MATERNAL SOCIOECONOMIC MOBILITY: RELATIONS WITH PRETERM DELIVERY AND PRENATAL DEPRESSION

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A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

Epidemiology—Doctor of Philosophy

2017

ABSTRACT

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Preterm delivery (PTD) and prenatal depression are major public health problems. Previous studies suggest that socioeconomic position (SEP) has been negatively associated with the risk of PTD and mental health problems. However, the association between maternal socioeconomic mobility (SM) and the risk of PTD or prenatal depression is rarely investigated. We hypothesized that women with low childhood SEP and low adulthood SEP will be at greatest risk of PTD or prenatal depression; upward SM from childhood to adulthood will lower women's risk of PTD or prenatal depression; and downward SM from childhood to adulthood will increase risk of PTD or prenatal depression. We aimed (1) to evaluate the relationship between maternal SM and risk of PTD; and (2) to assess the association between maternal SM and risk of prenatal depression in a Michigan, community-based cohort study that is racially and socioeconomically diverse. Because other studies reported that the relation of SEP (or SM) with risk of PTD or prenatal depression varied by maternal race/ethnicity, we also examine evidence for this effect modification.

Data were collected from 3,019 pregnant women recruited from 5 Michigan communities at mid-trimester (16-27 weeks' gestation) in the Pregnancy Outcomes and Community Health (POUCH) Study (1998-2004). Pregnant women provided their parents' SEP indicators (education, occupation, receipt of public assistance) and their own and child's father's SEP indicators (education, occupation, Medicaid status, and household income) at enrollment. PTD

was defined as deliveries less than 37 completed weeks' gestation. Prenatal depressive symptoms were assessed by the Center for Epidemiologic Studies Depression Scale (CES-D) and CES-D≥16 was defined as high CES-D. Latent class analysis was conducted to identify latent groups of childhood SEP indicators, adulthood SEP indicators, and SM from childhood to adulthood, respectively. A model-based approach to latent class analysis with distal outcome assessed relations between latent class and PTD or prenatal depression, overall and within race/ethnicity groups.

Three latent groups (low, middle, high) were identified for childhood SEP indicators and adulthood SEP indicators, respectively; while four latent groups (static low, upward, downward, and static high) best described SM. Women with upward SM had decreased odds of PTD (odds ratio (OR)=0.60, 95% confidence interval (CI): 0.42, 0.87), compared to those with static low SEP. Women with upward SM had decreased odds of high CES-D (OR=0.22, 95% CI: 0.17, 0.29), compared to those with static low SEP. Women in downward group had elevated odds of high CES-D (OR=4.13, 95% CI: 2.75, 6.22), compared to those in static high group. This SM advantage was true for white/other women for PTD and most pronounced in white/other women for high CES-D.

Maternal experiences of upward SM or downward SM may be important considerations when assessing risk of PTD or prenatal depression. Our results support the argument that policies and programs aimed at improving women's SEP could lower PTD or prenatal depression risk. Our study suggests that policies or programs to increase opportunities for upward mobility may play an important role in decreasing the risk of PTD or prenatal depression. Further research is needed to understand the specific elements accompanying SM that are protective for PTD or prenatal depression and the best strategies for increasing SM among all race/ethnic groups.

This dissertation is dedicated to Emily and Grace,
with love.

ACKNOWLEDGEMENTS

I would like to acknowledge many people for help with my doctoral education. I am most grateful to my dissertation advisor, Dr. Claudia Holzman, for her mentorship, constant guidance and support throughout the time of my dissertation research. I am thankful for my committee members' continuous guidance and support. Dr. Slaughter and Dr. Margerison assisted me in deep understanding of relative aspects of social epidemiology. Dr. Luo and Dr. Todem gave their time and wisdom to help me with statistical methods. All the committee members provided me challenging ideas, careful reading, inspiring suggestions and critical comments. Without their ongoing support, I could not have finished my research.

Furthermore, I would like to express my gratitude to many faculties for their helpful teaching and guidance in the Department of Epidemiology and Biostatistics. In addition, it has been a great opportunity to work on the Pregnancy Outcomes and Community Health (POUCH) Study. I am grateful for Dr. Bertha Bullen and Crista Valentine's direct assistance and constant encouragement.

I am extremely grateful to my family and friends for constant support and unfailing encouragement. I especially thank my husband, Xiaodong, for sharing the housework, taking care of kids, and providing plentiful support. I am also grateful to my daughters, Emily and Grace, for their encouragement. This would not have been possible without them by my side.

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KEY TO ABBREVIATIONS

CES-D	Center for Epidemiologic Studies Depression Scale
CI	Confidence Interval
OR	Odds Ratio
POUCH	Pregnancy Outcomes and Community Health Study
PTD	Preterm Delivery
RR	Rate Ratio
SEP	Socioeconomic Position
SM	Socioeconomic Mobility
UK	United Kingdom
USA	United States of America

CHAPTER 1

BACKGROUND LITERATURE

1.1 Preterm delivery

Preterm delivery (PTD), defined as delivery of a baby before 37 completed weeks of gestation age, is a major public health problem. The worldwide rates of PTD are generally 5-18% and about 15 million babies are born preterm annually. According to data from Centers for Disease Control and Prevention, PTD occurred in about one of every ten deliveries in the United States in 2014 (Hamilton, et al. 2015).

PTD is a leading cause of perinatal mortality and morbidity, accounting for 70% of neonatal death and 75% of neonatal morbidity (Blencowe et al. 2013). The mortality rate for preterm babies is 15 times greater than that of term babies (Mathews et al. 2004). In addition, PTD may cause infants and children to have morbidity or severe health problems, e.g. breathing problems, jaundice, respiratory distress syndrome, as well as such developmental difficulties as blindness, sensory, learning, cognitive and language deficits (Allen 2008). Some evidence demonstrated that the very PTD (28 to <32 weeks) children at school ages had more inattention, hyperactivity, and peer problems, compared with term-born children (Delobel-Ayoub et al. 2009). Furthermore, children born preterm may have an increased risk of cardiovascular disease in adult life (Barker et al. 1993).

PTD is an increasingly heterogeneous condition and has substantial impacts (Allen 2008). From the respect of economy, PTD has a most important direct and indirect cost. The PTD

babies often need extra hospitalization and additional care, which increases the general health expenses. The 2007 statistics shows the annual cost for PTDs is on average 10-fold that of term births. The costs increase exponentially as the gestational age declines (Gilbert et al. 2003). So the direct cost may be seen from intensive and extended newborn care, as well as financial, emotional, and psychological burden to the parents. The indirect cost to the society can be caused from long-term care of disabled premature children and the care of the premature children by the parents who may give up their jobs (Behrman & Butler, 2007). Therefore, prevention of PTD can help save the major infant and pediatric costs.

The PTD rate varies by maternal race/ethnicity. From 2008 to 2010, in the United States, PTD rates were highest for non-Hispanic African-American babies (17.4%). PTD rates for Native Americans, Hispanics, non-Hispanic whites, and Asians were 13.7%, 12.0%, 10.9%, and 10.6%, respectively. In 2012, the PTD rate remains the highest among African-American infants at 16.5%. The difference between African Americans and whites has been slowly narrowing, but the PTD rate among African Americans is still more than 1.5 times the rate of whites. During 2011-2013, 16.5% of African-American women and 10.3% of non-Hispanic white women in the U.S. delivered prematurely. The disparities in PTD rates between population subgroups defined by socioeconomic status are striking (Blumenshine et al. 2010). Many social factors greatly affect African Americans in terms of the PTD rates. For example, poor education, unfavorable neighborhood or low economic status increases low self-esteem, poor nutrition and sanitation, and even level of stress (O'Campo et al. 2008). In addition, a body of previous studies suggested lifetime adverse socioeconomic experiences and racism-related stress should also be considered to elucidate the racial disparity in PTD (Lu & Halfon 2003, Domingues 2008, Domingues et al. 2008, Kramer & Hogue 2009, Braveman 2011).

There are many risk factors for PTD. Previous PTD, multifetal pregnancy, and cervical incompetence have been repeatedly indicated as risk factors for PTD. Being an African American, at low socio-economic status, and getting pregnant at extreme maternal age also increase the risk of PTD. Some other behavioral, psychosocial, and nutrition factors have also been implicated as risk factors of PTD, such as maternal smoking during pregnancy, maternal cocaine use, maternal psychosocial stress, anxiety, low pre-pregnancy BMI, and poor weight gain during pregnancy. Additionally, previous literature provided some evidence about potential mechanisms linking SEP and PTD, e.g. behaviors, immune function, stress axis hormones, hypertensive disorders, sexually transmitted disease, etc. (Kramer et al. 2000).

1.2 Maternal adulthood socioeconomic position and preterm delivery

Maternal disadvantaged socioeconomic position (SEP) in adulthood has been associated with a higher risk of PTD. Measures of SEP have included occupation, education and household income, and the relationship with PTD often varied by race/ethnicity (Morgen et al. 2008, Auger, Giraud, and Daniel 2009, Blumenshine et al. 2010, Blumenshine et al. 2011, Mortensen, Helweg-Larsen, and Andersen 2011, Matijasevich et al. 2012, Whitehead 2012, Joseph et al. 2014, Shankardass et al. 2014).

Table 1.1 shows studies reporting on associations between maternal adulthood SEP and risk of PTD. The Danish National Birth Cohort study (Morgen et al. 2008) reported that the risk of PTD increased among women with low SEP measured by maternal education level. In a systematic review of 106 studies from 1999 to 2007, Blumenshine et al. (2010) suggested that disadvantaged SEP was consistently linked to greater risk of adverse birth outcomes and

observed racial/ethnic heterogeneity in the effect of SEP measures. The inverse associations between maternal education and adverse birth outcomes were significant among non-Hispanic white pregnant women, but not among African-American women. In a California study, Blumenshine et al. (2011) found that infants whose father had not completed college were at significantly elevated risk of being born preterm; the association with paternal education was particularly strong among unmarried women. A study of UK and Brazil noted higher rates of PTD among the poorest and least educated women (Matijasevich et al. 2012). Whitehead et al. (2012) examined 37 U.S. states data from the Pregnancy Risk Assessment Monitoring System, and reported that the risk of PTD was greatest among women who had not finished high school, whose household income was in the lowest 5%, and who were enrolled in Medicaid Insurance. A Nova Scotia study by Joseph et al. (2014) observed a decreased risk of spontaneous PTD among women with high family income compared to those with low family income. After adjusting for other maternal characteristics the relationship between family income and spontaneous PTD became attenuated. Shankardass et al. (2014) found that the risk of spontaneous PTD was elevated across all the indicators of lower SEP, and women in the adverse neighborhood had greater risk of medically indicated and spontaneous PTD.

1.3 Maternal childhood socioeconomic position and preterm delivery

Fewer studies have examined mother's childhood SEP and pregnancy outcomes, though there is evidence that SEP in childhood has a significant effect on adult health (Cohen et al. 2010). A Brazilian intergenerational, population-based cohort study by Gigante et al. (2015) observed that maternal childhood poverty, measured by family income, was strongly associated with shorter gestations.

Three conceptual models have been proposed to explain how disadvantaged life course SEP affects health later in life (Kuh et al. 2003, Kendzor, Caughy, and Owen 2012). The critical period model postulates that SEP-related factors have their greatest effect on adult health during specific developmental period. The accumulation model supposes that increasing intensity and duration of exposure to socioeconomic disadvantage may elevate the risk of poor adult health. Individuals experiencing adverse SEP during both childhood and adulthood have higher risk for poor adult health compared to those experiencing that during only one life stage. The accumulation model focuses on the effect of gradually accumulated risk on later health problem. The social mobility model hypothesizes that upward socioeconomic mobility (SM) remediates the negative effect of earlier disadvantage SEP, however, downward SM may result in poorer adult health despite relative socioeconomic advantages at earlier stages (Kuh et al. 2003, Cohen et al. 2010, Kendzor, Caughy, and Owen 2012). These three models are theoretically different, but closely correlated, which makes it hard to practically distinguish differential effects. However, all of three models work together to provide a better understanding of how life course SEP can be related to later life (Hallqvist et al. 2004). In all these models, determining the temporal order of SEP and health can be challenging.

1.4 Maternal socioeconomic mobility and preterm delivery

SM was defined as "situations where an individual's increase or decrease in SEP depends on parental SEP compared with the level of SEP as an adult" (Owens and Jackson 2015). SM has been studied in relation to low birthweight (Basso et al. 1997, Spencer 2004, Colen et al. 2006, Astone, Misra, and Lynch 2007, Love et al. 2010, Osypuk et al. 2016), small for gestational age (Love et al. 2010, Osypuk et al. 2016, Slaughter-Acey et al. 2016), and newborn body

composition (Sletner et al. 2014). In our review of the literature, however, we found fewer studies examining SM and PTD (Collins et al. 2007, Love et al. 2010, Collins, Rankin, and David 2011, Kramer, Dunlop, and Hogue 2014, Collins, Rankin, and David 2015, Osypuk et al. 2016).

Recent studies on associations between maternal SM and risk of PTD are shown in Table 1.2. A Detroit study by Osypuk et al. (2016) observed no association between maternal SM and overall PTD, though improved SM was related to lower risk of spontaneous PTD among women who experienced upward SM or had any stable SEP. Using the Illinois transgenerational birth file with US Census income data, Collins et al. (2011) found that upward SM from an impoverished childhood was related to a decreased risk of PTD among African Americans. Women who experienced low, modest, or high upward SM had lower PTD rates of 16.0%, 15.2%, and 12.4%, respectively, than those with lifelong lower class status; rate ratio (RR) and 95% confidence interval (CI) = 0.9 (0.8, 0.9), 0.8 (0.7, 0.9), 0.7 (0.6, 0.8), respectively. In contrast, downward SM was linked to an elevated risk of PTD among white urban women (Collins et al. 2015). Those who experienced slight, moderate, or extreme downward SM had a higher risk of PTD rates than women with lifelong upper class status, with RR and 95% CI of 1.2 (1.0, 4.0), 1.6 (1.3, 1.9), and 1.9 (1.3, 2.6), respectively. Using the same data, Collins et al. (2007) revealed a twofold greater risk of PTD among African-American women than among whites (RR=2.2, 95% CI: 1.7, 2.9). All of these three studies used quartiles of neighborhood census tract median family income at two time points of the mother's residence, when she was born and when she delivered her baby.

Table 1.1. Studies reporting on associations between maternal adulthood socioeconomic position and risk of preterm delivery

First Author (Year)	Sample	Explanatory Variable	Dependent Variable	Statistical Analyses	Results
Joseph (2014)	Canada Nova Scotia (N=132,714)	SEP: family income	PTD: spontaneous and iatrogenic PTD.	Logistic regression	• Women with lowest family income had a significantly increased risk of spontaneous PTD (RR=1.14, 95% CI 1.03, 1.25), but not iatrogenic PTD (RR=0.95, 95% CI 0.75, 1.19). • The relationship between family income and spontaneous PTD became attenuated in the adjusted model.
Shankardass (2014)	Canada Nova Scotia (N=117,734)	SEP: family income, neighborhood material deprivation index	PTD: spontaneous and iatrogenic PTD.	Multiple logistic regression	• The risk of spontaneous PTD was elevated across all the indicators of adverse SEP. • Higher neighborhood material deprivation was related to greater risk for iatrogenic and spontaneous PTD.
Matijasevich (2012)	UK, Brazil (N=5,168, N=4,147)	SEP: education, family income	PTD, IUGR, breastfeeding for <3 months	Logistic regression	• Higher prevalence of PTD was observed among the poorest and less educated. • In the Pelotas cohorts, greater education-related inequalities in PTD were found.

Table 1.1. (cont'd)

First Author (Year)	Sample	Explanatory Variable	Dependent Variable	Statistical Analyses	Results
Whitehead (2012)	USA 37 states (N=107,926)	SEP: income, education, insurance	Preterm contractions and PTD	Logistic regression	• The risk of PTD was greatest among women who had not finished high school, whose income was in the lowest 5%, and who were enrolled in Medicaid Insurance.
Blumenshine (2011)	USA California (N=21,712)	SEP: father's education	PTD	Logistic regression	• Infants whose father had not completed college were at significantly elevated risk of being born preterm (adjusted OR=1.26, 95% CI 1.01, 1.58). • The association was particularly strong among unmarried women.
Mortensen (2011)	Denmark Danish register data	SEP: education, income	Stillbirth, PTD, birthweight, infant mortality	Review	• The risk of PTD was reversely associated with mother's education attainment.

