THE TRANSITION TO MOTHERHOOD:

CHILDBEARING AND SUBSEQUENT BODY MASS INDEX

by

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ABSTRACT

The purpose of this research is: 1) to advance our understanding of the impact early childbearing may have on becoming obese among US women; and 2) to determine if earlier age at first birth among minority women may contribute to their higher prevalence of obesity relative to white women. Analyses are conducted with data from the Panel Study of Income Dynamics (PSID).

There are three specific aims.

Specific Aim 1: Describe how allostatic load provides a framework to understand the contributions of reproductive events to body mass index (BMI) over the life course.

Specific Aim 2: Determine the impact of the transition to motherhood on BMI.

Specific Aim 3: Determine if the association between the transition to motherhood and subsequent BMI differs by age at first birth and minority status.

Chapter three completes specific aim one by presenting the conceptual basis for the pathways connecting childbearing, obesity and stress. It describes the manner in which these linkages may contribute to obesity disparities among women in the US.

Chapter four completed specific aim two. It examines the association of the transition to motherhood with a woman's body mass index (BMI). Evidence supports a relation between parity and an increase in BMI ($p<0.004$, 95%CI: 0.23, 1.12).

Chapter five completes specific aim three by examining associations of obesity with age at first birth and minority status. Results suggest that for each year beyond age 15 that a woman's first birth is delayed, BMI decreases by 0.20 units ($p<0.001$; 95%CI: -0.34, -0.06). Age at first birth was most strongly associated with BMI among the youngest group of women. Women who experienced their first birth at 21 years or younger had a BMI five units greater than women who delayed childbearing until at least 30 years (5.02; $p=0.02$, 95%CI: 0.65, 9.40).

Evidence from these analyses support a positive association between childbearing and increasing BMI. Findings suggest the most substantial impact occurs with the first birth and among women who experience the transition to motherhood at 21 years or younger.

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DEDICATION

This dissertation is dedicated to my husband, Cesar A. Torres,

and my daughter, Solana A. Torres.

There is nothing greater than this life we share together.

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CHAPTER 1

1.1 Purpose

Understanding how reproductive events may shape women's long-term health status is the overarching goal of this research. Gynecology and obstetrics are specialty fields that focus specifically on the reproductive system, with emphasis on identification and treatment of pathology. Structuring the provision of health care to women through the lens of their reproductive system has resulted in a tendency to understand women's health through their reproductive capacity. This orientation may lend itself to thinking of women's reproductive capacity as separate and distinct from, rather than integral to, their overall health and wellness.[1] By recognizing and considering the way in which reproductive events are linked to other health outcomes, this research may advance a more cohesive understanding of health and wellness in women's lives.

Childbearing is the reproductive event of interest, particularly timing of first birth, and obesity is the primary health outcome. The central research question guiding the analyses is whether age at first birth impacts BMI for women. Differences in the timing of childbearing are evident among racial and ethnic groups in the United States. While the mean age at first birth among all US women between 2006 and 2010 was 23 years, it was higher for non-Hispanic white women and lower for non-Hispanic black women, 24.1 and 20.9 years respectively.[2] Mean age at first birth for Hispanic women was 21.2.[2] In 2012, the mean age at first birth was 26.6 years for non-Hispanic white women, 23.6 years for non-Hispanic black women, and 23.8 years for Hispanic women.[3] As age at first birth is different for minority (black and Hispanic) and white women in the United States, findings may provide new insights to the factors that contribute to health inequalities in obesity by minority status.

The life course perspective tenders the theoretical orientation of this research. This approach integrates the ways that situation, culture, time, and social organization affect and are effected by individual developmental processes.[4] The life course perspective has guided research in the field of maternal and child health successfully.[5, 6] Allostatic load provides the conceptual framework connecting reproduction and obesity. By introducing allostatic load as a potential mechanism linking these events, scholars recognize childbearing as a potentially stressful event that may serve as a catalyst for changes in physiological responses within the individual that, over time, may result in obesity.[7]

While research already has identified childbearing as one factor specific to women that contributes to overweight and obesity, this work has focused primarily on gestational weight gain and post-partum weight retention as the pathway that connects childbirth and increased weight in mothers.[8-15] This work is helpful to understand proximal factors relating childbirth and maternal weight, but is less informative for appreciating a long-term relation between childbearing and obesity. A focus on gestational weight gain and postpartum weight retention also makes it difficult to consider how the experiences of nulliparous women further inform the contribution of childbearing to weight status among women.

1.2 Specific Aims

The purpose of this research is: 1) to advance our understanding of the impact early childbearing may have on becoming obese among US women; and 2) to determine if earlier age at first birth among minority women may contribute to their higher prevalence of obesity relative to white women. There are three specific aims:

Specific Aim 1: Describe how allostatic load provides a framework to understand the contributions of reproductive events to BMI over the life course.

Specific Aim 2: Determine the impact of the transition to motherhood on BMI.

Specific Aim 3: Determine if the association between the transition to motherhood and subsequent BMI differs by age at first birth and minority status.

Although it will not be directly evaluated, chronic disease is the logical endpoint of this research agenda. Abundant evidence has established the link between obesity and the onset of conditions such as hypertension and heart disease.[16, 17] Genetics, race and ethnicity also are independent risk factors for these chronic health conditions.[18-20] As age at first birth is different between minority (black and Hispanic) and white women, a relation between timing of childbirth and obesity may suggest broader health implications. Achieving more similar timing of reproductive events among racial and ethnic groups may offer the potential to narrow inequities in other health care outcomes related to obesity, such as diabetes and hypertension. The dual significance of the primary outcome of this research is unusual.

Elevated BMI is not only an important outcome in its own right, but also one that has important linkages to other public health priorities of considerable magnitude.

The conceptual framework guiding this research is portrayed in Figure 1. It displays the proposed linkages between childbearing, obesity, stress and age at first birth. Chapter 3 discusses the theoretical origins of this framework, which draws upon the life course perspective,[4] allostatic load,[21, 22] the weathering hypothesis,[23] and the environmental affordances model.[24]

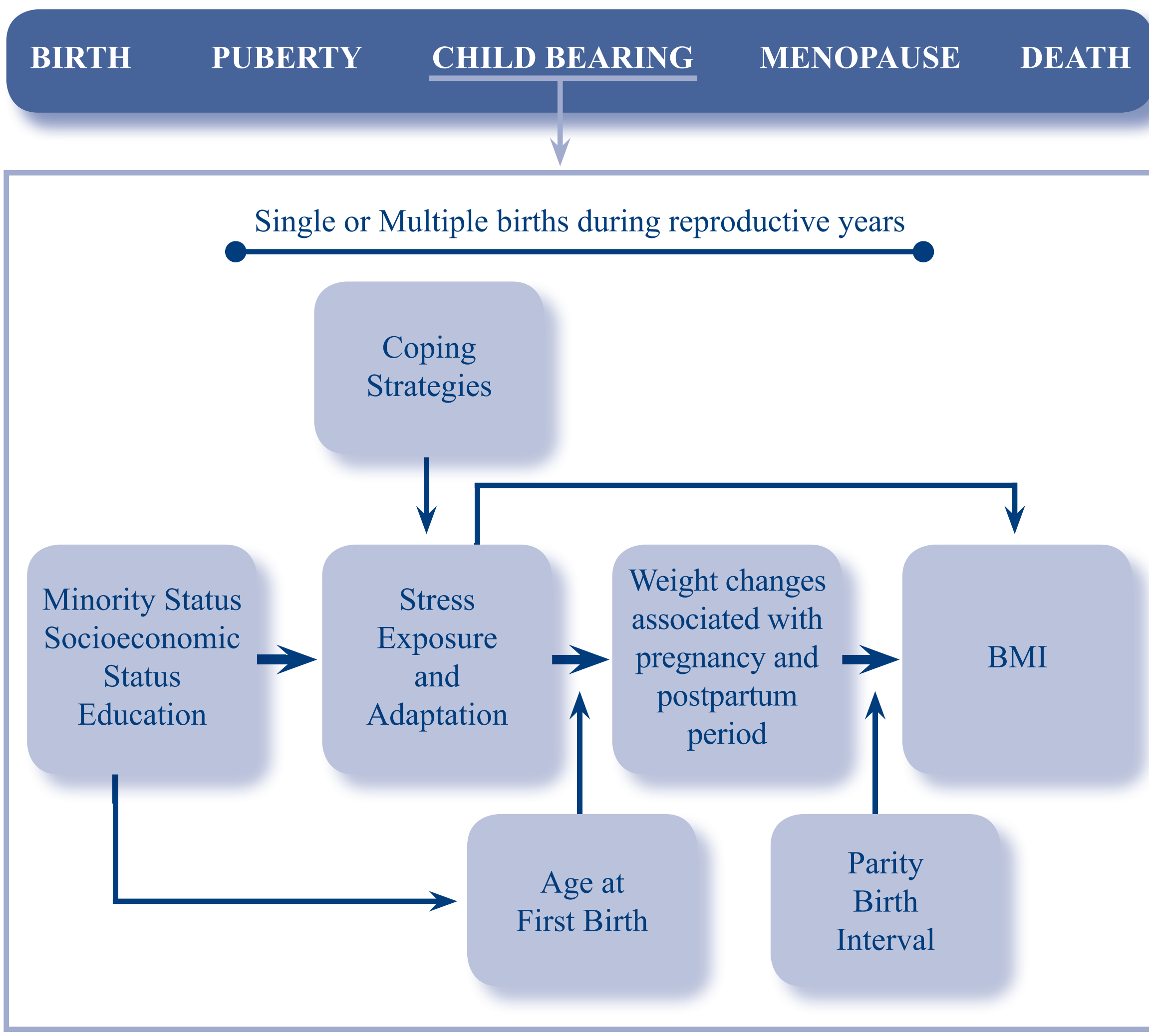

Figure 1: *The conceptual framework is grounded in the life course perspective and draws upon core concepts from weathering, allostatic load and environmental affordances.*

1.3 Presentation of the Research

The chapter that follows (chapter two) presents a detailed description of the methods used to conduct the analyses presented in chapters four and five. It includes a description of the data, study inclusion and exclusion criteria, definitions of key variables, measurement and a detailed discussion of the statistical tests used to perform analyses. Chapter three is the first article and presents the theoretical basis for the link between early childbearing and obesity, with particular attention to how this orientation offers new insight to obesity inequities between minority (black and Hispanic) and white women. It also reviews research related to childbearing and obesity.

Chapter four, the second article, examines BMI trajectories after childbirth and compares nulliparous and parous women. While many studies have examined the difference between weight prior to pregnancy and after delivery,[15, 25-27] a focus on change in mean weight may obscure the range of changes in weight experienced by individuals. For example, Olson found the mean weight gain one year after delivery was 1.51 kg, yet almost 25% of women in the study gained 4.55 kg or more during this period.[26] Other studies related weight gain to maternal BMI, reporting average change in BMI classification after childbearing.[10, 28-30]

There is limited consensus about the optimal follow-up period to evaluate retention of gestational weight gain and studies demonstrate variability in length of follow-up.[26, 28, 29, 31] Studies also compared maternal weight to the weight of women who do not have children during the study period.[25, 29-32] By including women who do not have children, the analyses presented in chapter four account for the effects of normative trends and aging on obesity as distinct from childbearing. It also considers parity as a time-varying, rather than indicator, variable.

The final article is presented in chapter five. It investigates how the transition to motherhood may impact BMI differently by age at first birth and minority status. Prior studies of maternal age at childbirth and maternal weight are limited. Among women who became mothers in adolescence, prepregnancy BMI has been identified as a significant predictor of obesity after childbearing.[33] Adolescents also have greater gestational weight gain[34] and develop more central adiposity compared to adults.[35] One study found that young mothers (age 14-22) were more likely to be obese five years after delivery than young women who did not have children, suggesting that early childbearing may have unique implications for long-term weight status among women.[31] Findings from other studies suggest that younger age at menarche and short interval from menarche to first birth may increase the likelihood of developing obesity.[10, 30]

Analyses of age at first birth and obesity are conducted with attention to the differences in the timing of childbearing by minority status. Between 2006 and 2010, the National Survey of Family Growth (NSFG) reported the probability of a first birth before age 20 among Non-Hispanic black women and Hispanic women was 32% and 30% respectively, it was just 14% among white women.[2] If more women in the US delay childbearing, it also will be important to understand the relative contribution of aging and timing of first birth to maternal BMI. Analyses presented in chapter five inform public health interventions so they may appropriately tailor strategies to mothers of different ages and racial/ethnic background.

Chapter six summarizes the results from chapters three, four and five. It discusses how findings relate to the overarching research goal of this work, to advance understanding of how reproductive events may influence the long-term health of women. Implications for public health research, policy, and interventions are considered.

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CHAPTER 2

Methods

2.1 General Design

I conducted analyses using a mixed effects longitudinal linear regression with random effects for intercept. The model had two levels: 1) change within women over time; and 2) between women using nested data, specifically, multiple BMI values over time for the same woman.

Women had a minimum of three data collection points. While the timing of measures was not specified for nulliparous women, childbearing women had at least one BMI measure prior to pregnancy and at least two after childbirth.

2.2 Panel Study of Income Dynamics

The Panel Study of Income Dynamics (PSID) is a nationally representative longitudinal study of US families that started in 1968. The original study sample included about 18,000 individuals in approximately 5,000 families.[1] The PSID adopted a genealogical sampling frame that follows the descendants of original family members. By adopting this framework, the initial sample grew to include over 65,000 individuals from approximately 8,000 families. Study participants were interviewed annually between 1968 and 1996. To maintain a sample that was representative of the US population, adjustments made in 1996 resulted in many African-American families leaving and immigrant families joining the study.[2] In 1992, PSID conducted its first systematic attempt to locate and renew participation of families that had not responded during prior years. This effort was successful, yielding more than 2,000 participants who became active again in the study.[2] Data collection has occurred every other year since 1997.

