PTB and SGA in all three ethnic groups and across both generations.

Conclusions

In summary, we found that maternal education was an important predictor of PTB and SGA both in 1979-82 and in 1999-2011. Grandmother's education was as strong a predictor of PTB in grandchildren as mothers. However, grandmother's education was not strongly related to SGA in the grandchildren. Our results suggest that mother's childhood and preconception socioeconomic environment, including the educational level of her childhood household, are independent predictors for delivering preterm, but have less effect on intra-uterine growth.

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Acknowledgement

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1. THESIS INTRODUCTION

United States has one of the highest infant mortality rates among western countries. Preterm births (PTB) and small-for-gestational age (SGA) infants are major contributors to this problem and are known to account for more than half of perinatal mortality and long-term morbidity in children. [1,2] Within the US there is a substantial difference between women of European and of African ancestry in the rates of adverse birth outcomes and infant mortality and morbidity. In 2005, the overall rate of PTB was between 10-11%, but the rate among non-Hispanic black women was 17%, almost double the rate seen in non-Hispanic white women (9%-10%). Continuing disparity was seen for PTB in 2015, when the overall rate of PTB in US was 9.6%, but the rate of PTB among black women was 13%, almost 50 percent higher than the rate of preterm birth among white women, at 9%. The rates in Hispanics were also higher than whites for both of these outcomes. Similar trends in rates were seen in New Jersey too, where the blacks and Hispanics had higher rates of PTB & SGA as compared to whites.[3-5]

Maternal educational, a dimension of socioeconomic status (SES), is known to be strongly associated with reproductive success. Extensive evidence shows that low level of maternal education is associated with PTB and SGA. Kramer has put forward a schema of potential pathways through which SES might operate[6], and other authors have provided evidence for an SES effect in African American women on low birth weight. According to Kramer, effect of mother's current SES could either be mediated by a direct effect of SES itself or other components or correlates of SES such as low level of education, since low level of education may limit accessibility to employment and other social resources, and increase the likelihood of certain risky behaviors and lifestyle that all could lead to adverse birth outcomes.

In addition to mother's current education level, her childhood socioeconomic environment may also affect her reproductive health. For instance, Collins et al.[7] reported that African American mothers with a lifelong residence in impoverished neighborhoods had a higher PTB rate as compared to white mothers in the same SES group. However, if the black women experienced upward economic mobility by the time they gave birth themselves, they had strikingly lower PTB rates, after adjusting for other potential confounders. Another study conducted by Love et. al.[8] reported that African-American women who were born in poor neighborhoods and were still poor when they became mothers had higher odds of having low birth weight (LBW) and small for gestational age (SGA) babies as compared to white women; however, they did not find a similar association with respect to PTB. The study also showed that African-American women in upper-income areas at both time points had a steady fall in LBW and SGA rate with age, similar to the pattern seen in white women. However, no groups of white women, not even those who always lived in poorer neighborhoods, exhibited higher risk of preterm birth than comparably situated black women.

PTB is known to repeat across generations and it is reasonable to suppose that the transgenerational persistence of social status could contribute to this. To explore this effect across different race and ethnicity, we will examine the effect of grandmother's and mother's education on PTB (<37 weeks) and SGA (<10th percentile) among non-Hispanic White, non-Hispanic Black and Hispanic women. Maternal education is one of the strongest SES predictors of PTB and SGA[19], so we will use grandmother's and mother's education as indicators of SES across generations and will examine whether grandmother's education modifies the risk of PTB and SGA, independent of mother's education. Finally, we will examine whether grandmothers education affects PTB and SGA incidence in an equivalent manner.

Previous studies that have examined the intergenerational effect of SES status on birth outcomes, have mostly focused on whites, and those studies that did investigate this effect in both whites and blacks did not have large enough samples to detect modest association of economic mobility and adverse birth outcomes. We believe this is the first to examine the intergenerational effect of mother's SES status not only in non-Hispanic Whites and non-Hispanic Blacks, but also in Hispanics, who comprised nearly 26 percent of New Jersey births in 2014.

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2. CONSTRUCTION OF DATABASE AND MATCHING

2.1. Study design

This is a retrospective cohort study in which subjects are women born in 1979-1983 in New Jersey and are identified as having births themselves in 1999-2010. The cohort is assembled by matching the birth certificates across the two periods (female infants in 1979-1983 to mothers in 1999-2011). In general, these records include all births to mothers who are NJ residents at the time of their own birth and who delivered in New Jersey during 1999-2011. We created a transgenerational birth file with one record for each pair that was assembled from the two sets of birth certificates using Link King software[1] and included two generations of births.

2.2. Study population

Birth certificate data for the years 1979-83 and 1999- 2011, was provided by the New Jersey Department of Health and Senior Services. For the years 1979-83 there were 490,143 births in total. After excluding male births, the total sample for matching was 241,221. For the years 1999 through 2011, there were 1,499,891 births in total. However we retained only NJ Resident births where the mother's birthplace was New Jersey (including out-of-state, births to residents, which gave us the total of 611,737 births. Lastly, we excluded the out-of-state births to New Jersey residents where mother's place of birth was New Jersey, they resided out of state and delivered in New Jersey, which gave us the final sample of 602,336 births.

2.3. Matching

A combined probabilistic/deterministic record linkage software program was used to match the birth records of the mothers that were born in 1979 – 83 to the delivery records of their infants born in New Jersey in the years 1999 through 2011. This software, called “Link King” is in the public domain. It was originally developed for the federal Substance Abuse and Mental Health Services Administration (SAMHSA) by the State of Washington’s Department of Alcohol and Substance Abuse and a private firm, MedStat.[1] The software was easy to run and although it does not allow detailed customization of matching parameters, we only needed few variables such as - last name, first name, date of birth and race for matching. Before the data was used for linkage, [2] the linking variables were cleaned and recoded as necessary to make the data fields in the two files compatible. In addition a unique identifier was created for each subject in each file.

2.4. Data preparation for matching

2.4.1. Data elements used for the 1979-83 cohort:

- First Name of the child
- Middle name of the child
- Last Name of the child
- Birth date of the child
- Maiden Name of the mother
- Race

2.4.2. Data elements used for the 1999-11 cohort:

- First name of the mother
- Maiden middle name of the mother
- Maiden Last Name of the mother
- Birth date of the mother
- Race

- Client Identifier: This is the identifier that I created which will uniquely identify individuals to the extent possible in this dataset. I made sure that there is no replication of client identifiers ***across*** the datasets being linked

2.4.3. Cleaning of data

- If the names in any of the data set had missing values, that record was deleted from the matching.
- For the matching purpose, the race was formatted only to white, black and others
- If any other variable, except name were missing, the values were set to '9'

2.5. Blocking the Data

Link King uses comparable "blocks of data from the two files to link pairs of identifiers with the highest probability of being a "match". The process of comparing all pairs of identifiers is resource intensive; therefore blocking is used to minimize the computer time and space required to identify matched pairs.

2.6. Deterministic Evaluation of Data Element Similarity in the Blocked Data

For each record-pair in the blocked dataset the data elements for individual record from cohort 1979-83 are compared to those individual from cohort 1999-2011and classified according to the extent to which they match. The deterministic protocol begins by classifying each the data elements into hierarchical categories which represent decreasing levels of certainty that the 2 elements "match". For example, pairs of first names and pairs of last names are classified into one of the following categories.

- The names are an exact match

- Application of “approximate string matching” algorithm2 resulted in a score of at least .75 (max value=1)
- The “cost” of SAS’s spelling distance algorithm is <=50
- One of the names is a nickname of the other
- One of the names is fully embedded within the other
- The names are phonetic equivalents by SOUNDEX and/or NYSIIS and/or Double Metaphone
- 4 of the first 5 characters in the name are positionally correct
- The names share a minimum of a 5 character string
- The names share a minimum of a 4 character string
- The names appear to have been “swapped” (i.e. first name of person A = last name of Person B)
- The names do not match

Similar criteria are used in comparing birthdates (e.g., we look for transposed date fields).

2.6.1. Confirming Approximate String Matches

With the help of spelling distance algorithms and phonetic similarity, Link King software was allowed to use identifying pairs of names that were found to be "similar" by these "fuzzy" matching methods to either treat the name pair as a nickname/common misspelling" or as "no match", or as "similar". (The program uses comparability of other variables to assist in this process.

During this step, we had 105,779 exact matches when using only last name, 103,635 exact match using first name and only 89,118 records when using middle name.

Matching by Name: First, Last and Middle

Match by Name	**Frequency**
EXACT MATCH by Last Name	105779
EXACT MATCH by First Name	103635
EXACT MATCH by Middle Initial	89118

2.6.2. Probabilistic Evaluation of Data Element Similarity in the Blocked Data

The probabilistic estimation routine developed by MEDSTAT for SAMHSA containing default settings for minimum weights values was used. It generates a numeric score for each record-pair in the blocked dataset. Based on the distribution of probabilistic scores and deterministic evaluation of record-pairs, The Link King identifies “definite matches”, “possible matches”, and “definite non- matches. We examined the distribution of probabilistic scores for each of these groups.

2.7. Classifying record-pairs by the degree of certainty that a match can be made

After deterministic and probabilistic evaluation of similarity between data elements has been completed, a series of algorithms are used to determine if the similarity across all the data elements is strong enough to consider the two members of the record-pair a “match”. As described briefly below, these matches are made at one of 6 certainty categories.

Level 1: Highest Possible: Criteria for classification as a Level 1 linkage include: Classification as “Definite Match” based upon probabilistic protocol, or Meet deterministic criteria specified in Appendix D of user manual. (1).

Level 2: Very High: Level 2 linkages must meet the deterministic criteria specified in Appendix D of user manual (1).

Level 3: High: Level 3 linkages must meet the deterministic criteria specified in Appendix D of user manual (1).

Level 4: Moderate to High: Level 4 linkages must meet more generalized deterministic criteria that is too involved to succinctly describe in a table. In general, most of these cases have similarity in DOB and some of the name elements (first name, last name, and middle initial).

Level 5: Does not exist

Level 6: Probabilistic probable twins: In this category, the deterministic protocol has concluded that the records are not a match but the probabilistic protocol has flagged the record-pair as possible twins because:

- the last name is identical,
- the date of birth is identical,
- the SSN is similar, identical or missing, and
- the first name does not match

In many cases record-pairs fall into this category simply because the first name is miss spelled in a manner that is too extreme to be considered "similar" by the spelling comparison protocols. In other cases the first names are clearly different and they may in fact be "twins".

Level 7: Probabilistic maybe: In this category, the deterministic protocol has concluded that the records are not a match but the probabilistic protocol considers these records to be “possible matches”.

During this step, we had 107,347 linked records, out of which 96.8% linked records were highest possible match, 3% were high level match and rest were at level 3 and level 6 as shown below.

Level of Certainty of the linked pairs

Level of Certainty	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Level 1: Highest Possible	103856	96.75	103856	96.75
Level 2: Very High	3217	3.00	107073	99.74
Level 3: High	43	0.04	107116	99.78
Level 6: Low - Moderate	231	0.22	107347	100.00

2.8. Manual review of uncertain linkages

Since Levels 1-3 are extremely rigorous and invalid links are minimal, I manually reviewed only Links at Level 6

2.9. Validating a random sample of matches

After manual review has been completed, the program generates a table by linkage method (deterministic only, probabilistic only, or deterministic and probabilistic). During this step, 96.7% records were linked using deterministic linkage method, 0.2% records were linked using probabilistic method and 2.8% were linked using both methods as shown below.

Matching by Linkage method

Linkage Method	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Deterministic only	104104	96.98	104104	96.98
Probabilistic only	243	0.23	104347	97.21
Both	3000	2.79	107347	100.00

2.10. Mapping of linked identifiers

In the mapping process, the matrix of links is used to create “look-up” tables which was used to extract analysis variables from administrative datasets (e.g., service records).

2.11. Sensitivity analysis

To confirm our validation of matching and making sure that we don’t have false positive we performed matching by manipulating the date of birth for mothers that were born during 1979-1983. For these mothers we added 5 years to the date, thus creating a false birthdate and then matching with mothers who gave birth during 1999-2011. The matching was performed in a manner similar as before, which is it was based on name, race and date of birth. This approach yield very few false positive matches, as seen in table below.

Certainty	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Level 1: Highest Possible	87	85.29	87	85.29
Level 2: Very High	11	10.78	98	96.08
Level 3: High	4	3.92	102	100.00

Finally, using the “Review/Edit Results” interface I reviewed the final “map” of linkages. The final dataset had 107,347 linked pairs.

2.12. Covariates definition

2.12.1. Maternal age

The birth years of the two cohorts were such that mother's age at delivery in the second cohort had to fall in the range of 16 (1999-1983) to 32 (2011 – 1979) years. Therefore, older mothers, who are known to be at increased risk for preterm birth, were not represented in the second cohort.

2.12.2. Maternal race and ethnicity

Due to uncertainty of the race/ethnicity classification for the 1979-83 cohort, we used the race/ethnicity variable from the 1999-2011 to code the final race/ethnicity for all linked records. We created the following four categories: Non-Hispanic whites, Non-Hispanic blacks, Hispanics and others. Because of the heterogeneous composition and the limited numbers of the "others", we only analyzed the first three categories.

2.12.3. Maternal Education

We categorized maternal education into 6 categories: less than high school (0-8 yrs), some high school (9-11 yrs), high school graduate (12 yrs), some college (13-15 yrs), college graduate (16+ yrs) and missing.

2.12.4. Date of last menstrual menses (LMP)

Year: For the cohort 1978 – 83, the year was only single digit. So we used an algorithm where we used date of birth of the child born during that time frame to infer the year for LMP. If the month in the child's birth date was less than month in last menstrual date, we assigned the LMP to the prior year. Otherwise we used the same year as the date of birth.

Day of the Month: For the cohort 1979-83, we had ~30,000 cases that had the month and year of LMP but were missing the day of the month. Since this comprised more than 10% of subjects, we assigned a random day of the month using a Monte-Carlo method to impute values for the missing day for these mothers.

2.12.5. Use of clinical estimation vs. LMP for gestational age.

For the cohort, 1979-83, an LMP was recorded on the birth certificate, but a clinical estimate of gestational age was not. For 1999-2011, we had both LMP and a clinical estimate, but to, maintain consistency we used LMP to calculate preterm birth and SGA for both cohorts.

2.12.6. Birthweight

Birthweight was converted to grams to create birthweight categories of <2500, >=2500 and missing.

2.12.7. Preterm births

As noted above, we used LMP to estimate gestational age in both cohorts. We categorized gestational length in the following categories: 20-<28, 28-<32, 32-<34, 34-<37 and 37+. All births <37 weeks were considered to be preterm.

2.12.8. Kessner's Index of adequacy of prenatal care

The index was calculated for both cohorts using variables such as month the prenatal care begin, total number of prenatal visits and weeks of gestation to create the following categories: Adequate, Intermediate and Inadequate.

2.12.9. Small-for-gestational age (SGA)

SGA birth was defined as race-sex-specific birthweight below the 10th percentile for gestational age based on 1999-2011 live births for both cohorts. The same 10th percentile cut points from 1999-2011 were used to define SGA in both cohorts. Gestational age– and sex-specific birth weight means, SDs, and smoothed percentiles (3rd, 5th, 10th, 90th, 95th, 97th) were calculated for livebirths in our cohort 1999-2011, and the 10th and 90th percentiles were compared with published population-based references.

2.13. References

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2. Campbell, K., Deck, D., Cox, A., & Broderick, C. (2006). The Link King User Manual.
   Retrieved April 1, 2008, from The Link King Web site: www.the-linkking.
   com\user_manual.zip.

3. MATERNAL EDUCATION AND RISK OF PRETERM BIRTH ACROSS GENERATIONS

3.1. Abstract

3.1.1. Aim/Purpose

The principal objective of this analysis was to ascertain whether grandmother's education was associated with the risk of preterm birth (PTB) in her grandchildren after accounting for mother's education. In addition, we were interested to explore whether the association of maternal education was similar in both cohorts and whether the increased maternal education across generations was associated with a fall in preterm birth rates in the different race/ethnic groups.

3.1.2. Background

Maternal lifelong socioeconomic status (SES) is known to affect reproductive health. There are many studies that have shown strong association of mother's current SES with adverse birth outcomes. However, few studies have investigated associations with mother's childhood SES or grandparents' education. In U.S. blacks, previous data suggest that improvement in SES from childhood to adulthood is associated with improved birth outcomes, but results for whites have been mixed.

3.1.3. Methods

We created a transgenerational dataset to examine the effect of grandmother's education, a dimension of SES, on risk of PTB in grandchildren. Using Link King Software we matched female infants listed on NJ birth certificates in 1979-1983 to mothers listed

on NJ birth certificates for the years 1999-2011. Thus, grandmothers were the women delivering in 1979-1983, and mothers were those born to the grandmothers who in turn delivered grandchildren in 1999-2011. We performed descriptive tabulations and multivariate logistic regression for risk estimates using Statistical Analysis System (SAS) software.

3.1.4. Results

In total we linked 107,347 grandmother and mother pairs. After exclusions (multiple births, gestational age of less than 20 weeks and greater than 47 weeks and other races) there were 99,463 pairs available for analysis. Overall, maternal education was associated inversely with PTB births in each of the largest demographic groups (non-Hispanic whites and blacks and Hispanics). There was a substantial inter-generational increase in education between grandmothers and mothers in each group, but it was most striking in Hispanics. Preterm births declined in female babies across generations. After adjusting for potential confounders including mother's education, grandmother's education continued to be associated with preterm birth of her grandchildren. Father's education was inversely related to PTB in all three ethnic groups and across both generations.