Table 1.1. (cont'd)

First Author (Year)	Sample	Explanatory Variable	Dependent Variable	Statistical Analyses	Results
Blumenshine (2010)	106 studies from 1999 to 2007	SEP: education, income, occupational class	Birth weight; PTD; low birth weight; small for gestational age	Systematic review	• The inverse associations between maternal education and adverse outcomes were significant among non-Hispanic white pregnant women.
Auger (2009)	Canada Québec (N = 353,120)	SEP: household income, immigrant density, income inequality	PTD and small-for-gestational age	Multi-level logistic regression	• Among foreign-born mothers, low immigrant density was associated with decreased risk of PTD (OR=0.79, 95% CI 0.63, 1.00), compared to the high immigrant density. • Among Canadian-born mothers, low immigrant density was associated with an increased risk of PTD (OR=1.14, 95% CI 1.07, 1.21).
Morgen (2008)	Denmark (N=75,890)	SEP: education, occupation, household income.	PTD: extremely PTD, very PTD and moderately PTD.	Cox regression analyses	• Women with lower lever of education attainment had an elevated risk of PTD compared to those with higher level of education. • The above association interacted with parity.

Table 1.2. Studies reporting on associations between maternal socioeconomic mobility and risk of preterm delivery

First Author (Year)	Sample	Explanatory Variable	Dependent Variable	Statistical Analyses	Results
Osypuk (2016)	USA Detroit (N=1,410)	SM: education, income	PTD, small for gestational age	Poisson regression	• SM was not associated with overall PTD. • Among upwardly mobile or stable high women, improved financial mobility was related to 16% marginally lower risk of spontaneous PTD.
Collins (2015)	USA Illinois White (N = 12,498)	Downward SM: neighborhood income	PTD	Logistic regression	• Compared to women without downward mobility, higher risk of PTD was found among those who experienced slight (RR (95 % CI) = 1.2 (1.0, 4.0), moderate (RR (95 % CI) = 1.6 (1.3, 1.9), or extreme (RR (95 % CI) = 1.9 (1.3, 2.6), downward mobility. • Compared to non-low birthweight (LBW) women, those who had former LBW and experienced moderate to extreme downward mobility had greater risk of PTD (RR (95% CI) =2.8 (1.4, 5.8), and 1.6 (1.3, 1.9), respectively).

Table 1.2. (cont'd)

First Author (Year)	Sample	Explanatory Variable	Dependent Variable	Statistical Analyses	Results
Kramer (2014)	USA Georgia (N=413,048)	SM: cumulative neighborhood deprivation index (NDI)	PTD	Binomial regression	• On average, Georgia women experienced upward mobility. • The association between cumulative NDI and PTD was modified by the effect of history of prior PTD and advancing age.
Collins (2011)	USA Illinois African American (N = 11,265)	SM: neighborhood income	PTD	Logistic regression	• Compared to women without upward SM, those who experienced low, modest, or high upward SM had decreased risk of PTD (RR (95 % CI) = 0.9 (0.8, 0.9), 0.8 (0.7, 0.9), and 0.7 (0.6, 0.8), respectively). • Among former low birthweight (LBW) and non-LBW mothers aged 20 to 35 years, those who experienced modest to high upward SM had decreased risk of PTD (adjusted RR (95% CI) = 0.9 (0.5, 1.6) and 0.7 (0.5, 0.9), respectively).

Table 1.2. (cont'd)

First Author (Year)	Sample	Explanatory Variable	Dependent Variable	Statistical Analyses	Results
Love (2010)	USA Illinois (N=70,409)	SM: neighborhood income	PTD, small for gestational age, low birthweight	Race-specific multilevel logistic regression	• Among African American women with static low SEP, those aged 20–24 years had the lowest risk of PTD. • Among white women with static low SEP and static high SEP, those aged ≥20 years older had significantly decreased risk of PTD than teens.
Collins (2007)	USA Illinois (N=3,104)	SM: neighborhood income	PTD, low birthweight	Stratified logistic regression	• Compared to whites, African Americans had a twofold greater PTD rate (RR=2.2, 95% CI=1.7, 2.9). • The association became attenuated in the adjusted model (adjusted OR=1.2, 95% CI=0.4, 2.0).

1.5 Prenatal depression

Prenatal depression is an important worldwide public health problem and is a major cause of disease-related disability among women (Kessler 2003). The prevalence of prenatal depression is about 10% to 20% in high income countries, (Marcus et al. 2003, Gavin et al. 2005, Evans et al. 2007, Melville et al. 2010), while it is over 20% in low and middle income countries (Faisal-Cury et al. 2009, Golbasi et al. 2010, Husain et al. 2011). It is estimated by the American Congress of Obstetricians and Gynecologists that about 14-23% of women have prenatal depression symptoms. A systematic review by Gavin et al. (2005) found that about 18.4% of women experiencing prenatal depression, and 12.7% having an episode of major depression. Another systematic review of 21 studies by Bennett et al. (2004) reported an overall prevalence of 10.7% and 7.4%, 12.8%, and 12.0% of pregnant women experienced depression during the first, second, and third trimester, respectively. Prenatal depression is likely to be under diagnosed by health care providers since it is highly ascribed to emotional changes of pregnancy hormones (Brown and Solchany 2004).

Depression during pregnancy have often linked with some socioeconomic and lifestyle factors, e.g. smoking, substance use, alcohol consumption, improper nutrition, and inadequate weight gain (Marcus 2009). Women with a history of depression before pregnancy have as 22.4-fold increased risk for major depression during pregnancy as those who do not have any prior history of depression (Räisänen et al. 2014). In addition, prenatal depression is positively associated with postpartum depression and recurrent depression, all of which have the potential to adversely affect the general health and well-being of mother and her children (Bennett et al. 2004, Cents et al. 2013). Some studies report a link between prenatal depression and increases in adverse pregnancy outcomes, e.g. PTD, low birthweight, and stillbirth (Field, Diego, and

Hernandez-Reif 2006, Evans et al. 2007, Rahman et al. 2007, Wisner et al. 2009, Grote et al. 2010, Grigoriadis et al. 2013, Ncube et al. 2017). Several studies observe that the prevalence of perinatal depression is more common among African Americans than among white women (Dole et al. 2004, Nicholson et al. 2006, Li et al. 2008, Gavin et al. 2011, Mukherjee et al. 2016). Furthermore, previous studies provided some evidence about potential mechanisms linking SEP and depression, e.g. health behaviors (substance use, preventive care, etc.), psychological factors (stress/negative affect, mastery/control, etc), physiological factors (physiological dysregulation, altered cortical development, etc.) (Cohen et al. 2010). Compared to women with higher SEP, lower SEP women experienced higher levels of perceived stress and negative affect which increased the risk of depression during pregnancy (Rutter & Quine 1990). Hudson (2005) found that economic stress mediated the association between SEP and mental illness. Mastery was also reported to be mediators for the association between SEP and psychological distress (Myer et al. 2008, Gadalla 2009, Alang 2014). A recent study by Elwell-Sutton et al. (2017) observed that the association between unemployment and job loss and depression was mediated through income.

1.6 Adulthood socioeconomic position and depression

Maternal disadvantaged SEP in adulthood has been related to a greater risk of prenatal depression (Holzman et al.2006, Miyake et al. 2012, Bahk et al. 2015); measures of SEP have included occupation, education and household income, although the results with different SEP measures are not always consistent in general population (Lorant et al. 2003). A Michigan study by Holzman et al. (2006) observed particularly high risk of prenatal depression among women with low SEP measured by maternal income. Perinatal depression was measured by the Center for Epidemiologic Studies Depression Scale (CES-D), a screening test for depression during the

past week (CES_D≥16 vs CES_D<16). About 46% of teens and 47% of disadvantaged women had a positive CES-D screen (≥16), more common than advantaged women (23%).

Socioeconomic inequity in depression varies with the definition and measurement of SEP. Table 1.3 shows recent studies reporting on associations between adulthood SEP and risk of depression. In a met-analysis of 56 studies from 1980 to 2002, Lorant et al. (2003) suggested that disadvantaged SEP was linked to higher odds of being depressed. Based on data from the National Survey of American Life, Hudson et al. (2012) reported a link between SEP and depression which varied according to sex. Among African-American men, low level of education attainment, unemployment and low household income predicted higher risk of 12-month major depressive episode (MDE). For African-American women, household income was inversely associated with 12-month MDE. A study by Stewart et al. (2007) found low SEP and material deprivation were associated with the presence of depression among pregnant women. Miyake et al. (2012) examined Japanese data and identified that a lower prevalence of prenatal depression were more common among women who had full-time employment, especially, a professional or technical job. Production, service, sales, and other occupations were not significantly related to prenatal depression. However, no significant association between household income or education and prenatal depression were observed. A recent Korean study (Bahk et al. 2015) showed that maternal education, paternal education, and household income were inversely associated with maternal postpartum depressive symptoms, while no significant association was observed for depressive symptoms one month before childbirth.

Previous studies among non-pregnant population indicate a consistent inverse relationship between SEP and depression among whites, however, evidence for African Americans is mixed (Lorant et al. 2003, Williams et al, 2007, Gavin et al. 2010). For instance,

some studies observed a higher prevalence of depression among African Americans with lower SEP (Banks & Kohn-Wood 2002, Bromberger et al. 2004, Roxburgh 2009); however, other studies of African Americans find no significant association between SEP and depression (Gavin et al. 2010, Williams et al. 2007). Even studies examining multiple SEP indicators among African Americans find no significant relationship between SEP and depression (Rodriguez et al. 1999, Hudson et al. 2012). These inconsistent findings may be explicated by the differences in study sample, study design and methodology, such as various SEP measures, and variable depression screening timing and instruments. Another potential explanation for the racial/ethnic disparity for the effect of SEP on depression is that African Americans may not experience the same protection as whites against the development of depression with higher SEP (Farmer & Ferraro 2005). African Americans are more probable than whites to have adverse experiences in childhood, hence, those African Americans who experience upward SM may have residual effects of early disadvantage. Moreover, African Americans are more likely to encounter racial discrimination which may limit them to attain some level of education or achieve advanced occupation status compared to their white peers (Cole & Omari 2003). Experiences of racial discrimination may provoke stress responses which ultimately wear down the health of Africa Americans (Watkins et al. 2010) and may weaken the protective effects of improved levels of SEP among Africa Americans (Hudson et al. 2012).

1.7 Childhood socioeconomic position and depression

Fewer studies have examined mother's childhood SEP and maternal mental health, though there is evidence that SEP in childhood has an inconsistent effect on adult mental health

among general population (Ritsher et al. 2001, Gilman et al. 2002, Harper et al. 2002, Nicholson et al. 2008, Gale et al. 2011, Stansfeld et al. 2011). Table 1.4 shows recent studies reporting on associations between childhood SEP and risk of depression. Most studies found that childhood SEP had a strong impact on depression in later life (Ritsher et al. 2001, Gilman et al. 2002, Nicholson et al. 2008, Stansfeld et al. 2011). A study from US National Collaborative Perinatal Project (1959 – 1966) observed that low childhood SEP, measured by parental occupation, had been linked to an elevated risk of major depression among adults (Gilman et al. 2002). In the same study, participants with socioeconomically disadvantaged childhood had as three-fold risk of depression as those with advantaged childhood, independent of adulthood SEP and family history of mental illness. In addition, a study of the 1958 British Birth Cohort reported that participants from lower childhood SEP only marginally increased the risk of depressive and anxiety disorder in the mid-life, and part of the effect of childhood SEP was mediated through adulthood SEP (Stansfeld et al. 2011). However, the impact of childhood SEP on later depression has not been found in some studies (Harper et al. 2002, Gale et al. 2011).

The relationships between childhood SEP, adulthood SEP and mental health are likely varied and complex with a multitude of explanations (Stansfeld et al. 2011). The 'social causation' theory postulates that low SEP increases the risk of a mental health disorder, mainly depression and anxiety. This may be explained by critical period model or by pathway model (Ljung and Hallqvist 2006). In one critical period model, the effect of disadvantage childhood SEP on biological systems remains latent until adulthood, and is independent of adverse adulthood SEP. In one pathway model, low childhood SEP increases the likelihood of low adulthood SEP and this life course trajectory escalates the risk of mental disorders. There is also

the ‘health selection’ theory which asserts that childhood mental health disorders increase the probability of low adult SEP.

1.8 Socioeconomic mobility and depression

Although a rather large body of evidence linked childhood SEP or adulthood SEP to depression in later life, limited studies have tested whether SM is associated with depression. Moreover, to our knowledge, no previous study has directly investigated the association between SM and depression in pregnancy. In a study among 101 well-educated, African-American pregnant women, Owens et al. (2015) reported life-course SEP and mobility, defined by family class, did not moderate the association between contextualized stress and depression, and contextualized stress was the only predictor for depression.

Prior studies of non-pregnant populations found that upward SM and stable high SEP were protective against depressive symptoms (Luo and Waite 2005, Nicklett and Burgard 2009, Hudson et al. 2013, Ro 2014, Dal Grande et al. 2015, Ward et al. 2016, Kwon et al. 2017). Table 1.5 shows recent studies reporting on associations between SM and risk of depression. Using the United States nationally representative data of late middle age individuals, Kwon et al. (2017) showed that high and increasing depression was associated with low financial status in childhood and adverse adulthood SEP in terms of education and income; those with upward SM were less likely to have high and increasing depression, compared to those with persistently low SEP. In an observational study of mothers of young children in California, Walsemann et al. (2017) found that compared with longstanding advantaged neighborhood, long-term disadvantaged and increasing poverty neighborhood were associated with higher odds of depressive symptoms,

decreasing poverty neighborhood were about half as likely to report depressive symptoms. An intergenerational study in a population of Mexican origin observed the lowest prevalence of depression symptoms occurred in participants with upward SM, compared to those with stable low education attainment; and among adults, stable low or downward SM was related to depression symptoms (Ward et al. 2016). A significant association was also found in participants from South Australia between stable low SEP for both childhood and adulthood and downward SM, measured by housing tenure and financial situation, and mental health conditions (Dal Grande et al. 2015). Using data from young adults in the United States, Hudson (2013) observed an association between life course SEP and depressive symptoms, but this relationship was only statistically significant in African Americans. In an American longitudinal study, participants with upward SM had fewer depressive symptoms, compared to those with stable low SEP, in terms of a single index created from parental education and other childhood socioeconomic measures (Luo and Waite 2005). Adverse childhood SEP may be partially or wholly attenuated by upward SM. A prosperity cohort study in northeast England by Tiffin (2005) also showed that a downward SM over the whole life course was related to poorer mental health in men ($p<0.001$), instead of women ($p=0.8$). Among immigrants, Nicklett and Burgard (2009) observed that downward SM was linked to poorer mental health; Ro (2014) observed that both upward and downward SM, as measured by a change in occupational prestige and educational match, were related to higher depression among foreign-born women in the United States. These previous findings implied that effect of adulthood SEP on depressive symptoms also depends on childhood SEP. These results also demonstrated that joint effects of SEP across multiple generations played an essential role in depression.

Table 1.3. Studies reporting on associations between adulthood socioeconomic position and risk of depression

First Author (Year)	Sample	Explanatory Variable	Dependent Variable	Statistical Analyses	Results
Bahk (2015)	Korea (N=2,065) Non-pregnant population	SEP: education, occupation, household income	Depression (Kessler 6-Item Psychological Distress Scale)	Generalized estimating equation	• Parental education and household income were inversely associated with maternal depressive symptoms. • No significant association was observed between paternal occupation and maternal depressive symptoms over the study period.
Lindström (2013)	Sweden (N=28,198) Non-pregnant population	SEP: occupation	Psychological health (GHQ12).	Logistic regression	• This study confirmed the social mobility hypothesis and the accumulation hypothesis, but not the critical period hypothesis. • Exposures to economic stress during both childhood and adulthood were related to poor psychological health in adulthood.

Table 1.3. (cont'd)

First Author (Year)	Sample	Explanatory Variable	Dependent Variable	Statistical Analyses	Results
Hudson (2012)	USA African Americans (N=2,137) Non-pregnant population	SEP: household income, education, employment status, wealth	Major Depressive Episode (MDE)	Logistic regression	• Among African-American men, low level of education attainment, unemployment, and low household income predicted greater risk of 12-month major depressive episode (MDE); unemployment was statistically related to lifetime MDE. • For African-American women, household income was inversely associated with 12-month MDE.
Miyake (2012)	Japan (N=1,741) Pregnant population	SEP: employment, household income, education	Depression (Center for Epidemiologic Studies Depression Scale) (CES-D)	Logistic regression	• A lower prevalence of prenatal depression was more common among women who had full-time employment, especially, a professional or technical job. Production, service, sales, and other occupations were not significantly related to prenatal depression. • No significant association between household income or education and prenatal depression were observed.