In addition to being nationally representative of the United States (U.S.), the genealogically derived sample has resulted in three to four generations of family members. PSID has maintained a high response rate and investigations of the effects of attrition indicate that it is not a large problem.[1, 3-5] Chapter six discusses sample attrition in greater detail. Weights are available to adjust for survey design and other factors affecting representativeness of the U.S. population.

Classification of individuals within the PSID dataset fall into four main categories and are defined as head, wife, "wife" and other family members. Originally defined to be consistent with the 1968 U.S. Census Bureau, the terms are outdated today. Nonetheless, the original terms continue to be used in order to maintain consistency and continuity within the panel. For family units with a married couple, the husband is defined as the head unless for some reason he is incapable of participating in the survey. Head may also be a single female in a household without a married or cohabitating couple. The wife of the married couple is defined as a wife and cohabitating females are classified as "wife." Roles are assigned to promote consistency in survey respondent for the family unit at each wave. McGonagle reported that over 90% of PSID families have the same person responding for the family unit in consecutive waves.[6]

Although designed to study income, PSID now includes information on a range of collateral topics, including education, marriage, fertility, health behaviors, health status and health insurance. The comprehensive variables included in PSID and its genealogical sample frame offer an unusual opportunity to study events over the life course. Several thousand peer reviewed publications have drawn upon information from PSID, including scholarship on obesity. For example, between 2004 and 2012, over 25 peer-reviewed articles examined topics related to obesity, ranging from the link between breastfeeding and obesity[7] to the relationship of obesity and employment.[8]

2.2.1 Survey Administration

When PSID began in 1968, interviews were conducted in-person, and these face-to-face interviews continued through 1972. In 1973, telephone interviews began. Telephone interviews using traditional data collection techniques that relied on question trees and pencil and paper data collections persisted through 1992. Between 1993 and 1994, PSID made the transition to computer assisted telephone interviews. PSID transitioned from annual to biannual data collection in 1997. PSID staff recognized that lengthening the time between interview periods increased the potential for inaccurate participant recall. To address this potential problem, interviews were conducted with event histories.[9]

2.2.2 Data Center

While the initial study was funded by the Office of Economic Opportunity, the majority of its current support is provided by the National Science Foundation. Other public agencies, such as the National Institute on Aging and the National Institute of Child Health and Human Development, also support the PSID.

Non-restricted data files are accessed directly from the PSID website (http://psidonline.isr.umich.edu/default.aspx) using the online data center. Variables may be examined through a variety of search options, including individual files, an index of data across years, and by specific variables. Data are available in a variety of formats, including SAS, SPSS, and Stata. The website also allows investigators to create codebooks corresponding to variable selection.[1]

The PSID website provides a series of tutorials to assist investigators, principally to understand how the data are organized. Detailed information is provided about topics such as identifying original study families and “split-off families” (a family member leaves the PSID enrolled household, or splits-off, to set up a unique and separate households, which is then enrolled in PSID); merging individual and family data files; and understanding how variables are coded (e.g., determining if the value for a variable is actual or imputed; etc.).

Restricted data are not required for these analyses. The Institutional Review Board at the Johns Hopkins Bloomberg School of Public Health concluded that this protocol is not human subjects research and did not require IRB oversight.

2.2.3 Study Questionnaires

Between 1999 and 2011, data has been collected biannually using computer assisted telephone interviews. PSID staff use event history calendars to promote accurate recall of events.[10] Questions about height and weight were asked for head of household and wife of head of household. These questions are placed within a general section of the questionnaire about health status and behaviors.

PSID staff receives ongoing training on study protocols and procedures to ensure consistency in data collection.

2.3 Sample Size

There are 505 women in the PSID sample that met exclusion criteria. Figure 1 illustrates the selection of potential participants.

Women Who Met Sample Exclusion Criteria

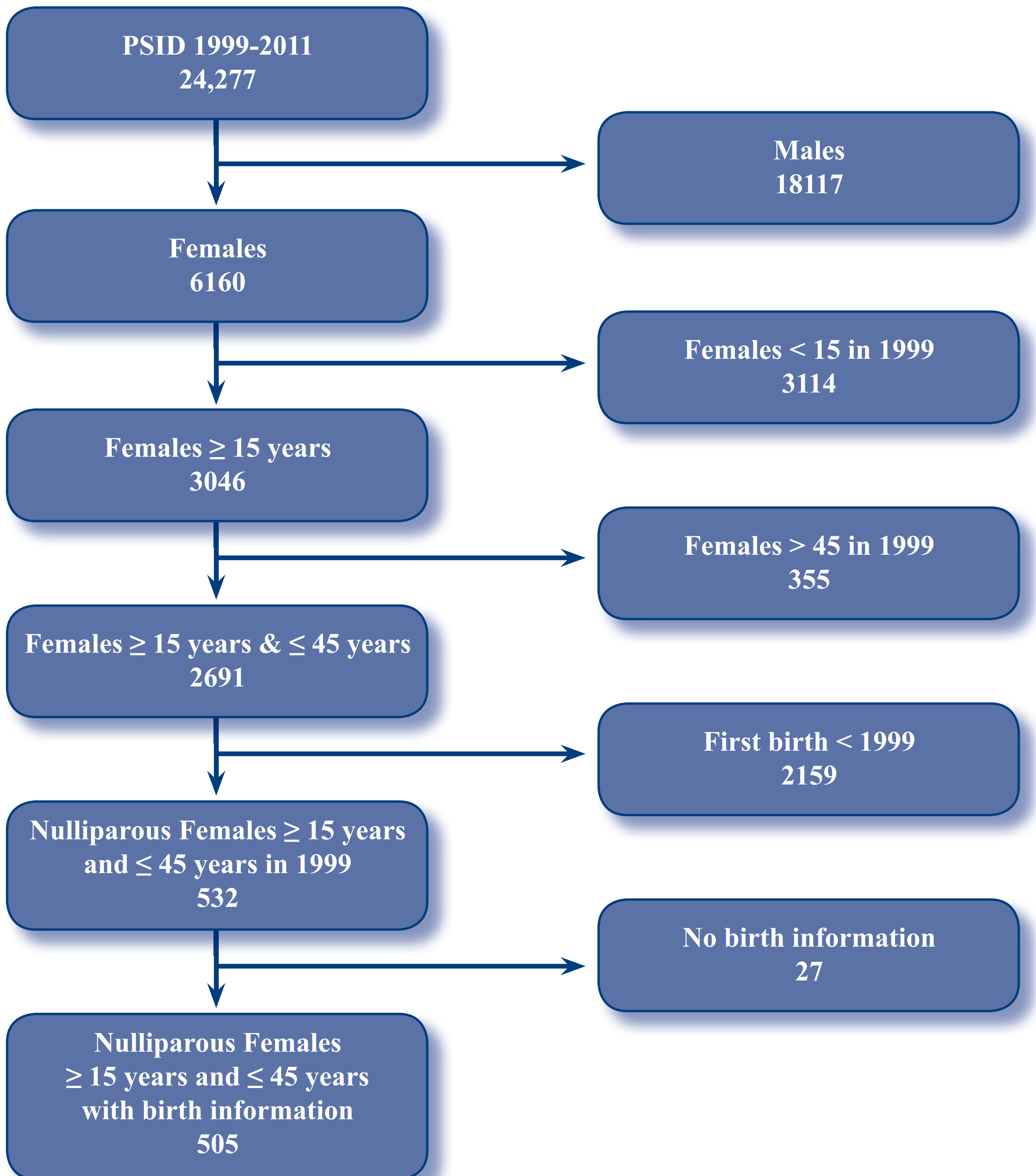

Figure 1: *In 1999 there were 505 nulliparous females between the ages of 15 and 45 with birth information.*

Women needed at least three waves of BMI data to be included in the final sample, with a minimum of one observation prior to first birth and two observations after first birth. Combined exclusion and inclusion certeria yielded a final sample of 257 women with 1,799 observations. Figure 2 displays final sample selection. Among this sample, 146 (57%) had a history of childbirth. The mean number of observations per participant in the sample is 4.7. Data were collected every two years over seven waves, starting in 1999 and ending in 2011.

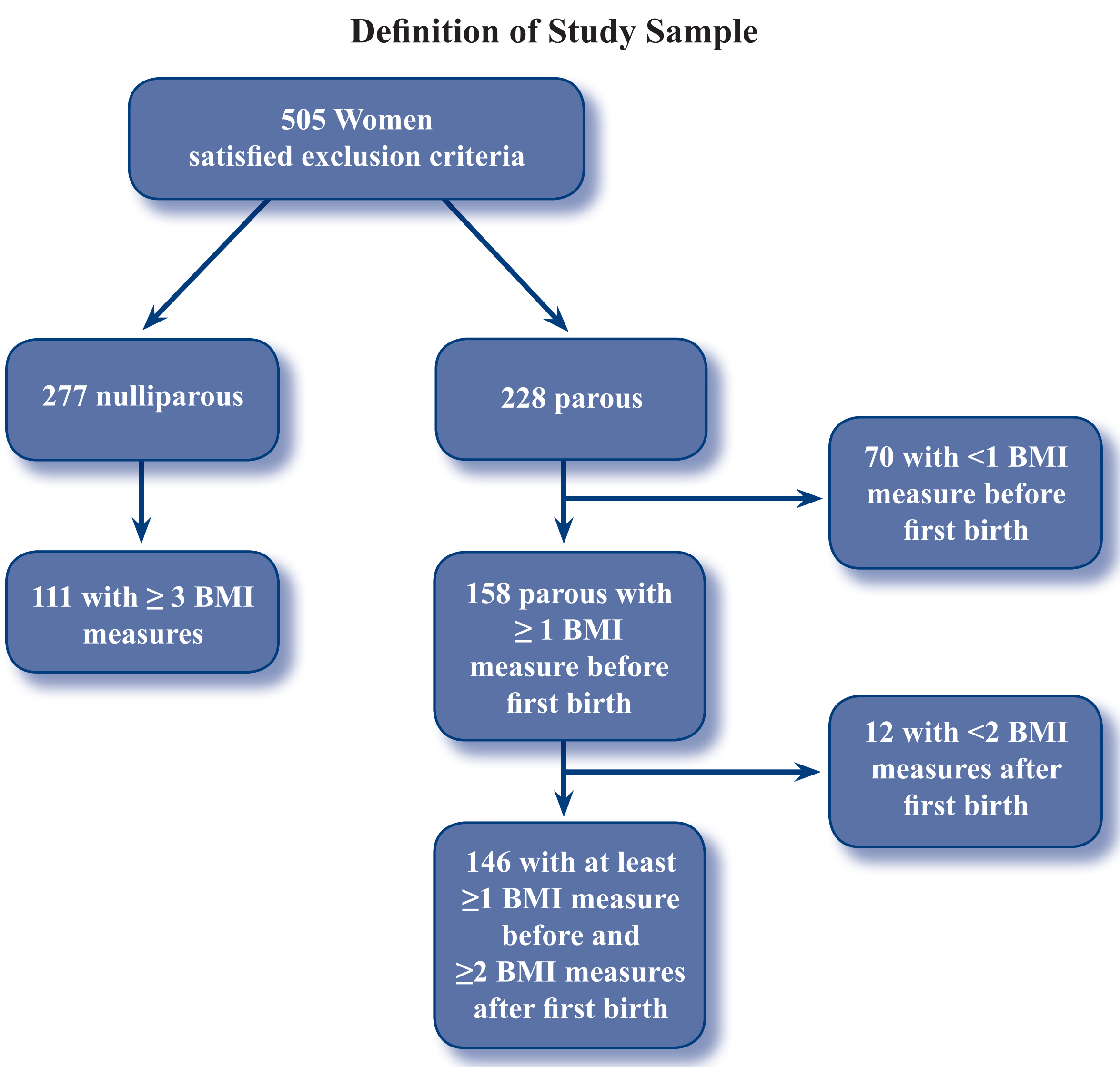

Figure 2: *The sample consists of 257 women.*

2.3.1.4 Primary Outcome

The primary outcome of the proposed research is BMI. BMI is weight in kilograms divided by height in meters squared.[11] Change in BMI among women between 15 and 45 is primarily the result of change in weight rather than height and, therefore, this dependent variable may be understood as an indication of change in body weight over time. A change in one BMI unit corresponds to approximately 6 pounds for a women of average height (5' 4") in the United States.[12]

Weight and height in PSID were self-reported. Self-reported height and weight has been validated in national samples.[13] PSID also has validated its height and weight data by comparing its data to the self-reported height and weight data of the National Health Information Survey (NHIS), demonstrating that it is comparable to other nationally representative surveys.[14] Figure 3 presents an analysis completed by Andreski and colleagues (2009) that compares self-reported weight for PSID and NHIS. Limitations of self-reported height and weight data are discussed in chapter six.