3.1.5. Conclusions/implications

In summary, we found that mother's education was an important predictor of PTB both in 1979-82 and in 1999-2011.Grandmother's education was an additional, independent predictor of PTB in her grandchildren. Our results suggest that mother's childhood and preconception socioeconomic environment, including the educational level of her childhood household, are independent predictors for delivering preterm.

3.2. Introduction

3.2.1. Background

United States has one of the highest infant mortality rates among Western Countries. Preterm birth (PTB) is the most important causes of infant mortality in developed countries, and the high PTB rate in US largely explains its excessive infant mortality.[1] Within the US there is a substantial difference between women of European and of African ancestry in the rates of preterm birth and infant mortality. In 2015, the overall rate of PTB in US was 9.6% whereas the rate of PTB among black women was 13%, almost 50 percent higher than the rate of preterm birth among white women, at 9%.[2] The 2015 rates are somewhat higher than 20 years earlier, an increase that has been attributed to iatrogenic preterm deliveries done for obstetric indications and to multiple births secondary to assisted reproductive technologies.[3] Many other risk factors contribute to PTB including maternal body weight, race and ethnicity, maternal age, low maternal education, late or no prenatal care, maternal illness, behavioral and psychosocial factors, infertility treatment, exposure to environmental toxins, low socioeconomic status, neighborhood characteristics and genetics.[4-16]

A mother's socioeconomic status (SES), at childhood and adulthood, has been known to be a strong predictor of PTB. A study conducted by Collins et al.[17] reported that African American mothers with a lifelong residence in impoverished neighborhoods had a higher PTB rate as compared to white mothers within the same group. However, if the black women experienced high upward economic mobility by the time they gave birth themselves, they had strikingly lower PTB rates, after adjusting for other potential confounders. Furthermore, a study conducted by Love et. al.[18] reported that African-American women who were born in poor neighborhoods and were still poor when they became mothers had higher odds of having low birth weight (LBW) and small for gestational age (SGA) babies as compared to white women; however, they did not find a similar association with respect to PTB. The study also showed that African-American women in upper-income areas at both time points had a steady fall in LBW and SGA rate with age, similar to the pattern seen in white women. However, no groups of white women, not even those who always lived in poorer neighborhoods, exhibited higher risk of preterm birth than comparably situated black women.

It is well established that preterm birth tends to repeat across generations, so that women who were themselves born preterm are at increased risk for having a preterm delivery.[19] Although transgenerational persistence of social status could contribute to this, the extent to which the persistence of SES may explain the transgenerational repetition of PTB is not well defined.

Based on this background, we conducted an analysis of the association of grandmother's and mother's education with PTB (<37 weeks) among non-Hispanic Whites, non-Hispanic Blacks and Hispanic women. Maternal education is one of the strongest SES predictors of PTB[19], so we used grandmother's and mother's education as indicators of SES across generations and examined whether grandmother's education modified the risk of PTB, independent of mother's education. Finally, we examined whether grandmothers education is associated with PTB incidence in an equivalent manner after adjusting for maternal education.

So far studies that have examined the intergenerational effect of SES status on birth outcomes, have mostly focused on whites, and those studies that did investigate this effect in both whites and blacks did not have large enough samples to detect modest association of economic mobility and adverse birth outcomes. We believe this is the first study to examine the intergenerational effect of mother's SES status not only in non-

Hispanic Whites (referred to as whites) and non-Hispanic Blacks (referred to as Blacks), but also in Hispanic mothers. In 2014, Hispanics made up nearly 26 percent of all New Jersey births.[20]

3.2.2. Significance of Preterm birth

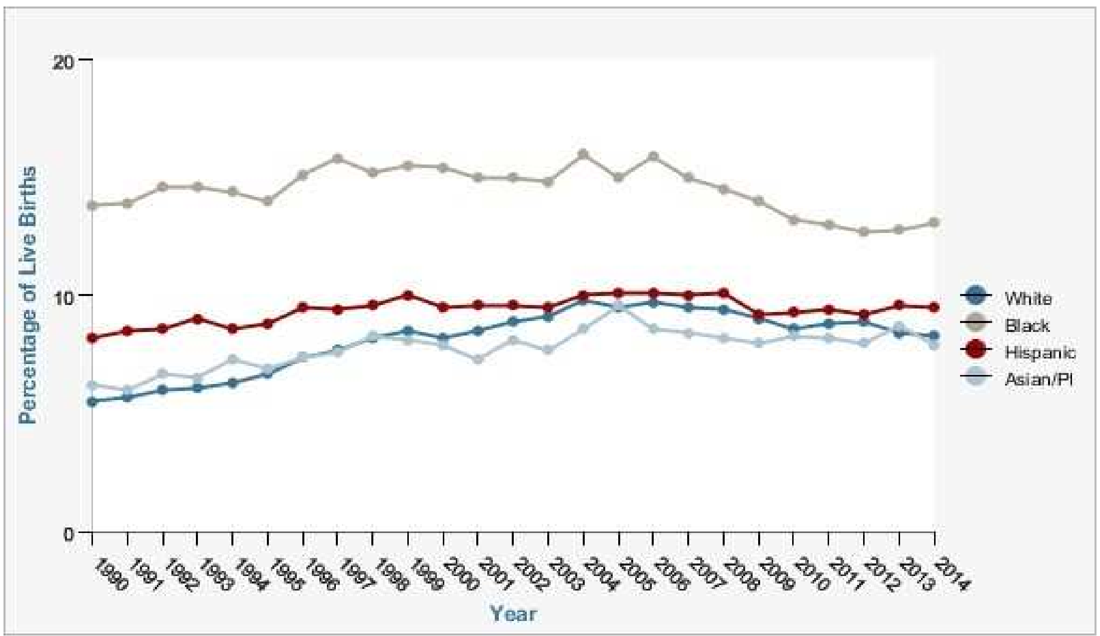
According to a recent international report[2] on preterm births worldwide, PTB is now the second leading cause of death worldwide, after pneumonia, for children under the age of five. In 2010, approximately 15 million pre-term babies were born and more than 1 million infants died as a result of prematurity. PTB account for 11.1% of the world's live births, 60% of them in South Asia and sub-Saharan Africa. In the poorest countries, on average, 12% of babies are born too soon, compared to 9% in higher-income countries. The international ranking for US for preterm births in 2010 was 54th with a rate of 12.0 percent as compared to other developed nations such as UK which is 134th and Canada which is 135th.

In 2014 there were total of 4,131,019 births in the US[21] of which 548,162 (12.2%) were preterm. The PTB rate has declined slightly from its peak in 2006 of 12.8%. This decline was mainly seen in singleton births, among women under 40 years of age. The decline occurred in each of the major race/ethnic groups and in the majority of the 50 states. In addition the decline was also observed among births at less than 34 weeks from 3.7% in 2006 to 3.6% in 2008 and late preterm infants from 9.1% in 2006 to 8.8% in 2008. The PTB rate is still far from the Healthy People 2010 goal of 7.6%.[22]

Figure 1 shows the trend in PTB in NJ from 1990 through 2014.[23] From the figure we can see that the overall PTB increased from 7.3 percent in 1990s to 10.4 percent in 2006 and then started to slowly decline to 9.3 percent in 2014. When stratified by mother's race and ethnicity, for non-Hispanic Whites, it increased from 5.5 percent to

9.8 percent in 2004 and then decreased to 8.3 percent in 2014. For non-Hispanic Blacks it increased from 13.8 percent in 1990 to 16.0 percent in 2004 and then decreased to 13.1 percent in 2014. For Hispanics the rates it increased from 8.2 percent in 1990 to 10.1 percent in 2008 and then decreased to 9.5 percent in 2014. Among all the races non-Hispanic Blacks had the highest incidence of preterm births, followed by Hispanics who had slightly higher rates than non-Hispanic Whites.

Fig 1: Trends in Preterm Birth by Mother's Race/Ethnicity, New Jersey, 1990-2014 (HNJ2020)



***SOURCE: Birth Certificate Database, Office**

In the U.S. PTB accounts for 50-75% of perinatal mortality and more than half the long-term morbidity originating in infancy.[24] Thus, the risk of being born early extends beyond the first year to childhood and adulthood. A population-based study of late preterm and term infants from Utah[25] reported an infant mortality rate that was highest at 34 weeks gestation (8.2 per 1000 live births) compared with the lowest rate of infants born at 40 weeks gestation (0.5 per 1000 live births). Preterm babies also face greater risks of serious health problems such as cerebral palsy, intellectual impairment, chronic lung disease and vision and hearing loss. Also these babies have poor growth, higher incidence of developing diabetes and hypertension later in their life and long-term lung and gastrointestinal disease. [26, 27]

In addition to health problems, preterm birth incurs a huge medical cost to society. According to IOM, in 2005, cost of preterm birth in the United States was at least $26.2 billion, not including medical care beyond early childhood or the total cost of special educational services, lost productivity or any cost of caregiver.[28]

3.2.3. Methods

In order to assess the association of maternal education with PTB across generations, we created a transgenerational file that included all 1999-2011 births in New Jersey (NJ) to mothers who were themselves born in the state in 1979-83. The cohort was assembled by matching the birth certificates across the two periods. Female infants born in 1979-1983 were matched to mothers delivered in 1999-2011, using Link King Software.[29,30] Principal matching variables were infant name, date of birth, race and ethnicity in 1979-83 and mother's maiden name, date of birth, race and ethnicity in 1999-2011. Birth data were provided by the NJ Department of Health.

For the years 1979-83 there were 490,143 births in total of which 241,221 were girls. For the years 1999 through 2011, there were 1,499,891 births to NJ residents of which 611,737 births were to mothers whose own birthplace was in New Jersey and who delivered either in or out of state. We excluded the births that occurred out of state which gave us the final sample of 602,336 births.

For women giving birth in 1979-83, which we refer to as "grandmother's generation", we had data only on grandmother's and grandfather's age, education and marital status, all taken from the 1979-83 birth certificates. Race and ethnicity was somewhat incomplete in the 1979-83 file, so we used race and ethnicity that was available for the mothers on the matched 1999-2011 birth certificates, which we refer to as "mother's generation". These were used to create white non-Hispanic, black non-Hispanic, and Hispanics, termed hereafter as whites, blacks and Hispanics. In addition to the basic demographics (mothers and fathers age, education, marital status), we also examined the association of maternal medical risk factors and complications in mothers. However, because of limited numbers and missing data we did not use these variables in regression analysis. In 1979-83, NJ did not collect information on smoking or on medical risk factors and complications, so we could not examine these variables for grandmothers. . A more detailed description of the construction of the New Jersey transgenerational birth file is included in the Methods Chapter. We performed descriptive tabulations of maternal and birth outcome data for both sets of deliveries and used chi square tests and t-tests, as appropriate to test for statistically significant differences. Multivariate logistic regression analyses were used to examine the effect of grandmother's education on risk of PTB before and after adjusting for her age, marital status, prenatal care and grandfather's education and age. Next we examined the similar relationship for mother's generation.

3.3. Statistical Analysis

Studies have shown that gestational age based on clinical estimation (CE) is a better predictor of perinatal outcomes as compared to gestational age calculated based on date of last menstrual period (LMP).[31] Ananth et al., [32] showed that livebirths appears to closely approximate to gestational age based on menstrual dates at <28 and 37-41 weeks and the concordance between menstrual and CE of gestational age at 28–36 and at 42 weeks seems poor. Because CE was not available for the 1979-82 births, we used gestational age based on date of last menstrual period (LMP) to create PTB categories for both generations. We conduct sensitivity analysis in mothers using both CE and LMP to investigate the misclassification of PTB and our findings were consistent with those of Ananth et al. As shown in the table 1, the PTB rate calculated using LMP closely approximates CE at <28, slightly higher for 28-32 and lower for 33-<37. This does indicate that there is some discordance in late PTB rates based on LMP and CE; however the difference is not very large.

Finally logistic regression was used to estimate intergenerational effect of PTB. To test this, we examined the effect of grandmother's education on risk of PTB independent of mother's education. In these analyses, the following categories of the independent variables were used as reference category, 'age 25 -<30,' 'some college', 'married' and 'adequate prenatal care'. "Crude and adjusted odds ratio were calculated for each analysis. All statistical tests were two sided and were tested at 0.05 significance value. Exploratory analysis was tested at 0.05 and 0.10 significance value.

All statistical analysis was performed using Statistical Analysis System (SAS) software (SAS Institute, Inc., Cary, NC), Windows version 9.4. This study was approved by the NJDOH & Rutgers University Human Research Ethic Committee.

3.4. Results

3.4.1. Characteristics of mothers across two generations by race/ethnicity

In total we linked 107,347 grandmother and mother pairs. After excluding records that had missing month in LMP dates, the sample for table 1 was 105,033 pairs of mothers and grandmothers. Characteristics of grandmothers and mothers are shown in Table 2. Grandmothers were more likely to be young and married as compared to mothers. In terms of education, there was a huge shift in educational level between grandmothers and mothers that was seen in all race/ethnic groups. This was most prominent among

Hispanics where 23% of mothers had some college education as compared to only 7% of grandmothers. Conversely, 59% of Hispanic grandmothers had <12 years of education vs only 24% of Hispanic mothers. Similar shifts in education were seen in fathers among all races although the data were missing for a substantial number of the minority fathers. In terms of PTB, mothers had higher very PTB as compared to grandmothers, however late PTB was higher in grandmothers as compared to mothers. Among whites and Hispanics there was no substantial difference in the frequency of low birth weight, however black mothers had lower incidence as compared to grandmothers. There was no substantial difference in the prenatal care index or in the frequency of small-for-gestational age offspring between grandmothers and mothers.

3.4.2. Preterm rates across two generations among all race/ethnicity

Tables 3, 4, and 5 show the preterm birth rates among white, black and Hispanic grandmothers and mothers by education level and other characteristics. These tables include plural births (twins and a very few triplets), but the data are also shown in Tables 3.1, 4.1, and 5.1 for female and male singleton births. Based on figure 2 and table 3, among white grandmothers and mothers, we see a significant trend in education and preterm rates, where preterm rates decrease as the level of education increases. Grandmothers and mothers that are less than 20 years of age have higher preterm rates and the rates decrease as they get older. Married grandmothers and mothers have lower preterm rates as compared to unmarried. Also grandmothers and mothers that had inadequate or intermediate prenatal care have higher preterm rates as compared to those who did receive adequate care. We see a similar pattern in grandfather and father's education level and preterm rates as seen for grandmothers and mothers.

For blacks as seen in figure 2 and table 4, there is a significant trend in grandmothers and mothers education level and preterm rates, where higher the education lower the rates. The absolute magnitude of the difference in rates between women with less than high school education and college graduates was substantial and similar to that seen in whites (4-5 preterm babies per 100 births) but as a percentage difference it was smaller because of the high baseline rate of preterm births among black women. Unlike the situation in whites, the black mothers giving birth in 1999-2011 had lower preterm rates as compared to the grandmothers across all education levels. We saw a U-shaped relationship between grandmothers and mothers age and preterm rates, where younger and older age groups have slightly higher preterm rates. Married grandmothers and mothers tend to have lower preterm rates as compared to unmarried grandmothers and mothers, although this difference is small in 1999-2011 when only 19% of this sample black mothers were married

Hispanic mothers (shown in Table 5) were similar to the other two groups in showing a substantial decreasing trend of preterm rates with increasing education of mothers and grandmothers. Grandfather's educational level showed little association with preterm rates. In all three race/ethnic groups PTB rates were high when fathers (or grandfather's) educational level were missing. There was Grandmothers younger than 20 years had higher preterm rates, however age effect on preterm rates was not seen in mothers. Married grandmothers had significantly lower rates of preterm birth than unmarried, and was significant, however marital status did not have any impact in mothers since unmarried mothers had similar preterm rates. Prenatal care was significantly associated with preterm rates in both grandmother's and mothers, where higher preterm rates were seen in those that received inadequate or intermediate care. Grandfather's education level was significant, however father's educational level was not associated with preterm rates.

Tables 3.1, 4.1 and 5.1 show PTB rates for female and male singleton births among whites, blacks and Hispanics that were born during 1999-2011. Because the twin and triplet births are excluded along with other races, the preterm rates are lower than in Tables 3, 4, and 5. Furthermore, it should be noted the preterm rates for boys were a little higher than girls, indicating that the comparison of rates between1979-83 and 1999-2011 shown in Tables 3, 4, and 5 is slightly biased, because all of the births in the earlier cohort were daughters whereas both sexes were included in the later cohort. The inverse association of PTB with maternal education is very similar in male and female babies.

3.4.3. Effect of (grand) mother's education, crude and adjusted, on risk of PTB during 1979-83 among White non-Hispanic

The tables 6-8 shows unadjusted and adjusted odds ratio for PTB for grandmothers by race. As seen in Table 6, white grandmothers less than 20 years old and 35 years and older had higher risk of preterm births as compared to grandmothers that were 25 -30 years old. Grandmother's education was also strongly related (inversely) to preterm birth and PTB risk was also associated with low educational attainment in grandfathers. Grandmothers that were not married had 41% higher risk of having a preterm birth as compared to married Grandmothers. Also grandmothers that had intermediate or inadequate care were likely to have PTB as compared to grandmothers that had adequate prenatal care. After adjusting for all the covariates, grandmother's education, grandfather's education and prenatal care were still strongly associated with higher risk of PTB. However, grandmother's age and marital status maintained only weak associations with PTB after these adjustments.