Table 1.3. (cont'd)

First Author (Year)	Sample	Explanatory Variable	Dependent Variable	Statistical Analyses	Results
Stewart (2007)	USA (N=1,802) Pregnant population	SEP: education, income, public assistance, material deprivation, subjective social standing	Depression (CES-D)	Multiple linear regression	• Low education and low level of education attainment were associated with higher risk of depression. • Public assistance and material deprivation were significantly associated with depression. • Those with higher scores of subjective social standing were less depressed.
Holzman (2006)	USA (N=1,321) Pregnant population	SEP: Medicaid, housing, employment, telephone service, transportation	Depression (CES-D)	Generalized linear regression	• Compared to advantaged women (23%), depression symptom was more common among disadvantaged women (47%). • Among disadvantaged and advantaged women, abuse and economic problems were associated with higher risk of depression symptoms when these problems occurred in both childhood and adulthood.

Table 1.3. (cont'd)

First Author (Year)	Sample	Explanatory Variable	Dependent Variable	Statistical Analyses	Results
Lorant (2003)	Meta-analysis; 51prevalence studies, 5 incidence studies, 4 persistence studies. (1979-2001)	SEP: education, income, occupation, social class, assets	Depression	A random effects model; meta-regression	• Low SEP was associated with higher risk of depression (OR = 1.81, $p < 0.001$), no matter a new episode (OR = 1.24, $p = 0.004$), or a persisting depression (OR= 2.06, $p < 0.001$). • Education and income had a dose-response relation with risk of depression. • The association between SEP and risk of depression varied by the way depression is measured, the definition and measurement of SEP, region and time.

Table 1.4. Studies reporting on associations between childhood socioeconomic position and risk of depression

First Author (Year)	Sample	Explanatory Variable	Dependent Variable	Statistical Analyses	Results
Gale (2011)	UK Five cohorts (N=5,570)	SEP: Father's occupation; Own or husband's occupation	Depression and Anxiety (the Hospital Anxiety and Depression Scale)	Logistic regression	• Lower social class in childhood was associated with an increased risk of depression (OR=1.20, 95% CI 1.07, 1.34). • Lower social class in adulthood was linked to an elevated risk of depression OR=1.35, 95% CI 1.19, 1.58). • The associations between social class and depression became attenuated in the adjusted model (during childhood OR=1.10, 95% CI 0.95, 1.26; during adulthood: OR=1.09, 95% CI 0.81, 1.46)
Stansfeld (2011)	UK (N=9,377)	SEP: occupation	Depressive and anxiety disorders	Logistic regression	• Cumulative disadvantaged childhood SEP was associated with higher risk of mid-life disorder. • Psychological disorder in childhood was related to low adulthood SEP (OR = 3.33, 95% CI 2.63, 4.21). • Social causation and health selection explained the relation between disadvantage SEP in childhood and depression in adulthood.

Table 1.4. (cont'd)

First Author (Year)	Sample	Explanatory Variable	Dependent Variable	Statistical Analyses	Results
Nicholson (2008)	Russia, Poland, and the Czech Republic (N=12,053 men and N=13,582 women)	SEP: father's education; household amenities; own education; current financial difficulties; possession of household items.	Depression (CESD-20)	Logistic regression	• Among men, there was significant relationship between adulthood SEP and depression (OR= 3.16, 95% CI= 2.57, 3.89 in Russia; OR= 3.16, 95% CI= 2.74, 3.64 in Poland; and OR= 2.17, 95% CI= 1.80, 2.63 in the Czech Republic). • Among female, the relationship between SEP and depression was not observed.
Gilman (2002)	USA (N=1,132)	SEP: occupation	Major depressive episode	Survival analysis	• Compared to those with advantaged childhood SEP, participants with disadvantaged childhood SEP had an increased risk of major depression, independent of adult SEP and family history of mental illness. •

Table 1.4. (cont'd)

First Author (Year)	Sample	Explanatory Variable	Dependent Variable	Statistical Analyses	Results
Harper (2002)	Finland (N=2,585)	SEP: education, income, occupation	Depression (the Human Population Laboratory depression index)	Multiple linear regression	• Low level of education attainment and unskilled occupation were associated with higher risk of age-adjusted levels of depressive symptoms in adulthood. • There was no association between childhood SEP and adult depressive symptoms.
Ritsher (2001)	USA (N=756)	SEP: education, occupation	Major depressive disorder	Logistic regression	• There was a significant association between low parental education and higher risk for offspring depression, even after adjusting for parental depression, offspring age and gender. • Depression cannot predict offspring education, income or occupation.

Table 1.5. Studies reporting on associations between socioeconomic mobility and risk of depression

First Author (Year)	Sample	Explanatory Variable	Dependent Variable	Statistical Analyses	Results
Kwon (2017)	USA (N=8,532)	SM: parental education, financial status; own education, income	Depression (CESD-20)	Multinomial logistic regression	• Those who had a disadvantaged childhood and continued to experience limited or no upward mobility tended to experience more depressive symptoms. • Those who had a socioeconomically disadvantaged childhood but experienced upward mobility over their life course (low-high) still tended to be high and increasing depression symptoms.
Walsemann (2017)	USA California (N=2,726)	SM: Neighbor-hood-level poverty	Depressive symptoms, sense of control, number of stressors	Logistic regression, linear regression, zero-inflated Poisson regression	• Long-term high-poverty and increasing poverty neighborhoods were associated with higher odds of depressive symptoms than long-term low-poverty neighborhoods. • Decreasing poverty neighborhoods were associated with lower odds of depressive symptoms than long-term low-poverty neighborhoods. • Duration of residence was unrelated to depressive symptoms.

Table 1.5. (cont'd)

First Author (Year)	Sample	Explanatory Variable	Dependent Variable	Statistical Analyses	Results
Ward (2016)	USA Mexican-origin (N=603)	SM: education	Depression (CESD-10)	Generalized linear regression	• Compared to those with stable low education attainment, participants with upwardly SM and stable high SM had lower risk of depression (PR (95% CI) =0.55 (0.39, 0.78); 0.62 (0.44, 0.87), respectively). • Compared to those with stable low education attainment, participants with downwardly SM also had lower risk of depression (PR = 0.65; 95% CI = 0.38, 1.11).
Owens (2015)	USA Atlanta African American (N= 101)	SM: family class	Depression (Beck Depression Inventory-II)	Linear regression	• There was significant association between high contextual stress and depression. • The association between contextualized stress and depression was not modified by the life-course SEP and mobility

Table 1.5. (cont'd)

First Author (Year)	Sample	Explanatory Variable	Dependent Variable	Statistical Analyses	Results
Grande (2015)	Australia (N=10,429)	SM: family financial situation and housing tenure	Anxiety, stress or depression, suicidal ideation, psychological distress.	Logistic regression	• Participants who had downward SM and stable low SM from childhood to adulthood had greater risk of anxiety, stress or depression and psychological distress.
Ro (2014)	USA Immigrants (N = 2,305)	SM: occupational prestige and educational match	Depression: the World Health Organization Composite International Diagnostic Interview Short-Form (CIDI-SF)	Logistic regression	• Both upward and downward SM were related to higher depression among foreign-born women in the United States.
Hudson (2013)	USA (N=3,620)	SM: parental education; own occupation	Depression (CESD-20)	Multivariate regression	• Overall, greater levels of life course SEP were significantly associated with fewer depressive symptoms ($\beta = -0.33$, $p = 0.001$). • There was a relationship between life course SEP and depressive symptoms, but this relationship was only statistically significant in blacks ($\beta = -0.52$, $p = 0.001$).

Table 1.5. (cont'd)

First Author (Year)	Sample	Explanatory Variable	Dependent Variable	Statistical Analyses	Results
Nicklett (2009)	USA immigrants (N=3,056)	Downward SM: social status	Major depression episode	Logistic regression	• Participants who had downward SM had an elevated risk of depression (OR= 3.0, 95% CI: 1.3, 6.6), compared to those with stable SM.
Luo (2005)	USA (N=19,949)	SM: education, household income, occupation	Depression (CESD)	Ordinary least squares regression	• Participants with upward SM had fewer depressive symptoms, compared to those with stable low SEP, in terms of a single index created from parental education and other childhood socioeconomic measures.
Tiffin (2005)	UK (N=508)	SM: occupational social class	General health questionnaire (GHQ-28)	Logistic regression	• Compared to those with the most advantaged SEP, participants who had the disadvantaged SEP at birth reported a significant poor mental health at age 50 (OR=5.5, 95% CI 1.2, 25.4). • The association between a downward SM and poorer mental health was found among men ($p<0.001$), instead of women ($p=0.8$).

1.9 Gap in the literature

Epidemiologic studies investigating the relationship between SM and perinatal health have employed various measures of maternal SEP. Some studies used neighborhood census tract median family income to measure childhood and adulthood SEP. Without measuring women's SEP at multiple time points during the life course, many SM studies in the United States used the linked birth files across generations and ecological SEP measures from the United States Census data (Collins et al. 2007, Love et al. 2010, Collins, Rankin, and David 2011, Collins, Rankin, and David 2015). These United States-based studies showed that women who experienced upward SM from childhood in a disadvantaged neighborhood to adulthood in an advantaged neighborhood had better birth outcomes, compared to those with lifelong residence in a disadvantaged neighborhood. However, these studies were unable to assess the impact of individual level wealth over the life course on birth outcomes. On the other hand, some studies used various combinations of household income, individual occupation, and education attainment to estimate the maternal SEP, but lack of information about contextual factors of maternal SEP.

Many prior studies measured SEP at a single time point and used a single indicator, e.g. education, occupation or family income (Auger, Giraud, and Daniel 2009, Nicklett and Burgard 2009, Blumenshine et al. 2011, Joseph et al. 2014, Gigante et al. 2015, Owens and Jackson 2015, Ward et al. 2016). However, the multidimensional nature of SEP and the complexity of SEP transition from one time point to another suggest that SEP and SM cannot be measured completely with one indicator. In pregnancy outcomes studies, methods for combining multiple SEP indicators and for measuring SM from childhood to adulthood varied (Gigante et al. 2015, Slaughter-Acey et al. 2016). In a mental health study with multiple SEP indicators, a single index

of SEP measure was defined as the average of standardized SEP indicators (Luo and Waite 2005).

In this study, we used a latent class analysis (LCA) for measuring SM in a dataset with individual-level data of maternal childhood and adulthood SEP measures, a novel approach for pregnancy studies. We also adopted the model-based approach to LCA with distal outcome to elucidate complex relationships between SM and the risk of PTD or prenatal depression among pregnant women. Typically, traditional classify-analyze strategies have been used to predict a distal outcome conditioned on latent class membership. In the first classification step, individuals were assigned to latent classes based on probabilities. In a second analysis step, the distal outcome was predicted from the latent class membership which was treated as observed. For these traditional strategies the results are biased due to classification error. However, the model-based approach that we use models measurement error (Collins & Lanza, 2010) and produces less biased estimates for the probability of prenatal depression conditional on latent class membership.

Despite growing evidence examining the effect of SM on pregnancy outcomes and mental health later in life, few studies have taken into account the multi-dimensional aspect of SEP when examining associations between SM and PTD; and to our knowledge, there has been no previous study to investigate the association between SM and depression among pregnant women. Therefore, there remains a gap in the literature exploring the associations of SM with both PTD and depression among pregnant women in the United States.

1.10 Aims

The main objective of this study is to investigate associations between maternal SM from childhood to adulthood and risk of PTD and risk of prenatal depression in a Michigan, community-based cohort study that is racially and socioeconomically diverse. The availability of in-depth, individual-level data on mothers and their childhood SEP provides a unique opportunity to study SM. The aims of this study are: 1) to identify and describe distinct groups of the childhood SEP indicators and adulthood SEP indicators and SM from childhood SEP to adulthood SEP; and to investigate the associations between latent groups and PTD using model-based approach; and to evaluate whether maternal race/ethnicity modifies the above associations; 2) to examine the associations between latent groups and perinatal depression using model-based approach; and to evaluate whether maternal race/ethnicity modifies the above associations.

In Chapter 2, based on the life course model of SEP trajectories, we hypothesize that: 1) women with lowest childhood SEP and lowest adulthood SEP will be at greatest risk of PTD; and 2) women who experience upward SM from childhood to adulthood will have a decreased risk of PTD relative to women who maintain a lower SEP during childhood and adulthood; and 3) women who experience downward SM from childhood to adulthood will have a higher risk of PTD relative to women who maintain a higher SEP during childhood and adulthood. Because other studies reported that the relation of SEP (or SM) with PTD risk varied by maternal race/ethnicity (P. Blumenshine et al. 2010, Collins, Rankin, and David 2011, Collins, Rankin, and David 2015), we also examine evidence for this effect modification.

In Chapter 3, we hypothesize that: 1) women with lowest childhood SEP and lowest adulthood SEP will be at greatest risk of prenatal depression; 2) women who experience upward

SM from childhood to adulthood will have a decreased risk of prenatal depression relative to women who maintain a lower SEP; and 3) women who experience downward SM from childhood to adulthood will have a higher risk of prenatal depression relative to women who maintain a higher SEP during childhood and adulthood. Because some studies reported that the relation between SEP (or SM) and depression varied by race/ethnicity (Luo and Waite 2005, Owens and Jackson 2015, Ward et al. 2016), we also examine evidence for this effect modification.

CHAPTER 2

MATERNAL SOCIOECONOMIC MOBILITY AND PRETERM DELIVERY: LATENT CLASS ANALYSIS

2.1 Introduction

Preterm delivery (PTD, delivery less than 37 completed weeks of gestation) is a major cause of perinatal mortality and morbidity (Blencowe et al. 2013). The disparities in PTD rates between population subgroups defined by race/ethnicity and socioeconomic status are striking (Blumenshine et al. 2010). Maternal disadvantaged socioeconomic position (SEP) in adulthood has been associated with higher PTD risk (Blumenshine et al. 2010, Morgen et al. 2008, Auger, Giraud, and Daniel 2009, Blumenshine et al. 2011, Mortensen, Helweg-Larsen, and Andersen 2011, Matijasevich et al. 2012, Whitehead 2012, Joseph et al. 2014, Shankardass et al. 2014). Measures of SEP have included occupation, education and household income, and the relationship with PTD often varied by race/ethnicity (Blumenshine et al. 2010). Childhood SEP has also been examined to have a significant effect on adult health (Cohen et al. 2010). However, few studies have examined mother's childhood SEP and the risk of PTD. A Brazilian intergenerational study observed that maternal childhood poverty, measured by family income, was strongly associated with shorter gestation (Gigante et al. 2015).

Socioeconomic mobility (SM) has been studied in relation to low birthweight (Basso et al. 1997, Spencer 2004, Colen et al. 2006, Astone, Misra, and Lynch 2007, Love et al. 2010, Osypuk et al. 2016), small for gestational age (Love et al. 2010, Osypuk et al. 2016, Slaughter-Acey et al. 2016), and newborn body composition (Sletner et al. 2014). In our review of the

literature, however, we found fewer studies examining SM and PTD (Love et al. 2010, Collins, Rankin, and David 2011, Collins et al. 2007, Kramer, Dunlop, and Hogue 2014, Collins, Rankin, and David 2015). Collins et al. (2011) found that upward SM was related to a decreased risk of PTD among African-American women. Downward SM was linked to an elevated risk of PTD among white urban women (Collins, Rankin, and David 2015). However, these studies measured SM based on neighborhood census tract median family income rather than individual or household data.

Three conceptual models have been proposed to explicate how disadvantaged life course SEP affects health later in life and they may not be mutually exclusive (Kuh et al. 2003, Kendzor, Caughy, and Owen 2012). One model focuses on critical developmental periods (e.g. childhood) when SEP may exert its strongest effect on later health. Another model views "accumulation" of socioeconomic disadvantage (intensity and duration) as posing the greatest health risk. A third model considers SEP trajectories, i.e. SM; it hypothesizes that upward SM remediates the negative effects of earlier disadvantage SEP, however, downward SM may result in poorer adult health despite relative socioeconomic advantages at earlier stages (Kuh et al. 2003, Cohen et al. 2010, Kendzor, Caughy, and Owen 2012). In all these models, determining the temporal order of SEP and health can be challenging.

Previous studies have typically measured SEP at a single time point, and used a single indicator, e.g. education, occupation or family income (Auger, Giraud, and Daniel 2009, Blumenshine et al. 2011, Joseph et al. 2014, Gigante et al. 2015). However, the multidimensional nature of SEP and the complexity of SEP transition from one time point to another suggest that SEP and SM cannot be measured completely with one indicator. In pregnancy outcomes studies, methods for combining multiple SEP indicators and for measuring SM from childhood to

adulthood vary (Gigante et al. 2015, Slaughter-Acey et al. 2016). Our study uses a latent class analysis (LCA) for measuring SM in a dataset with individual-level data of maternal childhood and adulthood SEP measures, a novel approach for pregnancy studies.