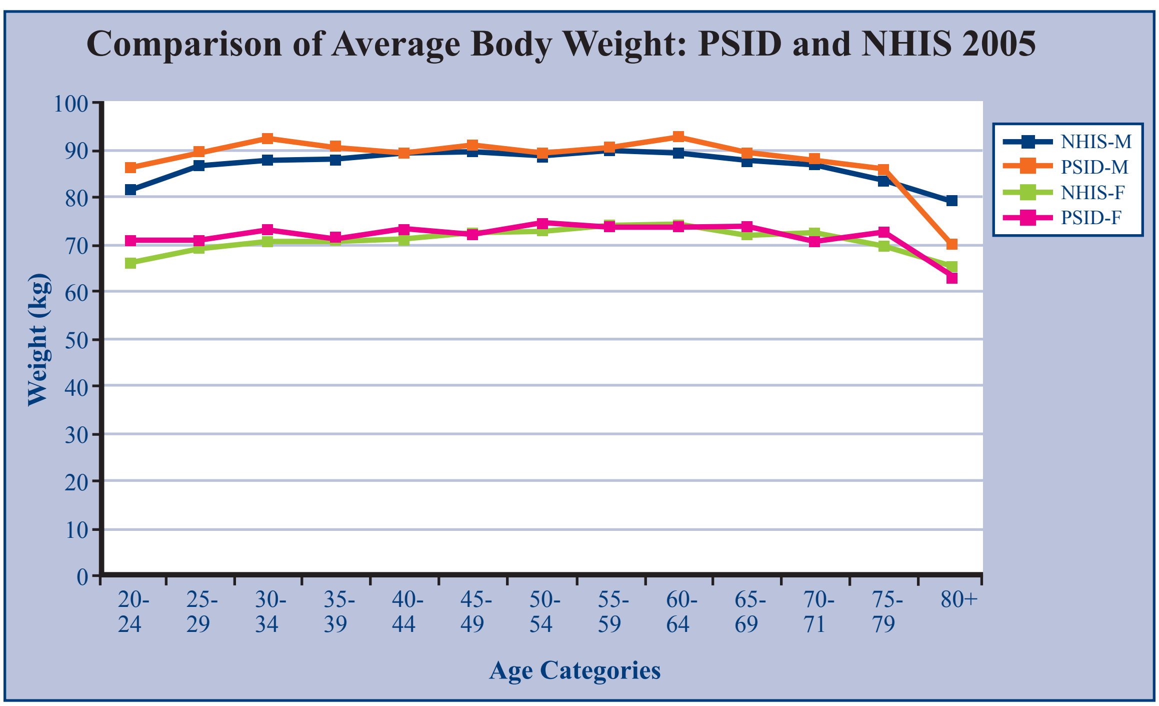

Figure 3: *The figure from Andreski's paper illustrates self-reported data for weight from PSID is similar to that reported in other nationally representative surveys.*[14]

2.3.2 Transition to motherhood

PSID began collecting birth history information in 1985 and updated it at each survey interval. Birth information was self-reported, and self-reported childbearing data are highly accurate.[11] Women without a history of childbirth were coded as nulliparous and remained distinct from women with missing birth data. Birth history data included the total number of children delivered by a women, as well as the month and year of each birth. Date of first birth generated a time-varying parity variable. Total number of children generated a parity variable to reflect nulliparity, primiparity, and multiparity.

2.3.3 Variability in Age at First Birth and Baseline BMI

Age at first birth was generated using the month and year of the participant's birth and month and year of her first birth. The sample demonstrates good variability across age at first birth, as illustrated by Figure 4. Mean age at first birth is 23 years (range 16 to 39). There are 111 nulliparous women in the sample.

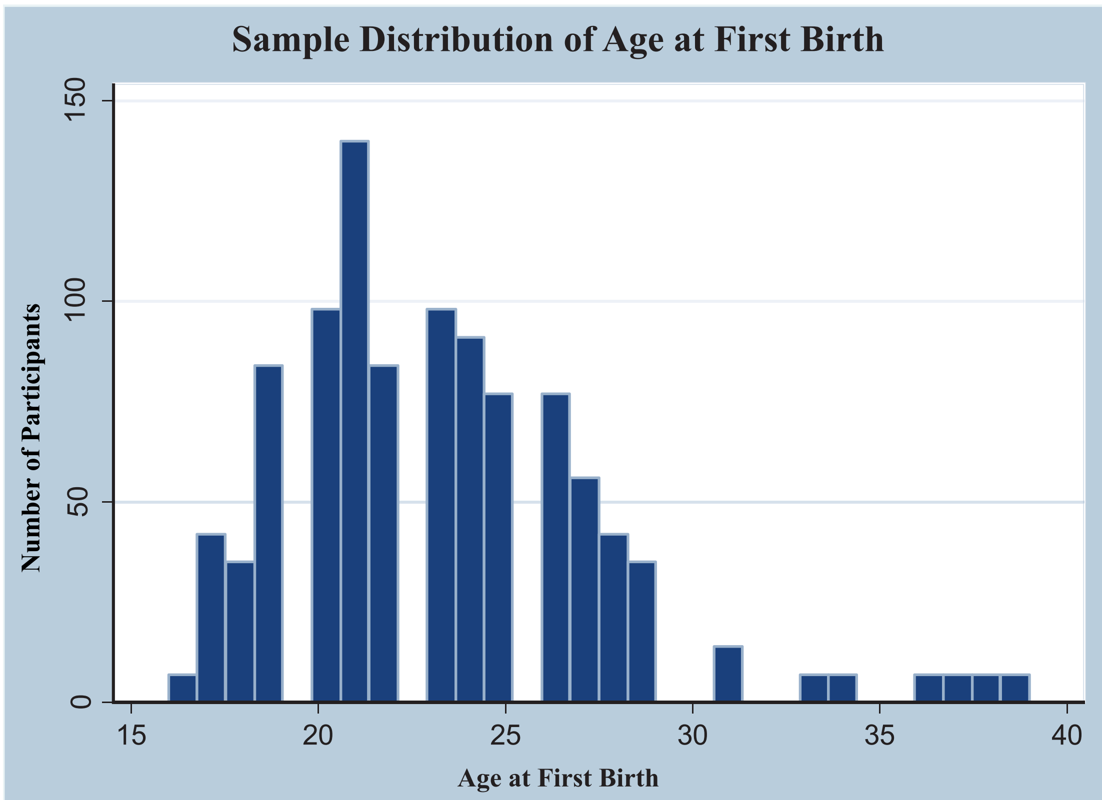

Figure 4: *Mean age at first birth is 23 years. The range is 16 to 39 years.*

BMI was generated using the height and weight of the participant. The sample demonstrates good variability across baseline BMI, as illustrated by Figure 5. Mean baseline BMI is 25.86 units (range 16.44 to 55.84).

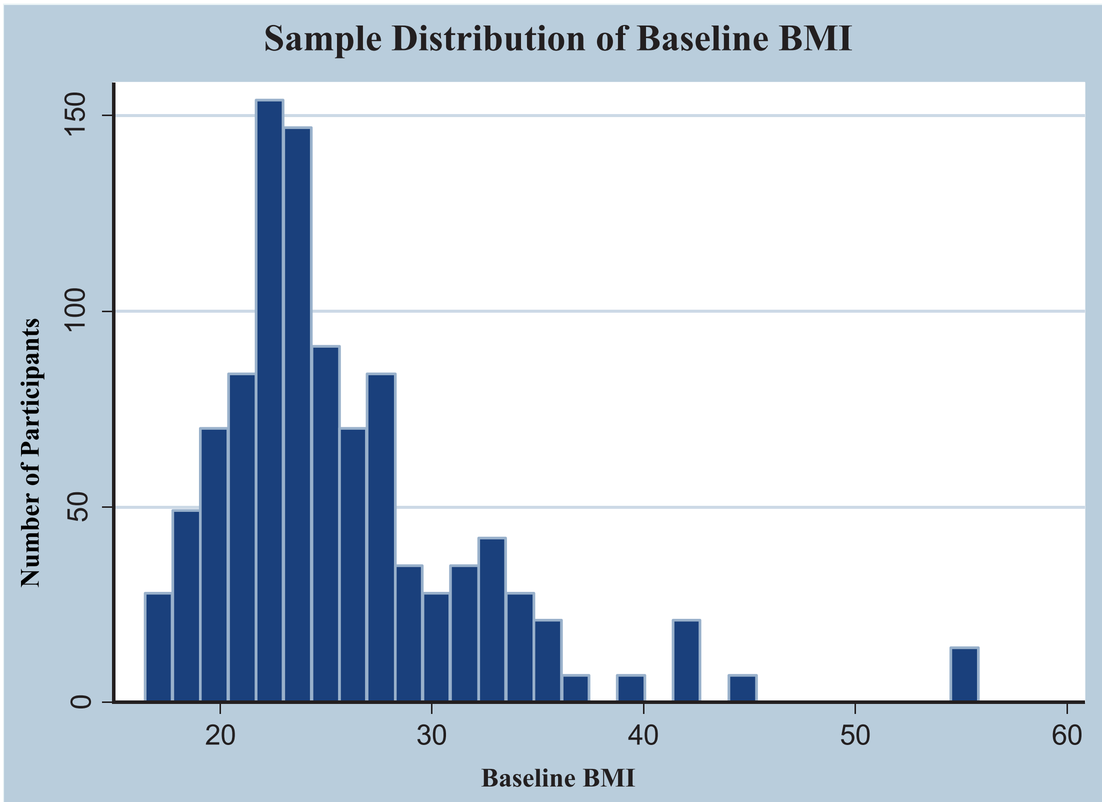

Figure 5: *Mean BMI at baseline is 25.86 units.*

2.3.4 Minority status

There were several changes in how PSID defined race and ethnicity over the years. Since these definitions were not consistent over panel waves, they were redefined in order to be consistent during the study period. The definitions of race were different between 1999 – 2003 and 2005 – 20011. Ethnicity was part of the race variable between 1999 and 2003. Given these parameters, it was not possible to distinguish both race and ethnicity for all participants during the study period, resulting in classification as minority and white for these analyses. The final sample includes 126 minority (49%) and 131 white (50.9%) participants.

2.3.5 Education and Household Income

The PSID offers some of the most sophisticated income measures available in survey research. These analyses included total family income as a time-varying variable. It is a measure that sums seven different parameters: head of household taxable income; spouse taxable income; head of household transfer income; spouse transfer income; taxable income of other household members, and total social security. Each wave of data provided a separate measure of total family income for the prior year. Years of completed education also were assessed at each wave. The actual grade completed and postgraduate work were updated and recorded as appropriate.

2.4 Statistical Tests of Mediation

Baron and Kenny (1986) delineated an approach to test for mediation that has been widely embraced.[12] This approach tests for mediation by considering the relationship between an independent variable and a dependent variable both in the presence and absence of a mediating variable. There is evidence of mediation when the relationship between the independent and dependent variable is different when the mediating variable is included in the analysis. This approach does not include an interaction term between the independent and mediating variables because it assumes this relation is zero. The approach does not specify a temporal relation between the variables.

2.5 Data Analyses

2.5.1 Specific Aim One

Specific aim one is to describe how allostatic load provides a framework to understand contributions of reproductive events to BMI over the life course. It did not require statistical analyses to complete and this aim is addressed by chapter three.

2.5.2 Specific Aim Two

The second specific aim is to determine the impact of the transition to motherhood on BMI after childbirth. A level one and a level two model are used to examine change within the individual and between individuals.

2.5.2.1 Model One of Specific Aim Two

The first model formally tested the hypothesis that a woman's BMI remains constant over each year of age.

H0: $\beta_1=0$ (meaning, age has no association with BMI)

H1: $\beta_1<0$ or >0 (two-sided).

The model may be expressed as:

$$Y_{it} = \beta_0 + \beta_1(A_{it}) + E_{it}$$

Where:

A_{it} is centered (at 15) age for the i_{th} individual at the t_{th} wave;

β_0 is expected baseline BMI for the i_{th} person;

β_1 is the expected change per year of age; and

E_{it} is error for the i_{th} individual at the t_{th} wave.

The results of the first model of specific aim two are presented in chapter four.

2.5.2.2 Model Two of Specific Aim Two

To determine the impact of the transition to motherhood on BMI, model two of specific aim two is a level two model to examine difference in within-person change between women. It tested the hypothesis that parturition does not alter BMI and may be defined as:

H0: β_2=0 (meaning, parturition has no association with expected BMI)

H1: β_2<0 or >0 (two-sided test).

If β_2<0 or >0, this indicates that the BMI of mothers increases after parturition, but, *there is no hypothesis about change in rate of change* in BMI before and after childbearing.

This model includes age, log household income, and minority status as covariates and is presented in Figure 6. It may be expressed as:

$$Y_{it} = \beta_0 + \beta_1(A_{it}) + \beta_2(P_{it}) + \beta_3(I_{it}) + \beta_4(M_i) + E_{it}$$

Where

A_{it} is centered (at 15) age for the i_{th} individual at the t_{th} wave;

P_{it} is an indicator variable such that P_{it} = 0 if the i_{th} person at the t_{th} wave is nulliparous, and P_{it} =1 if the i_{th} person at the t_{th} wave is parous;

I_{it} is log household income in dollars (not adjusted for inflation) for the i_{th} individual at the t_{th} wave;

M_i is an indicator variable for minority status (1 if minority, 0 if white; not time-varying);

β_0 is the expected baseline BMI for the i_{th} person;

β_1 is the expected change in BMI per year of age;

β_2 is the expected increase in BMI associated with measurement after childbearing;

β_3 is the expected difference in BMI per log dollar of unadjusted household income;

β_4 is the expected difference in BMI associated with minority status; and

E_{it} is error for the i_{th} individual at the t_{th} wave.

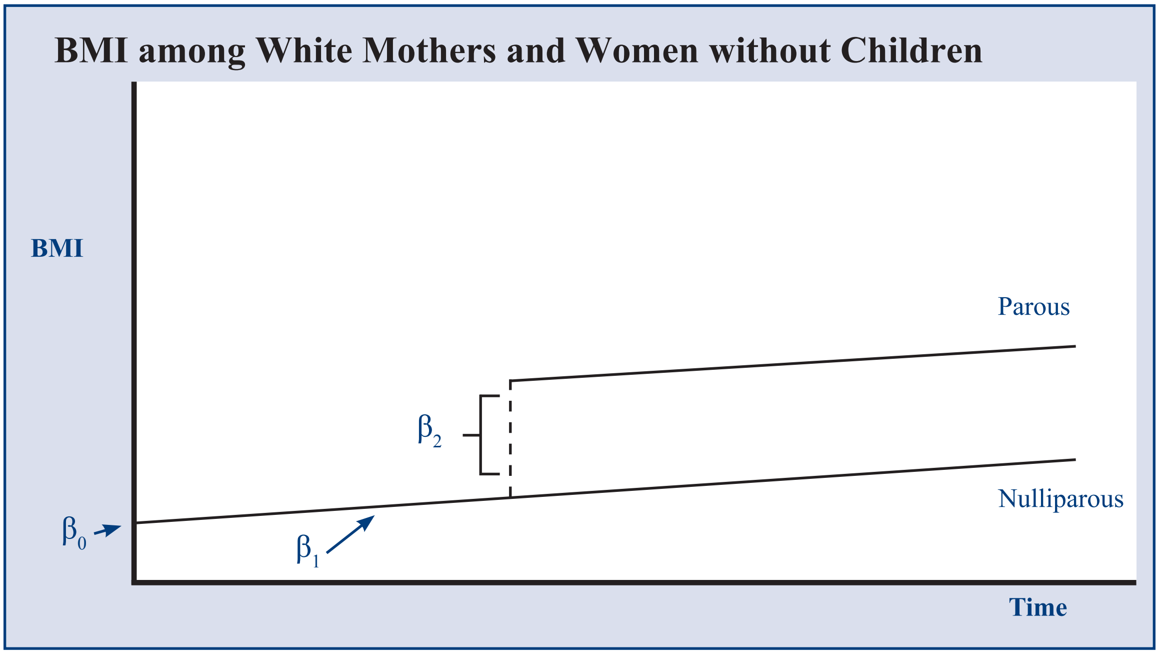

Figure 6: *This model tested the hypothesis that parturition does not alter BMI.*

The results of this model are presented in chapter four.