3.4.4. Effect of (grand) mother's education, crude and adjusted, on risk of PTB during 1979-83 among Black non-Hispanic

Table 7 shows that among the black grandmothers those with less education generally had higher preterm rates, although there was no significant difference between some college and college graduates. In addition, those who were less than 20 years old and 30 years and older, as well as the unmarried and those who had less than adequate prenatal care were at increased risk. Grandmothers with less than high school had 43% risk of PTB, high school graduates without further education had a 19% increased risk of PTB compared to those with further education. Mothers with high school had 10% risk of PTB as compare to mother with some college education. Grandfathers with lesser education were also significantly associated with higher risk of PTB. Grandmothers with intermediate and inadequate prenatal care were also higher risk of PTB. After adjusting for age, education, marital status and prenatal care, grandmother's education was significantly associated with increased risk of PTB.

3.4.5. Effect of (grand) mother's education, crude and adjusted, on risk of PTB during 1979-83 among Hispanics

In table 8, Hispanic grandmothers are seen to have a similar risk profile as black women except that education was relatively unimportant. Age showed a U-shaped relationship with those less than 20 years old having significantly higher risk of PTB. Grandmothers with less than high school and some high school were also associated with higher risk of PTB, but it was not significant. Grandfathers with 13-15 years education had a particularly low rate of PTB that seems likely to be a chance finding. Grandmothers that received intermediate and inadequate prenatal care also had higher risk of PTB. After adjusting for covariates, grandmother's education and age and grandfathers education were no longer not associated with PTB.

3.4.6. Effect of mother's education, crude and adjusted, on risk of PTB during 1999-2011.

The tables 9–11 are similar to the previous three tables but show data for the births occurring in 1999-2011. A gradient of risk for preterm birth is associated with lack of education in all three race/ethnic group and, except in Blacks, remains significant after adjustment for covariates. Many more women giving birth in these years were unmarried, but as it became more common, being unmarried conferred less disadvantage than it had in the previous generation. Likewise, father's education retained little association with preterm birth after adjustment for maternal education and other variables. Although the women giving birth in these later years were considerably more educated than were the grandmothers, the preterm rates were reduced only in Blacks and actually increased in Whites (Table 2).

3.4.7. Unadjusted and Adjusted Odd Ratio for PTB Birth in White Non-Hispanic Mothers, in NJ during 1999-2011– Model with Grandmother's education

The table's 12-14 shows effect of grandmother's education independent of mother's education on the risk of having a preterm grandchild among white, black and Hispanics. Among whites, the grandmother's education status showed a significant association of having a grandchild being born preterm, independent of the mother's education, after adjusting for other covariates. The lower the education of the grandmother, higher the risk of having a grandchild who is born preterm and the risk reduces with higher education. However, even with grandmother's education in the model, mother's education still showed a strong (though somewhat reduced) association with PTB.

The findings among blacks (table 13) are similar to whites. Grandmother's and mother's education are both substantially and significantly associated with preterm birth in the grandchildren, although the associations do not appear as large as in whites. When entered in the same model, both continue to show an association, but mother's education loses significance. The pattern seen in Hispanics was also very similar to whites (table 14), wherein grandmother's education showed an association with having a grandchild being born preterm that was as strong as mother's, and remained as strong and independent of mother's education and after adjusting for other covariates, but was not as strong as seen among whites and blacks. In addition, effect of mother's education still showed a strong association with PTB, even with grandmother's education in the model.

3.5. Discussion

This analysis of maternal education and preterm birth across two generations has yielded four salient findings: 1) Maternal education is associated inversely with preterm birth rates in the three main race/ethnic groups of New Jersey (and the U.S.) both in the years around 1980 and in the period 1999-2011; 2) Women in all three demographic groups delivering infants in 1999-2011 were substantially better educated than were their mothers who delivered in 1979-83; 3) Secular changes in preterm birth rates varied by race/ethnicity. They increased some in whites, remained quite stable in Hispanics, and fell modestly in blacks and 4) The educational level of grandmothers born in 1979-83 was inversely associated with preterm birth of their grandchildren, independent of the educational achievement of their daughters.

Educational level is a component of most measures of SES and its inverse association with preterm birth could either be mediated by other components or correlates of SES, or by specific health benefits of education on lifestyle and health habits that are beneficial to reproductive success. Our findings provide little support for a universal benefit of conventional education on preterm risk since educational level went up substantially across generations in whites and hardly changed in Hispanics who enjoyed the largest increase in educational level. Possibly other secular changes in lifestyle or obstetric practice obscured a favorable effect of education. In whites the deleterious effect of these on preterm rates must be even greater than is generally recognized to have overcome the benefits of improved education.

An alternative interpretation is that maternal education is a marker of social status and that other benefits of high social status reduce the risk of preterm labor. Kramer has put forward a schema of potential pathways through which SES might operate 33, and other authors have provided evidence for an SES effect in African American women. Collins et al., examined the effect of lifetime economic mobility on low birth weight, SGA, and PTB and reported that African-American mothers who grew up in impoverished neighborhoods and who then experienced low, modest, or high upward economic mobility by adulthood, had preterm birth rates of 16.0%, 15.2% and 12.4% after adjusting for important covariates.[17] Another study conducted by Love et. al., found that African-American women who were born in poor neighborhoods and were still poor as mothers had high odds of having LBW and SGA babies, although a similar association with PTB was not found.[18] We believe the lack of improvement in preterm rates in the face of the substantial increase in population educational levels favors a complex of advantages associated with SES, for which education is a marker, in addition to any direct effects of education itself..

The finding that maternal grandmother's education has an association with preterm birth in grandchildren that appears as strong as the maternal association is of considerable interest. The most obvious explanation is that grandmother's education is an indicator of the SES milieu in which mother grew up and that the better health and habits enjoyed by well-off children carry through to healthier pregnancies. The finding supports a life-course understanding of successful pregnancy that could include both physiological and lifestyle differences between advantaged and disadvantaged citizens. It is also a hopeful finding in that it suggests that the greater educational attainment seen in recent years may help to provide for better reproductive outcomes in another generation.

The results found for Hispanic families are of special interest because of limited data available on cross generational birth outcomes in this recent immigrant group. Hispanics were the only group in which we did not find an effect of maternal education on preterm rates in the 1979-83 data (Table 8). This is consistent with the “Hispanic paradox” reported by others[34] in which recent immigrants, who are likely to have been under-educated, nevertheless have better health indices than their peers who have been in the U.S. for longer periods of time. Interestingly, the educational level of these women, while not related to preterm risk in their children, was predictive of preterm births in their grandchildren (Table 14)--roughly to the same extent as seen in non-Hispanic whites (Table 12). The positive effects of education for preterm delivery may have been obscured by the healthier lifestyles that some of them brought from Mexico and other countries, but education may nevertheless have made it possible for them to provide a better childhood environment for their daughters that has been reflected in lower preterm rates in the next generation.

This study has a number of strengths including its large size, its inclusion of substantial data on blacks and Hispanics as well as whites and its unusual cross generation perspective. While New Jersey is not formally representative of the nation, it does have similar proportions of blacks’ and Hispanics as well as substantial populations in urban and rural settings and in all income strata. The matching of infant girls born in 1979-83 with mothers delivering in 1999-2011 was highly accurate as evidenced by the overwhelming majority (96.8%) of matches that were found to be at the highest level of certainty identified in the Link King software and by hand review of a large sample of matches. Its findings of higher rates of preterm birth in the more recent time period, the excess rates in black women, but greater improvement in preterm rates in blacks are consistent with prior work, but it goes beyond this earlier work in showing the effect of grandmother's education on preterm rates for their grandchildren. Limitations include the focus on women who have had a stable residential history who may not be representative of all births and the absence of measurements of many other risk factors for preterm birth. However, maternal education precedes the development of most other risk factors, so that it might not be appropriate to adjust for them even if they had been measured. And it could be argued that limiting some of the geographic movement in the population may make it easier to identify the correlates of maternal education.

In conclusion, we have found that maternal education continues to be inversely associated with preterm birth in the three largest race/ethnic groups in the U.S. (excepting the Hispanic paradox seen in 1979-83 births), and that grandmother's education has an independent protective association that is as large as that of mother's education. However, despite a substantial increase in educational levels of mothers, preterm birth rates have not improved in whites or Hispanics. The improvement in preterm rates in black women, who are the highest risk demographic group in the US, is heartening and supports the view that social changes can influence this important metric of reproductive health.

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3.7. Tables

Table 1: Comparison of Preterm Birth Rates among Mothers based on Last Menstrual Date and Clinical Estimates by Race/Ethnicity in NJ during 1999-2011

	Cohort – 1999-2011 (N=105,033)					
Preterm births	**Gestational age based on Last menstrual period**			**Gestational age based on Clinical estimation**		
	White NH %	**Black NH %**	**Hispanic %**	**White NH %**	**Black NH %**	**Hispanic %**
20- <28	0.50	1.42	0.72	0.45	1.45	0.81
28-32	1.43	2.91	1.73	1.25	2.42	1.46
33-<37	11.70	16.56	14.49	14.20	19.51	17.32

Table 2: Maternal Characteristics of Grandmothers and Mothers by Race/Ethnicity in NJ during 1979 -1983 and 1999-2011*

	Grandmothers– 1979 – 1983*			Mothers – 1999-2011*		
	White Non-Hispanic	Black Non-Hispanic	Hispanic	White Non-Hispanic	Black Non-Hispanic	Hispanic
	N=56,863	N=30,920	N=15,296	N=56,863	N=30,920	N=15,296
Maternal age						
12 -<20	9.76	33.50	24.57	7.36	19.58	17.61
20 -<25	33.24	35.99	36.35	28.37	44.58	40.85
25 -<30	35.61	18.60	22.68	49.65	30.93	35.36
30- <35	16.89	8.71	10.77	14.61	4.89	6.16
Missing	4.50	3.21	5.62	0.0	0.01	0.01
Maternal Education						
<12	15.26	38.50	35.20	9.25	22.55	24.28
12	52.04	41.10	31.23	32.60	45.16	39.87
13-15	16.24	11.57	6.82	23.80	22.33	23.23
>15 - <18	12.09	3.12	2.41	33.78	7.86	11.66
Missing	1.19	1.27	1.09	0.58	2.10	0.96
Fathers Education						
<12	12.61	10.17	26.31	8.51	11.02	20.32
12	44.00	25.19	28.27	37.02	36.40	41.22
13-15	15.01	6.62	6.51	20.11	12.45	16.10
>15 - <18	19.04	3.04	3.30	26.48	4.56	7.89
Missing	5.76	53.48	16.27	7.88	35.58	14.47
Preterm birth						
Very (20 -< 32)	1.05	4.11	1.97	1.48	3.45	1.84
Late (32 -< 37	11.54	20.94	15.92	6.75	10.56	8.37
Term (37-47)	86.54	73.81	81.40	89.25	81.92	86.97
Missing	0.87	1.13	0.71	2.51	4.07	2.82
Foreign born						
Yes	0.54	0.26	54.30	NA	NA	NA
Small-for-gestational age						
Female	10.65	11.44	10.32	9.91	9.88	9.86
Male	NA	NA	NA	9.94	9.86	9.83
Married						
No	10.02	70.31	39.74	37.49	86.98	69.29

	Grandmothers– 1979 – 1983*			Mothers – 1999-2011*		
	White Non-Hispanic	Black Non-Hispanic	Hispanic	White Non-Hispanic	Black Non-Hispanic	Hispanic
	N=56,863	N=30,920	N=15,296	N=56,863	N=30,920	N=15,296
Gender						
Male	NA	NA	NA	51.27	50.68	51.66
Female	100	100	100	48.73	49.31	48.34
Low Birthweight						
0- <2500	4.84	13.36	6.81	6.76	12.70	8.50
Kessner's Index of adequacy of prenatal care						
Adequate	80.56	53.08	62.99	77.39	54.60	65.29
Intermediate	14.84	27.64	21.58	15.83	26.03	22.40
Inadequate	4.59	19.28	11.73	5.13	15.40	9.58

*Values shown are percentages

Figure 2: Preterm Rates in Grandmothers and Mothers by Education status in Female babies in NJ during 1979 – 1983 and 1999-2011

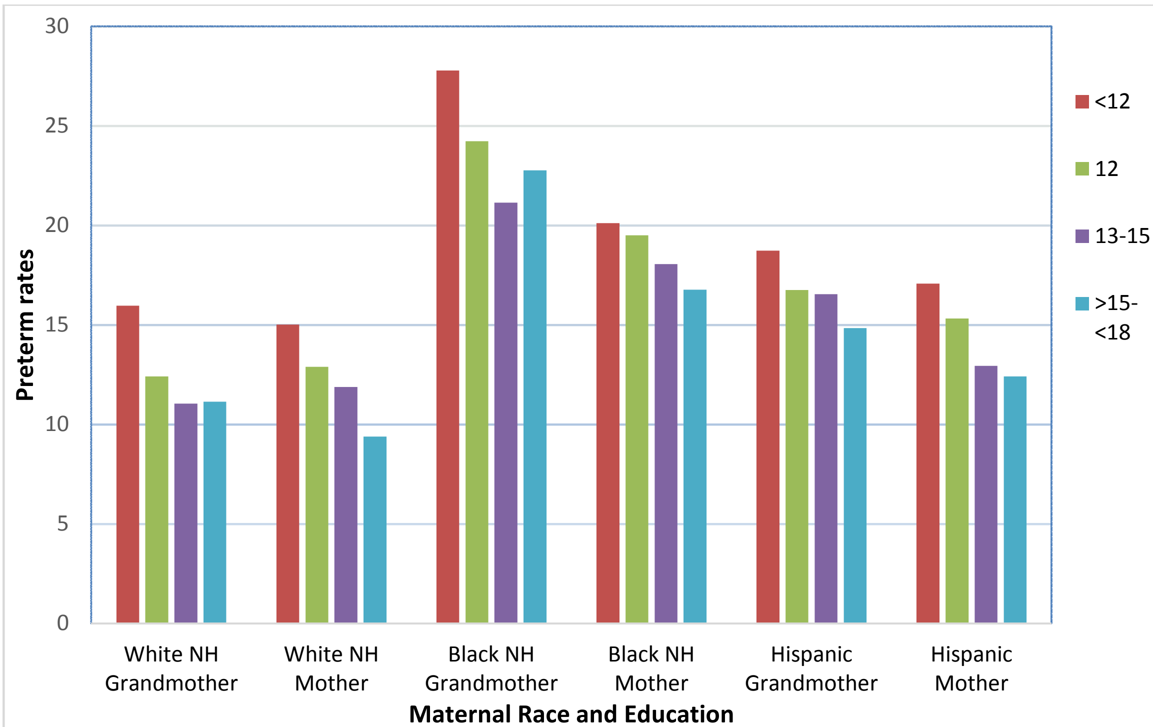

Table 3: Preterm Rates in White Non-Hispanic Grandmothers and Mothers in NJ during 1979 – 1983 and 1999-2011

	Grandmothers – 1979 – 1983		**Mothers – 1999-2011**	
	Number at risk (56,363) N	**Preterm (7,158) %**	**Number at risk (56,863) N**	**Preterm (7,753) %**
Maternal age				
12 -<20	5,473	14.73	4,187	14.26
20 -<25	18,721	12.57	16,132	13.72
25 -<30	20,101	12.37	28,234	13.50
30- <35	9,523	12.10	8,309	13.60
Missing	2,545	14.18	1	0
p-value*	<0.0001		<0.0001	
Maternal Education				
<12	10,387	15.97	5,258	15.82
12	29,937	12.41	18,536	14.19
13-15	9,131	11.05	13,533	13.80
>15 - <18	6,834	11.15	19,209	12.32
Missing	674	12.91	327	16.82
p-value**	<0.0001		<0.0001	
Fathers Education				
<12	9,114	15.17	4,841	15.49
12	24,826	12.18	21,048	13.89
13-15	8,456	11.77	11,437	13.74
>15 - <18	10,739	11.32	15,059	11.91
Missing	3,228	16.70	4,478	15.94
p-value**	0.0079		<0.0001	
Married				
No	5,622	16.45	21,315	14.43
Yes	50,721	12.28	35,546	13.16
p-value*	<0.0001		<0.0001	
Kessner's Index of adequacy of prenatal care*				
Adequate	45,023	11.46	44,005	12.96
Intermediate	8,277	16.19	9,004	15.77
Inadequate	2,546	21.09	2,915	19.52
Missing	517	23.21	939	6.71
p-value**	<0.001		<0.001	