The main objective of this study is to examine associations between maternal SM from childhood to adulthood and risk of PTD in a Michigan, community-based cohort study that is racially and socioeconomically diverse. The availability of in-depth, individual-level data provides a unique opportunity to study SM. Based on the model of SEP trajectories, We hypothesize that: 1) women with lowest childhood SEP and lowest adulthood SEP will be at greatest risk of PTD; and 2) women who experience upward SM from childhood to adulthood will have a decreased risk of PTD relative to women who maintain a lower SEP during childhood and adulthood; and 3) women who experience downward SM from childhood to adulthood will have a higher risk of PTD relative to women who maintain a higher SEP during childhood and adulthood. Because other studies reported that the relation of SEP (or SM) with PTD risk varied by maternal race/ethnicity (Blumenshine et al. 2010, Collins, Rankin, and David 2011, Collins, Rankin, and David 2015), we also examine evidence for this effect modification.

2.2 Methods

Study population

This study included 3,019 pregnant women enrolled at 16-27 weeks' gestation in the prospective Pregnancy Outcomes and Community Health (POUCH) study (1998-2004) from five Michigan communities. Eligibility criteria included: English-speaking, age >14 years, no pre-existing diabetes, singleton pregnancy with no known congenital anomalies, and prenatal

maternal serum alpha-fetoprotein screening at 15-22 weeks of gestation. The detailed study protocol can be found elsewhere (Holzman et al. 2001). Institutional review board approval for this study was received from Michigan State University and all nine participating delivery hospitals.

At enrollment each pregnant woman provided informed written consent, met with a study nurse for a structured in-person interview, and completed a self-administered questionnaire that collected information regarding demographics, lifestyle, psychosocial factors, medical history and health status. Pregnancy outcome data were abstracted from hospital delivery records. Self-reported maternal race/ethnicity was dichotomized as white/others or African American. The numbers of "others" race/ethnicity were small and their PTD rates were similar to that of whites, therefore these groups were combined.

Measures

Childhood SEP and adulthood SEP

Childhood SEP measures included a woman's self-report of her parents' socioeconomic indicators during her childhood, i.e. maternal mother's and father's highest level of education attainment, maternal mother's and father's usual occupation, and receipt of public assistance by the family. Adulthood SEP measures included maternal socioeconomic indicators at enrollment, i.e. maternal and child's father's highest level of education, maternal and child's father's usual occupation, Medicaid Insurance status, and maternal annual household income. SEP indicators were modeled as binary variables, i.e. education (≤high school, >high school); usual occupation status based on the United States Census Bureau's 1990 Occupational Classification System ("low"= service/blue collar, unemployed, and unknown; "high"= professional, manager,

technical, clerical/sales, homemaker, military, retired, and student); public assistance (yes/no); Medicaid Insurance (yes/no); maternal household income (<$50,000 and ≥$50,000). "Unknown" paternal and grandfather's occupation was assigned as "low" occupation status because it correlated with other low SEP indicators (Slaughter-Acey et al. 2016). Missing data for SEP indicators were handled primarily through statistical methods (see statistical methods section below). In separate models, a maternal neighborhood deprivation index (NDI) also was included in adulthood SEP. The NDI was calculated using information from the 1986 Census and followed a previously validated approach (Messer et al. 2006). The NDI was dichotomized at the medium of the study population.

Maternal SM

Maternal SM was defined by modeling both childhood and adulthood SEP indicators in LCA. The SEP indicator variables were dichotomized the same as the childhood SEP and adulthood SEP variables.

Preterm delivery

Gestational age at delivery was estimated based on date of last menstrual period unless this estimate disagreed with early ultrasound (< 25 weeks' gestation) dating by two or more weeks, in which case ultrasound dating was used. PTD was defined as deliveries less than 37 completed weeks of gestation.

Statistical Analysis

Initially we assessed the distribution of maternal characteristics and SEP indicators overall and stratified by delivery timing (preterm/term), and used chi-square tests to test

differences in proportions. We used latent class analysis (LCA) to identify and describe distinct groups of childhood SEP indicators and adulthood SEP indicators and SM from childhood to adulthood. LCA classifies individuals with similar SEP characteristics into groups based on conditional probabilities (Collins and Lanza 2010). SM was defined by LCA according to a multidimensional set of SEP indicators from childhood to adulthood. We determined the optimal number of LCA groups by: 1) visualizing the plot of log-likelihoods of each model and eliminating model where the log-likelihood did not show a substantial improvement (Nylund, Asparouhov, and Muthén 2007); 2) using the Bayesian Information Criterion (BIC), with a smaller BIC representing a better-fitted model (Schwarz 1978); 3) evaluating the entropy, an indicator for class separation and precision, that measures how well an individual fits into a specific class with values closer to 1 representing better fit (Ramaswamy et al. 1993); and 4) considering the size of the latent classes, uniqueness of classes, and meaningful interpretation of the response probability pattern for each class. As a next step, after the optimal number of groups was determined we used the model-based approach to LCA with distal outcome to predict the risk of PTD based on the latent class membership of exposure variables (i.e. childhood SEP, adulthood SEP, SM) (Lanza, Tan, and Bray 2013).

Race/ethnicity was added as a grouping variable in LCA models to investigate associations among SEP, SM and risk of PTD within race/ethnic groups (white/others, African American). Because SEP indicators may have different ranges and occur in different contexts across race/ethnic groups, we computed group-specific LCA following the same methodology described above. In another set of models, we added the NDI to adulthood SEP to examine its contribution to identifying SEP associations with PTD risk.

All statistical analyses were conducted using PROC LCA and its corresponding distal outcome macro in SAS 9.4 (Statistical Analysis Software, Cary, NC) (Lanza et al. 2015, Dziak et al. 2016). Proc LCA program uses full information maximum likelihood estimation to cope with missing data in the SEP indicators.

2.3 Results

Sample characteristics

In the total sample of 3019 women, 11.1% of pregnancies ended in PTD and about one fourth of women were African American (Table 2.1). For the childhood SEP indictors, about 60% of grandmothers and 55% of grandfathers did not graduate from high school. Approximately 32% of grandmothers and 71% of grandfathers had a low-level occupation. About one third of families received public assistance during the mother's childhood period. For adulthood SEP indicators, 47% of mothers and 55% of fathers did not graduate from high school; 39% of mothers and 65% of fathers had a low-level occupation; 48% of pregnant women were insured by Medicaid; and 66% of families had an annual income of <$50,000. In bivariate analyses, increased risk of PTD was associated with two childhood SEP indicators, i.e., grandmother's low-level occupation and family history of public assistance; and with all adulthood indicators of lower SEP, except NDI.

Latent Class Profile

In the LCA of childhood SEP, a three-group solution was considered optimal according to criteria described in our statistical methods section (Table 2.2). The three-group model had the

lowest BIC and substantial improvement in log-likelihood difference when moving from a three-group to two-group model, compared to that from a four-group model to a three-group model. The subgroups characterized by particular SEP indicators were interpreted and labelled according to the parameter estimates. For childhood SEP, compared to other groups, Group 1, "low group", (38% of women) grandmothers and grandfathers were less likely to graduate from high school (17% and 11%, respectively), to have a high-level occupation (23% and 11%, respectively), or to avoid public assistance during the mother's childhood (43%) (Table 2.3). The probabilities of positive childhood SEP indicators improved in childhood SEP Group 2, "middle group", (38% of women) with the exception of grandfathers' education (11%) and occupation (17%). Childhood SEP Group 3, "high group", (24% of women) showed high probabilities of all positive SEP indicators.

For adulthood SEP, a four-group model had the lowest BIC, however there was minimal improvement when moving from a three-group to four-group model, compared to the substantial log-likelihoods difference from a two-group to a three-group model. Furthermore, the entropy for the four-group model was smaller than that for the three-group model, indicating poor latent group separation for the four-group model (Ramaswamy et al. 1993). Based on additional considerations of group prevalence and interpretability we chose the three-group model for adulthood SEP (Table 2.2). For adulthood SEP, compared to other group, Group 1,"low group", (51% of women) mothers and fathers were less likely to graduate from high school (22% and 15%, respectively), to have a high-level occupation (40% and 16%, respectively), to have medical insurance other than Medicaid (15%), or to a family income > $50,000 (4%) (Table 2.3). The probabilities of SEP indicators in adulthood SEP Group 2, "middle group", (18% of women) varied; for example, fathers in this group had low probabilities of having a high-level education

(19%) and occupation (23%) but women were more likely to have high-level occupations (73%) and medical insurance other than Medicaid (94%). About half of the families had an annual household income exceeding $50,000 (54%). In adulthood SEP Group 3, "high group", (31% of women), all probabilities of positive SEP indicators were increased; about 64% of these families had annual household incomes exceeding $50,000.

We used both childhood and adulthood SEP indicators for the SM LCA. The BIC values decreased with increasing number of groups until 6 groups. After reviewing the plot of log-likelihoods of each model with specified group, improvements in model fit, size of the groups, and interpretability we chose the four-group solution for modeling SM from childhood to adulthood (Table 2.2). In SM from childhood to adulthood, Group 1, "static low group", (45% women) women had low-level childhood SEP and low-level adulthood SEP indicators (Table 2.3). SM Group 2, "upwardly mobile group", (24% of women) showed some improvement in two childhood indicators, i.e. probabilities of grandmother with high-level occupation (75%) and avoiding public assistance (81%), and higher probabilities in all positive adulthood SEP indicators. SM Group 3, "downwardly mobile group", (16% of women) tended to have high-level childhood SEP and moderate to low-level adulthood SEP. In this group the fathers' education and occupation were unlikely to be high-level (39% and 27%, respectively) and the probability of household income >$50,000 was low (15%). SM Group 4, "static high group", (15% of women) had high-level SEP indicators throughout childhood and adulthood.

Latent class models also were examined for white/others women and African-American women separately using the methodology described above. For each race/ethnic group, based on fit indices and interpretability, we chose a three-group model for childhood SEP and adulthood SEP indicators and a four-group model for SM. The race/ethnicity-specific item-response

probabilities for each indicator conditional on latent class membership are presented in Table 2.3. For the childhood SEP, the group percentages for white/others and African American, respectively, were: low group 24%, 78%; middle group 46%, 13%; and high group 30%, 9%. For the adulthood SEP, the group percentages for white/others and African American, respectively, were: low group 44%, 48%; middle group 19%, 31%; and high group 37%, 21%. For SM, the group percentages for white/others and African American, respectively, were: static low 38%, 57%; upwardly mobile 28%, 15%; downwardly mobile; 16%, 21%; and static high 18%, 7%.

LCA with Distal Outcome: Preterm Delivery

Overall, the frequency of PTD in the low, middle, and high childhood SEP groups was 13.2%, 9.6%, 10.1%, respectively. The frequency of PTD in the low, middle, and high adulthood SEP groups was 12.9%, 10.3%, and 8.5%, respectively. In comparisons with their respective high SEP groups, women in the low SEP groups were more likely to deliver preterm: low childhood SEP group PTD odds ratio (OR) =1.36, 95% confidence interval (95% CI): 0.98, 1.90; and low adulthood PTD OR=1.59, (95% CI: 1.18, 2.15) (Table 2.4). PTD occurred in13.1%, 8.3%, 11.6%, and 8.8% of women who had experienced static low SM, upward SM, downward SM, and static high SM, respectively. Women in the upward SM group had decreased odds of PTD (OR=0.60, 95% CI: 0.42, 0.87) compared to women in the static low SM group. The odds of PTD among women with downward SM was higher (OR=1.36, 95% CI: 0.80, 2.30) than that of women with static high SM, however, the association was not statistically significant.

In a separate set of analyses we used race/ethnic-specific LCA models. Among the white/others women, low childhood SEP and low adulthood SEP were associated with increased odds of PTD in comparisons with their respective high SEP groups, PTD ORs=1.21, (95% CI:

0.98, 1.90) and 1.44 (95% CI: 1.02, 2.04). Women who experienced upward SM had a lower odds of PTD, OR=0.66, (95% CI: 0.43, 1.00) when compared to those in the static low SM group. Among African-American women, PTD odds were greater in the low childhood SEP and low adulthood SEP groups compared to their respective high SEP groups, however, the small samples sizes for each SEP group resulted in more limited statistical power and no statistically significant associations.

We incorporated the NDI in the adulthood SEP LCA to examine its added effect on SEP associations with PTD. Table 2.5 summaries the LCA model fit statistics. In consideration of a combination of fit statistics and interpretability, we selected a three-group model for adulthood SEP with NDI and a four-group model for SM that included childhood SEP and adulthood SEP with NDI. The item-response probabilities for each SEP indicator conditional on latent class membership of adulthood SEP with NDI and SM are shown in Table 2.6. The latent class profiles were similar to those in adulthood SEP without NDI. When we assessed the associations between latent class membership and PTD (Table 2.7), NDI did not substantially change our original findings.

2.4 Discussion

Using a latent class approach with relevant indicators, we identified constructs of pregnant women's childhood SEP, adulthood SEP, and SM from childhood to adulthood in association with risk of PTD. We found that women with low childhood SEP and low adulthood SEP were at greatest risk of PTD; and pregnant women who experienced upward SM had a lower likelihood of delivering preterm than those who had static low SEP. This SM advantage

was true in white/others women. Our findings are consistent with Slaughter-Acey et al.'s analysis of POUCH Study data showing decreased risk of delivering a small-for-gestational-age infant among pregnant women with upward SM (Slaughter-Acey et al. 2016). In another study of African-American pregnant women, Collins et al. reported that upward SM was related to a decreased risk of PTD (Collins, Rankin, and David 2011).

We also observed that disadvantaged SEP at adulthood was related to a higher likelihood of PTD, a finding that is echoed across many previous studies (Morgen et al. 2008, Blumenshine et al. 2011, Matijasevich et al. 2012, Whitehead 2012, Joseph et al. 2014). In a systematic review of 106 studies from 1999 to 2007, Blumenshine et al. (2010) suggested that disadvantaged SEP was consistently linked to greater risk of adverse birth outcomes and observed racial/ethnic heterogeneity in the effect of SEP measures (Blumenshine et al. 2011). The inverse associations between maternal education and adverse birth outcomes were significant among non-Hispanic white pregnant women. Shankardass et al. (2014) found that the risk of spontaneous PTD was elevated across all the indicators of lower SEP, and women living in neighborhoods with higher NDI had greater risks of medically indicated and spontaneous PTD (Shankardass et al. 2014). In our study, the addition of NDI to the model did not substantively change the adulthood SEP relation to PTD risk.

Our findings support the hypothesis that improving women's SEP from childhood to adulthood may improve pregnancy outcomes. According to the cumulative pathway life-course model, upward SM might decrease the accumulation of adverse exposures that create "wear and tear" to the body (allostatic load) (McEwen 1998), and thereby create a more optimal in-utero environment for the growing fetus (Slaughter-Acey et al. 2016). Pregnant women who experience upward SM may have: 1) greater access to high-quality food, reliable housing, a safe

living environment, and high-quality health care; 2) more support for healthy lifestyle choices (diet, physical activity, no smoking, no alcohol use, etc.); and 3) greater opportunity for psychological health (less stress, more social integration, etc.). Our results also imply that the childhood environment (SEP) is not deterministic for women's future risk of PTD. In our data, the adulthood SEP had the strongest association with PTD risk.

To our knowledge, this study is the first to use the model-based approach to LCA with distal outcome to elucidate complex relationships between SM and the risk of PTD among pregnant women in the United States. Typically, traditional classify-analyze strategies have been used to predict distal outcome from latent class membership. In the first classification step, individuals were assigned to latent classes based on probabilities. In a second analysis step, the distal outcome was predicted from the latent class membership which was treated as observed. For these strategies the results were biased to the extent that there is classification error. However, this model-based approach models measurement error and produces less biased estimates for the probability of PTD conditional on latent class membership (Collins and Lanza 2010). Moreover, use of the full-information expectation-maximization algorithm in LCA may include all participants who responded to at least one SEP indicator (Collins and Lanza 2010). Most previous studies investigating the effect of SM on PTD used a single SEP indicator to measure SM (Love et al. 2010, Collins, Rankin, and David 2011, Collins et al. 2007, Kramer, Dunlop, and Hogue 2014, Collins, Rankin, and David 2015). Our study used multiple SEP indicators for childhood SEP and adulthood SEP measures, which may minimize misclassification bias. In addition, this study enrolled pregnant women with diverse SEP, which allowed us to observe a wider range of SM.