2.5.2.3 Model Three of Specific Aim Two

To determine if multiparity impacts BMI, model three of specific aim two also is a level two model to examine difference in within-person change between women. It tested the hypothesis that the association of primiparity and multiparity on BMI were not different and may be defined as:

H0: β_2=0 (meaning, multiparity had no additional association with expected BMI)

H1: β_2<0 or >0 (two-sided test).

If β_2 <0 or >0, this indicates that the BMI of multiparous mothers increases even more than BMI of primiparous women, but, *there is no hypothesis about change in rate of change* in BMI before and after childbearing.

This model includes age, household income and minority status as covariates and is presented in Figure 7. It may be expressed as:

$$Y_{it} = \beta_0 + \beta_1(A_{it}) + \beta_2(P_{it}) + \beta_3(I_{it}) + \beta_4(M_i) + E_{it}$$

Where

A_{it} is centered (at 15) age for the i_{th} individual at the t_{th} wave;

P_{it} is an indicator variable such that $P_{it} = 0$ if the i_{th} person at the t_{th} wave is nulliparous, $P_{it} = 1$ if the i_{th} person at the t_{th} wave is primiparous, and $P_{it} = 2$ if the i_{th} person at the t_{th} wave is multiparous;

I_{it} is log household income in dollars (not adjusted for inflation) for the i_{th} individual at the t_{th} wave;

M_i is an indicator variable for minority status (1 if minority, 0 if white; not time-varying);

β_0 is the expected baseline BMI for the i_{th} person;

β_1 is the expected change in BMI per year of age;

β_2 is the expected increase in BMI associated with measurement after first childbearing and higher order births;

β_3 is the expected difference in BMI per log dollar of unadjusted household income;

β_4 is the expected difference in BMI associated with minority status; and

E_{it} is error for the i_{th} individual at the t_{th} wave.

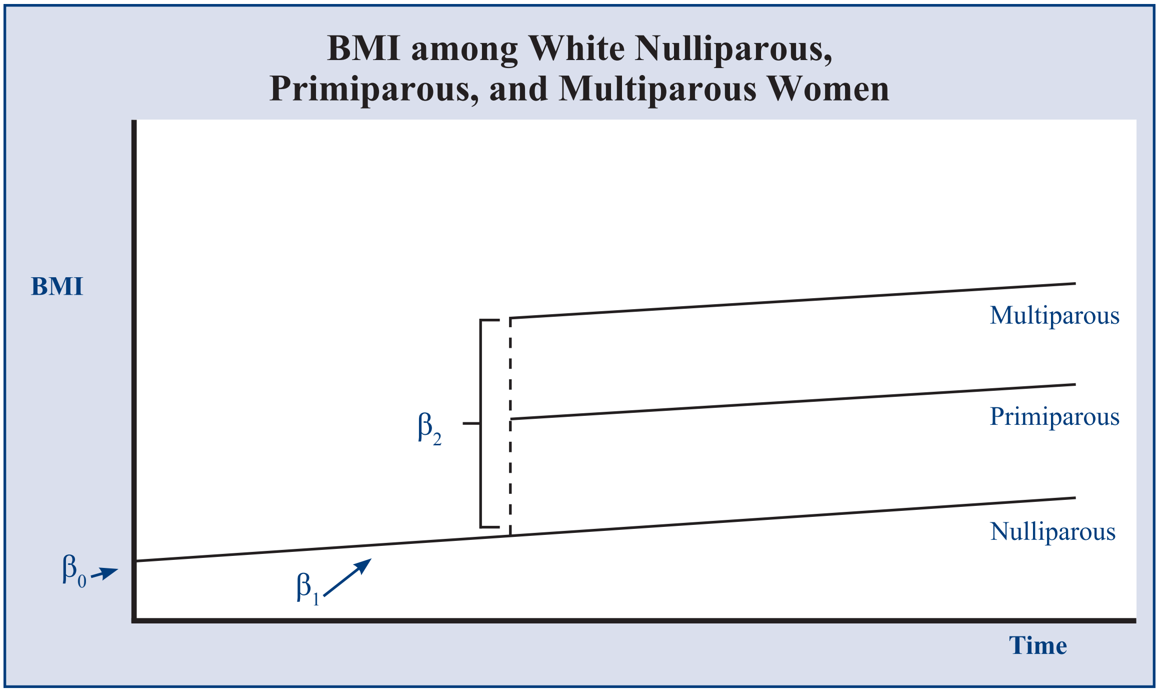

Figure 7: *Differences between nulliparity, parimiparity, and multiparity were tested.*

Results of this model are presented in chapter 4.

2.5.3 Specific Aim Three

The third specific aim is to determine if BMI differs by age at first birth and minority status among mothers.

2.5.3.1 Model One of Specific Aim Three

Analyses for this aim were completed using a level two model that examined change between groups and included age and log household income as covariates. Only women who transitioned to mothers were considered.

The first hypothesis for specific aim three considers the main effect of minority status on BMI among childbearing women and may be defined as:

H0: β_3=0 (meaning, minority status has no effect on expected BMI among childbearing women)

H1: β_3<0 or >0 (two-sided test).

The first model is presented in Figure 8 and may be expressed as:

$$Y_{it} = \beta_0 + \beta_1(A_{it}) + \beta_2(I_{it}) + \beta_3(M_i) + E_{it}$$

Where

A_{it} is centered (at 15) age for the i_{th} individual at the t_{th} wave;

I_{it} is log household income in dollars (not adjusted for inflation) for the i_{th} individual at the tth wave;

M_i is an indicator variable for minority status (1 if minority, 0 if white; not time-varying);

β_0 is the expected baseline BMI for the i_{th} person;

β_1 is the expected change in BMI per year of age;

β_2 is the expected difference in BMI per log dollar of unadjusted household income;

β_3 is the expected difference in BMI associated with minority status; and

E_{it} is error for the i_{th} individual at the t_{th} wave.

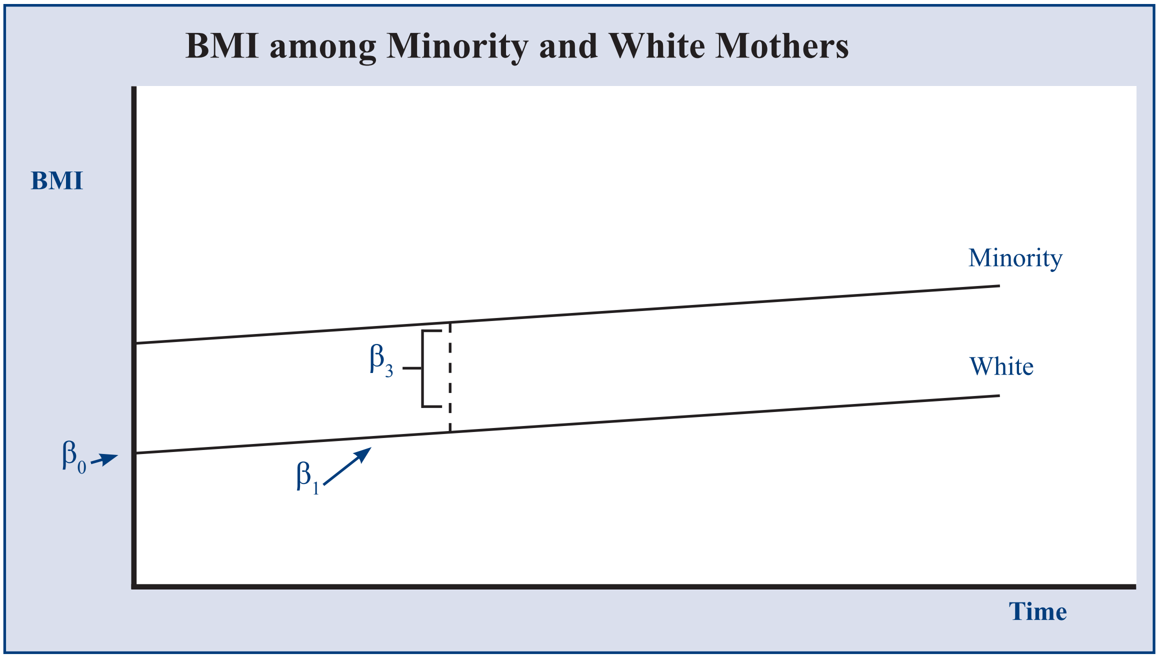

Figure 8: *In this model, β_3 is the expected difference in BMI associated with minority status among childbearing women.*

Results from this model are presented in chapter five.

2.5.3.2 Model Two of Specific Aim Three

The second hypothesis for specific aim three considers the association of age at first birth on BMI among childbearing women and may be defined as:

H0: β_4=0 (meaning, age at first birth has no association with expected BMI among childbearing women)

H1: β_4<0 or >0 (two-sided test).

The second model for specific aim three tested the association of age at first birth among childbearing women and included minority status and log household income as covariates. It is presented in Figure 9 and may be expressed as:

$$Y_{it} = \beta_0 + \beta_1(A_{it}) + \beta_2(I_{it}) + \beta_3(M_i) + \beta_4(AFB_i) + E_{it}$$

Where

A_{it} is centered (at 15) age for the i_{th} individual at the t_{th} wave;

I_{it} is log household income in dollars (not adjusted for inflation) for the i_{th} individual at the t_{th} wave;

M_i is an indicator variable for minority status (1 if minority, 0 if white; not time-varying);

AFB_i is age at first birth in years;

β_0 is the expected baseline BMI for the i_{th} person;

β_1 is the expected change in BMI per year of age;

β_2 is the expected difference in BMI per log dollar of unadjusted household income;

β_3 is the expected difference in BMI associated with minority status;

β_4 is the expected increase in BMI (over the whole time, including nulliparous period) associated with a one unit difference in age at first birth; and

E_{it} is error for the i_{th} individual at the t_{th} wave.

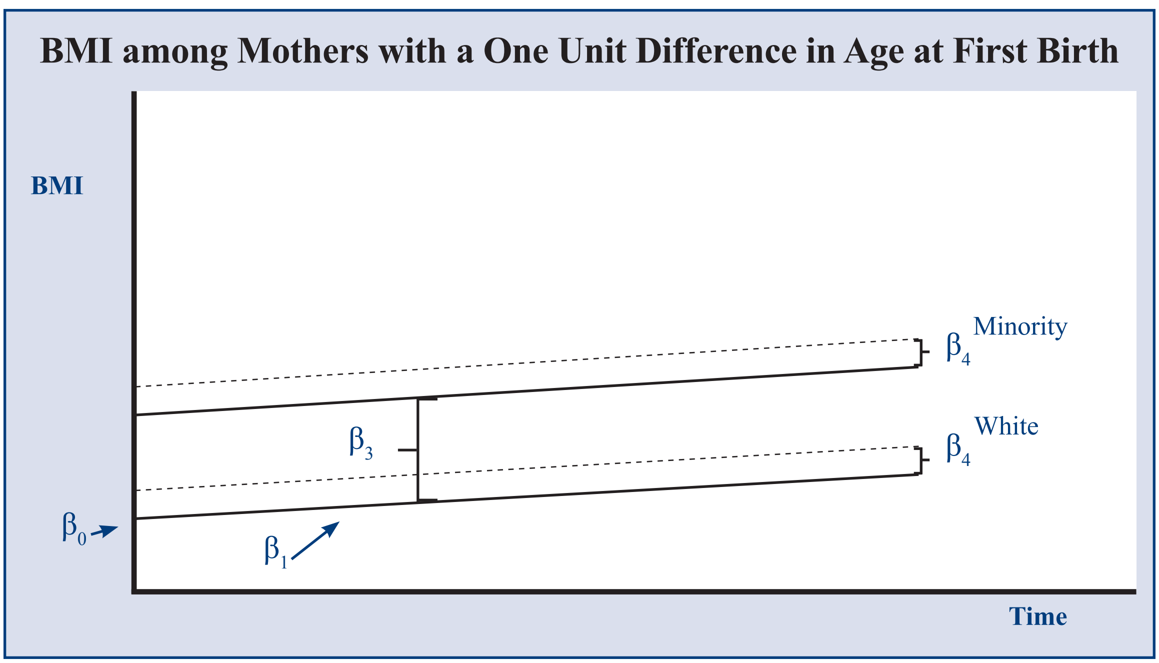

Figure 9: *In this model, β_4 represents the expected difference in BMI, without distinguishing the nulliparous and parous period, associated with a one unit difference in age at first birth.*

Results from this model are presented in chapter five.

2.5.3.2 Model Three of Specific Aim Three

The third model of specific aim three defined an interaction term, β_5 = (M*AFB), to test the hypothesis that the association of age at first birth varies as a function of minority status and is defined as:

H0: $\beta_5 = 0$ (meaning, the association of age at first birth on BMI does not vary as a function of minority status)

H1: $\beta_5 < 0$ or > 0 (two-sided test).