* p-values for chi-square; **p-values for chi-square trend test

Table 3.1: Preterm Rates in White Non-Hispanic Mothers in NJ during 1999-2011

	Mothers – Female babies Singleton Births		**Mothers – Male babies Singleton Births**	
	Number at risk (26,051) N	**Preterm (3,037) %**	**Number at risk (27,373) N**	**Preterm (3,393) %**
Maternal age				
15 -<20	1,799	13.79	1,981	15.40
20 -<25	7,338	12.69	7,917	13.14
25 -<30	13,074	11.21	13,618	11.87
30- <35	3,839	10.24	3,857	11.17
35- <50	0	0	0	0
p-value*	<0.0001		<0.0001	
Maternal Education				
<12	2,303	15.02	2538	16.47
12	8,521	12.90	8963	13.24
13-15	6,222	11.88	6509	12.34
>15 - <18	8,850	9.39	9211	10.39
Missing	155	14.19	152	18.42
p-value**	<0.0001		<0.0001	
Fathers Education				
<12	2,144	14.23	2,390	15.48
12	9,707	12.23	10,147	12.98
13-15	5,372	11.30	5,424	12.41
>15 - <18	6,860	9.01	7,258	9.75
Missing	1,968	16.26	2,154	15.09
p-value**	<0.0001		<0.0001	
Married				
No	9,639	13.73	10,342	14.09
Yes	16,411	10.44	17,030	11.37
p-value*	<0.0001		<0.0001	
Kessner's Index of adequacy of prenatal care*				
Adequate	20,454	10.71	21,350	11.17
Intermediate	4,191	13.65	4,415	15.67
Inadequate	1,306	19.07	1,479	19.47
Missing	100	25.00	129	22.48
p-value**	<0.0001		<0.0001	

* p-values for chi-square; **p-values for chi-square trend test

Table 4: Preterm Rates in Black Non-Hispanic Grandmothers and Mothers in NJ during 1979 – 1983 and 1999-2011

	Grandmothers– 1979 – 1983		**Mothers – 1999-2011**	
	Number at risk (30,563) N	**Preterm (7,745) %**	**Number at risk (30,920) N**	**Preterm (6,411) %**
Maternal age				
12 -<20	10,237	27.48	6,055	19.92
20 -<25	10,994	23.98	13,784	20.06
25 -<30	5,694	23.23	9,565	22.10
30- <35	2,659	25.72	1,512	21.56
Missing	979	29.52	0	0
p-value*	<0.0001		<0.0001	
Maternal Education				
<12	13,121	27.78	6,973	21.48
12	12,565	24.23	13,965	21.18
13-15	3,532	21.15	6,904	19.83
>15 - <18	953	22.77	2,430	18.31
Missing	392	23.21	648	21.76
p-value**	<0.0001		<0.0001	
Fathers Education				
<12	3,560	26.01	3,406	21.08
12	7,696	22.73	11,255	20.64
13-15	2,027	21.85	3,850	19.30
>15 - <18	928	22.09	1,409	17.39
Missing	16,352	27.04	11,000	21.65
p-value**	<0.0001		<0.0001	
Married				
No	21,483	26.47	26,891	20.83
Yes	9,067	22.69	4,027	20.04
p-value*	<0.0001		<0.0001	
Kessner's Index of adequacy of prenatal care**				
Adequate	15,840	22.22	16,883	19.39
Intermediate	8,207	26.78	8,047	23.18
Inadequate	5,692	30.97	4,763	24.42
Missing	824	32.16	1,227	8.96
p-value	<0.001		<0.0001	

* p-values for chi-square; **p-values for chi-square trend test

Table 4.1: Preterm Rates in Black Non-Hispanic Mothers in NJ during 1999-2011

	Mothers – Female babies Singleton Births		**Mothers – Male babies Singleton Births**	
	Number at risk (28,535) N	**Preterm (5,637) %**	**Number at risk (14,492) N**	**Preterm (2,956) %**
Maternal age				
12 -<20	2,604	19.70	2,730	21.90
20 -<25	6,271	18.39	6,512	19.66
25 -<30	4,462	19.81	4,564	20.44
30- <35	704	18.61	684	21.20
35- <50	1	0.00	2	0.00
p-value*	0.3443		0.4510	
Maternal Education				
<12	3,071	20.12	3,222	22.13
12	6,424	19.50	6,510	20.84
13-15	3,189	18.06	3,293	18.89
>15 - <18	1,103	16.77	1,182	15.57
Missing	255	19.22	285	28.07
p-value**	0.0647		0.0008	
Fathers Education				
<12	1,559	18.99	1,600	21.19
12	5,119	18.66	5,352	20.40
13-15	1,741	17.35	1,847	18.14
>15 - <18	634	15.46	688	13.23
Missing	4,989	20.65	5,005	21.96
p-value**	0.0017		0.2606	
Married				
No	12,183	19.40	12,599	20.64
Yes	1,859	17.11	1,891	18.72
p-value*	0.0191		0.0538	
Kessner's Index of adequacy of prenatal care**				
Adequate	7,863	16.56	8,169	18.25
Intermediate	3,769	20.88	3,878	22.51
Inadequate	2,244	24.51	2,309	23.60
Missing	166	25.30	136	34.56
p-value	<0.0001		<0.0001	

* p-values for chi-square; **p-values for chi-square trend test

Table 5: Preterm Rates in Hispanic Grandmothers and Mothers in NJ during 1979 – 1983 and 1999-2011

	Grandmothers– 1979 – 1983		**Mothers – 1999-2011**	
	Number at risk (15,185) N	**Preterm (2,737) %**	**Number at risk (15,296) N**	**Preterm (2,580) %**
Maternal age				
12 -<20	3,758	20.41	2,694	17.04
20 -<25	5,523	16.59	6,249	16.27
25 -<30	3,429	17.41	5,409	17.51
30- <35	1,623	17.74	942	16.67
Missing	852	19.84	2	0
p-value*	<0.0001		<0.0001	
Maternal Education				
<12	8,899	18.74	3,714	18.23
12	4,740	16.75	6,098	17.43
13-15	1,021	16.55	3,553	16.44
>15 - <18	357	14.85	1,784	13.34
Missing	168	31.55	147	12.24
p-value**	0.3809		<0.0001	
Fathers Education				
<12	6,975	17.75	3,108	16.80
12	4,295	16.30	6,305	17.07
13-15	977	13.51	2,462	17.38
>15 - <18	491	18.94	1,207	13.17
Missing	2,447	23.46	2,214	17.84
p-value**	<0.0001		0.6275	
Married				
No	6,045	20.43	10,598	16.88
Yes	9,136	16.41	4,698	16.84
p-value*	<0.0001		<0.0001	
Kessner's Index of adequacy of prenatal care*				
Adequate	9,456	15.70	9,987	16.25
Intermediate	3,796	21.42	3,427	18.70
Inadequate	1,748	22.60	1,465	19.52
Missing	185	24.78	417	7.19
p-value**	<0.001		<0.0001	

* p-values for chi-square; **p-values for chi-square trend test (2-sided)

Table 5.1: Preterm Rates in Hispanic Mothers in NJ during 1999-2011

	Mothers – Female babies Singleton Births		**Mothers – Male babies Singleton Births**	
	Number at risk (6,979) N	**Preterm (1,037) %**	**Number at risk (7,483) N**	**Preterm (1,291) %**
Maternal age				
12 -<20	1,165	15.36	1,294	19.94
20 -<25	2,890	14.53	3,069	16.72
25 -<30	2,501	14.75	2,659	16.85
30- <35	421	16.39	461	15.62
35- <50	2	0.00	0	0
p-value*	0.8036		0.0248	
Maternal Education				
<12	1,658	17.07	1,777	19.19
12	2,807	15.32	2,993	17.88
13-15	1,629	12.95	1,757	17.07
>15 - <18	822	12.41	891	12.12
Missing	63	17.46	65	10.77
p-value**	0.0033		<0.0001	
Fathers Education				
<12	1,413	14.44	1,499	17.81
12	2,895	15.27	3,100	17.39
13-15	1,135	14.80	1,220	17.79
>15 - <18	547	9.51	607	13.34
Missing	989	17.29	1,057	17.69
p-value**	0.0015		0.4005	
Married				
No	4,853	15.21	5,141	17.49
Yes	2,126	14.06	2,342	16.74
p-value*	0.2166		0.4265	
Kessner's Index of adequacy of prenatal care*				
Adequate	4,679	14.04	4,917	15.76
Intermediate	1,565	16.10	1,742	19.35
Inadequate	669	17.49	757	21.40
Missing	66	16.67	67	25.37
p-value**	0.0418		<0.0001	

* p-values for chi-square; **p-values for chi-square trend test (2-sided)

Table 6: Unadjusted and Adjusted Odd Ratio for Preterm Birth in White Non-Hispanic Grandmothers in NJ during 1979 – 1983

	Grandmothers – Crude OR		**Grandmothers – Adjusted OR**	
	Crude OR	**P-value**	**Adjusted OR**	**P-value**
Maternal age				
12 -<20	1.22 (1.12 – 1.33)	<.0001	0.93 (0.84 – 1.02)	0.1090
20 -<25	1.02 (0.96 – 1.08)	0.5487	0.93 (0.88 – 0.99)	0.0275
25 -<30	Ref	-	Ref	-
30- <35	0.98 (0.91 – 1.06)	0.5076	0.98 (0.91 – 1.06)	0.6362
35- <50	1.17 (1.04 – 1.32)	0.0092	1.12 (0.99 – 1.26)	0.0748
Maternal Education				
<12	1.53 (1.41 – 1.66)	<.0001	1.30 (1.18 – 1.43)	<.0001
12	1.14 (1.06 – 1.23)	0.0005	1.12 (1.04 – 1.22)	0.0034
13-15	Ref	-	Ref	-
>15 - <18	1.01 (0.91 – 1.12)	0.8425	1.03 (0.93 – 1.14)	0.5713
Fathers Education				
<12	1.34 (1.23 – 1.46)	<.0001	1.11 (1.00 – 1.22)	0.0446
12	1.04 (0.96 – 1.12)	0.3084	0.98 (0.90 – 1.06)	0.6015
13-15	Ref	-	Ref	
>15 - <18	0.96 (0.88 – 1.05)	0.3394	0.98 (0.89 – 1.08)	0.6789
Married				
No	1.41 (1.31 – 1.52)	<.0001	1.10 (1.00 – 1.21)	0.0546
Yes	Ref	-	Ref	-
Kessner's Index of adequacy of prenatal care				
Adequate	Ref	-	Ref	-
Intermediate	1.49 (1.40 – 1.59)	<.0001	1.42 (1.33 – 1.52)	<.0001
Inadequate	2.07 (1.87 – 2.28)	<.0001	1.85 (1.66 – 2.05)	<.0001

Table 7: Unadjusted and Adjusted Odd Ratio for Preterm Birth in Black Non-Hispanic Grandmothers in NJ during 1979 – 1983

	Grandmothers – Crude OR		Grandmothers – Adjusted OR	
	Crude OR	**P-value**	**Adjusted OR**	**P-value**
Maternal age				
12 -<20	1.25 (1.16 – 1.35)	<.0001	1.05 (0.97 – 1.14)	0.2602
20 -<25	1.04 (0.97 – 1.12)	0.2856	0.96 (0.89 – 1.04)	0.3402
25 -<30	Ref	-	Ref	-
30- <35	1.14 (1.03 – 1.27)	0.0132	1.16 (1.04 – 1.29)	0.0080
35- <55	1.38 (1.19 – 1.61)	<.0001	1.37 (1.18 – 1.60)	<.0001
Maternal Education				
<12	1.43 (1.31– 1.57)	<.0001	1.24 (1.13 – 1.37)	<.0001
12	1.19 (1.09 – 1.31)	0.0001	1.14 (1.00 – 1.25)	0.0089
13-15	Ref	-	Ref	-
>15 - <18	1.10 (0.93 – 1.31)	0.2801	1.14 (0.95 – 1.37)	0.1632
Fathers Education				
<12	1.26 (1.11 – 1.43)	0.0005	1.05 (0.92 – 1.20)	0.4892
12	1.05 (0.93 – 1.18)	0.4039	0.96 (0.85 – 1.08)	0.4752
13-15	Ref	-	Ref	-
>15 - <18	1.01 (0.84 – 1.22)	0.8858	1.00 (0.83 – 1.22)	0.9657
Married				
No	1.23 (1.16 – 1.30)	<.0001	1.09 (1.01 – 1.18)	0.0267
Yes	Ref	-	Ref	-
Kessner's Index of adequacy of prenatal care				
Adequate	Ref	-	Ref	-
Intermediate	1.28 (1.20 – 1.36)	<.0001	1.25 (1.18 – 1.33)	<.0001
Inadequate	1.57 (1.47 – 1.68)	<.0001	1.50 (1.40 – 1.61)	<.0001

Table 8: Unadjusted and Adjusted Odd Ratio for Preterm Birth in Hispanic Grandmothers in NJ during 1979 – 1983

	Grandmothers – Crude OR		Grandmothers – Adjusted OR	
	Crude OR	**P-value**	**Adjusted OR**	**P-value**
Maternal age				
12 -<20	1.22 (1.08 – 1.37)	0.0012	1.07 (0.94 – 1.21)	0.3280
20 -<25	0.94 (0.84 – 1.06)	0.3113	0.90 (0.80 – 1.01)	0.0643
25 -<30	Ref	-	Ref	-
30- <35	1.02 (0.88 – 1.20)	0.7702	1.02 (0.87 – 1.19)	0.8256
35- <55	1.17 (0.97 – 1.42)	0.0986	1.15 (0.95 – 1.39)	0.1663
Maternal Education				
<12	1.16 (0.98 – 1.38)	0.0880	0.97 (0.80 – 1.17)	0.7086
12	1.01 (0.85 – 1.22)	0.8774	0.97 (0.80 – 1.17)	0.7566
13-15	Ref	-	Ref	-
>15 - <18	0.88 (0.63 – 1.23)	0.4505	0.79 (0.56 – 1.13)	0.1924
Fathers Education				
<12	1.38 (1.14 – 1.68)	0.0011	1.23 (1.00 – 1.51)	0.0474
12	1.25 (1.02 – 1.52)	0.0313	1.20 (0.97– 1.47)	0.0887
13-15	Ref	-	Ref	-
>15 - <18	1.50 (1.12 – 2.00)	0.0067	1.61 (1.19 – 2.17)	0.0021
Married				
No	1.31 (1.20 – 1.42)	<.0001	1.15 (1.04 – 1.27)	0.0051
Yes	Ref	-	Ref	-
Kessner's Index of adequacy of prenatal care				
Adequate	Ref	-	Ref	-
Intermediate	1.46 (1.33 – 1.61)	<.0001	1.41 (1.28 – 1.56)	<.0001
Inadequate	1.57 (1.38 – 1.78)	<.0001	1.44 (1.27 – 1.64)	<.0001

Table 9: Unadjusted and Adjusted Odd Ratio for Preterm Birth in White Non-Hispanic Mothers in NJ during 1999-2011

	Mothers – Crude OR		**Mothers – Adjusted OR**	
	Crude OR	**P-value**	**Adjusted OR**	**P-value**
Maternal age				
12 -<20	1.31 (1.19 – 1.45)	<0.0001	0.94 (0.84 – 1.05)	0.2878
20 -<25	1.14 (1.07 – 1.21)	<0.0001	0.94 (0.88 – 1.01)	0.0795
25 -<30	Ref	-	Ref	-
30- <35	0.92 (0.85 – 1.00)	0.0409	1.01 (0.93 – 1.10)	0.8190
Maternal Education				
<12	1.36 (1.24 – 1.49)	<0.0001	1.16 (1.04 – 1.29)	0.0065
12	1.09 (1.02 – 1.17)	0.0130	1.03 (0.96 – 1.11)	0.4222
13-15	Ref	-	Ref	-
>15 - <18	0.80 (0.74 – 0.86)	<0.0001	0.90 (0.83 – 0.98)	0.0150
Fathers Education				
<12	1.30 (1.18 – 1.44)	<0.0001	1.12 (1.00 – 1.25)	0.0494
12	1.07 (1.00 – 1.15)	0.0547	1.02 (0.94 – 1.10)	0.6542
13-15	Ref	-	Ref	-
>15 - <18	0.77 (0.71 – 0.84)	<0.0001	0.83 (0.76 – 0.91)	<0.0001
Marital Status				
No	1.32 (1.25 – 1.39)	<0.0001	1.07 (1.00 – 1.14)	0.0488
Yes	Ref	-	Ref	-
Kessner's Index of adequacy of prenatal care				
Adequate	Ref	-	Ref	-
Intermediate	1.40 (1.31 – 1.50)	<0.0001	1.33 (1.24 – 1.42)	<0.0001
Inadequate	1.94 (1.76 – 2.15)	<0.0001	1.70 (1.54 – 1.89)	<0.0001

Table 10: Unadjusted and Adjusted Odd Ratio for Preterm Birth in Black Non-Hispanic Mothers in NJ during 1999-2011

	Mothers – Crude OR		**Mothers – Adjusted OR**	
	Crude OR	**P-value**	**Adjusted OR**	**P-value**
Maternal age				
12 -<20	1.04 (0.96 – 1.14)	0.3159	0.93 (0.85 – 1.02)	0.1151
20 -<25	0.93 (0.87 – 1.00)	0.0436	0.87 (0.81 – 0.93)	0.0001
25 -<30	Ref	-	Ref	-
30- <35	0.99 (0.86 – 1.13)	0.8314	1.03 (0.90 – 1.19)	0.6568
Maternal Education				
<12	1.18 (1.08 – 1.29)	0.0002	1.07 (0.97 – 1.18)	0.1765
12	1.12 (1.03 – 1.20)	0.0050	1.06 (0.98 – 1.15)	0.1747
13-15	Ref		Ref	
>15 - <18	0.85 (0.75 – 0.97)	0.0124	0.92 (0.81 – 1.06)	0.2359
Fathers Education				
<12	1.17 (1.03 – 1.32)	0.0139	1.08 (0.95 – 1.23)	0.2376
12	1.13 (1.02 – 1.24)	0.0184	1.07 (0.97 – 1.19)	0.1866
13-15	Ref	-	Ref	-
>15 - <18	0.77 (0.65 – 0.92)	0.0042	0.81 (0.67 – 0.97)	0.0209
Marital Status				
No	1.15 (1.05 – 1.25)	0.0026	1.03 (0.93 – 1.13)	0.6178
Yes	Ref	-	Ref	-
Kessner's Index of adequacy of prenatal care*				
Adequate	Ref	-	Ref	-
Intermediate	1.31 (1.23 – 1.41)	<.0001	1.29 (1.21 – 1.38)	<0.0001
Inadequate	1.50 (1.39 – 1.63)	<.0001	1.45 (1.34 – 1.57)	<0.0001