An important limitation in most SM research pertains to the inferences. When we study individuals we don't randomly assign SM, therefore it is difficult to disentangle the extrinsic benefits of an improved socioeconomic environment from the unique attributes of individuals who are able to climb the SEP ladder (self-selection). In addition, all SEP indicators were self-reported and recall bias cannot be ruled out, but the recall bias should apply equally to those with and without PTD because reporting occurred mid-pregnancy, well before delivery. Few African-American women experienced SM in this study, making it difficult to calculate accurate race/ethnicity-specific estimates of the SM-PTD association in this group. Our software and modeling strategy, i.e. model-based approach to LCA with distal outcome, could not accommodate adjustment for other covariates (potential confounders); this leaves open the possibility of unmeasured confounding. While we stratified on race/ethnicity, we considered maternal age, parity, and pre-pregnancy body mass index as important covariates. In sensitivity analyses we also looked to see whether our results would vary by these covariates. The analyses results suggested that our findings were robust even after the stratification.

In summary, our study suggests that policies or programs to reduce socioeconomic inequalities may play an essential part in decreasing adverse pregnancy outcomes such as PTD. Upward SM among pregnant women was associated with decreased risk of PTD. This relationship was most evident among white/others women in our study. Further research is needed to understand the specific elements accompanying SM that are protective for PTD and the best strategies for increasing SM among all race/ethnic groups.

Table 2.1. Maternal Characteristics and Socioeconomic Position Indicators (n=3,019), Pregnancy Outcomes and Community Health Study, Michigan, 1998-2004

	Overall (n=3,019)		Preterm (n=335)		Term (n=2,684)		
	No.	%	No.	%	No.	%	*P* value[a]
Race/ethnicity							0.0002
White/others	2276	75.4	225	67.2	2051	76.4	
African American	743	24.6	110	32.8	633	23.6	
Childhood SEP							
Grandmother's education							0.55
Missing	128	4.2	19	5.7	109	4.1	
≤ high school	1810	60.0	193	57.6	1617	60.3	
>high school	1081	35.8	123	36.7	958	35.7	
Grandfather's education							0.20
Missing	477	15.8	62	18.5	415	15.5	
≤ high school	1662	55.1	188	56.1	1474	54.9	
>high school	880	29.2	85	25.4	795	29.6	
Grandmother's usual occupation[b]							0.03
Low occupational status	959	31.8	124	37.0	835	31.1	
High occupation status	2060	68.2	211	63.0	1849	68.9	
Grandfather's usual occupation[b]							0.25
Low occupational status	2145	71.1	247	73.7	1898	70.7	
High occupation status	874	29.0	88	26.3	786	29.3	
Family history of public assistance							0.03
Missing	112	3.7	11	3.3	101	3.8	
Yes	1081	35.8	138	41.2	943	35.1	
No	1826	60.5	186	55.5	1640	61.1	

Table 2.1. (cont'd)

	Overall (n=3,019)		Preterm (n=335)		Term (n=2,684)		
	No.	%	No.	%	No.	%	*P* value[a]
Adulthood SEP							
Maternal education							0.03
≤ High school	1406	46.6	175	52.2	1231	45.9	
>High school	1613	53.4	160	47.8	1453	54.1	
Father's education							0.04
Missing	138	4.6	18	5.4	120	4.5	
≤ High school	1655	54.8	199	59.4	1456	54.3	
>High school	1226	40.6	118	35.2	1108	41.3	
Maternal usual occupation[b]							0.02
Low occupational status	1180	39.1	151	45.1	1029	38.3	
High occupation status	1839	60.9	184	54.9	1655	61.7	
Father's usual occupation[b]							0.0004
Low occupational status	1952	64.7	246	73.4	1706	63.6	
High occupation status	1067	35.3	89	26.6	978	36.4	
Mother's Medicaid insured							0.002
Missing	3	0.1	1	0.3	2	0.1	
Yes	1454	48.2	188	56.1	1266	47.2	
No	1562	51.7	146	43.6	1416	52.8	
Annual household income							0.01
Missing	92	3.1	9	2.7	83	3.1	
< $50,000	2005	66.4	243	72.5	1762	65.6	
≥ $50,000	922	30.5	83	24.8	839	31.3	
Neighborhood deprivation index							0.09
Missing	5	0.2	0	0.0	5	0.2	
≥ Medium	1506	49.9	182	54.3	1324	49.3	
< Medium	1508	50.0	153	45.7	1355	50.5	

Abbreviation: SEP, socioeconomic position.

[a] *P* value for chi-square test between term and preterm groups.

[b] Low occupation status includes service/blue collar, unemployed, and unknown; high occupation status includes professional, manager, technical, clerical/sales, homemaker, and other (military, retired, student).

Table 2.2. Fit statistics for latent class analysis (n=3,019), Pregnancy Outcomes and Community Health Study, Michigan, 1998-2004

Group	Log-likelihood	Bayesian Information Criterion	Entropy
Childhood SEP			
2	-8431.3	244.6	0.74
3	-8380.5	191.2	0.70
4	-8366.2	210.7	0.82
5	-8365.0	256.4	0.81
Adulthood SEP			
2	-10102.4	609.1	0.81
3	-9978.9	418.3	0.78
4	-9896.7	309.9	0.72
5	-9876.6	325.8	0.74
6	-9869.4	367.6	0.74
SM: childhood SEP & adulthood SEP			
2	-18443.8	3160.4	0.84
3	-18134.1	2637.1	0.80
4	-17938.8	2342.7	0.76
5	-17869.5	2300.2	0.74
6	-17803.0	2263.3	0.73
7	-17758.2	2269.8	0.69

Abbreviation: SEP, socioeconomic position; SM, socioeconomic mobility.

Table 2.3. Estimated item-response probabilities of the socioeconomic position indicators conditional on latent class membership with distal outcome preterm delivery overall and by race/ethnicity (n=3,019), Pregnancy Outcomes and Community Health Study, Michigan, 1998-2004

		Latent Group								
		Overall (n=3,019)			White/others (n=2,276)			African American (n=743)		
		Low	Middle	High	Low	Middle	High	Low	Middle	High
Childhood SEP	No.	1159	1130	730	538	1059	679	579	97	67
Latent class membership probabilities		0.38	0.38	0.24	0.24	0.46	0.30	0.78	0.13	0.09
Indicator	%	Item-response probabilities								
Grandmother's education: >High school	0.36	0.17	0.34	0.74	0.11	0.27	0.72	0.22	0.87	0.93
Grandfather's education: >High school	0.29	0.11	0.11	0.97	0.08	0.13	0.94	0.13	0.01	0.98
Grandmother's occupation: High	0.68	0.23	0.98	0.93	0.09	0.93	0.94	0.41	0.97	0.82
Grandfather's occupation: High	0.29	0.11	0.17	0.76	0.11	0.16	0.77	0.11	0.12	0.64
Family history of public assistance: No	0.60	0.43	0.67	0.89	0.47	0.72	0.90	0.30	0.50	0.69

Table 2.3. (cont'd)

		Latent Group								
		Overall (n=3,019)			White/others (n=2,276)			African American (n=743)		
		Low	**Middle**	**High**	**Low**	**Middle**	**High**	**Low**	**Middle**	**High**
Adulthood SEP	No.	1554	529	936	1000	443	833	359	226	158
Latent class membership probabilities		0.51	0.18	0.31	0.44	0.19	0.37	0.48	0.31	0.21
Indicator	%	Item-response probabilities								
Mother's education: >High school	0.53	0.22	0.68	0.97	0.25	0.70	0.97	0.12	0.26	0.90
Father's education: >High school	0.41	0.15	0.19	0.99	0.17	0.21	0.99	0.09	0.09	0.70
Mother's occupation: High	0.61	0.40	0.73	0.89	0.39	0.76	0.90	0.09	0.94	0.77
Father's occupation: High	0.35	0.16	0.23	0.74	0.18	0.23	0.76	0.13	0.12	0.50
Mother's Medicaid status: No	0.52	0.15	0.94	0.89	0.22	0.98	0.91	0.09	0.07	0.61
Annual household income: ≥$50,000	0.31	0.04	0.54	0.64	0.06	0.58	0.66	0.004	0.03	0.35

Table 2.3. (cont'd)

		Latent Group											
		Overall (n=3,019)				White/others (n=2,276)				African American (n=743)			
		SL	UM	DM	SH	SL	UM	DM	SH	SL	UM	DM	SH
SM: childhood SEP & adulthood SEP	No.	1372	715	475	456	855	639	365	418	424	114	152	54
Latent class membership probabilities		0.45	0.24	0.16	0.15	0.38	0.28	0.16	0.18	0.57	0.15	0.21	0.07
Indicator	%	Item-response probabilities											
Grandmother's education: >High school	0.36	0.20	0.24	0.67	0.76	0.15	0.23	0.66	0.76	0.20	0.44	0.59	0.89
Grandfather's education: >High school	0.29	0.07	0.15	0.64	0.95	0.06	0.16	0.72	0.95	0.08	0.00	0.39	0.87
Grandmother's occupation: High	0.68	0.49	0.75	0.86	0.97	0.52	0.77	0.91	0.97	0.45	0.60	0.52	0.89
Grandfather's occupation: High	0.29	0.09	0.18	0.51	0.82	0.10	0.19	0.57	0.82	0.08	0.15	0.21	0.67
Family history of public assistance: No	0.60	0.40	0.81	0.70	0.96	0.49	0.83	0.75	0.97	0.24	0.47	0.52	0.68
Mother's education: >High school	0.53	0.16	0.86	0.68	1.00	0.17	0.89	0.67	1.00	0.08	0.79	0.45	1.00
Father's education: >High school	0.41	0.11	0.69	0.39	0.93	0.12	0.71	0.37	0.94	0.08	0.57	0.08	0.91
Mother's occupation: High	0.61	0.39	0.85	0.55	0.94	0.40	0.86	0.52	0.95	0.36	0.78	0.53	0.83
Father's occupation: High	0.35	0.15	0.52	0.27	0.80	0.16	0.53	0.27	0.82	0.14	0.56	0.00	0.55
Mother's Medicaid status: No	0.52	0.18	0.93	0.44	0.97	0.27	0.94	0.50	0.97	0.03	0.45	0.30	0.71
Annual household income: ≥$50,000	0.31	0.05	0.65	0.15	0.73	0.09	0.65	0.19	0.74	0.00	0.25	0.06	0.46

Abbreviation: DM, downward mobility; SEP, socioeconomic position; SH, stable high; SL, stable low; SM, socioeconomic mobility; UM, upward mobility.

Table 2.4. Odds ratios of preterm delivery conditional on latent class membership (n=3,019), Pregnancy Outcomes and Community Health Study, Michigan, 1998-2004

	Overall (n=3,019)			White/others (n=2,276)			African American (n=743)		
	N	OR	95% CI	N	OR	95% CI	N	OR	95% CI
Childhood SEP									
Low	1159	1.36	0.98, 1.90	538	1.21	0.79, 1.86	579	1.48	0.53, 4.14
Middle	1130	0.95	0.62, 1.45	1059	0.84	0.56, 1.26	97	1.18	0.28, 5.07
High (referent)	730	1.00		679	1.00		67	1.00	
Adulthood SEP									
Low	1554	1.59*	1.18, 2.15	1000	1.44*	1.02, 2.04	359	1.44	0.78, 2.68
Middle	529	1.24	0.78, 1.98	443	1.29	0.77, 2.17	226	0.67	0.24, 1.89
High (referent)	936	1.00		833	1.00		158	1.00	
SM: childhood SEP & adulthood SEP									
Static low (referent)	1372	1.00		855	1.00		424	1.00	
Upward mobile	715	0.60*	0.42, 0.87	639	0.66*	0.43, 1.00	114	1.03	0.51, 2.07
Downward mobile	475	0.87	0.57, 1.33	365	1.10	0.68, 1.77	152	0.82	0.35, 1.92
Static high	456	0.64*	0.44, 0.95	418	0.75	0.49, 1.17	54	0.49	0.17, 1.46
Downward mobile vs. Static high (referent)	475	1.36	0.80, 2.30	365	1.45	0.83, 2.56	152	1.65	0.46, 5.93

Abbreviation: CI, confidence interval; OR, odds ratio; SEP, socioeconomic position; SM, socioeconomic mobility.
* $P < 0.05$.

Table 2.5. Fit statistics for latent class analysis (n=3,019), Pregnancy Outcomes and Community Health Study, Michigan, 1998-2004

Group	Log-likelihood	Bayesian Information Criterion	Entropy
Childhood SEP			
2	-8431.3	244.6	0.74
3	-8380.5	191.2	0.70
4	-8366.2	210.7	0.82
5	-8365.0	256.4	0.81
Adulthood SEP & neighborhood deprivation index			
2	-11971.3	805.4	0.82
3	-11865.7	658.3	0.76
4	-11713.6	418.3	0.73
5	-11703.3	461.8	0.75
6	-11677.2	473.8	0.71
7	-11667.3	518.0	0.75
SM: childhood SEP & adulthood SEP & neighborhood deprivation index			
2	-20295.5	4243.5	0.85
3	-19969.8	3696.5	0.80
4	-19755.6	3372.2	0.76
5	-19656.5	3278.0	0.75
6	-19588.7	3246.6	0.70
7	-19537.1	3247.6	0.70

Abbreviation: SEP, socioeconomic position; SM, socioeconomic mobility.

Table 2.6. Estimated item-response probabilities of the socioeconomic position indicators conditional on latent class membership with distal outcome preterm delivery overall and by race/ethnicity (n=3,019), Pregnancy Outcomes and Community Health Study, Michigan, 1998-2004

		Latent Group								
		Overall (n=3,019)			White/others (n=2,276)			African American (n=743)		
		Low	Middle	High	Low	Middle	High	Low	Middle	High
Childhood SEP	No.	1159	1130	730	538	1059	679	579	97	67
Latent class membership probabilities		0.38	0.38	0.24	0.24	0.46	0.30	0.78	0.13	0.09
Indicator	%	Item-response probabilities								
Grandmother's education: >High school	0.36	0.17	0.34	0.74	0.11	0.27	0.72	0.22	0.87	0.93
Grandfather's education: >High school	0.29	0.11	0.11	0.97	0.08	0.13	0.94	0.13	0.01	0.98
Grandmother's occupation: High	0.68	0.23	0.98	0.93	0.09	0.93	0.94	0.41	0.97	0.82
Grandfather's occupation: High	0.29	0.11	0.17	0.76	0.11	0.16	0.77	0.11	0.12	0.64
Family history of public assistance: No	0.60	0.43	0.67	0.89	0.47	0.72	0.90	0.30	0.50	0.69

Table 2.6. (cont'd)

		Latent Group								
		Overall (n=3,019)			White/others (n=2,276)			African-American (n=743)		
		Low	**Middle**	**High**	**Low**	**Middle**	**High**	**Low**	**Middle**	**High**
Adulthood SEP & NDI	No.	1567	413	1039	1109	240	927	499	176	67
Latent class membership probabilities		0.52	0.14	0.34	0.49	0.10	0.41	0.67	0.24	0.09
Indicator	%	Item-response probabilities								
Mother's education: >High school	0.53	0.20	0.83	0.93	0.26	0.87	0.94	0.08	0.80	0.90
Father's education: >High school	0.41	0.09	0.77	0.77	0.12	0.95	0.79	0.07	0.43	0.80
Mother's occupation: High	0.61	0.40	0.72	0.89	0.41	0.76	0.90	0.37	0.71	0.84
Father's occupation: High	0.35	0.13	0.56	0.60	0.16	0.70	0.62	0.12	0.32	0.58
Mother's Medicaid status: No	0.52	0.22	0.46	0.98	0.33	0.55	0.99	0.07	0.27	0.91
Annual household income: ≥$50,000	0.31	0.08	0.06	0.76	0.12	0.06	0.78	0.01	0.07	0.67
Neighborhood deprivation index: < Medium	0.50	0.32	0.43	0.80	0.47	0.47	0.82	0.09	0.21	0.44

Table 2.6. (cont'd)

		Latent Group											
		Overall (n=3,019)				White/others (n=2,276)				African American (n=743)			
		SL	UM	DM	SH	SL	UM	DM	SH	SL	UM	DM	SH
SM: childhood SEP & adulthood SEP & NDI	No.	1375	710	477	456	845	629	384	417	431	112	145	55
Latent class membership probabilities		0.46	0.24	0.16	0.15	0.37	0.28	0.17	0.18	0.58	0.15	0.20	0.07
Indicator	%	Item-response probabilities											
Grandmother's education: >High school	0.36	0.21	0.23	0.68	0.75	0.16	0.23	0.65	0.76	0.20	0.44	0.61	0.89
Grandfather's education: >High school	0.29	0.08	0.15	0.64	0.93	0.06	0.15	0.71	0.94	0.08	0.00	0.39	0.87
Grandmother's occupation: High	0.68	0.49	0.74	0.87	0.96	0.52	0.76	0.91	0.97	0.45	0.61	0.51	0.89
Grandfather's occupation: High	0.29	0.09	0.17	0.53	0.81	0.10	0.18	0.57	0.82	0.09	0.15	0.19	0.67
Family history of public assistance: No	0.60	0.39	0.81	0.73	0.96	0.48	0.83	0.77	0.97	0.24	0.47	0.50	0.69
Mother's education: >High school	0.53	0.17	0.84	0.70	1.00	0.17	0.87	0.68	1.00	0.09	0.78	0.44	1.00
Father's education: >High school	0.41	0.11	0.66	0.44	0.93	0.12	0.70	0.41	0.93	0.08	0.58	0.09	0.88
Mother's occupation: High	0.61	0.40	0.83	0.57	0.95	0.39	0.86	0.54	0.95	0.36	0.79	0.54	0.81
Father's occupation: High	0.35	0.15	0.50	0.32	0.79	0.15	0.52	0.31	0.81	0.14	0.56	0.00	0.53
Mother's Medicaid status: No	0.52	0.17	0.94	0.45	0.99	0.26	0.94	0.50	0.99	0.03	0.45	0.30	0.69
Annual household income: ≥$50,000	0.31	0.05	0.64	0.15	0.75	0.09	0.65	0.18	0.76	0.00	0.26	0.05	0.45
Neighborhood deprivation index: < Medium	0.50	0.27	0.72	0.53	0.82	0.42	0.75	0.59	0.84	0.08	0.26	0.16	0.44

Table 2.6. (cont'd)

Abbreviation: DM, downward mobility; NDI, neighborhood deprivation index; SEP, socioeconomic position; SH, stable high; SL, stable low; SM, socioeconomic mobility; UM, upward mobility.