The second model is presented in Figure 10 and may be expressed as:

$$Y_{it} = \beta_0 + \beta_1(A_{it}) + \beta_2(I_{it}) + \beta_3(M_i) + \beta_4(AFB_i) + \beta_5(M_i{*}AFB_i) + E_{it}$$

Where

A_{it} is centered (at 15) age for the i_{th} individual at the t_{th} wave;

I_{it} is log household income in dollars (not adjusted for inflation) for the i_{th} individual at the t_{th} wave;

M_i is an indicator variable for minority status (1 if minority, 0 if white; not time-varying);

AFB_i is age at first birth in years;

$M_i{*}AFB_i$ is an interaction between minority status and age at first birth;

β_0 is the expected baseline BMI for the i_{th} person;

β_1 is the expected change in BMI per year of age;

β_2 is the expected difference in BMI per log dollar of unadjusted household income;

β_3 is the expected difference in BMI associated with minority status;

β_4 is the expected increase in BMI (over the whole time, including nulliparous period) associated with a one unit difference in age at first birth;

β_5 is the association of age at first birth with BMI as a function of minority status; and

E_{it} is error for the i_{th} individual at the t_{th} wave.

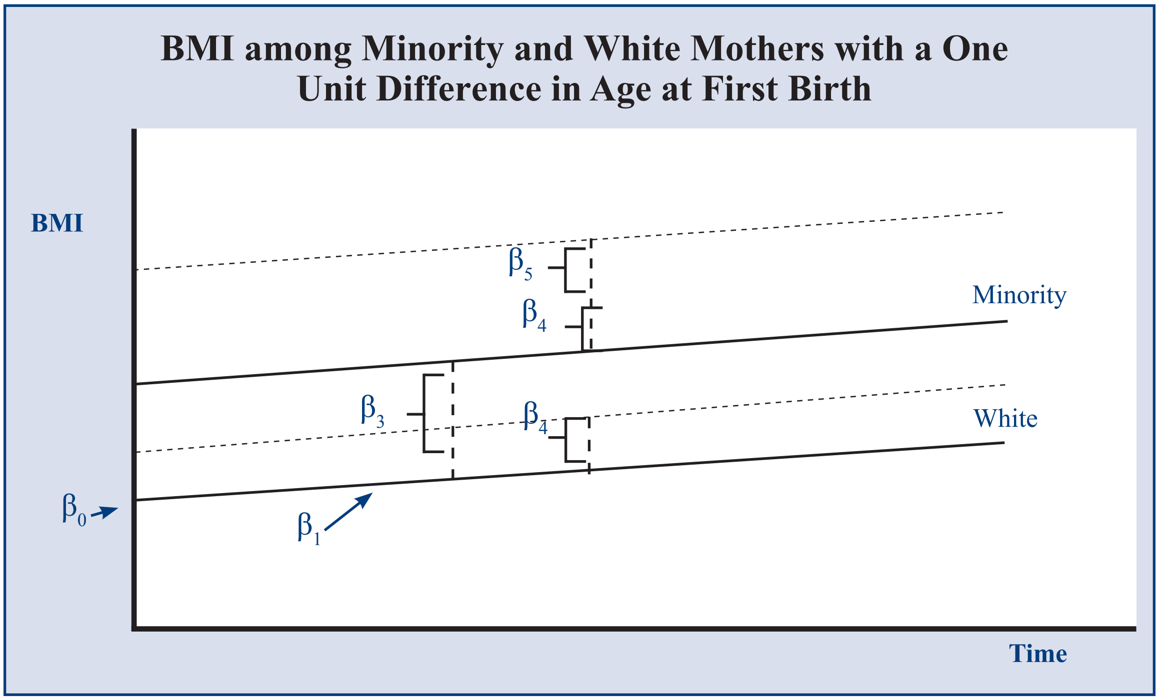

Figure 10: *This model tested the interaction of age at first birth and minority status on BMI to determine if it operated differently for minority and white mothers.*

The results of model three found no evidence that age at first birth operated differently among minority and white mothers (p = 0.46, 95%CI: -0.65 – 0.29).

2.5.3.4 Model Four of Specific Aim Three

Model four of specific aim three also considered the association of age at first birth (AFB) on BMI. It was a level two model and included age, household income and minority status as covariates. This model examined age at first birth as defined by three groups (rather than as a continuous variable): age 21 years and younger; ages 22 to 29 years; and age 30 years and older (comparison group). Here, the difference in BMI associated with age 21 years and 22 to 29, as compared to 30 years and older, was considered. The hypothesis may be defined as:

H0: β_4=0 (meaning, experiencing a first birth at age 21 years and 22 to 29 years has no association with expected BMI, as compared to women 30 years and older)
H1: β_4<0 or >0 (two-sided test).

The model is presented in Figure 11 and may be expressed as:

$$Y_{it} = \beta_0 + \beta_1 (A_{it}) + \beta_2(I_{it}) + \beta_3 (M_i) + \beta_4 (AFB\text{-}CAT_i) + E_{it}$$

Where

A_{it} is centered (at 15) age for the i_{th} individual at the t_{th} wave;

I_{it} is log household income in dollars (not adjusted for inflation) for the i_{th} individual at the t_{th} wave;

M_i is an indicator variable for minority status (1 if minority, 0 if white; not time-varying);

AFB-CAT$_i$ is age at first birth by group (≤21; 22-29; ≥30) in years ;

β_0 is the expected baseline BMI for the i_{th} person;

β_1 is the expected change in BMI per year of age;

β_2 is the expected difference in BMI per log dollar of unadjusted household income;

β_3 is the expected difference in BMI associated with minority status;

β_4 is the expected difference in BMI (over the whole time, including nulliparous period) associated with age category; and

E_{it} is error for the i_{th} individual at the t_{th} wave.

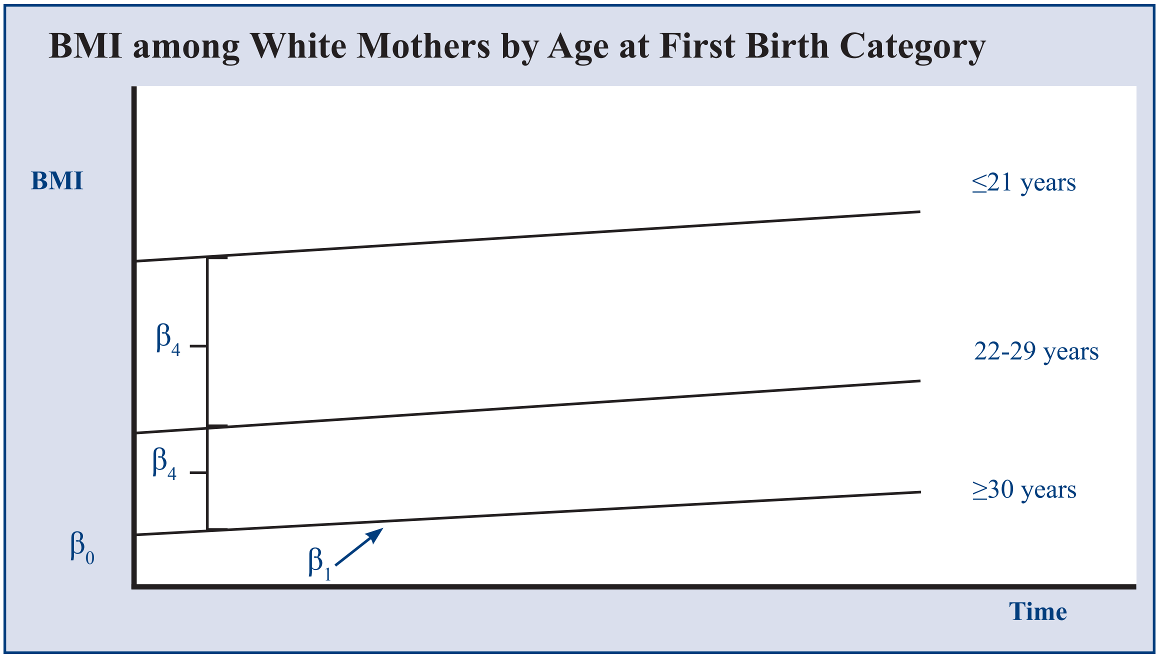

Figure 11: *This model examined the association of age at first birth on three different groups of white mothers, age 21 years and under; age 22 to 29 years; and age 20 years and older.*

Results from this model are presented in chapter five.

2.5.3.5 Model Five of Specific Aim Three

The fifth model for specific aim three also defined an interaction term, β_6 = (AFB*P), to test the hypothesis that the association of parturition with BMI varies as a function of age at first birth. It may be defined as:

H0: $\beta_6=0$ (meaning, the association of parturition with BMI does not vary as a function of age at first birth)

H1: $\beta_6<0$ or >0 (two-sided test).

This model considered the association of age at first birth on the period *after* childbearing, rather than the entire observation period. By defining the interaction term, the association of age at first birth with BMI only occurs after parturition.

This model is presented in Figure 12 and may be expressed as:

$$Y_{it} = \beta_0 + \beta_1 (A_{it}) + \beta_2 (P_{it}) + \beta_3 (I_{it}) + \beta_4 (M_i) + \beta_5 (AFB_i) + \beta_6 (P_{it} {*} AFB_i) + E_{it}$$

Where

A_{it} is centered (at 15) age for the i_{th} individual at the t_{th} wave;

P_{it} is an indicator variable such that $P_{it} = 0$ if the i_{th} person at the t_{th} wave is nulliparous, and $P_{it} =1$ if the i_{th} person at the t_{th} wave is parous;

I_{it} is log household income in dollars (not adjusted for inflation) for the i_{th} individual at the t_{th} wave;

M_i is an indicator variable for minority status (1 if minority, 0 if white; not time-varying);

AFB_i is age at first birth in years;

P*AFB is an interaction between parity and age at first birth;

β_0 is the expected baseline BMI for the i_{th} person;

β_1 is the expected change in BMI per year of age;

β_2 is the expected increase associated with measurement after childbearing;

β_3 is the expected difference in BMI per log dollar of unadjusted household income;

β_4 is the expected difference in BMI associated with minority status;

β_5 is the expected difference in BMI (over the whole time, including nulliparous period) associated with a one unit difference in age at first birth;

β_6 is the association of parturition with BMI as a function of age at first birth, indicating impact of age at first birth during the childbearing period; and.

E_{it} is error for the i_{th} individual at the t_{th} wave.

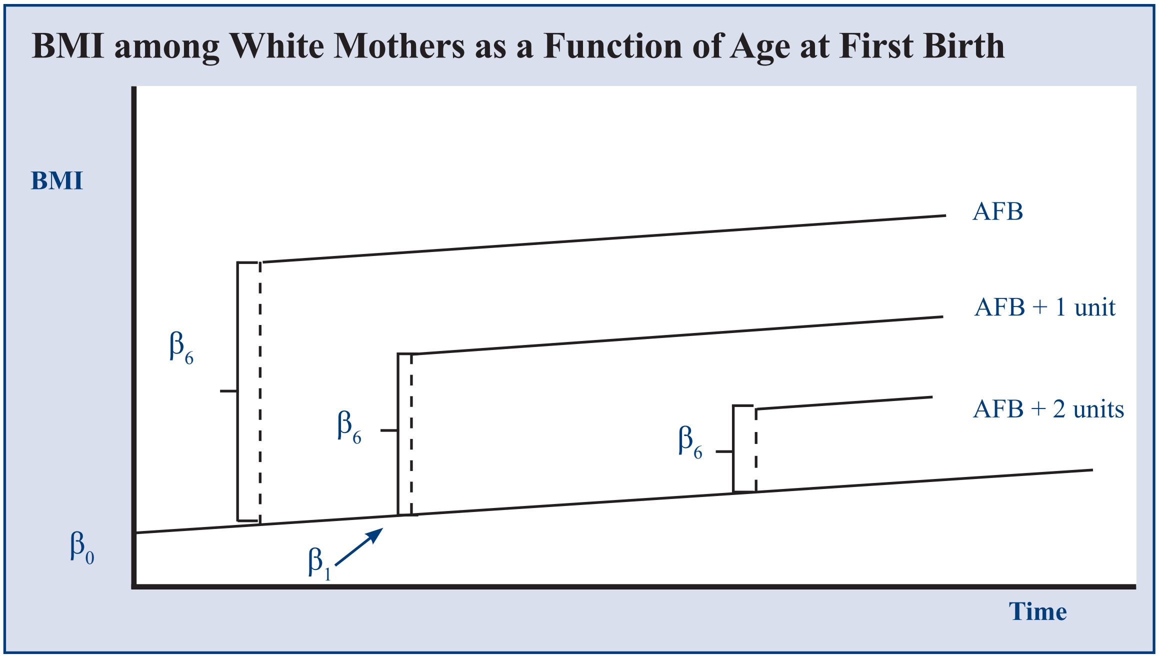

Figure 12: *In this model, β_6 is an interaction term representing the difference in parturition-related weight change as a function of age at first birth.*

The results of model five found no evidence that age at first birth operated differently in the nulliparous and childbearing periods (p = 0.39; 95%CI: -0.08 – 0.20).

2.5.5 Statistical Software

All analyses were conducted using *Stata Statistical Software: Release 12*.

Chapter 2 Endnotes

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CHAPTER 3

Understanding the Role of Childbirth in Obesity Disparities Among Women

Abstract

This article reviews the conceptual basis for linkages between childbearing, obesity and stress, and the manner in which these connections may contribute to obesity disparities among women. Pathways within this conceptual orientation are presented and discussed. Childbirth is an event unique to women that may contribute to obesity. Examining the different ways in which minority groups and white women experience stress associated with childbearing may advance our ability to understand additional factors that give rise to and perpetuate obesity disparities. Limitations, future directions, and implications for midwifery practice are considered.