Table 11: Unadjusted and Adjusted Odd Ratio for Preterm Birth in Hispanic Mothers in NJ during 1999-2011

	Mothers – Crude OR		Mothers – Adjusted OR	
	Crude OR	**P-value**	**Adjusted OR**	**P-value**
Maternal age				
12 -<20	1.15 (1.01 – 1.31)	0.0330	1.00 (0.86 – 1.15)	0.9641
20 -<25	0.99 (0.89 – 1.09)	0.7990	0.91 (0.82 – 1.01)	0.0834
25 -<30	Ref	-	Ref	-
30- <35	1.01 (0.83 – 1.23)	0.9084	1.07 (0.88 – 1.30)	0.5015
Maternal Education				
<12	1.25 (1.10 – 1.42)	0.0007	1.25 (1.08 – 1.45)	0.0030
12	1.12 (1.00 – 1.26)	0.0516	1.13 (0.99 – 1.27)	0.0637
13-15	Ref		Ref	-
>15 - <18	0.79 (0.66 – 0.93)	0.0063	0.82 (0.68 – 0.98)	0.0306
Fathers Education				
<12	0.99 (0.85 – 1.14)	0.8651	0.85 (0.73 – 1.00)	0.0546
12	1.00 (0.88 – 1.14)	0.9863	0.92 (0.80 – 1.05)	0.2285
13-15	Ref	-	Ref	-
>15 - <18	0.67 (0.54 – 0.82)	0.0002	0.73 (0.58 – 0.90)	0.0044
Marital Status				
No	1.07 (0.97 – 1.18)	0.1669	0.93 (0.85 – 1.06)	0.3536
Yes	Ref	-	Ref	-
Kessner's Index of adequacy of prenatal care*				
Adequate	Ref	-	Ref	-
Intermediate	1.24 (1.11 – 1.37)	<0.0001	1.16 (1.09 – 1.34)	0.0005
Inadequate	1.24 (1.20 – 1.60)	<0.0001	1.19 (1.14 – 1.53)	0.0002

Table 12: Unadjusted and Adjusted Odd Ratio for Preterm Birth in White Non-Hispanic Mothers, in NJ during 1999-2011– Model with Grandmother's education

	Mothers – Crude OR		**Mothers – Adjusted OR**	
	Crude OR	**P-value**	**Adjusted OR**	**P-value**
Maternal age				
12 -<20	1.31 (1.19 – 1.45)	<0.0001	0.94 (0.84 – 1.06)	0.3170
20 -<25	1.14 (1.07 – 1.21)	<0.0001	0.94 (0.88 – 1.01)	0.0884
25 -<30	Ref	-	Ref	-
30- <35	0.92 (0.85 – 1.00)	0.0409	1.01 (0.93 – 1.10)	0.8207
Maternal Education				
<12	1.36 (1.24 – 1.49)	<0.0001	1.14 (1.02 – 1.27)	0.0228
12	1.09 (1.02 – 1.17)	0.0130	1.02 (0.95 – 1.10)	0.6512
13-15	Ref	-	Ref	-
>15 - <18	0.80 (0.74 – 0.86)	<0.0001	0.92 (0.84 – 0.99)	0.0303
Fathers Education				
<12	1.30 (1.18 – 1.44)	<0.0001	1.12 (1.00 – 1.25)	0.0564
12	1.07 (1.00 – 1.15)	0.0547	1.02 (0.94 – 1.10)	0.6969
13-15	Ref	-	Ref	-
>15 - <18	0.77 (0.71 – 0.84)	<0.0001	0.84 (0.77 – 0.92)	<0.0001
Grandmother's Education*				
<12	1.39 (1.27 – 1.52)	<0.0001	1.17 (1.06 – 1.29)	0.0013
12	1.23 (1.14 – 1.33)	<0.0001	1.17 (1.07 – 1.26)	0.0002
13-15	Ref	-	Ref	-
>15 - <18	0.99 (0.89 – 1.10)	0.8086	1.07 (0.96 – 1.20)	0.2082
Marital Status				
No	1.32 (1.25 – 1.39)	<0.0001	1.06 (1.00 – 1.14)	0.0710
Yes	Ref	-	Ref	-
Kessner's Index of adequacy of prenatal care*				
Adequate	Ref	-	Ref	-
Intermediate	1.40 (1.31 – 1.50)	<0.0001	1.33 (1.24 – 1.42)	<0.0001
Inadequate	1.94 (1.76 – 2.15)	<0.0001	1.70 (1.54 – 1.88)	<0.0001

Table 13: Unadjusted and Adjusted Odd Ratio for Preterm Birth in Black Non-Hispanic Mothers in NJ during 1999-2011– Model with Grandmother's education

	Mothers – Crude OR		Mothers – Adjusted OR	
	Crude OR	**P-value**	**Adjusted OR**	**P-value**
Maternal age				
12 -<20	1.04 (0.96 – 1.14)	0.3159	0.93 (0.85 – 1.02)	0.1247
20 -<25	0.93 (0.87 – 1.00)	0.0436	0.87 (0.81 – 0.93)	0.0001
25 -<30	Ref	-	Ref	-
30- <35	0.99 (0.86 – 1.13)	0.8314	0.89 (0.89 – 1.19)	0.6712
Maternal Education				
<12	1.18 (1.08 – 1.29)	0.0002	1.06 (0.96 – 1.17)	0.2511
12	1.12 (1.03 – 1.20)	0.0050	1.05 (0.97 – 1.14)	0.2465
13-15	Ref	-	Ref	-
>15 - <18	0.85 (0.75 – 0.97)	0.0124	0.93 (0.81 – 1.07)	0.2906
Fathers Education				
<12	1.17 (1.03 – 1.32)	0.0139	1.08 (0.95 – 1.23)	0.2599
12	1.13 (1.02 – 1.24)	0.0184	1.07 (0.97 – 1.19)	0.1905
13-15	Ref	-	Ref	-
>15 - <18	0.77 (0.65 – 0.92)	0.0042	0.81 (0.67 – 0.97)	0.0217
Grandmother's Education				
<12	1.19 (1.07 – 1.31)	0.0008	1.10 (0.99 – 1.22)	0.0796
12	1.19 (1.07 – 1.31)	0.0009	1.14 (1.03 – 1.26)	0.0130
13-15	Ref	-	Ref	-
>15 - <18	0.95 (0.78 – 1.16)	0.6407	1.00 (0.82 – 1.23)	0.9802
Marital Status				
No	1.15 (1.05 – 1.25)	0.0026	1.02 (0.93 – 1.12)	0.6922
Yes	Ref	-	Ref	-
Kessner's Index of adequacy of prenatal care*				
Adequate	Ref	-	Ref	-
Intermediate	1.31 (1.23 – 1.41)	<.0001	1.29 (1.20 – 1.38)	<0.0001
Inadequate	1.50 (1.39 – 1.63)	<.0001	1.45 (1.34 – 1.57)	<0.0001

Table 14: Unadjusted and Adjusted Odd Ratio for Preterm Birth in Hispanic Mothers in NJ during 1999-2011– Model with Grandmother's education.

	Mothers – Crude OR		Mothers – Adjusted OR	
	Crude OR	**P-value**	**Adjusted OR**	**P-value**
Maternal age				
12 -<20	1.15 (1.01 – 1.31)	0.0330	1.01 (0.87 – 1.16)	0.9376
20 -<25	0.99 (0.89 – 1.09)	0.7990	0.91 (0.82 – 1.01)	0.0896
25 -<30	Ref	-	Ref	-
30- <35	1.01 (0.83 – 1.23)	0.9084	1.07 (0.87 – 1.30)	0.5297
Maternal Education				
<12	1.25 (1.10 – 1.42)	0.0007	1.20 (1.03 – 1.39)	0.0176
12	1.12 (1.00 – 1.26)	0.0516	1.10 (0.97 – 1.25)	0.1308
13-15	Ref		Ref	-
>15 - <18	0.79 (0.66 – 0.93)	0.0063	0.83 (0.69 – 1.01)	0.0562
Fathers Education				
<12	0.99 (0.85 – 1.14)	0.8651	0.84 (0.72 – 0.99)	0.0393
12	1.00 (0.88 – 1.14)	0.9863	0.92 (0.80 – 1.05)	0.2042
13-15	Ref	-	Ref	-
>15 - <18	0.67 (0.54 – 0.82)	0.0002	0.73 (0.58 – 0.91)	0.0050
Grandmother's Education				
<12	1.40 (1.15 – 1.70)	0.0007	1.29 (1.06 – 1.58)	0.0122
12	1.16 (0.95 – 1.43)	0.1431	1.14 (0.93 – 1.40)	0.2028
13-15	Ref	-	Ref	-
>15 - <18	1.00 (0.69 – 1.44)	0.9982	1.06 (0.74 – 1.54)	0.7388
Marital Status				
No	1.07 (0.97 – 1.18)	0.1669	0.94 (0.85 – 1.05)	0.2912
Yes	Ref	-	Ref	-
Kessner's Index of adequacy of prenatal care*				
Adequate	Ref	-	Ref	-
Intermediate	1.24 (1.11 – 1.37)	<0.0001	1.21 (1.08 – 1.34)	0.0006
Inadequate	1.24 (1.20 – 1.60)	<0.0001	1.32 (1.14 – 1.53)	0.0002

4. MATERNAL EDUCATION AND RISK OF SMALL-FOR-GESTATIONAL-AGE BIRTHS ACROSS GENERATIONS

4.1. Abstract

4.1.1. Aim/Purpose

In this chapter we examine the effect of grandmother's education on the risk of small-for-gestational (SGA) in her grandchildren to determine if an association exists and, if so, whether it is independent of mother's education.

4.1.2. Background

Maternal lifelong socioeconomic status (SES) is known to affect reproductive health. There are many studies that have shown strong association of mother's current SES with adverse birth outcomes. However, few studies have investigated associations with mother's childhood SES or grandparents' education. In U.S. blacks, previous data suggest that improvement in SES from childhood to adulthood is associated with improved birth outcomes, but results for whites have been mixed.

4.1.3. Methods

We created a transgenerational dataset to examine the effect of grandmother's education, a dimension of SES, on risk of SGA in grandchildren. Using Link King Software we matched female infants listed on NJ birth certificates in 1979-1983 to mothers listed on NJ birth certificates for the years 1999-2011. Thus grandmothers were the women delivering in 1979-1983, and mothers were those born to the grandmothers who in turn delivered grandchildren in 1999-2011. We performed descriptive tabulations and multivariate logistic regression to get for risk estimates using Statistical Analysis System (SAS) software.

4.1.4. Results

In total we linked 107,347 grandmother and mother pairs. After excluding records that had missing month in LMP dates, the final sample for analysis was 105,033. Overall, maternal education was associated inversely with SGA births in each of the three largest demographic groups in New Jersey (non-Hispanic whites and blacks and Hispanics). There was a substantial inter-generational increase in education between grandmothers and mothers in each group, but it was most striking in Hispanics. SGA was more common in 1979-83 births than in 1999-2011. In univariate analysis, mother's education was strongly and consistently, inversely related to SGA, whereas grandmother's education was related less strongly and only in whites. After adjusting for potential confounders, the relationship to grandmother's education largely disappeared. SGA in grandchildren was more common among low-education mothers, but grandmother's education had little effect. Although the overall SGA rates were higher in blacks and Hispanics as compared to whites, the effect of lower maternal education on risk of SGA was strongest in whites, and after adjusting for confounders it lost significance in blacks and Hispanics especially in the 1999-2011 births. Father's education was inversely related to SGA in all three ethnic groups and across both generations.

4.1.5. Conclusions/implications

In summary, we found that maternal education was an important predictor of SGA both in 1979-82 and in 1999-2011. Grandmother's education was not strongly related to SGA in the grandchildren. Our results suggest that mother's childhood and preconception socioeconomic environment, including the educational level of her childhood household, are independent predictors for delivering preterm, but have less effect on intra-uterine growth.

4.2. Introduction

4.2.1. Background

Small-for-gestational age (SGA) babies are defined as babies that are below the 10th centile of birthweight-for-gestational-age, gender-specific reference population. SGA is an important risk factor not only for infant morbidity and mortality, but also for long-term developmental, medical, and economic disadvantage for the infants and their families.[1,2]

A body of evidence has shown that in addition to other established risk factors, mother's current socioeconomic disadvantage is strongly associated with risk of SGA, even after controlling for important confounding variables. Different markers of socioeconomic disadvantage such as maternal and paternal occupation, neighborhood environment and education have been examined and the results have shown that they all influence SGA to some extent. A study conducted by Beard et al.[3] found nearly half of the increased risk for SGA in socioeconomically disadvantaged women was accounted for by maternal smoking and delayed entry into antenatal care. However, a strong relationship between socioeconomic disadvantage and SGA remained after controlling for both of these covariates as well as race. Another recent Europe-wide systematic review of child cohort studies demonstrated a higher risk of SGA among babies born to mothers with low levels of education.[4]

There is an extensive literature on the effect of mother's current SES and its effect on SGA. However only a few studies have investigated the effect of mother's lifelong SES and its effect on SGA A study conducted by Love et. al.[5] reported that African-American women who were born in poor neighborhoods and were still poor as mothers had higher odds of having SGA babies compared to White women. The study also showed that

African-American women in upper-income areas at both time points had a steady fall in SGA rate with maternal age, similar to the pattern seen in White women. However, after controlling for other potential confounders no group of white women, even those always living in poor neighborhoods, exhibited higher risk of SGA than their African- American peers. This could be partly because of small sample size in different age groups. Other inherent limitations of the data may include missing or inaccurate recall of last menstrual date or too homogenous a population. However, the extent to which experience of grandmothers may affect SGA in grandchildren is incompletely understood.

It is well established that SGA birth tends to repeat across generations, so that women who were themselves born SGA are at increased risk for having an SGA delivery.[6] Although transgenerational persistence of social status could contribute to this, the extent to which the persistence of SES may explain the transgenerational repetition of SGA is not well defined. Therefore we propose here to examine the effect of grandmother's and mother's education on SGA among non-Hispanic Whites, non-Hispanic Blacks and Hispanic women in New Jersey. Maternal education is one of the strongest SES predictors of SGA[7], so we will use grandmother's and mother's education as indicators of SES across generations and examine whether grandmother's education modifies the risk of SGA, independent of mother's education. Finally, we will examine whether grandmothers education affects SGA incidence in an equivalent manner after adjusting for maternal education.

Previous studies that have examined the intergenerational effect of SES status on birth outcomes, have mostly focused on whites, and those studies that did investigate this effect in both whites and blacks did not have large enough samples to detect modest association of economic mobility and adverse birth outcomes. We believe this is the first analysis to examine the intergenerational effect of mother's SES status not only in non-Hispanic Whites (referred to as whites) and non-Hispanic Blacks (referred to as Blacks), but also in Hispanic mothers. In 2014 Hispanics made up nearly 26 percent of all New Jersey births.[8]

4.2.2. Significance of small-for-gestational age

According to WHO expert committee small for gestational age (SGA) is defined as infants below the 10th centile of a birthweight-for-gestational-age in a gender-specific reference population;[1,2] that is SGA babies will have birthweight below the 10th percentile for babies of the same gestational age. Across the world there is considerable variation in the prevalence of infants born SGA; in Europe the prevalence of SGA is about 4.6–15.3 % [3] while in low and middle-income countries, it is estimated that 27 % of all live births were SGA (more than 32 million infants) in 2010.[4]

In US, in the late 20th century the average birth weight increased, however more recent data have shown the mean birth weight among the term babies (37-41 weeks) has decreased since the last decade and thus the birthweight distribution has shifted to the left. Similar trends are seen in New Jersey too. In 2015 in state of NJ, 7.8% of total births were LBW. SGA births comprise 40-43% of LBW infants in all of the three major race/ethnic groups. [9]

4.2.3. Methods

In order to assess the association of maternal education with SGA across generations, we created a transgenerational file that included all 1999-2011 births in New Jersey (NJ) to mothers who were themselves born in the state in 1979-83. The cohort was assembled by matching the birth certificates across the two periods. Female infants born in 1979-1983 were matched to mothers who delivered in 1999-2011, using Link King Software.[10,11] Principal matching variables were infant name, date of birth, race and ethnicity in 1979-83 and mother's maiden name, date of birth, race and ethnicity in 1999-2011. Birth data were provided by the NJ Department of Health.

For the years 1979-83 there were 490,143 births in total of which 241,221 were girls. For the years 1999 through 2011, there were 1,499,891 births to NJ residents of which 611,737 births were to mothers whose own birthplace was in New Jersey and who delivered either in or out of state. We excluded the births that occurred out of state which gave us the final sample of 602,336 births.