Table 2.7. Odds ratios of preterm delivery conditional on latent class membership (n=3,019), Pregnancy Outcomes and Community Health Study, Michigan, 1998-2004

	Overall (n=3,019)			White/others (n=2,276)			African American (n=743)		
	N	OR	95% CI	N	OR	95% CI	N	OR	95% CI
Childhood SEP									
Low	1159	1.36	0.98, 1.90	538	1.21	0.79, 1.86	579	1.48	0.53, 4.14
Middle	1130	0.95	0.62, 1.45	1059	0.84	0.56, 1.26	97	1.18	0.28, 5.07
High (referent)	730	1.00		679	1.00		67	1.00	
Adulthood SEP & neighborhood deprivation index									
Low	1567	1.70*	1.26, 2.30	1109	1.52*	1.08, 2.14	499	1.42	0.57, 3.56
Middle	413	1.22	0.65, 2.29	240	1.15	0.53, 2.49	176	1.23	0.39, 3.85
High (referent)	1039	1.00		927	1.00		67	1.00	
SM: childhood SEP & adulthood SEP & neighborhood deprivation index:									
Static low (referent)	1375	1.00		845	1.00		431	1.00	
Upward mobile	710	0.61*	0.43, 0.88	629	0.66*	0.43, 1.00	112	1.04	0.52, 2.08
Downward mobile	477	0.87	0.58, 1.32	384	1.07	0.67, 1.70	145	0.80	0.33, 1.96
Static high	456	0.62*	0.42, 0.92	417	0.73	0.47, 1.13	55	0.50	0.17, 1.46
Downward mobile vs. Static high (referent)	477	1.39	0.83, 2.36	384	1.47	0.85, 2.57	145	1.59	0.43, 5.88

Abbreviation: CI, confidence interval; OR, odds ratio; SEP, socioeconomic position; SM, socioeconomic mobility.
* $P < 0.05$.

CHAPTER 3

MATERNAL SOCIOECONOMIC MOBILITY AND PRENATAL DEPRESSION: LATENT CLASS ANALYSIS

3.1 Introduction

Prenatal depression is a worldwide public health problem (Kessler 2003); Prevalence estimates range from 8% to 20% in high income countries (Marcus et al. 2003, Gavin et al. 2005, Evans et al. 2007, Vesga-López et al. 2008, Melville et al. 2010), and over 20% in low and middle income countries (Faisal-Cury et al. 2009, Golbasi et al. 2010, Husain et al. 2011). Prenatal depression is associated with postpartum depression and recurrent depression, which have the potential to adversely affect the general health and well-being of mother and her children (Bennett et al. 2004, Cents et al. 2013). Some studies report a link between prenatal depression and increases in adverse pregnancy outcomes, e.g. stillbirth, preterm birth, and low birth weight (Field, Diego, and Hernandez-Reif 2006, Evans et al. 2007, Rahman et al. 2007, Wisner et al. 2009, Grote et al. 2010, Grigoriadis et al. 2013, Ncube et al. 2017). The prevalence of perinatal depression is higher among African-American women compared to white women (Dole et al. 2004, Nicholson et al. 2006, Li et al. 2008, Gavin et al. 2011, Mukherjee et al. 2016).

Maternal disadvantaged socioeconomic positions (SEP) in adulthood has been linked to a greater risk of prenatal depression (Holzman et al.2006, Miyake et al. 2012, Bahk et al. 2015). Measures of SEP have included occupation, education and household income, although the results with different SEP measures are not always consistent in the general population (Lorant et al. 2003). Childhood SEP has also been shown to be important risk factor for depression during

adulthood in the general population (Ritsher et al. 2001, Gilman et al. 2002, Harper et al. 2002). However, few studies have examined mother's childhood SEP and prenatal depression. In addition, prior studies of non-pregnant populations have considered not only SEP but also changes in SEP, i.e. socioeconomic mobility (SM), and found that upward SM and stable high SEP were protective against depressive symptoms (Luo and Waite 2005, Nicklett and Burgard 2009, Hudson et al. 2013, Ro 2014, Dal Grande et al. 2015, Ward et al. 2016, Walsemann et al. 2017, Kwon et al. 2017). However, to our knowledge, no previous study has directly investigated the association between maternal SM and depression in pregnancy.

Studies of non-pregnant women have found poorer mental health in association with socioeconomic disadvantage during childhood (Ritsher et al. 2001, Gilman et al. 2002, Harper et al. 2002) and during adulthood (Lorant et al. 2003, Hudson et al. 2012). These investigations typically measured SEP at a single time point and used a single indicator, e.g. education, occupation or family income (Nicklett and Burgard 2009, Owens and Jackson 2015, Ward et al. 2016). However, the multidimensional nature of SEP and the complexity of SEP transition from one time point to another suggest that SEP and SM cannot be measured completely with one indicator. Even in a study with multiple SEP indicators, a single index of SEP measure was defined as the average of standardized SEP indicators (Luo and Waite 2005). Our study uses a latent class analysis (LCA) for measuring SM in a dataset with individual-level data of maternal childhood and adulthood SEP indicators, a novel approach for pregnancy studies.

Thus our study investigates associations between maternal SM from childhood to adulthood and risk of prenatal depression in a Michigan community-based cohort study that is racially and socioeconomically diverse. The availability of in-depth, individual-level data on mothers and their childhood SEP provides a unique opportunity to study SM. We hypothesized

that: 1) women with lowest childhood SEP and lowest adulthood SEP will be at greatest risk of prenatal depression; 2) women who experience upward SM from childhood to adulthood will have a decreased risk of prenatal depression relative to women who maintain a lower SEP; and 3) women who experience downward SM from childhood to adulthood will have a higher risk of prenatal depression relative to women who maintain a higher SEP during childhood and adulthood. Because some studies reported that the relation between SEP (or SM) and depression varied by race/ethnicity (Luo and Waite 2005, Owens and Jackson 2015, Ward et al. 2016), we also examine evidence for this effect modification.

3.2 Methods

Study population

This study included 3,019 pregnant women enrolled at 16-27 weeks' gestation in the prospective Pregnancy Outcomes and Community Health (POUCH) study (1998-2004) from five Michigan communities. Eligibility criteria included: English-speaking, age >14 years, no pre-existing diabetes, singleton pregnancy with no known congenital anomalies, and prenatal maternal serum alpha-fetoprotein screening at 15-22 weeks of gestation. The detailed study protocol can be found elsewhere (Holzman et al. 2001). Institutional review board approval for this study was received from Michigan State University and all nine participating delivery hospitals.

At enrollment each pregnant woman provided informed written consent, met with a study nurse for a structured in-person interview, and completed a self-administered questionnaire that collected information regarding demographics, lifestyle, psychosocial factors, medical history

and health status. Self-reported maternal race/ethnicity was dichotomized as white/others or African American. The numbers of "others" race/ethnicity were small and their scores on the prenatal depression symptoms measure were similar to that of whites, therefore these groups were combined.

Measures

Childhood SEP and adulthood SEP

Childhood SEP measures included a woman's self-report of her parents' socioeconomic indicators during her childhood, i.e. maternal mother's and father's highest level of education attainment, maternal mother's and father's usual occupation, and receipt of public assistance by the family. Adulthood SEP measures included maternal socioeconomic indicators at enrollment, i.e. maternal and child's father's highest level of education, maternal and child's father's usual occupation, Medicaid Insurance status, and maternal annual household income. SEP indicators were modeled as binary variables, i.e. education (≤high school, >high school); usual occupation status based on the United States Census Bureau's 1990 Occupational Classification System ("low"= service/blue collar, unemployed, and unknown; "high"= professional, manager, technical, clerical/sales, homemaker, military, retired, and student); public assistance (yes/no); Medicaid Insurance (yes/no); maternal household income (<$50,000 and ≥$50,000). "Unknown" paternal and grandfather's occupation was assigned as "low" occupation status because it correlated with other low SEP indicators (Slaughter-Acey et al. 2016). Missing data for SEP indicators were handled primarily through statistical methods (see statistical methods section below). In separate models, a maternal neighborhood deprivation index (NDI) also was included in adulthood SEP. The NDI was calculated using information from the 1986 Census and

followed a previously validated approach (Messer et al. 2006). NDI was dichotomized at the medium of the study population.

Maternal SM

Maternal SM was defined by modeling both childhood and adulthood SEP indicators in LCA. The SEP indicator variables were dichotomized the same as the childhood SEP and adulthood SEP variables.

Prenatal depression

Prenatal depression symptoms were measured by the Center for Epidemiological Studies – Depression (CES-D) scale (Radloff 1977) in the self-administered interview. The 20-item CES_D is widely used in the general population to assess depressive symptoms during the prior week. In the analysis, CES-D was dichotomized with a cutoff, i.e. > 16, frequently used to indicate presence of depressive symptoms. Nine women did not complete the CES-D, leaving a final sample size of 3,010.

Statistical methods

Initially we assessed maternal characteristics and SEP indicators overall and stratified by CES-D score (low/high), and used chi-square tests to test for differences in proportions. We used LCA to identify and describe distinct groups of childhood SEP indicators, adulthood SEP indicators and SM from childhood to adulthood. LCA classifies individuals with similar SEP characteristics into groups based on conditional probabilities (Collins and Lanza 2010). We determined the optimal number of LCA groups by: 1) visualizing the plot of log-likelihoods of each model and eliminating model where the log-likelihood did not show a substantial improvement (Nylund, Asparouhov, and Muthén 2007); 2) using the Bayesian Information

Criterion (BIC), with a smaller BIC representing a better-fitted model (Schwarz 1978); 3) evaluating the entropy, an indicator for class separation and precision, that measures how well an individual fits into a specific class with values closer to 1 representing better fit (Ramaswamy et al. 1993); and 4) considering the size of the latent classes, uniqueness of classes, and meaningful interpretation of the response probability pattern for each class. As a next step, after the optimal number of group was determined we used the model-based approach to LCA with distal outcome to predict the risk of prenatal depression based on the latent class membership of exposure variables (i.e. childhood SEP, adulthood SEP, SM) (Lanza, Tan, and Bray 2013).

Race/ethnicity was added as a grouping variable in LCA models to investigate associations among SEP, SM and risk of CES-D within race/ethnic groups (white/others, African American). Because SEP indicators may have different ranges and occur in different contexts across race/ethnic groups, we computed group-specific LCA following the same methodology described above. In another set of models, we added the NDI to adulthood SEP to examine its contribution to identifying SEP associations with CES-D risk.

All statistical analyses were conducted using PROC LCA (Lanza et al. 2015) and its corresponding distal outcome macro (Dziak et al. 2016) in SAS 9.4 (Statistical Analysis Software, Cary, NC). The Proc LCA program uses full information maximum likelihood estimation to cope with missing data in the SEP indicators.

3.3 Results

Sample characteristics

For the childhood SEP indictors, about 60% of grandmothers and 55% of grandfathers did not graduate from high school. Approximately 32% of grandmothers and 71% of grandfathers had a low-level occupation. About one third of families received public assistance during the mother's childhood period. For adulthood SEP indicators, 47% of mothers and 55% of fathers did not graduate from high school; 39% of mothers and 65% of fathers had a low-level occupation; 48% of pregnant women were insured by Medicaid; and 67% of families had an annual income of <$50,000. In bivariate analyses, all childhood SEP indicators and all adulthood SEP indicators were significantly related to CES-D in the direction hypothesized, i.e. lower SEP linked to greater prevalence of a positive CES-D screen (Table 3.1).

Latent class profile

In the LCA of childhood SEP, a three-group solution was considered optimal according to criteria described in our statistical methods section (Table 3.2). The three-group model had the lowest BIC and substantial improvement in log-likelihood difference when moving from a three-group to two-group model, compared to that from a four-group model to a three-group model. The subgroups characterized by particular SEP indicators were interpreted and labelled according to the parameter estimates. For childhood SEP, compared to other group, Group 1, "low group", (40% of women) grandmothers and grandfathers were less likely to graduate from high school (22% and 11%, respectively), to have a high-level occupation (45% and 9%, respectively), or to avoid public assistance during the mother's childhood (28%) (Table 3). The probabilities of positive childhood SEP indicators were greater in childhood SEP Group 2,

"middle group", (35% of women), compared to other group, with the exception of grandfathers' education (10%) and occupation (19%). Childhood SEP Group 3, "high group", (25% of women) showed high probabilities of all positive SEP indicators.

For adulthood SEP, a four-group model had the lowest BIC, however there was minimal improvement when moving from a three-group to four-group model, compared to the substantial log-likelihoods difference from a two-group to a three-group model. Additionally, the entropy for the four-group model was smaller than that for the three-group model, indicating poor latent group separation for the four-group model (Collins & Lanza, 2010). Based on additional considerations of group prevalence and interpretability we chose the three-group model for adulthood SEP (Table 2). For adulthood SEP, compared to other group, Group 1,"low group", (52% of women) mothers and fathers were less likely to graduate from high school (23% and 15%, respectively), to have a high-level occupation (40% and 16%, respectively), to have medical insurance other than Medicaid (15%), or to have a family income > $50,000 (4%) (Table 3). The probabilities of SEP indicators in adulthood SEP Group 2, "middle group", (18% of women) varied; for example, fathers in this group had low probabilities of having a high-level education (20%) and occupation (25%) but women were more likely to have high-level occupations (73%) and medical insurance other than Medicaid (94%). About half of the families had an annual household income exceeding $50,000 (54%). In adulthood SEP Group 3, "high group", (30% of women), all probabilities of positive SEP indicators were increased; about 64% of these families had annual household incomes exceeding $50,000.

We used both childhood and adulthood SEP indicators for the SM LCA. The BIC values decreased with increasing number of groups until 6 groups. After reviewing the plot of log-likelihoods of each model with specified group, improvements in model fit, size of the groups,

and interpretability we chose the four-group solution for modeling SM from childhood to adulthood (Table 3.2). In SM from childhood to adulthood, Group 1, "static low group", (45% women) women had low-level childhood SEP and low-level adulthood SEP indicators (Table 3.3). SM Group 2, "upward mobile group", (24% of women) showed some improvement in two childhood indicators, i.e. probabilities of grandmother with high-level occupation (75%) and avoiding public assistance (82%), and higher probabilities in all positive adulthood SEP indicators. SM Group 3, "downward mobile group", (16% of women) tended to have high-level childhood SEP and moderate to low-level adulthood SEP. In this group the fathers' education and occupation were unlikely to be high-level (38% and 27%, respectively) and the probability of household income >$50,000 was low (14%). SM Group 4, "static high group", (15% of women) had high-level SEP indicators throughout childhood and adulthood.