Introduction

The magnitude of the change in obesity rates resulting in its current status as a national priority is impressive. Between 1960 and 2006, the prevalence of obesity in the United States (US) as defined by body mass index (BMI) rose from 13.4% to 35.1%, with the prevalence of extreme obesity increasing from 0.9% to 6.2%.[1] There has not been a significant change in obesity prevalence among US women of reproductive age since 2004.[2] Today, more than one-third (36.1%) of the female population is obese.[2]

Overweight and obesity describe a range of weights that exceed a threshold considered optimal for a given height. The terms are generally defined by calculating BMI, which is weight in kilograms divided by height in meters squared.[3] Calculation of BMI is simple and it is widely used in a variety of settings. Nonetheless, it has been criticized for not being able to distinguish between muscle mass and adipose tissue because it does not directly measure body fat, resulting in misleading results for some individuals. For most people, however, it corresponds appropriately to adipose tissue and at the population level BMI has been found reliable.[4] Other measures of obesity, such as anthropometric measurements and magnetic resonance imaging, are available and may be more accurate for an individual; however, these methods also are more invasive and expensive.[3]

The health-related consequences of obesity are multiple and well-established. Obesity is linked to adverse chronic health conditions including cardiovascular disease, diabetes, hypertension, and cancer.[3, 5, 6] Poor health also has significant economic ramifications. Obese adults in the US spent $2741 (in 2005 dollars) more on health care than individuals of normal weight, suggesting that about 20% of health care expenses may be related to obesity and its health-related consequences.[7]

The rise in obesity prevalence is evident among all age categories, racial and ethnic groups, income strata, and educational levels.[8] Nonetheless, like many adverse health outcomes, minority groups experience a greater share of the disease burden.[9] In 2012, 44.4% of Hispanic women and 56.6% of non-Hispanic black women were classified as obese compared to 32.8% of non-Hispanic whites.[2] Such high rates of obesity prevalence resulted in an estimated 1.0 million years of life lost for black women in 2008 alone.[10] The attendant loss of social, emotional and economic contributions resulting from the premature death of black women on their families, communities, and society is incalculable.

Health Disparities

Health disparities, health inequities, and health equality are terms that broadly refer to the consideration of differences in health status that are systematic, preventable, and identified by affiliation with vulnerable groups. Vulnerable groups may be defined by such variables as race, ethnicity, sexual orientation, and economic status. Several definitions of health disparities exist.[11] In the United States, the legal definition comes from Public Law 106-525 and defines a health disparity as "a significant disparity in the overall rate of disease incidence, prevalence, morbidity, mortality or survival rates in the population as compared to the health status of the general population (p. 2498)."[12] This definition focuses on difference in outcomes between groups but does not explicitly acknowledge the underlying concepts of advantage and vulnerability that is a key feature of scholarship on health disparities. [11] It also does not address the premise that these health outcomes are modifiable. Finally, it compares health status of a vulnerable population to the general population, rather than the most advantaged group within the population.

Braveman provides an alternative definition of health disparity that considers disparities and inequalities as one concept and defines it as "…a particular type of difference in health or in the most important influences on health that could potentially be shaped by policies; it is a difference in which disadvantaged social groups (such as the poor, racial/

ethnic minorities, women, or other groups that have persistently experienced social disadvantage or discrimination) systematically experience worse health or greater health risks than more advantaged groups (p. 180)."[11] This definition incorporates both proximal and distal determinants of health and explicitly acknowledges the importance of policy to address these differences. It also defines the relevant assessment as a comparison between a vulnerable and privileged group within the population.

As evident from the contrasting definitions, different approaches are used to measure health disparities. The challenge with comparing the outcome of a vulnerable group with that of the general population is that disparities may be obscured. This occurs when the outcome of a vulnerable group is similar to the population average but different from that of the advantaged groups.[11] It is more informative to use the "rate ratio" and "rate difference (p.178)."[11] Braveman defines the rate ratio as "the rate of a given health indicator in one group divided by the rate in another group."[11] In 2011 – 2012, obesity rates among all US women, non-Hispanic white women, non-Hispanic black women, and Hispanic women were 36.1%, 32.8%, 56.6%, and 44.4% respectively. The rate ratio reveals that the rate of obesity among non-Hispanic blacks is over two-thirds higher (1.73) than among Non-Hispanic whites. If using the general population as the reference group, the magnitude of the disparity decreases, from 1.73 to 1.57. The rate difference is the "absolute difference in rates (p. 178)."[11] The rate difference in obesity between non-Hispanic black and non-Hispanic white women is 23.8%. As is evident from comparing these parameters, the apparent scale of the disparity is different depending on the measure used.

Obesity and Childbearing

When taking into account pregnancy, gestational weight gain is associated with becoming overweight and obese for many women in the US.[13-19] A meta-analysis indicates that three years after delivery, women with weight gain during pregnancy that exceeded Institute of Medicine guidelines retained 3.06 kg (95% CI: 1.50 – -4.63 kg) more than women with weight gain within recommended parameters.[20] Parity, birth spacing and baseline BMI are important factors to consider in this association.

Studies have presented conflicting evidence regarding the role of multi-parity. While some found that weight gain associated with first pregnancy is greater than subsequent births,[18, 21-25] evidence is inconsistent.[26-33]

Inter-pregnancy interval may be a significant factor, with shorter intervals increasing the likelihood of obesity.[34] Excessive gestational weight gain in the first pregnancy also is associated with excessive weight gain during subsequent pregnancies as well.[35] The association between gestational weight gain and subsequent maternal obesity also depends on the follow-up period observed. Mannan and colleagues examined this relation in the immediate, intermediate and long-term follow-up periods; findings suggest a U-shaped pattern among women with excessive gestational weight gain.[36]

When considering the relevance of BMI as it relates to weight, higher pre-pregnancy BMI is associated with greater gestational weight gain[22, 25, 37-40] and subsequent weight retention.[17, 24, 25, 37-39, 41, 42] Excessive gestational weight gain among women with a normal

BMI prior to pregnancy also is associated with greater maternal weight after delivery.[20, 24, 43] Maternal weight retained between pregnancies may also be associated with poor obstetrical outcomes in subsequent pregnancies, such as increased gestational diabetes and cesarean delivery, regardless of maternal BMI.[44] Overall, the evidence suggests that gestational weight gain and pre- pregnancy BMI are important factors that influence the association between childbearing and maternal obesity.

Typically, studies that examine pregnancy and obesity compare a woman's weight prior to pregnancy and after delivery.[18, 43, 45, 46] A focus on change in mean weight may obscure the extent of variability in weight gain experienced by women after childbirth. For example, Olson found the mean weight gain one year after delivery was 1.51 kg, yet almost 25% of women in the study gained 4.55 kg or more during this period.[43] Studies also have used BMI as the primary outcome and reported average change in BMI classification after childbearing.[24, 25, 31, 47] The follow-up period ranges from 12 months[43, 47] to 10 years.[23, 31] An alternative approach is to compare maternal weight to the weight of women who do not have children during the study period.[18, 23, 25, 31, 48] Such variability in measurement, follow-up periods, and design makes it challenging to synthesize interpretation and compare across studies. In their review and meta-analysis of pregnancy and obesity, Schmitt and colleagues propose 12 to 18 months as the optimal follow-up period for evaluation of "postpartum weight retention".[49]

Physiologically lactogenesis is associated with increased maternal energy expenditure, suggesting it may logically be associated with weight loss after pregnancy. Studies, however, provide conflicting evidence with many reporting null findings. Primary challenges of these observational studies include measurement of breastfeeding duration, identification of exclusive versus mixed feeding practices and definitions of exclusive and mixed feeding practices. In a systematic review of evidence examining the role of breastfeeding in weight loss after pregnancy, including weight retention and body composition, Neville and colleagues concluded that "the available evidence challenges the widely held belief that breastfeeding promotes weight loss."[50] Nonetheless, the authors acknowledged that the available evidence is unable to settle this question as more studies with improved designs are needed. Further, four of the five studies determined to be of high quality in their review did report an association between breastfeeding and weight loss.[50] Maternal obesity also has been associated with a reduced likelihood to initiate breastfeeding as well as briefer duration of breastfeeding.[51] While these studies also suffer from methodological challenges, the evidence suggests obese woman may need increased professional and social supports in order to experience breastfeeding success.

Prior studies have considered minority status and weight changes associated with childbearing, with attention to patterns of weight gain during pregnancy and weight loss after delivery. A review conducted by Headen and colleagues identified an "apparent paradox."[16] Minority women were more likely to experience inadequate gestational weight gain when compared to white women; however black women were more likely to retain weight after pregnancy than white and Hispanic women.[16] Estimates of the magnitude of the difference identified by race and ethnicity vary by study, as well as the duration of the follow-up period.

Linking Obesity, Childbearing, and Health Disparities

The life course perspective is an orientation that integrates the ways in which situation, culture, time, and social organization affect and are affected by individual developmental processes.[52] Significant life transitions (sometimes called turning points) as well as trajectories over time are points of emphasis.

Timing is a key analytic variable in the life course perspective. One expression is timing at the individual level, or when an event occurs within the context of a woman's life. Timing at the individual level is indexed by age. Timing at the social level, refers to when an event occurs with respect to broader social, political, and economic situations. For example, traditionally childbirth took place after marriage. So while an unmarried woman who gives birth at age 28 is older than a married women who gives birth at age 23 in individual time, a life course analyst might characterize her as being of a younger "social age." Although the life course perspective considers context as a significant factor in individual development, it also recognizes personal agency. While external forces may exert considerable influence, individual agency ultimately defines the manner in which shared external forces evolve into a unique and personal biography.

The life course perspective already has guided research successfully in the field of maternal and child health disparities. Lu and Halfon identified two primary frameworks that guided research related to disparities in birth outcomes between white and black infants, and used the life course perspective to integrate the two approaches.[53] Lu and colleagues also used a life course perspective to investigate the specific challenge of birth weight disparities.[54]

Weathering is a conceptual orientation that has guided research focused on disparities in perinatal outcomes, such as preterm delivery and low birth weight. The weathering hypothesis draws upon the life course perspective to develop a framework to link aspects of social, economic, and political organization to inequality and connects the lived experience of this inequality over time to the "early health deterioration" of black women.[55] Geronimus tested the weathering hypothesis by comparing the likelihood of having a low birth weight infant by maternal age among black and white women.[56] Her results suggested that young maternal age was protective for low birth weight among black women. The risk of having a low birth weight infant increased for black women as maternal age increased, but this was not evident among white women.[56] Other researchers also have used the weathering framework to investigate health disparities with findings demonstrating support for this model.[57-60] A significant contribution of the weathering hypothesis has been explicitly mapping inequality, as it relates to racism, to health outcomes. It also introduces "early health deterioration" as a key element in the conceptualization of health disparities among black and white women.

Allostasis is the process of "achieving stability through change"; it refers to the "physiological adaptations" an organism makes in order to maintain balance, or "stability", as it experiences environmental and social variability through exposure to change.[61] It also draws upon the life course perspective as it considers the influence of early life events in shaping health outcomes, as well as the interface between biology and behavior. The hypothalamic-pituitary adrenal and sympathetic adrenal medullary axes are two key physiologic systems stimulated by external changes. Response at the individual level is determined by a woman's perception and interpretation of events and the corresponding activation of systems required to maintain allostasis in the context of environmental and social change. The brain organizes and coordinates the cognitive recognition and interpretation of change as well as the physiological response through primary mediators such as cortisol, epinephrine, norepinephrine, insulin-like growth factor-1, and others.[62-64] These primary mediators are associated with factors such as insulin, glucose, and blood pressure, which in turn have a role in regulating overall health status.

Allostatic load "is the wear and tear on the body and brain resulting from chronic overactivity or inactivity of physiological systems that are normally involved in adaptation to environmental challenge (p. 37)."[61] In other words, if an individual works excessively to maintain physiological balance, this effort may exact a cost on her physical systems and ultimately result in poor health. Quickly calling upon primary mediators in response to challenges and then rapidly terminating them when the stimuli resolve may be adaptive and protective. Frequent and prolonged stimulation, however, may result in undesired outcomes such as obesity. When environmental and social change is understood as stress, the concept of allostatic load provides a framework to study its physiologic impact on health.

An index is used to operationalize allostatic load, and it generally includes biomarkers that represent both primary mediators such as epinephrine and insulin-like growth factor-1, as well as outcomes associated with these mediators such as blood pressure. A diverse range of studies have used an index of allostatic load.[62, 65] Using an index provides flexibility to allow for individual variability and still capture evidence of physiological change. This concept was validated in initial studies of allostatic load, as the composite index was a better predictor of mortality than individual biomarkers.[66, 67] At present, there is no single index of allostatic load and no consensus on scoring parameters included in the index. Further measurement challenges include the wide range of methods used to collect and evaluate biomarkers; the limited availability of longitudinal data; and, reliance on cross-sectional study designs, making causal and chronological interpretations problematic. Continued efforts to refine and develop the index are needed and may ultimately result in a measure that supports earlier identification of individuals at risk for a variety of adverse outcomes, allowing for more timely intervention. Table 1 provides a summary of biomarkers frequently used in studies of allostatic load.

Biomarkers Frequently Used as Part of an Index of Allostatic Load	
Cardiovascular & Respiratory	**Metabolic**
Systolic blood pressure	Triglycerides
Diastolic blood pressure	Total cholesterol
Anthropometric	Glycosylated hemoglobin
Waist-to-hip ratio	High density lipoprotein cholesterol
Body mass index	Total to high density lipoprotein cholesterol ratio
Neuroendocrine	
Norepinephrine	Glucose
Epinepherine	Albumin
Dehydroepiandrosterone-sulphate	**Immune**
Cortisol	Interleukin-6
	C-reactive protein

Table 1: *These biomarkers have been used as part of an allostatic load index in at least ten studies.*[65]

The conceptual framework of allostasis and allostatic load articulates the biological connection to social context, promoting a better understanding of the manner in which social dynamics determine health status. Nonetheless, it does not fully integrate the interface of individual coping strategies and stress as part of its conceptual orientation. This limitation is important for the consideration of health care disparities as blacks experience higher levels of chronic stress (as a generic social construct rather than an individual person's social or psychological pathology) as compared to whites.[68]

The Environmental Affordances Model considers these factors as a principal construct, making it an effective compliment to allostasis and allostatic frameworks.[68] While the overarching goal of the Environmental Affordances Model is to explain the origins of mental health disparities, the model also unambiguously considers the role of "health-related self-regulatory and coping behaviors" adopted by individuals in response to stress, and the way in which these behaviors, in turn, have an impact on health outcomes.[68] Authors suggest that "health-related self-regulatory and coping behaviors" may interrupt the biological chain between chronic stress and poor health outcomes "by acting on the hypothalamic-pituitary-adrenocortical (HPA) axis and related neuroendocrine systems (p. 8)."[68] Just as consuming calorie-dense foods and a high fat diet have been associated with stress and coping with stress in both human and animal studies,[69-73] eating a high fat, high calorie diet is a health-related coping behavior recognized by the EA model. It further highlights the importance of considering "self-regulatory" responses to stress in a conceptual model of obesity disparities.