For women giving birth in 1979-83, which we refer to as "grandmother's generation", we had data only on grandmother's and grandfather's age, education and marital status, all taken from the 1979-83 birth certificates. Race and ethnicity was somewhat incomplete in the 1979-83 file, so we used race and ethnicity that was available for the mothers on the matched 1999-2011 birth certificates, which we refer to as "mother's generation". These were analyzed separately for white, black and Hispanics. In addition to the basic demographics (mothers and fathers age, education, marital status), we also examined the association of maternal medical risk factors and complications in mothers. However, because of limited numbers and missing data we did not use these variables in regression analysis. In 1979-83, NJ did not collect information on smoking or on medical risk factors and complications, so we could not examine these variables for grandmothers. . A more detailed description of the construction of the New Jersey transgenerational birth file is included in the Methods Chapter.

4.3. Statistical Analysis

We defined SGA as race-sex-specific birthweight below the 10th percentile for gestational age for both cohorts based on 1999-2011 livebirths. Gestational age– and sex-specific birth weight means, SDs, and smoothed percentiles (3rd, 5th, 10th, 90th, 95th, 97th) were calculated for livebirths in the 1999-2011 cohort, and the 10th and 90th percentiles were compared with the livebirths born in 1979-83. We decided to use race/ethnicity specific internal standards, because our main interest was to look at the relationship to education within these groups separately rather than to emphasize the well-known differences among them.[12,13]

We performed descriptive tabulations of maternal and birth outcome data for both sets of deliveries and used chi- square tests and t-tests, as appropriate to test for statistically significant differences. Multivariate logistic regression analyses were used to examine the effect of grandmother's education on risk of SGA in the 1979-83 deliveries before and after adjusting for her age, marital status, prenatal care and grandfather's education. Next we examined the similar relationship for mother's generation (1999-2011 births).

Finally we used logistic regression models that included both grandmother's and mother's educational levels to estimate the effect of grandmother's education on SGA, after accounting for the effect of maternal education and other covariates . Crude and adjusted odds ratio were calculated for each analysis. All statistical tests were two sided and were tested at 0.05 significance value. Some exploratory analyses were tested at a 0.10 significance value.

4.4. Results

4.4.1. Characteristics of mothers across two generations among all race/ethnicity

In total we linked 105,033 grandmother and mother pairs. After excluding records that had missing month in LMP dates, the final sample for analysis was 105,033 pairs of mothers and grandmothers. Characteristics of grandmothers and mothers are shown in Table 1. Grandmothers were more likely to be young and married as compared to mothers.

There was a large positive shift in educational attainment in mothers as compared to grandmothers and mothers among all race/ethnic groups. This shift was most striking among Hispanics where 28% of mothers had some college education as compared to only 6% of grandmothers. A similar shift in education was also seen in fathers.

4.4.2. SGA rates in births to grandmothers and mothers among Whites, Blacks and Hispanics

The proportion of infants who were SGA was slightly smaller in the 1999-2011 births than in the 1979-83 births in each race/ethnic group (table 1). Figure 2 and tables 2-4 show the trends in SGA delivery rates with maternal education among both grandmothers and mothers. Among whites (table 2) more education was associated with lower SGA rates in both grandmothers and mothers. In both generations women educated beyond high school were more likely than their less educated peers to avoid having an SGA baby although the relationship appeared stronger in 1999-2011. Since we only studied female births in 1979-83, in Table 2 we limited the 1999-2011 births to females as well. Data for 1999-2011 male births are shown in Table 2.1 and were almost identical in their relationship to maternal education. In blacks (table 3), a similar significant inverse association of maternal education with SGA was seen —the lower the educational level, the higher the SGA risk. However, the rates of SGA for black mothers were lower at all educational levels as compared to the grandmothers. SGA rates in Hispanics (table 4) followed a similar pattern with maternal education as seen in whites and blacks except that the SGA rates did not change much between generations. We calculated SGA morbidity ratios standardized for the changes in educational levels (SMR's) across generations in each of the race/ethnic groups to explore whether the changes in education could explain the changes in SGA rates (data not shown). When the SGA rates seen in the 1979-1983 births were applied to the educational levels of 1999-2011 mothers, the

SMR's were 1.02 for whites, 1.07 for blacks, and 0.94 for Hispanics. This suggests that the change in educational levels is sufficient to explain the small improvement in SGA seen in whites, but not sufficient to explain the larger improvements seen in blacks. The substantial improvement in educational levels in Hispanics was associated with a smaller decrease in SGA rates than would have been expected based on the education-specific rates that obtained in the earlier years.

As noted above Tables 2.1, (and 3.1 and 4.1) show SGA rates for male babies among whites, blacks and Hispanics who were born during 1999-2011. The SGA rates and their association with maternal education is very similar to female babies and so are the rates.

4.4.3. Effect of maternal education, crude and adjusted, on risk of SGA in singleton during 1979-83 births.

Tables 5-7 show odds ratios for SGA births among grandmothers (1979-1983) before and after adjustment for other risk factors recorded on the birth certificates. These and subsequent tables are limited to singleton births in order to show that twins and triplets are not skewing the results. The crude odds ratios reflect the SGA rates shown for grandmothers in Tables 2, 3, and 4. The adjustments for covariates (right hand columns) do not substantially attenuate the relationship of maternal education to SGA birth in most instances in either whites or blacks, but they are somewhat attenuated in Hispanics. In contrast, the association of fathers' educational attainment with SGA birth seems to be largely explained by other variables, especially mothers' education. The modest univariate relationships of maternal age to SGA seen in the grandmothers nearly all becomes non-significant when adjusted for the other covariates. The excess risk of SGA associated with being unmarried and with inadequate prenatal care are somewhat attenuated in multivariate analysis but persist as statistically significant.

Tables 8-10 show odds ratios for SGA singleton births to mothers (1999-2011). Again the crude odds ratios reflect the SGA rates shown in Tables 2-4 where twins and triplets were included. The substantial inverse association of maternal education with SGA in whites (Table 8) is attenuated only slightly in the multivariate analysis and remains statistically significant. Fathers' education has only a modest inverse association with SGA in these white babies, and this disappears when mothers' education and other variables are included in the multivariate model. Because maternal education may influence the choice of partner, age at childbirth, attendance at prenatal care and other perinatal risk factors, it is not clear that the adjusted odds ratios are more meaningful than the unadjusted ones.

In blacks and Hispanics maternal education has a weaker univariate association with SGA than it does in whites and the association largely disappears when other variables are taken into account. Fathers' education is also weak and unimpressive as a protective factor in these two minority groups.

Maternal age is limited to the range 16-32 years in the 1999-2011 births because only births to women born in 1979-83 were included. This may help to explain the weak and mostly non-significant association of mother's age with SGA in the later birth cohort.

Being unmarried was still associated with SGA in the 1999-2011 births in whites, although the relative risks were lower than they were in 1979-1983. The pattern in Hispanics was similar to whites although being unmarried was associated with a more modest relative risk that was not statistically significant in multivariate analysis. There was very little SGA risk associated with being unmarried among black women.

4.4.4. Effect of grandmother's education on risk of SGA in grandchildren, after adjusting for mother's education and other covariates

To examine the intergenerational effect of grandmother's education on risk of her grandchildren being SGA, we added the grandmother's education to other maternal characteristics as shown in Tables 11-13. Grandmother's educational level was generally not predictive of SGA in the grandchildren and was not a significant predictor in the presence of maternal and other birth certificate predictors.

4.5. Discussion

Over the two generations included in this analysis the proportion of infants born SGA decreased slightly. The percentage decrease was most prominent in blacks (14%), modest in whites (7%) and slight in Hispanics (4%). Maternal education was associated inversely with SGA birth rates in both generations and in all three race/ethnic groups (Figure 2), although the association appeared weaker in Hispanics and in the younger generation in blacks. The strength of the associations with maternal education were attenuated by inclusion of father's education, marital status and prenatal care attendance, but it is not clear if it is appropriate to adjust for these attributes since they may be in the causal pathway that would link maternal education to SGA. Although grandmother's education was inversely associated with SGA in her children, born in 1979-1983, it had no influence on risk of SGA in grandchildren after taking mother's education into account.

Women in all three demographic groups delivering infants in 1999-2011 were substantially better educated than were their mothers who delivered in 1979-83. Fathers were also more educated than grandfathers and in the three ethnic groups, paternal education was also inversely associated with SGA births;

Educational level is a component of most measures of SES and is more likely than income or wealth to remain constant during the child-rearing period. It also is less prone to misreporting than is income or wealth. Our findings were supported by a study conducted by Parker et.al.[14] where white mothers with less than high school had approximately twice the odds of having a LBW and SGA infant as did mothers with some college education. Similar to our study they also did not see as strong an association between education and SGA among blacks. Another meta-analysis[15] based on 12 European cohorts with data on maternal education and adverse birth outcomes, also showed that in some cohorts, low maternal education was strongly associated with a greater risk of SGA.

In our study, although the overall SGA rates are higher in blacks and Hispanics as compared to whites, the effect of lower maternal education on risk of SGA was strongest among whites. In blacks and Hispanics, the inverse association of maternal education was weaker, especially in the 1999-2011 births, and lost statistical significance when correlated variables including father's education, Kessler index and marital status were included in the multivariate models. As noted above maternal education may have some of its effect through these other correlates of social status, so it may be inappropriate to adjust for these variables. Nevertheless, the inconsistent relationship among the three ethnic groups does indicate that education does not translate the same social position in white, black and Hispanic women[17,18], because income and education indicators do not fully capture SES. There is evidence that the actual socioeconomic conditions of African Americans and Whites at the same income or education level are not equivalent.[17,18]

The use of customized centiles for measurement of socioeconomic inequalities has been challenged[19,20] since this inherently adjust for ethnicity which is itself associated with socioeconomic status and, thus, might attenuate or mask pathological (or nonphysiologic) inequalities.[19,21] In the present study we used the10th percentiles of birth weight for gestational age as defined separately for white, black and Hispanic infants, based on race-specific birth weight distributions of births that occur during 1999-2011 and used these race/ethnicity standards across both generations. Clearly, the use of these different standards obscures any race/ethnic differences in birth weight at the different gestational ages. Thus, the differences in SGA in our analysis can only be interpreted within race/ethnic groups.

Another consistent finding in our study was that among all three ethnic groups and across two generations, father's education was strongly (inversely) associated with risk of SGA. These results are consistent with previous studies that were conducted in United States.[14] The consistency of this association may reflect the gender inequality seen in American life, where most high paid level jobs are held by men, while less-well-paid jobs are held by women. Another possible explanation could be that most of the women are single or unmarried and are dependent either on family member for financial support or government programs. This could cause severe economic stress, which may cause major physiological changes leading to worse gestational outcomes. In our study unmarried mothers were at higher risk of delivering SGA infants in all three race/ethnic groups.

We showed in Chapter 3 that the education of grandmothers had a consistent inverse association with the occurrence of preterm birth in their grandchildren that was independent of the educational level of the mothers. This intergenerational association was not seen for SGA, suggesting that more proximal SES circumstances are dominant in mediating SES effects on SGA. We could not find any previous studies that investigated the intergenerational effect using education as a marker of SES. However, a few studies have investigated intergenerational effects on SGA, using neighborhood or other SES markers. Collins., et al.[18] examined life-long economic mobility on SGA, LBW & PTB and reported that African-American mothers with extended childhood residence in impoverished neighborhoods but who experienced upward economic mobility by adulthood nevertheless had SGA rates that were similar to their adult peers who did not have this SES improvement. The upward mobility was significantly associated with low preterm birthrates but such effect was not seen for SGA. Another study conducted by Love et. al.[17] reported that African-American women who were born in poorer neighborhoods and were still poor as mothers had higher odds of having LBW and SGA babies, but were not able to establish the similar association with respect to PTB.

One possible explanation why we did not see any intergeneration effect of education on SGA could be because SGA is mainly determined by contemporaneous events in pregnancy. Thus, any economic contraction that happens early in pregnancy may be significantly associated with higher risk of SGA. There are several mechanisms may explain the observed association between the economic recession and increase in LBW/SGA. Based on the work done by Margerison-Zilko et al. and others[22-25], the unexpected economic collapse happening early in pregnancy might increase the stress levels among pregnant women causing direct physiological changes to the endocrine, immune and cardiovascular systems; changes that may adversely affect the process of gestation. Furthermore, these stressful conditions, such as income shocks may promote adverse health behaviors, thus acting as mediators between the stress caused by the economic collapse and the observed increase in LBW and SGA.

This study has a number of strengths including its large size, its inclusion of substantial data on blacks and Hispanics as well as whites and its unusual cross generation perspective. While New Jersey is not formally representative of the nation, it does have similar proportions of blacks' and Hispanics as well as substantial populations in urban and rural settings and in all income strata. The matching of infant girls born in

1979-83 with mothers delivering in 1999-2011 was highly accurate as evidenced by the overwhelming majority (96.8%) of matches that were found to be at the highest level of certainty identified in the Link King software and by hand review of a large sample of matches. Our findings of lower rates of SGA birth in the more recent time period, and to that education may not translate the same social position in white, black and Hispanic women are consistent with prior work, but it goes beyond this earlier work in showing that there is no effect of grandmother's education on SGA in grandchildren as there is for preterm birth. Limitations include the focus on women who have had a stable residential history who may not be representative of all births and the absence of measurements of many other risk factors for SGA birth. However, maternal education precedes the development of most other risk factors, so that it might not be appropriate to adjust for them even if they had been measured.[26-29] And it could be argued that limiting some of the geographic movement in the population may make it easier to identify the correlates of maternal education.

4.6. Tables

Table 1: Characteristics of Grandmothers and Mothers by Race/Ethnicity in NJ during 1979 -1983 and 1999-2011*

	Grandmothers– 1979 – 1983			Mothers – 1999-2011		
	White Non-Hispanic	Black Non-Hispanic	Hispanic	White Non-Hispanic	Black Non-Hispanic	Hispanic
	N=56,863	N=30,920	N=15,296	N=56,863	N=30,920	N=15,296
Maternal age						
12 -<20	9.76	33.50	24.57	7.36	19.58	17.61
20 -<25	33.24	35.99	36.35	28.37	44.58	40.85
25 -<30	35.61	18.60	22.68	49.65	30.93	35.36
30- <35	16.89	8.71	10.77	14.61	4.89	6.16
Missing	4.50	3.21	5.62	0.0	0.01	0.01
Maternal Education						
<12	15.26	38.50	35.20	9.25	22.55	24.28
12	52.04	41.10	31.23	32.60	45.16	39.87
13-15	16.24	11.57	6.82	23.80	22.33	23.23
>15 - <18	12.09	3.12	2.41	33.78	7.86	11.66
Missing	1.19	1.27	1.09	0.58	2.10	0.96
Fathers Education						
<12	12.61	10.17	26.31	8.51	11.02	20.32
12	44.00	25.19	28.27	37.02	36.40	41.22
13-15	15.01	6.62	6.51	20.11	12.45	16.10
>15 - <18	19.04	3.04	3.30	26.48	4.56	7.89
Missing	5.76	53.48	16.27	7.88	35.58	14.47
Preterm birth						
Very (20 -< 32)	1.05	4.11	1.97	1.48	3.45	1.84
Late (32 -< 37	11.54	20.94	15.92	6.75	10.56	8.37
Term (37-47)	86.54	73.81	81.40	89.25	81.92	86.97
Missing	0.87	1.13	0.71	2.51	4.07	2.82
Foreign born						
Yes	0.54	0.26	54.30	NA	NA	NA
Small-for-gestational age						
Female	10.65	11.44	10.32	9.91	9.88	9.86
Male	NA	NA	NA	9.94	9.86	9.83

	Grandmothers– 1979 – 1983			Mothers – 1999-2011		
	White Non-Hispanic	**Black Non-Hispanic**	**Hispanic**	**White Non-Hispanic**	**Black Non-Hispanic**	**Hispanic**
	N=56,863	**N=30,920**	**N=15,296**	**N=56,863**	**N=30,920**	**N=15,296**
Married						
No	10.02	70.31	39.74	37.49	86.98	69.29
Gender						
Male	NA	NA	NA	51.27	50.68	51.66
Female	100	100	100	48.73	49.31	48.34
Low Birthweight						
0- <2500	4.84	13.36	6.81	6.76	12.70	8.50
Kessner's Index of adequacy of prenatal care						
Adequate	80.56	53.08	62.99	77.39	54.60	65.29
Intermediate	14.84	27.64	21.58	15.83	26.03	22.40
Inadequate	4.59	19.28	11.73	5.13	15.40	9.58

***Values shown are percentages**

Figure 2: SGA Rates (%) in Grandmothers and Mothers by Educational status in NJ during 1979–1983 and 1999-2011