Latent class models also were examined for white/other women and African-American women separately using the methodology described above. For each race/ethnic group, based on fit indices and interpretability, we chose a three-group model for childhood SEP and adulthood SEP indicators and a four-group model for SM. The race/ethnicity-specific item-response probabilities for each indicator conditional on latent group membership are presented in Table 3.3. For the childhood SEP, the class percentages for white/others and African American, respectively, were: low group 38%, 77%; middle group 31%, 13%; and high group 31%, 10%. For the adulthood SEP, the group percentages for white/other and African American, respectively, were: low group 44%, 69%; middle group 20%, 23%; and high group 36%, 8%. For SM, the group percentages for white/other and African American, respectively, were: static low 37%, 59%; upward mobile 28%, 15%; downward mobile 16%, 19%; and static high 19%, 7%.

LCA with distal outcome: prenatal depression

Overall, the frequency of a positive prenatal CES-D screen in the low, middle, and high childhood SEP groups was 49.8%, 25.2%, 21.1%, respectively. Similar percentages were observed in the low, middle, and high adulthood SEP groups, i.e. 48.3%, 25.6%, and 15.1%, respectively. Using the respective high SEP as the referent group, a positive prenatal CES-D screen was more common in the low childhood SEP group (OR= 3.72, 95% 95% CI: 2.74, 5.04); and the low adulthood SEP group, (OR=5.26, 95% CI: 4.17, 6.64) (Table 3.4).

A positive prenatal CES-D screen was observed in 48.4%, 17.4%, 38.7%, and 13.2% of women who experienced static low SM, upward SM, downward SM, and static high SM, respectively (Table 3.4). Women in the upward SM group were less likely to have a positive prenatal CES-D screen compared to women in the static low SM group (OR=0.22, 95% CI: 0.17, 0.29). By contrast, women in the downward SM group were at greater risk of a positive prenatal CES-D screen compared to women with static high SM, (OR=4.13, 95% CI: 2.75, 6.22). In a separate set of analyses we used race/ethnic-specific LCA models. Among the white/others women, patterns of SEP (childhood and adulthood) and SM in relation to a positive prenatal CES-D screen mirrored those observed overall and described above (Table 3.4). Among African-American women, the associations between low SEP, SM and a positive prenatal CES-D screen were more modest than those found in white/other women. Perhaps due to smaller sample sizes, only low and middle adulthood SEP groups had a significantly greater prevalence of a positive prenatal CES-D screen.

We incorporated NDI in the adulthood SEP to examine its added effect on SEP associations with prenatal CES-D screen. Table 3.5 summaries the LCA model fit statistics. In

consideration of a combination of fit statistics and interpretability, we selected a three-group model for adulthood SEP with NDI and a four-group model for SM that included childhood SEP and adulthood SEP with NDI. The item-response probabilities for each SEP indicator conditional on latent class membership of adulthood SEP with NDI and SM are shown in Table 3.6. The latent class profiles were similar to those in adulthood SEP without NDI. When we assessed the associations between latent class membership and a positive prenatal CES-D screen (Table 3.7), NDI did not add appreciably to our original findings.

3.4 Discussion

Overall, we found that a positive screen for depression (CES-D $\geq$16) in mid-pregnancy was more common in women with low childhood and adulthood SEP, or a downward SM trajectory, and was less common in women who experienced upward SM. These relations between SEP, SM and depressive symptoms were stronger in white/other women as compared to African-American women. Links between SM and depression have been reported for non-pregnant women (Tiffin, Pearce, and Parker 2005, Hudson et al. 2013, Dal Grande et al. 2015, Walsemann et al. 2017, Kwon et al. 2017), but, to our knowledge, have not been assessed previously in pregnant women.

The relationships between childhood SEP, adulthood SEP and mental health are likely varied and complex with a multitude of explanations (Stansfeld et al. 2011). The 'social causation' theory postulates that low SEP increases the risk of a mental health disorder, mainly depression and anxiety. This may be explained by critical period models or by pathway models (Ljung and Hallqvist 2006). In a critical period model, the effect of low SEP in childhood on

biological systems remains latent until adulthood and is independent of adult exposure to adversity. In a pathway model, low childhood SEP increases the likelihood of low adulthood SEP and this life course trajectory escalates the risk of mental disorders. There is also the 'health selection' theory which asserts that childhood mental health disorders increase the probability of low adult SEP.

Our findings are consistent with these theories explaining links between SEP and mental health. In support of the social mobility model, upward SM may decrease the accumulation of adverse exposures that create 'wear and tear' to the body (allostatic load) (McEwen 1998, McEwen 2000). Pregnant women who experienced upward SM (compared to women with stable low childhood and adulthood SEP) may have: 1) greater access to high-quality food, reliable housing, a safer living environment, and higher-quality health care; 2) more support for healthy lifestyle choices (diet, physical activity, no smoking, no alcohol use); and 3) greater opportunity for psychological health (less stress, more social integration). Thus, the lower levels of 'wear and tear' might be protective against depression in pregnant women who experienced upward SM (Field, Diego, and Hernandez-Reif 2006). Our observation that a positive depression screen is less likely in women with upward SM and more likely in women with downward SM points to adulthood SEP is salient and perhaps a 'critical window.' The SM pattern and maternal depression link also fits with the 'health selection' theory, i.e. women with mental health problems may be less likely to obtain or maintain high SEP, though, without measures of depression in childhood, we can't complete this theory test in this study.

Previous studies among non-pregnant population indicate a consistent inverse relationship between SEP and depression among whites, however, evidence for African Americans is mixed (Lorant et al. 2003, Williams et al, 2007, Gavin et al. 2010). For example,

some studies observed a higher prevalence of depression among African Americans with lower SEP (Banks & Kohn-Wood 2002, Bromberger et al. 2004, Roxburgh 2009); however, other studies find no significant relationship between SEP and depression among African Americans (Gavin et al. 2010, Williams et al. 2007). Even studies examining multiple SEP indicators find no significant association between SEP and depression among African Americans (Rodriguez et al. 1999, Hudson et al. 2012). In our study, we observed that the relations between SEP, SM and depressive symptoms were stronger in white/other women as compared to African-American women. Fewer African-American women experienced SM in this study, making it difficult to calculate accurate race/ethnicity-specific estimates of the SM-CES-D association in this group.

To the best of our knowledge, this study is the first to use the model-based approach to LCA with distal outcome to elucidate complex relationships between SM and the risk of prenatal depression among pregnant women in the United States. Typically, traditional classify-analyze strategies have been used to predict distal outcome from latent class membership. In the first classification step, individuals were assigned to latent classes based on probabilities. In a second analysis step, the distal outcome was predicted from the latent class membership which was treated as observed. For these traditional strategies the results are biased to the extent that there is classification error. However, our model-based approach models measurement error (Collins & Lanza, 2010) and produces less biased estimates for the probability of prenatal depression conditional on latent class membership. Moreover, use of the full-information expectation-maximization algorithm in LCA may include all participants who responded to at least one SEP indicator (Collins & Lanza, 2010). Most previous studies examining the impact of SM on depression used a single SEP indicator to measure SM (Nicklett and Burgard 2009, Owens and Jackson 2015, Ward et al. 2016). Our study used multiple SEP indicators for childhood SEP and

adulthood SEP measures, which may minimize misclassification bias. In addition, this study enrolled pregnant women with diverse SEP, which allowed us to observe a full range of SM.

An important limitation in most SM research pertains to the inferences. When we study individuals we don't randomly assign SM, therefore it is difficult to disentangle unique attributes of individuals who climb the SEP ladder (self-selection) versus the extrinsic benefits of a better environment. In addition, all SEP indicators were self-reported and recall bias cannot be ruled out. Our software and modeling strategy, i.e. model-based approach to LCA with distal outcome, could not accommodate adjustment for other covariates (potential confounders), which leaves open the possibility of unmeasured confounding. While we stratified on race/ethnicity, we considered maternal age and parity as important covariates. In sensitivity analyses we also looked to see whether our results would vary by maternal age and parity, which they did not.

Comprehensive modeling of childhood and adulthood SEP indicators sheds light on risks for prenatal depression. Our study suggests that low SEP in childhood alone does not raise the risk of a positive depression screen in pregnancy as evidenced by the decreased risk for women with upward SM. The explanations for these observations may be multiple, but overall the findings lead to an optimistic conclusion: increasing opportunities for upward SM could help lower the prevalence of maternal depression. Women with low SEP in childhood and adulthood are the group most likely to screen positive for depression in pregnancy. Clinics and providers serving these pregnant women need adequate capacity to conduct depression screens and carry out appropriate referrals and interventions.

Table 3.1. Maternal Characteristics and Socioeconomic Position Indicators (n=3,010), Pregnancy Outcomes and Community Health Study, Michigan, 1998-2004

	Overall (n=3,010)		CES-D<16 (n=1,984)		CES-D≥16 (n=1,026)		*P* value[a]
	No.	%	No.	%	No.	%	
Race/ethnicity							<0.0001
White/others	2268	75.3	1610	81.1	658	64.1	
African American	742	24.7	374	18.9	368	35.9	
Childhood SEP							
Grandmother's education							0.03
Missing	125	4.2	53	2.7	72	7.0	
≤ high school	1806	60.0	1183	59.6	623	60.7	
>high school	1079	35.8	748	37.7	331	32.3	
Grandfather's education							<0.0001
Missing	475	15.8	238	12.0	237	23.1	
≤ high school	1656	55.0	1066	53.7	590	57.5	
>high school	879	29.2	680	34.3	199	19.4	
Grandmother's usual occupation[b]							<0.0001
Low occupational status	954	31.7	566	28.5	388	37.8	
High occupation status	2056	68.3	1418	71.5	638	62.2	
Grandfather's usual occupation[b]							<0.0001
Low occupational status	2138	71.0	1340	67.5	798	77.8	
High occupation status	872	29.0	644	32.5	228	22.2	
Family history of public assistance							<0.0001
Missing	109	3.6	77	3.9	32	3.1	
Yes	1079	35.8	584	29.4	495	48.3	
No	1822	60.5	1323	66.7	499	48.6	

Table 3.1. (cont'd)

	Overall (n=3,010)		CES-D<16 (n=1,984)		CES-D≥16 (n=1,026)		*P* value[a]
	No.	%	No.	%	No.	%	
Adulthood SEP							
Maternal education							<0.0001
≤ High school	1402	46.6	779	39.3	623	60.7	
>High school	1608	53.4	1205	60.7	403	39.3	
Father's education							<0.0001
Missing	136	4.5	55	2.8	81	7.9	
≤ High school	1652	54.9	963	48.5	689	67.2	
>High school	1222	40.6	966	48.7	256	25.0	
Maternal usual occupation[b]							<0.0001
Low occupational status	1175	39.0	675	34.0	500	48.7	
High occupation status	1835	61.0	1309	66.0	526	51.3	
Father's usual occupation[b]							<0.0001
Low occupational status	1945	64.6	1175	59.2	770	75.1	
High occupation status	1065	35.4	809	40.8	256	25.0	
Mother's Medicaid insured							<0.0001
Missing	2	0.1	1	0.1	1	0.1	
Yes	1451	48.2	780	39.3	671	65.4	
No	1557	51.7	1203	60.6	354	34.5	
Annual household income							<0.0001
Missing	89	3.0	45	2.3	44	4.3	
< $50,000	2002	66.5	1183	59.6	819	79.8	
≥ $50,000	919	30.5	756	38.1	163	15.9	
Neighborhood deprivation index							<0.0001
Missing	5	0.2	5	0.3	0	0.0	
≥ Medium	1503	49.9	879	44.3	624	60.8	
< Medium	1502	49.9	1100	55.4	402	39.2	

Abbreviation: SEP, socioeconomic position.

[a] *P* value for chi-square test between CES-D<16 and CES-D≥16 groups.

[b] Low occupation status includes service/blue collar, unemployed, and unknown; high occupation status includes professional, manager, technical, clerical/sales, homemaker, and other (military, retired, student).

Table 3.2. Fit statistics for latent class analysis (n=3,010), Pregnancy Outcomes and Community Health Study, Michigan, 1998-2004

Group	Log-likelihood	Bayesian Information Criterion	Entropy
Childhood SEP			
2	-8431.3	244.6	0.74
3	-8380.5	191.2	0.70
4	-8366.2	210.7	0.82
5	-8365.0	256.4	0.81
Adulthood SEP			
2	-10102.4	609.1	0.81
3	-9978.9	418.3	0.78
4	-9896.7	309.9	0.72
5	-9876.6	325.8	0.74
6	-9869.4	367.6	0.74
SM: childhood SEP & adulthood SEP			
2	-18443.8	3160.4	0.84
3	-18134.1	2637.1	0.80
4	-17938.8	2342.7	0.76
5	-17869.5	2300.2	0.74
6	-17803.0	2263.3	0.73
7	-17758.2	2269.8	0.69

Abbreviation: SEP, socioeconomic position; SM, socioeconomic mobility.

Table 3.3. Estimated item-response probabilities of the socioeconomic position indicators conditional on latent class membership with distal outcome prenatal depression overall and by race/ethnicity (n=3,010), Pregnancy Outcomes and Community Health Study, Michigan, 1998-2004

		Latent Group								
		Overall (n=3,010)			White/others (n=2,268)			African American (n=742)		
		Low	Middle	High	Low	Middle	High	Low	Middle	High
Childhood SEP	No.	1211	1039	760	866	690	712	569	98	75
Latent class membership probabilities		0.40	0.35	0.25	0.38	0.31	0.31	0.77	0.13	0.10
Indicator	%	Item-response probabilities								
Grandmother's education: >High school	0.36	0.22	0.27	0.74	0.19	0.24	0.71	0.22	0.85	0.91
Grandfather's education: >High school	0.29	0.11	0.10	0.95	0.11	0.08	0.94	0.11	0.01	0.98
Grandmother's occupation: High	0.68	0.45	0.77	0.93	0.51	0.81	0.94	0.40	0.98	0.78
Grandfather's occupation: High	0.29	0.09	0.19	0.75	0.09	0.21	0.75	0.11	0.14	0.60
Family history of public assistance: No	0.60	0.28	0.85	0.88	0.35	0.99	0.90	0.30	0.49	0.67

Table 3.3. (cont'd)

		Latent Group								
		Overall (n=3,010)			White/others (n=2,268)			African American (n=742)		
		Low	**Middle**	**High**	**Low**	**Middle**	**High**	**Low**	**Middle**	**High**
Adulthood SEP	No.	1565	542	903	998	454	816	511	168	63
Latent class membership probabilities		0.52	0.18	0.30	0.44	0.20	0.36	0.69	0.23	0.08
Indicator	%	Item-response probabilities								
Mother's education: >High school	0.53	0.23	0.68	0.97	0.25	0.70	0.97	0.08	0.87	0.91
Father's education: >High school	0.41	0.15	0.20	0.99	0.17	0.22	0.99	0.07	0.44	0.80
Mother's occupation: High	0.61	0.40	0.73	0.89	0.39	0.75	0.90	0.37	0.71	0.87
Father's occupation: High	0.35	0.16	0.25	0.74	0.18	0.24	0.76	0.12	0.32	0.58
Mother's Medicaid status: No	0.52	0.15	0.94	0.90	0.22	0.98	0.92	0.08	0.28	0.92
Annual household income: ≥$50,000	0.31	0.04	0.54	0.64	0.06	0.58	0.66	0.010	0.06	0.70

Table 3.3. (cont'd)

		Latent Group											
		Overall (n=3,010)				White/others (n=2,268)				African American (n=742)			
		SL	UM	DM	SH	SL	UM	DM	SH	SL	UM	DM	SH
SM: childhood SEP & adulthood SEP	No.	1355	722	482	452	840	631	370	426	434	115	140	54
Latent class membership probabilities		0.45	0.24	0.16	0.15	0.37	0.28	0.16	0.19	0.59	0.15	0.19	0.07
Indicator	%	Item-response probabilities											
Grandmother's education: >High school	0.36	0.20	0.24	0.68	0.76	0.15	0.23	0.65	0.76	0.21	0.44	0.61	0.89
Grandfather's education: >High school	0.29	0.07	0.16	0.63	0.94	0.06	0.16	0.70	0.95	0.08	0.00	0.41	0.86
Grandmother's occupation: High	0.68	0.49	0.75	0.86	0.97	0.52	0.77	0.91	0.97	0.45	0.60	0.52	0.89
Grandfather's occupation: High	0.29	0.09	0.18	0.51	0.82	0.10	0.19	0.55	0.82	0.08	0.15	0.22	0.66
Family history of public assistance: No	0.60	0.39	0.82	0.70	0.95	0.49	0.83	0.75	0.96	0.24	0.47	0.52	0.68
Mother's education: >High school	0.53	0.16	0.85	0.67	1.00	0.17	0.88	0.66	1.00	0.08	0.79	0.46	1.00
Father's education: >High school	0.41	0.11	0.68	0.38	0.93	0.12	0.71	0.36	0.93	0.09	0.57	0.08	0.92
Mother's occupation: High	0.61	0.39	0.84	0.55	0.94	0.40	0.86	0.52	0.94	0.36	0.77	0.54	0.83
Father's occupation: High	0.35	0.15	0.51	0.27	0.79	0.16	0.53	0.26	0.82	0.14	0.55	0.00	0.55
Mother's Medicaid status: No	0.52	0.18	0.93	0.43	0.97	0.26	0.94	0.50	0.96	0.03	0.44	0.30	0.71
Annual household income: ≥$50,000	0.31	0.05	0.65	0.14	0.73	0.09	0.66	0.18	0.73	0.00	0.25	0.06	0.46

Abbreviation: DM, downward mobility; SEP, socioeconomic position; SH, stable high; SL, stable low; SM, socioeconomic mobility; UM, upward mobility.