Davis and colleagues drew upon core concepts of these conceptual orientations to develop a framework specific to childbearing and obesity.[74] Their model frames disparities in obesity among whites and blacks as the result of differences in responses to stress and reproductive events, with consideration of exogenous factors within the social, cultural, and physical environment. This framework presents obesity disparities among women as the result of "a combination of genetic risk, suboptimal living environment (e.g., social and physical), differential exposure and response to chronic stress, coping ability, and health risk behaviors." It responds to emerging evidence that excessive maternal weight gain and elevated maternal BMI during pregnancy are linked to increased obesity in their children, as well as cardiovascular disease, diabetes and hypertension, by recognizing genetic factors that arise from the fetal period and influence health conditions throughout the lifespan.[75]

Davis and colleagues advance the idea that a woman's response to stress affects the manner in which various factors may influence maternal weight.[74] Their framework is the first conceptual model identified by this review that explicitly considers the role of childbearing in women's obesity with specific consideration of health disparities. It successfully integrates the concepts of allostatic load with exogenous factors, including individual coping responses and self-regulatory behaviors, with particular consideration of the unique physiologic characteristics of pregnancy and weight gain. Further, the framework also responds to the potential for multiple cycles of pregnancy, identifying outcomes within the context of the life course by specifying short, intermediate and long term effects.

The model does not, however, consider timing of childbirth. The weathering hypothesis of "early health deterioration" suggests that models of health disparities may benefit from attention to the timing of events. BMI after childbearing may vary by timing of childbirth. If there is a linkage between obesity and childbearing, consideration of timing of childbirth is particularly important because obesity is not only an important outcome itself, but also has significant implications for other comorbid conditions such as cardiovascular disease. As a result, earlier childbearing may not only contribute to earlier onset of obesity but also give rise to earlier onset of disease and more years lived with disease.

While multiple cycles of pregnancy may occur over the life course and parity itself may have specific implications for obesity, timing of first birth may be a key variable affecting subsequent BMI if a woman's experience of stress associated with childbearing varies systematically by age. Age at first birth is influenced by race and socioeconomic status, and evidence from studies using allostatic load suggests that both of these factors influence stress appraisal and the physiological activation of the stress response.[62]

Beckie outlines additional factors to consider, including genetics, experience of childhood adversity (neglect, abuse, trauma, etc.), psychological status (depression, anxiety, optimism, etc.), behavioral choices (diet, smoking, sleep, etc.), and clinical interventions (medications, access to health care, etc.) (p. 312).[62] Prior research has established that many of these factors differ systematically among women by age. For example, studies demonstrate that sleep patterns[76] and mental health status[77, 78] vary across the life span.

Older women also are more likely to be married[79] and less likely to identify a pregnancy as unintended.[80] Davis and colleagues suggest that "impaired allostasis" ensues as a result of these multiple and nonlinear influences, ultimately manifesting in insulin resistance during the prenatal and peripartum period and serving as a key pathway to obesity after childbearing. This is consistent with findings that women with gestational diabetes have an increased risk for type two diabetes later in life.[81, 82]

A conceptual framework that builds upon the model proposed by Davis and colleagues to incorporate timing of first birth is presented in Figure 1.[74] The left side of the figure provides a set of exogenous factors that directly influence stress exposure and adaptation: minority status (black race and/or Hispanic ethnicity), education and socioeconomic status. The Community Child Health Network also identified significant differences by minority status and income in the type of stress reported.[83] As discussed, some evidence also suggests that a person's reaction to stress may vary systematically by age; meaning, a woman who gives birth at one age may react differently to subsequent stress than a woman who gives birth at another age. In addition, an extensive literature also has consistently demonstrated that socioeconomic status is inversely related to overweight and obesity. In their meta-analysis, Ball and Crawford established that years of education and income remain reliable indicators of this relationship among adults in developed countries.[84]

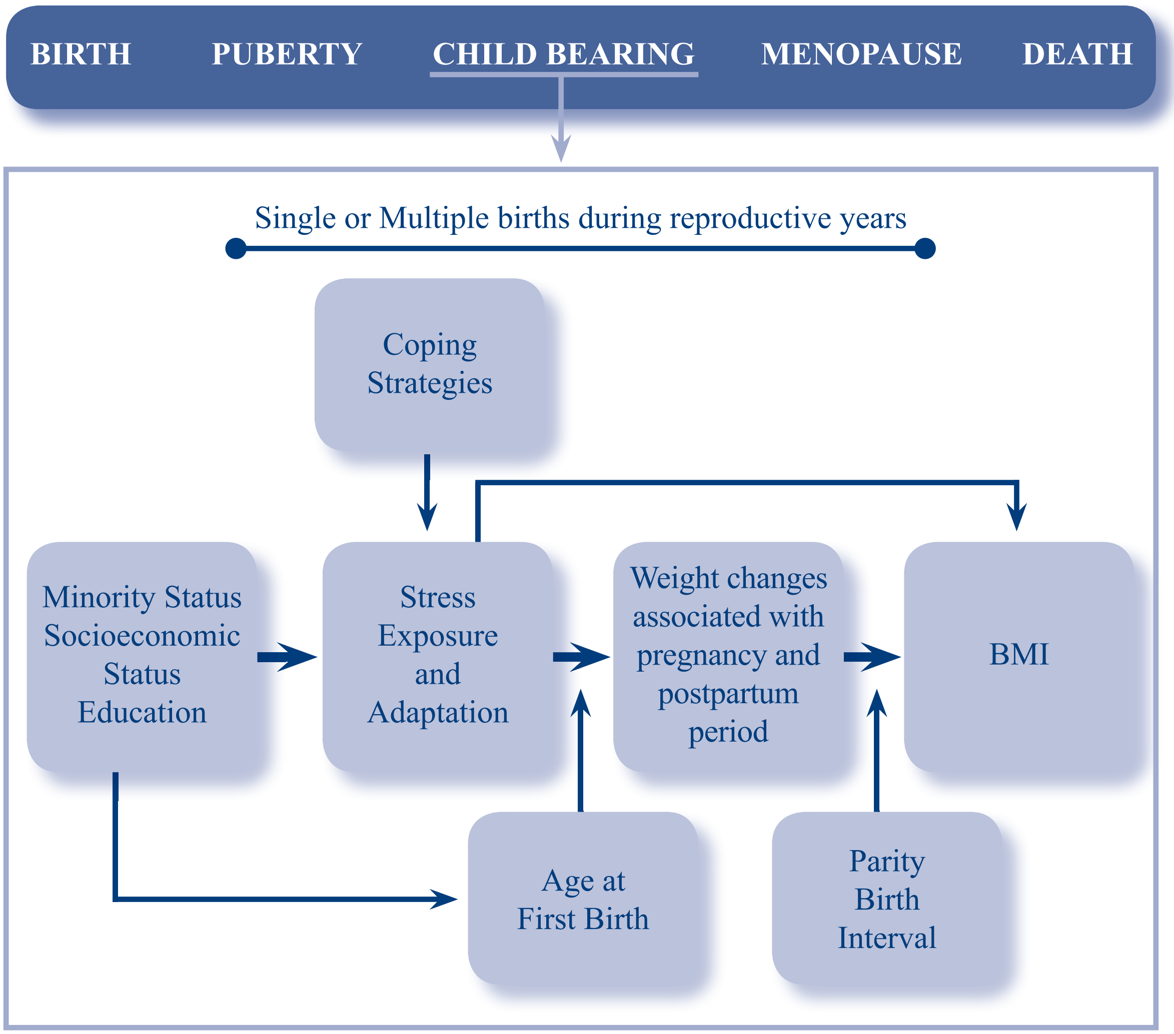

Figure 1: *Early childbearing has a direct impact on stress exposure and adaptation.*

Although education and income are important during childhood, they have independent effects on obesity among adults.[84, 85] Education and income also influence age at first birth. The National Survey of Family Growth (NSFG) reported the mean age at first birth between 2006 and 2010 was 24.1 years for non-Hispanic white women, 21.2 years for Hispanic women, and 20.9 years for non-Hispanic black women. Whereas the probability of a first birth before age 20 among Non-Hispanic black women and Hispanic women was 32% and 30% respectively, it was just 14% among white women.[86]

Figure 1 illustrates the direct effects of stress exposure and adaptation on weight changes associated with pregnancy and the postpartum period. In this model, these direct effects vary systematically by age at first birth. Stress also has independent effects on BMI. Consistent with the model proposed by Davis and colleagues, parity and birth interval modify the effect of childbearing on BMI in this model as well. This framework does not distinguish between gestational weight gain and post-partum weight retention. It presents a conceptual orientation that sees changes in BMI as part of a continuum and is neutral about when these changes occur in relation to pregnancy and birth. The framework benefits from the dual significance of its primary outcome. Elevated BMI is not only an important outcome in its own right, but also one that has important linkages to other public health priorities of consequence. Abundant evidence has established the link between obesity and the onset of conditions such as hypertension and heart disease.[87, 88]

Intersection of Theory and Midwifery Practice

Midwifery care purposefully attends to the social, emotional, and physical needs of a woman in a cohesive fashion that is responsive to her individual circumstances. Since 1993 the American College of Nurse-Midwives has embraced "Listen to Women" as an encapsulated statement of these principles and to communicate its "vision" of care.[89] A comprehensive and personal approach is one of its hallmarks and makes midwifery distinctive among modern health care settings driven by technologic efficiency and universal protocols. It also makes midwives uniquely prepared to provide care that specifically addresses chronic stress as an important health determinant. Understanding the tenants of the framework presented in this article will augment the skills midwives possess in a way that may promote targeted improvements in obesity and ultimately contribute to narrowing the obesity disparity.

One of the most basic elements to understanding the origins of health disparities in obesity among women, that the conditions under which women experience pregnancy and give birth matters, speaks directly to the ethos of midwifery care. Midwives have long recognized that a woman's experience of pregnancy and childbirth not only has important implications for the immediate outcomes directly linked to childbearing but also for her long-term well-being. CenteringPregnancy is a model of group prenatal care conceived, nurtured and disseminated by midwives that synthesizes these principles into a unified intervention.[90] This approach also has demonstrated tangible results for improved outcomes in areas such as preterm delivery, low-birth weight, and breastfeeding.[91-93] Importantly, evidence also substantiates the role of CenteringPregnancy in addressing health disparities. For example, black women participating in group care reduce their risk of preterm birth by 41%.[92]

The distinctive pathways and differentiating mechanisms that link participation in CenteringPregnancy to superior outcomes continue to be explored. Nonetheless, two aspects of the model are pertinent to addressing chronic stress. First, core topics used to guide CenteringPregnancy discussions include stress management (www.centeringhealthcare.org). Second, and perhaps more importantly, the group model not only serves as a forum for information exchange but also as a medium to connect women to one another. The support network that emerges may offer a direct means of stress reduction for participating women.

In settings where group prenatal care is not offered and under circumstances when it is not desired, midwives continue to have the opportunity to address stress as part of individual care. As previously discussed, basic elements of midwifery practice already attend to stress and stress reduction during pregnancy and childbirth implicitly. This framework argues for explicit attention to chronic stress and guiding women in their ability to recognize, manage and ultimately reduce stress.

Adopting a screening tool to assess stress systematically may be beneficial. Although it may be appealing to include this screening with the initial prenatal assessment, this visit already incorporates several baseline evaluations. Extending it further may be difficult for both the midwife and her client. For women initiating midwifery care with their pregnancy, waiting until a subsequent visit when the relationship is more well-established also may result in more candid responses. Because symptoms associated with pregnancy, such as increased fatigue, may also be part of the spectrum of characteristics consistent with maladaptive stress responses, it is important to select an instrument appropriate for screening during the prenatal period if the woman is pregnant and to distinguish acute versus chronic stress.[94] Nast and colleagues completed a comprehensive review of instruments to assess stress with attention to issues of reliability and validity for pregnancy as well as outside the prenatal period.[94] The review also included information about administering the instruments, the number of questions asked, and distinctions between acute versus chronic stress.

Adopting screening tools and explicitly attending to stress as a component of routine prenatal care and postpartum follow-up are valuable measures to support women. Midwives also need to remain mindful of the ways in which stress may be experienced in systemically different ways, depending on maternal age. Stress experienced by a first-time mother who is fourteen may be qualitatively and quantitatively different from someone who is having her first child at age thirty. Factors to consider include intendedness of conception and pregnancy; overall maternal health, especially with respect to pre-existing conditions such as diabetes and hypertension; type of health care coverage; and strength of community and family support systems. Additional stress also may be experienced by women when they are not perceived by society at large to be appropriate for mothering, such as women having children at the extremes of the childbearing years and single mothers.[95-97]

Midwifery practice routinely includes nutrition evaluation and counseling.[82, 98] During pregnancy, women may benefit from specific guidance early in gestation regarding dietary content as well as recommended total weight gain based on pregestational BMI. Continued monitoring and support throughout the postpartum period are indicated until women return to their pregestational BMI. Women who enter pregnancy overweight or obese may benefit from support beyond the postpartum period until they reach a more optimal weight. In addition to attention to nutrition and weight management, the conceptual orientation presented suggests that midwives identify and explore eating patterns that serve as coping mechanisms and self-regulatory behaviors in the context of adversity. Diet diaries are often difficult for patients to maintain, but the 24-hour dietary recall has been found acceptable and may be more easily obtained during a routine prenatal visit.[99, 100] Internet-based programs and electronic apps also are available. Diets high in fat, processed foods and calorie dense foods merit additional study for evidence of food as a coping strategy in response to stress.[71, 73]

Although not directly evaluated, chronic disease is the logical endpoint of this conceptual orientation. It is important to talk with women about the ways in which reproduction may affect their global health status. Knowing the connections between reproductive status and other health systems, such as endocrine and cardiac, is an important component of reproductive life planning. Adopting an integrative approach that includes attention to coping strategies, self-regulating behaviors, nutrition and stress is a key component to well-woman care. Midwives will be able to better serve the comprehensive health care needs of women, including chronic disease, by recognizing timing of childbirth and its connection to biobehavioral determinants of health through stress, and being responsive to these dynamics as part of normative midwifery care.