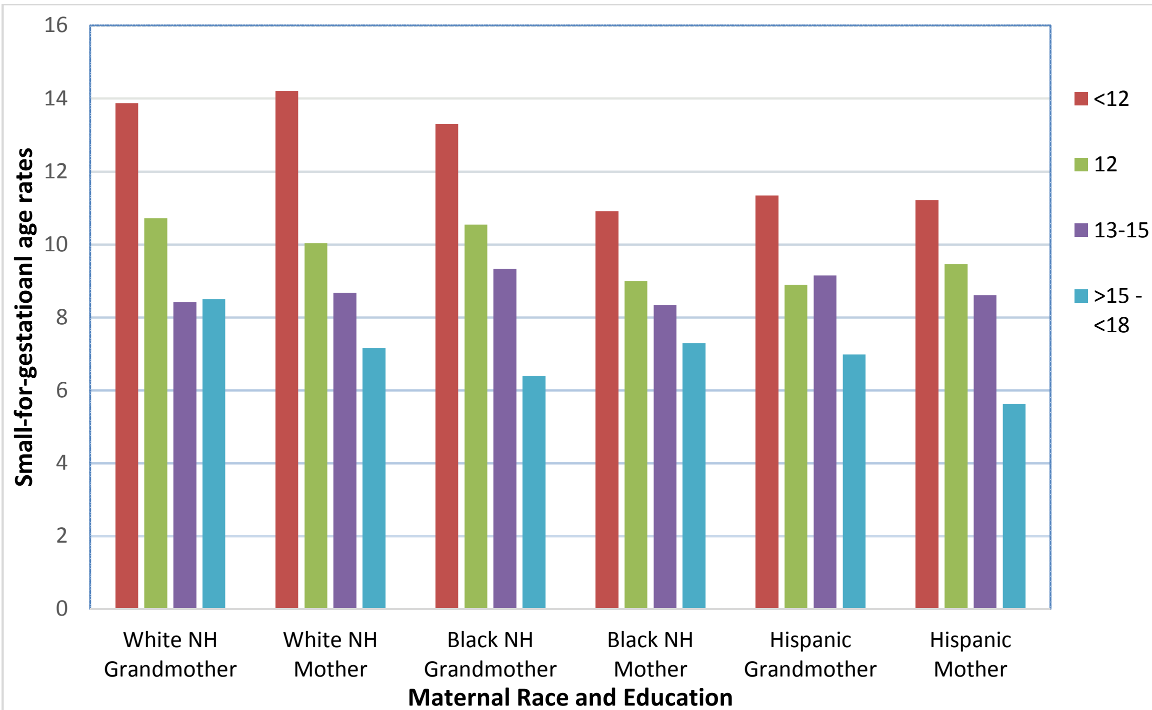

Table 2: SGA Rates among Female Births to White Non-Hispanic Grandmothers and Mothers in NJ during 1979–1983 and 1999-2011

	Grandmothers – 1979 – 1983		**Mothers – 1999-2011**	
	Number at risk (26,627) N	**SGA (2,837) %**	**Number at risk (26,738) N**	**SGA (2,650) %**
Maternal age				
12 -<20	2,627	11.84	1,786	11.93
20 -<25	8,823	11.53	7,414	11.01
25 -<30	9,493	9.95	13,495	9.39
30- <35	4,487	9.72	4,042	8.76
Missing	1,197	10.69	N/A	N/A
p-value*	0.0005		<.0001	
Maternal Education				
<12	4,930	13.98	2,311	15.06
12	13,874	10.61	8,682	10.69
13-15	4,235	8.41	6,377	9.44
>15- <18	3,292	8.63	9,216	8.17
Missing	296	12.16	152	12.50
p-value**	<.0001		<.0001	
Fathers Education				
<12	4,294	12.62	2,161	12.54
12	11,730	10.55	9,900	10.06
13-15	4,042	10.54	5,529	9.17
>15- <18	5,054	8.37	7,165	8.36
Missing	1,507	13.87	1,983	13.97
p-value**	0.0022		0.1382	
Married				
No	2,622	15.45	9,739	11.97
Yes	23,994	10.13	16,998	8.73
p-value*	<.0001		<.0001	
Kessner's Index of adequacy of prenatal care*				
Adequate	21,284	10.09	21,069	9.33
Intermediate	3,882	12.73	4,254	10.88
Inadequate	1,190	13.95	1,312	15.02
Missing	271	10.70	NA	NA
p-value**	<.0001		<.0001	

* p-values for chi-square; **p-values for chi-square trend test

Table 2.1: SGA Rates among Male and Female Births in White Non-Hispanic Mothers in NJ during 1999-2011

	Male babies		Female babies	
	Number at risk (27,036) N	**SGA (2,455) %**	**Number at risk (25,753) N**	**SGA (2,347) %**
Maternal age				
12 -<20	1,930	11.97	1,762	11.41
20 -<25	7,784	10.42	7,227	10.32
25 -<30	13,487	8.52	12,955	8.63
30- <35	3,835	6.88	3,808	7.41
Missing	0	0	1	0.00
p-value*	<.0001		<.0001	
Maternal Education				
<12	2,483	14.70	2,252	14.21
12	8,812	9.74	8,423	10.03
13-15	6,442	8.60	6,148	8.67
>15- <18	9,150	7.25	8,783	7.17
Missing	149	10.07	147	12.93
p-value**	<.0001		<.0001	
Fathers Education				
<12	2,343	11.57	2,106	11.82
12	10,014	9.57	9,593	9.36
13-15	5,370	7.90	5,317	8.37
>15- <18	7,207	7.19	6,807	7.20
Missing	2,102	13.51	1,930	13.73
p-value**	0.0309		0.1382	
Married				
No	10,142	11.44	9,487	11.36
Yes	16,893	7.67	16,265	7.80
p-value*	<.0001		<.0001	
Kessner's Index of adequacy of prenatal care*				
Adequate	21,102	8.32	20,251	8.52
Intermediate	4,355	10.91	4,124	10.16
Inadequate	1,453	14.59	1,280	14.14
Missing	126	10.32	98	21.43
p-value**	<.0001		<.0001	

*p-values for chi-square; **p-values for chi-square trend test

Table 3: SGA Rates among Female Births to Black Non-Hispanic Grandmothers and Mothers in NJ during 1979–1983 and 1999-2011

	Grandmothers– 1979 – 1983		Mothers – 1999-2011	
	Number at risk (14,704) N	SGA (1,682) %	Number at risk (14,383) N	SGA (1,421) %
Maternal age				
12 -<20	4,907	11.64	2,593	10.26
20 -<25	5,345	11.73	6,406	10.32
25 -<30	2,662	11.16	4,637	8.99
30- <35	1,311	10.45	746	10.32
Missing	479	10.44	NA	NA
p-value*	0.6294		0.1867	
Maternal Education				
<12	5,690	13.08	3,097	11.62
12	6,107	10.56	6,599	9.79
13-15	1,644	9.43	3,282	9.08
>15- <18	444	6.53	1150	8.17
Missing	186	9.68	255	9.02
p-value**	<.0001		0.0003	
Fathers Education				
<12	1,696	11.44	1,588	10.89
12	3,745	9.40	5,255	9.38
13-15	972	8.44	1,803	7.49
>15- <18	454	7.49	666	8.86
Missing	7,837	13.02	5,071	11.06
p-value**	<.0001		0.0506	
Married				
No	10,304	12.37	12,451	10.08
Yes	4,393	9.24	1,932	8.59
p-value*	<.0001		0.0446	
Kessner's Index of adequacy of prenatal care**				
Adequate	7,557	10.03	8,083	8.35
Intermediate	4,012	12.19	3,871	11.91
Inadequate	2,741	13.83	2,259	11.73
Missing	394	14.21	NA	NA
p-value	<.0001		<.0001	

* p-values for chi-square; **p-values for chi-square trend test

Table 3.1: SGA Rates among Male and Female Births to Black Non-Hispanic Mothers in NJ during 1999-2011

	Male Babies		**Female Babies**	
	Number at risk (14,496) N	**SGA (1,315) %**	**Number at risk (13,806) N**	**SGA (1,260) %**
Maternal age				
12 -<20	2,731	8.79	2,538	9.81
20 -<25	6,515	9.47	6,156	9.62
25 -<30	4,564	8.72	4,413	8.16
30- <35	684	8.77	698	8.45
Missing	0	0	1	0.00
p-value*	0.6484		0.1867	
Maternal Education				
<12	3,223	10.80	2,987	10.91
12	6,511	9.05	6,320	9.00
13-15	3,295	7.95	3,154	8.34
>15- <18	1,182	7.28	1,097	7.29
Missing	285	10.53	248	8.87
p-value**	0.0002		0.0003	
Fathers Education				
<12	1,602	9.49	1,538	10.40
12	5,354	9.23	5,046	8.60
13-15	1,848	7.85	1,725	7.01
>15- <18	688	6.69	630	8.10
Missing	5,004	9.55	4,867	10.15
p-value**	0.8452		0.1125	
Married				
No	12,602	9.24	11,966	9.35
Yes	1,892	7.98	1,840	7.66
p-value*	0.0784		0.0192	
Kessner's Index of adequacy of prenatal care**				
Adequate	8,173	7.89	7,740	7.60
Intermediate	3,880	9.82	3,711	10.97
Inadequate	2,306	11.71	2,194	11.21
Missing	137	13.87	161	11.80
p-value	<.0001		<.0001	

* p-values for chi-square; **p-values for chi-square trend test

Table 4: SGA Rates among Female Births to Hispanic Grandmothers and Mothers in NJ during 1979–1983 and 1999-2011 Hispanic

	Grandmothers– 1979 – 1983		**Mothers – 1999-2011**	
	Number at risk (7,165) N	**SGA (740) %**	**Number at risk (7,063) N**	**SGA (698) %**
Maternal age				
12 -<20	1,788	13.42	1,156	11.42
20 -<25	2,567	9.86	2,899	10.11
25 -<30	1,634	9.61	2,568	8.84
30- <35	784	8.29	438	10.05
Missing	392	6.38	2	0.00
p-value*	<.0001		<.0001	
Maternal Education				
<12	4,241	11.41	1,658	11.88
12	2,216	8.89	2,832	9.89
13-15	473	9.30	1,663	9.56
>15- <18	164	6.10	847	6.49
Missing	71	7.04	63	11.11
p-value**	0.0005		0.0001	
Fathers Education				
<12	3,311	10.60	1,419	10.78
12	2,054	9.35	2,937	10.21
13-15	434	8.76	1,152	7.90
>15- <18	232	4.31	567	7.23
Missing	1,134	13.14	988	11.44
p-value**	0.1605		0.5430	
Married				
No	2,878	12.61	4,881	10.51
Yes	4,286	8.77	2,182	8.48
p-value*	<.0001		0.0084	
Kessner's Index of adequacy of prenatal care**				
Adequate	4,475	9.99	4,754	9.09
Intermediate	1,773	10.55	1,587	11.09
Inadequate	821	11.57	657	13.09
Missing	96	11.46	65	6.15
p-value**	0.1526		0.0020	

* p-values for chi-square; **p-values for chi-square trend test (2-sided)

Table 4.1: SGA Rates among Male and Female Births to Hispanic Mothers in NJ during 1999-2011

	Males Babies		**Females Babies**	
	Number at risk (7,482) N	**SGA (689) %**	**Number at risk (6,865) N**	**SGA (633) %**
Maternal age				
15 -<20	1,294	11.67	1,142	11.12
20 -<25	3,068	9.06	2,828	9.62
25 -<30	2,659	8.24	2,475	7.88
30- <35	461	8.89	418	8.85
Missing	0	0	2	0
p-value*	0.0058		<.0001	
Maternal Education				
<12	1,775	11.61	1,622	11.22
12	2,994	8.98	2,759	9.46
13-15	1,758	7.91	1,604	8.60
>15- <18	890	7.42	818	5.62
Missing	65	13.85	62	9.68
p-value**	0.0003		<.0001	
Fathers Education				
<12	1,500	10.20	1,381	1,381
12	3,100	8.52	2,855	2,855
13-15	1,220	8.44	1,122	1,122
>15- <18	606	7.76	542	542
Missing	1,056	11.55	965	965
p-value**	0.3137		0.5319	
Married				
No	5,141	9.73	4,766	9.99
Yes	2,341	8.07	2,099	7.48
p-value*	0.0223		0.0009	
Kessner's Index of adequacy of prenatal care**				
Adequate	4,916	8.12	4,604	9.12
Intermediate	1,742	10.28	1,546	10.96
Inadequate	757	12.68	651	13.00
Missing	67	22.39	64	NA
p-value**	0.0004		0.0004	

* p-values for chi-square; **p-values for chi-square trend test (2-sided)

Table 5: Unadjusted and Adjusted Odd Ratio for SGA Births in White Non-Hispanic Grandmothers in NJ during 1979–1983

	Crude OR	P-value	Adjusted OR	P-value
Maternal age				
12 -<20	1.22 (1.07 - 1.39)	0.0035	0.87 (0.75 – 100)	0.0553
20 -<25	1.19 (1.09 - 1.30)	0.0002	1.07 (0.97 – 1.17)	0.1889
25 -<30	Ref	-	Ref	-
30- <35	0.96 (0.86 - 1.08)	0.5264	0.98 (0.87 – 1.10)	0.7021
Maternal Education				
<12	1.75 (1.53 - 2.00)	<.0001	1.57 (1.35 – 1.84)	<.0001
12	1.31 (1.16 - 1.47)	<.0001	1.28 (1.13 - 1.45)	0.0001
13-15	Ref	-	Ref	-
>15- <18	1.01 (0.86 - 1.19)	0.9014	1.10 (0.93 - 1.30)	0.2635
Fathers Education				
<12	1.23 (1.08 - 1.40)	0.0026	0.95 (0.82 – 1.10)	0.4994
12	1.02 (0.91 - 1.14)	0.7775	0.91 (0.81 – 1.03)	0.1393
13-15	Ref	-	Ref	
>15- <18	0.78 (0.68 - 0.90)	0.0004	0.82 (0.71 – 0.96)	0.0100
Married				
No	1.63 (1.46 - 1.82)	<.0001	1.45 (1.25 – 1.67)	<.0001
Yes	Ref	-	Ref	-
Kessner's Index of adequacy of prenatal care				
Adequate	Ref	-	Ref	-
Intermediate	1.30 (1.17 – 1.44)	<.0001	1.19 (1.07 – 1.33)	0.0010
Inadequate	1.46 (1.23 – 1.72)	<.0001	1.18 (1.00 – 1.41)	0.0512

Table 6: Unadjusted and Adjusted Odd Ratio for SGA Births in Black Non-Hispanic Grandmothers in NJ during 1979–1983

	Crude OR	P-value	Adjusted OR	P-value
Maternal age				
12 -<20	1.06 (0.92 - 1.23)	0.5320	0.79 (0.67 – 0.93)	0.0038
20 -<25	1.08 (0.93 - 1.24)	0.4492	0.95 (0.81 – 1.10)	0.4938
25 -<30	Ref	-	Ref	-
30- <35	0.94 (0.76 - 1.16)	0.5018	0.97 (0.79 – 1.21)	0.8115
Maternal Education				
<12	1.49 (1.25-1.78)	<.0001	1.34 (1.10 – 1.63)	0.0041
12	1.15 (0.94-1.37)	0.1466	1.08 (0.89 – 1.31)	0. 4424
13-15	Ref	-	Ref	-
>15- <18	0.66 (0.44-1.00)	0.0495	0.74 (0.48 – 1.14)	0.1704
Fathers Education				
<12	1.47 (1.12 - 1.92)	0.0050	1.22 (0.92 – 1.62)	0.1728
12	1.15 (0.90 - 1.48)	0.2643	1.05 (0.81 – 1.36)	0.7257
13-15	Ref	-	Ref	-
>15- <18	0.88 (0.57 – 1.32)	0.5146	0.99 (0.64 – 1.52)	0.9599
Married				
No	1.37 (1.22 – 1.54)	<.0001	1.15 (0.99 – 1.34)	0.0778
Yes	Ref	-	Ref	-
Kessner's Index of adequacy of prenatal care				
Adequate	1.00	-	Ref	-
Intermediate	1.26 (1.12 – 1.42)	0.0001	1.19 (1.05 – 1.34)	0.0052
Inadequate	1.51 (1.32 – 1.71)	<.0001	1.38 (1.20 – 1.57)	<.0001

Table 7: Unadjusted and Adjusted Odd Ratio for SGA Births in Hispanic Grandmothers in NJ during 1979–1983

	Crude OR	P-value	Adjusted OR	P-value
Maternal age				
12 -<20	1.45 (1.18 – 1.80)	0.0005	1.24 (0.99 - 1.55)	0.0628
20 -<25	1.04 (0.85 – 1.28)	0.7130	0.99 (0.80 - 1.22)	0.8907
25 -<30	Ref	-	Ref	-
30- <35	0.83 (0.61 – 1.12)	0.2208	0.82 (0.61 – 1.12)	0.2091
Maternal Education				
<12	1.71 (0.94 – 3.09)	0.0783	1.00 (0.71 - 1.42)	0.9990
12	1.30 (0.71 – 2.38)	0.3929	0.90 (0.63 - 1.28)	0.5594
13-15	Ref	-	Ref	-
>15- <18	1.34 (0.69 – 2.61)	0.3843	1.02 (0.51 – 2.03)	0.9537
Fathers Education				
<12	2.75 (1.45 – 5.23)	0.0020	1.10 (0.76 – 1.59)	0.6130
12	2.38 (1.24 – 4.55)	0.0090	1.05 (0.72 – 1.51)	0.8105
13-15	Ref	-	Ref	-
>15- <18	2.23 (1.09 – 4.56)	0.0273	0.47 (0.23 – 0.99)	0.0461
Married				
No	1.49 (1.28 – 1.73)	<.0001	1.24 (1.04 – 1.47)	0.0163
Yes	Ref	-	Ref	-
Kessner's Index of adequacy of prenatal care				
Adequate	Ref	-	Ref	-
Intermediate	1.06 (0.88 – 1.26)	0.5586	1.01 (0.80 – 1.29)	0.6867
Inadequate	1.17 (0.93 – 1.48)	0.1924	1.00 (0.53 – 1.89)	0.8917

Table 8: Unadjusted and Adjusted Odd Ratio for SGA Births in White Non-Hispanic Mothers in NJ during 1999-2011