Table 3.4. Odds ratios of prenatal depression conditional on latent class membership (n=3,010), Pregnancy Outcomes and Community Health Study, Michigan, 1998-2004

	Overall (n=3,010)			White/others (n=2,268)			African American (n=742)		
	N	OR	95% CI	N	OR	95% CI	N	OR	95% CI
Childhood SEP									
Low	1211	3.72*	2.74, 5.04	866	2.90*	2.18, 3.87	569	1.73	0.94, 3.19
Middle	1039	1.27	0.86, 1.87	690	1.27	0.84, 1.92	98	0.99	0.41, 2.37
High (referent)	760	1.00		712	1.00		75	1.00	
Adulthood SEP									
Low	1565	5.26*	4.17, 6.64	998	5.15*	3.94, 6.74	511	3.54*	1.65, 7.60
Middle	542	1.94*	1.37, 2.74	454	2.14*	1.47, 3.13	168	2.76*	1.14, 6.67
High (referent)	903	1.00		816	1.00		63	1.00	
SM: childhood SEP & adulthood SEP									
Static low (referent)	1355	1.00		840	1.00		434	1.00	
Upward mobile	722	0.22*	0.17, 0.29	631	0.25*	0.19, 0.34	115	0.65	0.38, 1.13
Downward mobile	482	0.67*	0.50, 0.91	370	0.74	0.53, 1.04	140	0.52*	0.27, 0.98
Static high	452	0.16*	0.12, 0.23	426	0.18*	0.13, 0.26	54	0.35*	0.18, 0.69
Downward mobile vs. Static high (referent)	482	4.13*	2.75, 6.22	370	4.08*	2.62, 6.36	140	1.47	0.79, 4.40

Abbreviation: CI, confidence interval; OR, odds ratio; SEP, socioeconomic position; SM, socioeconomic mobility.
* $P < 0.05$.

Table 3.5. Fit statistics for latent class analysis (n=3,010), Pregnancy Outcomes and Community Health Study, Michigan, 1998-2004

Group	Log-likelihood	Bayesian Information Criterion	Entropy
Childhood SEP			
2	-8431.3	244.6	0.74
3	-8380.5	191.2	0.70
4	-8366.2	210.7	0.82
5	-8365.0	256.4	0.81
Adulthood SEP & neighborhood deprivation index			
2	-11971.3	805.4	0.82
3	-11865.7	658.3	0.76
4	-11713.6	418.3	0.73
5	-11703.3	461.8	0.75
6	-11677.2	473.8	0.71
7	-11667.3	518.0	0.75
SM: childhood SEP & adulthood SEP & neighborhood deprivation index			
2	-20295.5	4243.5	0.85
3	-19969.8	3696.5	0.80
4	-19755.6	3372.2	0.76
5	-19656.5	3278.0	0.75
6	-19588.7	3246.6	0.70
7	-19537.1	3247.6	0.70

Abbreviation: SEP, socioeconomic position; SM, socioeconomic mobility.

Table 3.6 Estimated item-response probabilities of the socioeconomic position indicators conditional on latent class membership with distal outcome prenatal depression overall and by race/ethnicity (n=3,010), Pregnancy Outcomes and Community Health Study, Michigan, 1998-2004

		Latent Group								
		Overall (n=3,010)			White/others (n=2,268)			African American (n=742)		
		Low	Middle	High	Low	Middle	High	Low	Middle	High
Childhood SEP	No.	1211	1039	760	866	690	712	569	98	75
Latent class membership probabilities		0.40	0.35	0.25	0.38	0.31	0.31	0.77	0.13	0.10
Indicator	%	Item-response probabilities								
Grandmother's education: >High school	0.36	0.22	0.27	0.74	0.19	0.24	0.71	0.22	0.85	0.91
Grandfather's education: >High school	0.29	0.11	0.10	0.95	0.11	0.08	0.94	0.11	0.01	0.98
Grandmother's occupation: High	0.68	0.45	0.77	0.93	0.51	0.81	0.94	0.40	0.98	0.78
Grandfather's occupation: High	0.29	0.09	0.19	0.75	0.09	0.21	0.75	0.11	0.14	0.60
Family history of public assistance: No	0.60	0.28	0.85	0.88	0.35	0.99	0.90	0.30	0.49	0.67

Table 3.6. (cont'd)

		Latent Group								
		Overall (n=3,010)			White/others (n=2,268)			African American (n=742)		
		Low	**Middle**	**High**	**Low**	**Middle**	**High**	**Low**	**Middle**	**High**
Adulthood SEP & NDI	No.	1505	602	903	1100	235	933	505	173	64
Latent class membership probabilities		0.50	0.20	0.30	0.49	0.10	0.41	0.68	0.23	0.09
Indicator	%	Item-response probabilities								
Mother's education: >High school	0.53	0.23	0.64	0.98	0.26	0.87	0.94	0.09	0.82	0.90
Father's education: >High school	0.41	0.15	0.23	0.98	0.12	0.96	0.78	0.07	0.45	0.79
Mother's occupation: High	0.61	0.41	0.69	0.90	0.41	0.76	0.90	0.37	0.70	0.86
Father's occupation: High	0.35	0.17	0.24	0.75	0.16	0.70	0.62	0.12	0.33	0.57
Mother's Medicaid status: No	0.52	0.12	0.92	0.91	0.33	0.55	0.99	0.07	0.28	0.92
Annual household income: ≥$50,000	0.31	0.03	0.48	0.66	0.12	0.06	0.78	0.01	0.07	0.68
Neighborhood deprivation index: < Medium	0.50	0.23	0.64	0.98	0.47	0.47	0.82	0.09	0.21	0.44

Table 3.6. (cont'd)

		Latent Group											
		Overall (n=3,010)				White/others (n=2,268)				African American (n=742)			
		SL	UM	DM	SH	SL	UM	DM	SH	SL	UM	DM	SH
SM: childhood SEP & adulthood SEP & NDI	No.	1355	722	482	452	830	625	389	424	451	112	124	55
Latent class membership probabilities		0.45	0.24	0.16	0.15	0.36	0.28	0.17	0.19	0.61	0.15	0.17	0.07
Indicator	%	Item-response probabilities											
Grandmother's education: >High school	0.36	0.21	0.22	0.68	0.75	0.15	0.22	0.65	0.75	0.22	0.44	0.63	0.89
Grandfather's education: >High school	0.29	0.08	0.15	0.63	0.92	0.06	0.15	0.69	0.93	0.08	0.00	0.44	0.87
Grandmother's occupation: High	0.68	0.49	0.74	0.88	0.96	0.52	0.76	0.91	0.96	0.45	0.62	0.51	0.89
Grandfather's occupation: High	0.29	0.09	0.16	0.52	0.81	0.10	0.17	0.56	0.81	0.09	0.15	0.22	0.67
Family history of public assistance: No	0.60	0.39	0.81	0.73	0.95	0.48	0.83	0.77	0.96	0.25	0.48	0.52	0.69
Mother's education: >High school	0.53	0.17	0.83	0.69	1.00	0.17	0.86	0.68	1.00	0.10	0.78	0.47	1.00
Father's education: >High school	0.41	0.11	0.65	0.43	0.93	0.12	0.70	0.40	0.93	0.08	0.58	0.09	0.89
Mother's occupation: High	0.61	0.40	0.83	0.57	0.94	0.39	0.85	0.54	0.95	0.36	0.78	0.55	0.82
Father's occupation: High	0.35	0.15	0.49	0.31	0.79	0.16	0.51	0.30	0.81	0.14	0.55	0.00	0.54
Mother's Medicaid status: No	0.52	0.17	0.93	0.45	0.98	0.25	0.94	0.50	0.98	0.04	0.45	0.31	0.71
Annual household income: ≥$50,000	0.31	0.04	0.64	0.15	0.75	0.08	0.66	0.18	0.76	0.00	0.26	0.06	0.45
Neighborhood deprivation index: < Medium	0.50	0.26	0.72	0.53	0.82	0.41	0.75	0.59	0.83	0.08	0.26	0.17	0.44

Table 3.6. (cont'd)

Abbreviation: DM, downward mobility; NDI, neighborhood deprivation index; SEP, socioeconomic position; SH, stable high; SL, stable low; SM, socioeconomic mobility; UM, upward mobility.

Table 3.7. Odds ratios of prenatal depression conditional on latent class membership (n=3,010), Pregnancy Outcomes and Community Health Study, Michigan, 1998-2004

	Overall (n=3,010)			White/others (n=2,268)			African American (n=742)		
	N	OR	95% CI	N	OR	95% CI	N	OR	95% CI
Childhood SEP									
Low	1211	3.72*	2.74, 5.04	866	2.90*	2.18, 3.87	569	1.73	0.94, 3.19
Middle	1039	1.27	0.86, 1.87	690	1.27	0.84, 1.92	98	0.99	0.41, 2.37
High (referent)	760	1.00		712	1.00		75	1.00	
Adulthood SEP & neighborhood deprivation index									
Low	1505	5.65*	4.42, 7.22	1100	4.61*	3.58, 5.93	505	3.45*	1.58, 7.53
Middle	602	2.14*	1.52, 3.01	235	2.14*	1.30, 3.52	173	2.73*	1.10, 6.79
High (referent)	903	1.00		933	1.00		64	1.00	
SM: childhood SEP & adulthood SEP & neighborhood deprivation index:									
Static low (referent)	1355	1.00		830	1.00		451	1.00	
Upward mobile	722	0.22*	0.17, 0.29	625	0.25*	0.18, 0.34	112	0.64	0.37, 1.10
Downward mobile	482	0.63*	0.47, 0.84	389	0.70*	0.50, 0.97	124	0.47*	0.23, 0.98
Static high	452	0.15*	0.11, 0.21	424	0.17*	0.12, 0.25	55	0.37*	0.19, 0.71
Downward mobile vs. Static high (referent)	482	4.10*	2.72, 6.17	389	3.99*	2.57, 6.21	124	1.29	0.50, 3.32

Abbreviation: CI, confidence interval; OR, odds ratio; SEP, socioeconomic position; SM, socioeconomic mobility.
* $P < 0.05$.

CHAPTER 4

SUMMARY

4.1 Major findings

The two studies in this dissertation have explored different outcomes of maternal socioeconomic mobility using data from the POUCH Study. First, we investigated the association between socioeconomic mobility and the risk of PTD. We used latent class approach with relevant multiple indicators and identified constructs of pregnant women's childhood SEP, adulthood SEP, and SM from childhood to adulthood in association with risk of PTD. We found that women with low childhood SEP and low adulthood SEP were at greatest risk of PTD compared to women who experienced SM or had high childhood and adulthood SEP; and upward socioeconomic mobility among pregnant women was associated with decreased risk of PTD compared to women with low childhood and adulthood SEP. This SM advantage was true in white/other women. In chapter 2, we also confirmed previous observations that disadvantaged SEP at adulthood was associated with a greater likelihood of PTD. In a previous publication from the POUCH Study, decreased risk of delivering a small for gestational age baby was observed among pregnant women with upward SM (Slaughter-Acey et al. 2016).

Next, we assessed the relationship between SM from childhood to adulthood and the risk of prenatal depression. A positive screen for depression (CES-D $\geq$16) in mid-pregnancy was more common in women with low childhood and adulthood SEP or a downward SM trajectory than women with upward SM or high childhood and adulthood SEP; and was less common in women who experienced upward SM than women with low childhood and adulthood SEP. These

relations between SEP, SM and depressive symptoms were stronger in white/other women as compared to African-American women.

Previous studies have used predominately ecological measures of SEP, and only a few of these have considered SM in relation to PTD or prenatal depression. Our study is novel in several ways: it includes in-depth, individual-level and ecological level data to measure SM and it uses a latent class analysis with distal outcome, i.e. PTD or prenatal depression. In addition, the sample is large for this type of in-depth data and is racially and socioeconomically diverse. Our Michigan, community-based cohort was obtained by sampling from 52 prenatal care clinics, thereby avoiding biases that can arise in samples from select inner-city clinics and academic/teaching hospitals. While vital data, i.e. birth files, and other administrative data can provide large numbers of pregnant women, these data sources lack the granularity of childhood and adulthood SEP measures that is obtained in this study by carefully querying women during pregnancy.

4.2 Public health significance

Our study supports some conceptual models that explicate how life course SEP affect pregnancy outcomes and mental health. In chapter 2, our findings support the social mobility model that upward SM remediates the negative effects of earlier disadvantage SEP and improving women's SEP from childhood to adulthood may improve pregnancy outcomes among white/other women. Our results also imply that the childhood SEP is not deterministic for women's future risk of PTD. In chapter 3, our findings are consistent with these theories explaining links between SEP and mental health. Our observation that a positive depression

screen is less likely in women with upward SM and more likely in women with downward SM points to adulthood SEP is salient and perhaps a 'critical window.' The SM pattern and maternal depression link also fits with the 'health selection' theory, i.e. women with mental health problems may be less likely to obtain or maintain high SEP, though, without measures of depression in childhood, we can't complete this theory test in this study.

Our study suggests that programs or policies to increase opportunities for upward SM may play an essential part in women's reproductive and mental health. Our study provided evidence that PTD and prenatal depression are shaped by socioeconomic exposures across the life course and childhood disadvantages might be buffered by advantaged experiences in later life. From a life course perspective, disparities in birth outcomes are the consequences of not only differential exposures during pregnancy, but perhaps more important differential accumulation of risk and protective factors across the life course. Therefore, in order to reduce the risk of adverse pregnancy outcomes and mental illness, it is necessary to improve women's SEP not only during pregnancy, but before and between pregnancies and indeed, across their entire life course. Previous literature indicated that education may be a more precise indictor of SEP across the life course (Morgen et al. 2008). In addition, higher education has been effective for poor people to find opportunities to transform their SEP. Therefore, education policies are necessary to help promote equal opportunity for children, no matter their socioeconomic background. Moreover, good education policies are critical for reducing health inequalities during both childhood and adulthood. It is challenging to change health across the entire distribution of SEP, particularly, when the current generation may be less socially mobile than prior generations. Hence, a wide range of national education policies may promote to improve the quality of and access to education and potentially reduce health inequalities (Heveman &

Smeeding, 2006). Accordingly, improving pregnant women's socioeconomic circumstances could be a vital intervention, particularly for those with adverse SEP in childhood and adulthood. As a result, some policies may target low income populations to help achieve financial self-sufficiency and provide a financial safety net for basic needs. The United States has high rates of PTD relative to other high income countries; this is true when we consider all births or when we look only at births to non-Hispanic white women living in the United States. Our findings are interpreted with caution but support suggestions that policies or programs to advance women's upward SM could help decrease rates of PTD in the United States.

In spite of growing evidence examining SM and depression later in life, no study has investigated the association among pregnant women or taken into account the multi-dimensional aspect of SEP. Consequently, the findings of this dissertation fill an essential gap in the literature. Latent class analysis was used in this dissertation to examine the effect of SM across the life course on pregnancy outcome and prenatal depression and the findings would benefit the pregnant women in the United States. Findings from the second study in this dissertation suggest that low SEP in childhood alone does not raise the risk of a positive depression screen in pregnancy as evidenced by the decreased risk for women with upward SM. The explanations for these observations may be multiple, but overall the findings lead to an optimistic conclusion; increasing opportunities for upward SM could help lower the prevalence of maternal depression. Women with low SEP in childhood and adulthood are the group most likely to screen positive for depression in pregnancy. Clinics and providers serving these pregnant women need adequate capacity to conduct depression screens and carry through with appropriate referrals and interventions. In addition, inequalities in maternal depression may affect health disparities in later life, so it is imperative to have early detection and treatment for depressive mothers with

low SEP (Bahk et al. 2015). Further research is needed to understand the specific elements accompanying SM that are protective for PTD or prenatal depression and the best strategies for increasing SM among all race/ethnic groups.

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