	Crude OR	**P-value**	**Adjusted OR**	**P-value**
Maternal age				
12 -<20	1.36 (1.16 – 1.60)	0.0001	0.85 (0.70-1.01)	0.0678
20 -<25	1.22 (1.11 – 1.34)	<.0001	0.96 (0.87-1.07)	0.4975
25 -<30	Ref	-	Ref	-
30- <35	0.85 (0.74 – 0.97)	0.0165	0.93 (0.81 – 1.07)	0.3175
Maternal Education				
<12	1.75 (1.51 – 2.02)	<.0001	1.50 (1.27 – 1.77)	<.0001
12	1.18 (1.05 – 1.32)	0.0055	1.11 (0.98 – 1.25)	0.0951
13-15	Ref	-	Ref	-
>15- <18	0.81 (0.72 – 0.92)	0.0008	0.91 (0.80 – 1.04)	0.1818
Fathers Education				
<12	1.47 (1.25 – 1.73)	<.0001	1.11 (0.93 – 1.33)	0.2620
12	1.13 (1.00 - 1.27)	0.0737	1.01 (0.89 – 1.14)	0.8995
13-15	Ref	-	Ref	-
>15- <18	0.85 (0.74 – 0.97)	0.1088	0.95 (0.83 – 1.10)	0.5240
Marital Status				
No	1.51 (1.39 – 1.65)	<.0001	1.22 (1.09 – 1.35)	0.0003
Yes	Ref		Ref	-
Kessner's Index of adequacy of prenatal care*				
Adequate	Ref	-	Ref	-
Intermediate	1.21 (1.09 – 1.36)	0.0007	1.11 (0.99 – 1.25)	0.0640
Inadequate	1.77 (1.50 – 2.08)	<.0001	1.41 (1.19 – 1.67)	<.0001

Table 9: Unadjusted and Adjusted Odd Ratio for SGA Births in Black Non-Hispanic Mothers in NJ during 1999-2011

	Crude OR	P-value	Adjusted OR	P-value
Maternal age				
12 -<20	1.23 (1.03 – 1.45)	0.0191	1.08 (0.90 – 1.29)	0.4284
20 -<25	1.20 (1.04 – 1.37)	0.0099	1.13 (0.98 – 1.30)	0.0977
25 -<30	Ref	-	Ref	-
30- <35	1.04 (0.78 – 1.39)	0.7918	1.09 (0.82 – 1.46)	0.5618
Maternal Education				
<12	1.35 (1.14 – 1.60)	0.0006	1.14 (0.94 – 1.37)	0.1825
12	1.09 (0.93 – 1.27)	0.2816	0.99 (0.85– 1.17)	0.9384
13-15	Ref	-	Ref	-
>15- <18	0.87 (0.67 – 1.14)	0.2743	0.92 (0.70 – 1.22)	0.5731
Father's Education				
<12	1.54 (1.20 – 1.97)	0.0006	1.34 (1.03 – 1.75)	0.0227
12	1.25 (1.01 – 1.54)	0.0388	1.18 (0.95 – 1.47)	0.1315
13-15	Ref	-	Ref	-
>15- <18	1.17 (0.83 – 1.64)	0.3739	1.27 (0.89 – 1.81)	0.1874
Marital Status				
No	1.24 (1.04 – 1.49)	0.0418	1.06 (0.86 – 1.29)	0.6002
Yes	Ref	-	Ref	-
Kessner's Index of adequacy of prenatal care*				
Adequate	Ref	-	Ref	-
Intermediate	1.50 (1.31 – 1.71)	<.0001	1.45 (1.27 – 1.66)	<.0001
Inadequate	1.54 (1.31 – 1.80)	<.0001	1.43 (1.22 – 1.68)	<.0001

Table 10: Unadjusted and Adjusted Odd Ratio for SGA Births in Hispanic Mothers in NJ during 1999-2011

	Crude OR	P-value	Adjusted OR	P-value
Maternal age				
12 -<20	1.46 (1.16 – 1.85)	0.0015	1.22 (0.94 – 1.58)	0.1389
20 -<25	1.24 (1.03 – 1.51)	0.0265	1.11 (0.91 – 1.36)	0.3013
25 -<30	Ref	-	Ref	-
30- <35	1.14 (0.79 – 1.64)	0.4984	1.28 (0.88 – 1.86)	0.1898
Maternal Education				
<12	1.34 (1.06 – 1.70)	0.0131	1.62 (1.08 – 2.41)	0.0185
12	1.11 (0.89 – 1.38)	0.3442	1.41 (0.98 – 2.04)	0.0677
13-15	Ref	--	Ref	-
>15- <18	0.63 (0.45– 0.89)	0.0094	1.43 (0.99 – 2.07)	0.0604
Fathers Education				
<12	1.36 (1.03 – 1.81)	0.0334	1.13 (0.72 – 1.75)	0.6036
12	1.30 (1.01 – 1.68)	0.0430	1.23 (0.82 – 1.85)	0.3249
13-15	Ref	-	Ref	-
>15- <18	0.83 (0.55 – 1.25)	0.3667	1.01 (0.65 – 1.57)	0.9592
Marital Status				
No	1.37 (1.14 – 1.66)	0.0010	1.16 (0.94 – 1.42)	0.1667
Yes	Ref	-	Ref	-
Kessner's Index of adequacy of prenatal care*				
Adequate	Ref	-	Ref	-
Intermediate	1.27 (1.04 – 1.54)	0.0176	1.21 (0.99 – 1.47)	0.0583
Inadequate	1.63 (1.26 – 2.09)	0.0002	1.48 (1.14 – 1.91)	0.0032

Table 11: Unadjusted and Adjusted Odd Ratio for SGA Births in White Non-Hispanic Mothers, in NJ during 1999-2011– Model with Grandmother's education

	Crude OR	P-value	Adjusted OR	P-value
Maternal age				
12 -<20	1.36 (1.16 – 1.60)	0.0001	0.85 (0.70 – 1.02)	0.0722
20 -<25	1.22 (1.11 – 1.34)	<.0001	0.96 (0.87 – 1.07)	0.5076
25 -<30	Ref	-	Ref	-
30- <35	0.85 (0.74 – 0.97)	0.0165	0.93 (0.81 – 1.07)	0.3193
Maternal Education				
<12	1.75 (1.51 – 2.02)	<.0001	1.48 (1.25 – 1.76)	<.0001
12	1.18 (1.05 – 1.32)	0.0055	1.10 (0.98 – 1.25)	0.1092
13-15	Ref	-	Ref	-
>15- <18	0.81 (0.72 – 0.92)	0.0008	0.93 (0.81 – 1.06)	0.2667
Father's Education				
<12	1.47 (1.25 – 1.73)	<.0001	1.11 (0.92 – 1.33)	0.2686
12	1.13 (1.00 - 1.27)	0.0737	1.01 (0.88 – 1.14)	0.9245
13-15	Ref	-	Ref	-
>15- <18	0.85 (0.74 – 0.97)	0.1088	0.96 (0.83 – 1.11)	0.5844
Grandmother's Education				
<12	1.20 (1.04 – 1.38)	0.0126	0.97 (0.83 – 1.12)	0.6617
12	1.02 (0.91 – 1.15)	0.7354	0.95 (0.84 – 1.08)	0.4187
13-15	Ref	-	Ref	-
>15- <18	0.79 (0.67 – 0.93)	0.0042	0.84 (0.70 – 1.00)	0.0499
Marital Status				
No	1.51 (1.39 – 1.65)	<.0001	1.21 (1.09 – 1.35)	0.0004
Yes	Ref	-	Ref	-
Kessner's Index of adequacy of prenatal care*				
Adequate	Ref	-	Ref	-
Intermediate	1.21 (1.09 – 1.36)	0.0007	1.11 (0.99 – 1.25)	0.0668
Inadequate	1.77 (1.50 – 2.08)	<.0001	1.41 (1.19 – 1.67)	<.0001

Table 12: Unadjusted and Adjusted Odd Ratio for SGA Births in Black Non-Hispanic Mothers in NJ during 1999-2011– Model with Grandmother's education

	Crude OR	P-value	Adjusted OR	P-value
Maternal age				
12 -<20	1.23 (1.03 – 1.45)	0.0191	1.08 (0.90 - 1.30)	0.4132
20 -<25	1.20 (1.04 – 1.37)	0.0099	1.13 (0.98 - 1.30)	0.0959
25 -<30	Ref	-	Ref	-
30- <35	1.04 (0.78 – 1.39)	0.7918	1.09 (0.82 - 1.46)	0.5490
Maternal Education				
<12	1.35 (1.14 – 1.60)	0.0006	1.24 (0.92 – 1.67)	0.1609
12	1.09 (0.93 – 1.27)	0.2816	1.09 (0.83– 1.43)	0.5526
13-15	Ref	-	Ref	-
>15- <18	0.87 (0.67 – 1.14)	0.2743	1.09 (0.83 – 1.44)	0.5278
Fathers Education				
<12	1.54 (1.20 – 1.97)	0.0006	1.06 (0.74 - 1.52)	0.7637
12	1.25 (1.01 – 1.54)	0.0388	0.93 (0.67 – 1.29)	0.6720
13-15	Ref	-	Ref	-
>15- <18	1.17 (0.83 – 1.64)	0.3739	0.79 (0.55 – 1.12)	0.1864
Grandmother's Education				
<12	1.21 (0.99 – 1.47)	0.0682	0.81 (0.58 – 1.14)	0.2298
12	1.12 (0.91 – 1.37)	0.2809	0.80 (0.57 – 1.12)	0.1869
13-15	Ref	-	Ref	-
>15- <18	1.22 (0.84 – 1.77)	0.2928	0.74 (0.51 – 1.08)	0.1165
Marital Status				
No	1.24 (1.04 – 1.49)	0.0418	1.06 (0.86 - 1.29)	0.5979
Yes	Ref	-	Ref	-
Kessner's Index of adequacy of prenatal care*				
Adequate	Ref	-	Ref	-
Intermediate	1.50 (1.31 – 1.71)	<.0001	1.46 (1.28 – 1.67)	<.0001
Inadequate	1.54 (1.31 – 1.80)	<.0001	1.44 (1.22 – 1.69)	<.0001

Table 13: Unadjusted and Adjusted Odd Ratio for SGA Births in Hispanic Mothers in NJ during 1999-2011– Model with Grandmother's education

	Crude OR	P-value	Adjusted OR	P-value
Maternal age				
12 -<20	1.46 (1.16 – 1.85)	0.0015	1.22 (0.94 - 1.59)	0.1286
20 -<25	1.24 (1.03 – 1.51)	0.0265	1.11 (0.91 - 1.36)	0.2920
25 -<30	Ref	-	Ref	-
30- <35	1.14 (0.79 – 1.64)	0.4984	1.28 (0.88 - 1.86)	0.1951
Maternal Education				
<12	1.34 (1.06 – 1.70)	0.0131	1.58 1.05 – 2.39)	0.0274
12	1.11 (0.89 – 1.38)	0.3442	1.40 (0.97 – 2.04)	0.0764
13-15	Ref	--	Ref	-
>15- <18	0.63 (0.45– 0.89)	0.0094	1.43 (0.98 – 2.07)	0.0606
Father's Education				
<12	1.36 (1.03 – 1.81)	0.0334	1.12 (0.72 - 1.74)	0.6233
12	1.30 (1.01 – 1.68)	0.0430	1.22 (0.81 - 1.84)	0.3395
13-15	Ref	-	Ref	-
>15- <18	0.83 (0.55 – 1.25)	0.3667	1.01 (0.65 - 1.56)	0.9659
Grandmother's Education				
<12	1.33 (0.93 – 1.90)	0.1224	0.79 (0.46 – 1.36)	0.4279
12	1.07 (0.74 – 1.57)	0.7150	0.71 (0.41 – 1.23)	0.4021
13-15	Ref	-	Ref	--
>15- <18	1.30 (0.70 – 2.42)	0.4068	0.69 (0.37 – 1.29)	0.2212
Marital Status				
No	1.37 (1.14 – 1.66)	0.0010	1.15 (0.94 - 1.42)	0.1779
Yes	Ref	-	Ref	-
Kessner's Index of adequacy of prenatal care*				
Adequate	Ref	-	Ref	-
Intermediate	1.27 (1.04 – 1.54)	0.0176	1.21 (0.99 - 1.47)	0.0612
Inadequate	1.63 (1.26 – 2.09)	0.0002	1.47 (1.14 - 1.91)	0.0033

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5. CONCLUSION

In this inter-generational study of the association of maternal education with preterm birth (PTB) and small-for-gestational age (SGA) birth we found strong, inverse relationships for both outcomes. These inverse associations were found across all three of the largest race/ethnic groups (non-Hispanic Blacks, non-Hispanic Whites and Hispanics) in New Jersey both in the years around 1980 and again in the period 1999-2011. There was a striking increase in educational level between the grandmothers who gave birth in 1979-82 and the mothers who gave birth in 1999-2011 that occurred in each of these groups, but it was most striking in Hispanics. This increase can be illustrated by summing the decrease in the percentage of mothers who had less than a high school education and the increase in the percentage who had more than a high school education, which totaled 60% in Hispanics, 36% in blacks and 39% in whites.

Surprisingly, we found no correspondence between the magnitude of these educational changes and improvements in preterm and SGA birth rates. A rising trend in preterm birth rates over this period has been attributed to more aggressive obstetric intervention in high risk pregnancies.[1] In white women this amounted to an absolute preterm increase of 1.3% of births. Black women, whose educational advancement was roughly comparable to whites, saw an encouraging 3.7% absolute decrease in PTB, while Hispanic women, who had the most striking increase in educational level saw only a very narrow improvement in their preterm rate of 0.6% (Chapter 3, Table 1).

In this analysis SGA was defined separately for the six demographic categories based on race/ethnicity and infant sex. The 10^{th} percentile of birth weight at each gestational age for the 1999-2011 births was used. Data were only available across cohorts for female babies and showed that SGA was more common in the earlier birth cohort (1979-83) than the later one (1999-2011) in each race/ethnic group. The decline was most marked in the black families, (-1.5% of births). Smaller declines of 0.7% and 0.5% of births were seen in white and Hispanic families, respectively. As with preterm birth, the magnitude of these changes does not correspond to the changes in maternal educational level. It is well known that there was a substantial increase in obesity in many populations over this time period that almost certainly affected women of reproductive age in New Jersey, and it is likely that this contributed to the slight decline in SGA births. A secular decrease in maternal smoking may also have contributed to reducing SGA births.

Many other risk factors contribute to PTB and SGA including maternal body weight, race and ethnicity, maternal age, late or no prenatal care, maternal illness, behavioral and psychosocial factors, infertility treatment, exposure to environmental toxins, low socioeconomic status, neighborhood characteristics and genetics.[2-14] The lack of uniform improvement in preterm and SGA rates in the face of the substantial increase in population educational levels favors a complex of advantages associated with SES, for which education is a marker, as the dominant explanation for the persistent cross-sectional association of advanced education with reduced preterm and SGA birth.

The results found for Hispanic families are of special interest because of limited data available on cross generational birth outcomes in this recent immigrant group. An "Hispanic paradox" has been described in other health studies[15] in which recent immigrants, who are likely to have been under-educated, nevertheless have better health indices than their peers who have been in the U.S. for longer periods of time. We did not see this effect for preterm birth, but the association of education with SGA in Hispanics was weak, especially in the 1979-83 births.

In these New Jersey families who had new babies in 1999-2011, grandmother's education was as strongly associated with PTB as was maternal education. This suggests that the SES milieu in which mother grew up, including the economic security associated with it, likely was associated with favorable health and health habits that carried through to healthier pregnancies in the second generation. The finding supports a life-course understanding of successful pregnancy that could include both physiological and lifestyle differences between advantaged and disadvantaged citizens. It is also a hopeful finding in that it suggests that the greater educational attainment seen in recent years may help to provide for better reproductive outcomes in another generation.

A consistent finding in our study was that among all three ethnic groups and across two generations, father's education was inversely associated with risk of SGA and PTB. Similar findings have been reported from previous studies that were conducted in United States.[19] This association likely reflects the correlation of educational level between fathers and mothers and the role of fathers as providers of income and related aspects of socio-economic status.

With respect to SGA, grandmothers and mothers education did not show the same association as seen in PTB. Although the overall SGA rates were higher in blacks and Hispanics as compared to whites, the effect of lower maternal education on risk of SGA was strongest in whites and it lost significance in blacks and Hispanics especially in the 1999-2011 births. Again, this suggests that maternal education may have its effect through some of these other correlates of social status so that it may be inappropriate to adjust for these variables. Nevertheless, this inconsistent relationship among the three ethnic groups does indicate that education does not translate directly to social position in white, black and Hispanic women. Income and education indicators do not fully capture SES, and the actual socioeconomic conditions of African Americans and Whites at the same income or education level are often not equivalent.

In summary, in this study of birth outcomes to two generations of New Jersey women, we found that maternal education was an important predictor of preterm birth and SGA both in 1979-82 and in 1999-2011. Grandmother's education was available for the 1999-2011 births and its relation to preterm birth in grandchildren was roughly the same strength as that of the mothers. However, grandmother's education was not strongly related to SGA in the grandchildren. Our results suggest that mother's childhood and preconception socioeconomic environment remain important predictors for her reproductive success. The failure of a substantial increase in maternal educational levels to have a favorable effect on preterm rates in these New Jersey families is disappointing and suggests that the benefit of general education, per se, is not sufficient to overcome other societal and medical care changes that have led to increases in preterm births.

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