Chapter 3 Endnotes

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CHAPTER 4

Body Mass Index and the Transition to Motherhood during Women's Reproductive Years

Abstract

Life course research has established the importance of considering role transitions when examining health outcomes.[1-3] The association of the transition to motherhood with a woman's body mass index (BMI) has not been investigated extensively. This paper presents evidence that parity is associated with an increase in BMI ($p<0.004$, 95%CI: 0.23 – 1.12), and most of the increase occurs with the first birth. Income was inversely related to BMI, but the estimate of the association was not significant at the 0.05 level ($p=0.08$, 95%CI: -0.49 – 0.02); minorities have higher BMI ($p<0.001$, 95%CI: 2.20 – 5.68). Prenatal counseling to encourage gestational weight gain within recommended guidelines accompanied by interventions to promote a return to pre-pregnancy weight are important for maintaining optimal BMI over the life course.

Introduction

Overweight and obesity describe a range of body weights in excess of the maximum recommended for a specified height. Body mass index (BMI) is the typical unit of measurement and is calculated by weight in kilograms divided by height in meters squared.[4] Although it does not directly measure body fat, for most people BMI corresponds appropriately and has been found reliable at the population level.[5] In 2011-2012, almost one-third (31.8%) of reproductive age women (20 to 39 years) in the United States (US) were obese.[6] Obesity rates are different among racial and ethnic groups. Among all ages 32.8% of non-Hispanic white women, 56.6% non-Hispanic black women, and 44.4% of Hispanic women were obese.[6]

Obesity is associated with several comorbid conditions, including cardiovascular disease;[7] all types of cancers except esophageal and prostate; and osteoarthritis, asthma, gallbladder disease, and chronic back pain.[8] In women, type II diabetes has the strongest association with obesity among all co-morbid conditions (RR 12.41, 95% CI 9.03 – 17.06).[8] Premature mortality is linked to obesity as well. A meta-analysis of 57 prospective studies with a combined sample of nearly 900,000 participants estimated that median survival is reduced by 2 to 4 years for obese individuals.[9] Authors reported that median survival for morbidly obese individuals is reduced by 8 to 10 years. Obesity also increases health care expenditures. As much as 20% of health care expenses may be associated with obesity and its sequelae.[10]

Women's BMI during the reproductive years

Prior studies have established that the BMI of many women increases after childbearing and excessive gestational weight gain (GWG) is associated with becoming overweight and obese.[11-20] Gunderson reported GWG may explain approximately one-fifth to one-third of the change in maternal weight after childbirth.[17] A meta-analysis indicates that three years after delivery, women with weight gain during pregnancy that exceeded guidelines retained 3.06 kg (95% CI: 1.50 – 4.63 kg) more than women with weight gain within recommended parameters.[21] Several studies have found excessive gestational weight gain among women with a normal BMI prior to pregnancy to be associated with greater maternal weight after delivery.[17, 21-25] Studies also report that higher pre-pregnancy BMI is associated with greater subsequent weight retention after childbirth.[13, 22, 26-33] Higher education and income are generally protective for excessive gestational weight gain and subsequent obesity.[18, 34]

Studies also examined the difference between maternal weight prior to pregnancy and after delivery.[14, 29, 30, 34] A focus on change in mean weight may obscure the range of changes in weight experienced by individuals.[34] Studies also have reported average change in BMI classification after childbearing.[11, 13, 22, 35] Davis and colleagues considered the five-year incidence of obesity after childbirth among a cohort of young women age 14 to 22 years, comparing parous to nulliparous participants.[15] The authors found a higher rate of obesity among women who gave birth, especially among black and Hispanic participants. There is limited consensus about the optimal follow-up period to evaluate retention of gestational weight gain after childbearing. Studies exhibited great variation in the follow-up period after delivery, ranging from 12 months[13, 34] to 10 years.[11, 18] Other studies consider weight change during the birth to subsequent pregnancy interval.[22, 26] Studies also compared maternal weight to the weight of women who do not have children during the study period.[11, 14, 15, 18, 35]

This study had two goals. The first goal was to compare the BMI of nulliparous and parous women during the childbearing years. The second goal was to examine how the BMI of childbearing women may change after childbirth. If parity effects were present, an additional objective was to examine the association of multiparity, as compared to primiparity, on a mother's BMI.

Methods

Data

Panel Study of Income Dynamics

The Panel Study of Income Dynamics (PSID) is a nationally representative longitudinal study of US families that started in 1968. Although designed with the primary intent to study income dynamics, PSID also now includes information on a range of topics, including marriage, fertility, and health. The PSID adopted a genealogical sampling frame that follows the children of original family members, resulting in a multigenerational sample. The original sample included about 18,000 individuals in approximately 5000 families,[38] and it has maintained a high response rate. Investigations of the effects of attrition indicate that it is not a large problem.[38-41] PSID interviews were initially conducted in-person and face-to-face interviews continued through 1972. In 1973, telephone interviews began and continued through 1992, after which computer assisted telephone interviews were adopted. PSID moved from annual to biannual data collection starting in 1997.

Most PSID data are publically available through their website. This study was determined not to be human subjects research by the Institutional Review Board at the Johns Hopkins School of Public Health.

Sample Selected

Self-reported height and weight were added to the survey in 1999, making it possible to include seven waves of data (1999 to 2011) in these analyses. There were 2691 females who were at least 15 and not older than 45 years in 1999 in the panel. To compare BMI before and after childbearing, women with a birth prior to 1999 were excluded (n=2159). Women with no birth history data (n=27) also were excluded. These exclusion criteria resulted in a potential sample of 505 women. To be included in analyses, a minimum of three waves of BMI data were needed. While the timing of measures was not specified for nulliparous women, childbearing women had at least one BMI measure prior to pregnancy and at least two after childbirth. These inclusion criteria yielded a final sample of 257 women with 1799 observations. The mean number of observations per participant in the sample is 4.7. Among this sample, 146 (57%) have a history of childbirth and 111 were nulliparous.

Measures

Primary outcome

The primary outcome of the proposed research is BMI. Change in BMI among women between 15 and 45 is primarily the result of change in weight rather than height, and this dependent variable may be appreciated as change in body weight over time. A change in one BMI unit corresponds to approximately 6 pounds for a woman of average height (5’ 4”) in the United States. Overweight women have a BMI between 25 and 29.9 units, and women with a BMI 30 and over are obese.

Weight and height in PSID were self-reported. Self-reported height and weight has been validated in national samples.[42-44] PSID also compared its self-reported height and weight data to the self-reported height and weight data of the National Health Information Survey. There were no significant difference between the samples, demonstrating that height and weight responses from PSID are comparable to other nationally representative surveys.[45]

Transition to motherhood

PSID began collecting birth history information in 1985 and updated it at each survey interval. Birth information was self-reported, and self-reported information related to childbearing is highly accurate among women. Gartland and colleagues found greater than 90% agreement when comparing obstetric data from medical records and self-report.[46] Women without a history of childbirth were coded as nulliparous, distinguishing them from women with missing birth data. Birth history data included the total number of children delivered by a woman as well as the month and year of each birth. A time-varying variable for parity reflected onset of childbearing. Childbearing status also distinguished nulliparous from parous women, allowing for comparison of mothers and women without children.

Socio-demographic Variables

Initially conceived to study income, the PSID offers some of the best data on income available in survey research. These analyses included total family income, which is a measure that sums several different parameters: head of household taxable income; spouse taxable income; head of household transfer income; spouse transfer income; taxable income of other household members, and total social security. Each wave provided a separate measure of total family income in actual dollars for the prior year. Log income is used to account for the right skew of the income variable as is commonly done.

There were several changes in how PSID defined race and ethnicity over the years. Because panel definitions were not consistent over time, they were redefined in order to be consistent during the study period. The definitions of race were different between 1999 – 2003 and 2005 – 2011. Ethnicity was part of the race variable between 1999 and 2003. Given these parameters, it was not possible to distinguish both race and ethnicity for all participants during the study period, resulting in classification as white and non-white for these analyses. The final sample includes 126 non-white (49%) and 131 white (50.9%) participants.

Analytical Approach

Analyses were conducted using a mixed effects longitudinal linear regression with random intercept. The models examined change between women (comparing nulliparous and parous women) and change within women (comparing periods before and after childbearing) using nested data; specifically, multiple BMI values over time for the same woman. The association of time, age, and parity were of interest. Covariates were household income and minority status.

Equations

The first model formally tested the hypothesis that a woman's BMI remains constant over each year of age.   The model may be expressed as:

$$Y_{it} = \beta_0 + \beta_1(A_{it}) + E_{it}$$

Where A_{it} is centered (at 15) age and β_1 is the expected change per year of age.

To determine if the transition to motherhood impacts BMI, the second model tested the hypothesis that parturition does not impact BMI. This is a level two model to examine difference in within-person change between women. This model includes age, household income and minority status as covariates and may be expressed as:

$$Y_{it} = \beta_0 + \beta_1 (A_{it}) + \beta_2 (P_{it}) + \beta_3 (I_{it}) + \beta_4 (M_i) + E_{it}$$

where A_{it} is centered (at 15) age; P_{it} is an indicator variable for parity such that $P_{it} = 0$ if the i_{th} person at the t_{th} wave is nulliparous, and $P_{it} =1$ if the i_{th} person at the t_{th} wave is parous; I_{it} is household income in dollars (not adjusted for inflation) on the log scale; and M_i is an indicator variable for minority status. If β_2 is greater than zero, this indicates that the BMI of mothers increases after parturition.

Model three is a level two model to examine difference in within-person change between women to examine multiparity and BMI. This model includes age, household income and minority status as covariates and may be expressed as:

$$Y_{it} = \beta_0 + \beta_1(A_{it}) + \beta_2(P_{it}) + \beta_3(I_{it}) + \beta_4(M_i) + E_{it}$$

where A_{it} is centered (at 15) age; P_{it} is an indicator variable such that $P_{it} = 0$ if the i_{th} person at the t_{th} wave is nulliparous, $P_{it} = 1$ if the i_{th} person at the t_{th} wave is primiparous, and $P_{it} = 2$ if the i_{th} person at the t_{th} wave is multiparous; I_{it} is household income in dollars (not adjusted for inflation) on the log scale; and M_i is an indicator variable for minority status. If β_2 is greater than zero, the BMI of multiparous mothers increases even more than BMI of primiparous women.

Results

Table 1 presents descriptive information. There were 257 women in the sample with a total of 1799 observations and a mean of 4.7 observations per participant. Overall, 43% of women remained nulliparous throughout the study period (1999 to 2011). Baseline mean age of women who remained nulliparous and women who transition to mothers was 22 and 18 years ($p<0.001$), respectively. Minority women represented 49% of the sample, and there were no significant differences by their eventual parity status. There also were no significant differences in years of education at baseline between women who remained nulliparous and women who transition to mothers. Baseline family income of women who transitioned to mothers was significantly less than women remaining childless (p<0.001). On average, household income of women who went on to become mothers was $26,847 less than women who remained childless.

Descriptive Characteristics at First Wave (1999) by Eventual Childbearing Status										
	Total			Remain Childless			Transition to Mothers			
	N (%)	Mean	SD	N (%)	Mean	SD	N (%)	Mean	SD	p-value
Age	257 (100.00)	19.69	6.36	111 (43.19)	21.74	8.58	146 (56.81)	18.14	8.20	< 0.001
Minority Status	126 (49.03)	na	na	53 (47.74)	na	na	73 (50.00)	na	na	= 0.72
Years Education	253 (100.00)	9.23	4.88	108 (43.15)	9.80	4.74	145 (56.85)	8.81	4.97	= 0.11
Household Income	257 (100.00)	$61,569	$69,704	111 (43.19)	$80,286	$83,191	146 (56.81)	$47,338	$53,439	< 0.001

N = sample size; SD = standard deviation; p-value = significance level; na = not applicable.

Table 1: *Overall, the mean age of women in the study at baseline was just under twenty years and 49% of the sample were minority.*

By the last wave of data collection, unadjusted mean total years of education had increased to 13.52 years overall, indicating that most women completed at least one year of education beyond high school irrespective of childbearing status. Childless women and mothers increased their (unadjusted mean) education to 13.74 and 13.01 years, respectively (p<0.001). The difference in total education of women without children and mothers was less than one year. Unadjusted mean household income decreased between the first and last wave of data collection from $61,569 to $55,095. Unadjusted mean household income of mothers was $14,282 less than households of women without children (p<0.001). While the gap in unadjusted mean household income between childless women and mothers decreased, this was driven by a significant decrease in household income among childless women. Unadjusted mean household income for mothers decreased by $1511 between the first and last wave of data collection; this was not a significant change. Unadjusted mean household income for women who remained childless experienced a significant decline of $20,127 during the same period (p<0.001). Table 2 summarizes education and unadjusted mean household income data for 2011.

Years Education and Unadjusted Income at Last Wave (2011) by Childbearing Status										
	Total			Childless Women			Mothers			
	N (%)	Mean	SD	N (%)	Mean	SD	N (%)	Mean	SD	p-value
Years Education	248 (100.00)	13.52	2.93	103 (41.53)	13.74	3.32	145 (58.47)	13.01	1.96	< 0.001
Household Income	251 (100.00)	$55,095	$45,174	103 (41.04)	$60,159	$49,162	148 (58.95)	$45,877	$35,026	< 0.001

N = sample size; SD = standard deviation; p-value = signi icance level.

Table 2: *Unadjusted mean household income of childless women was greater than mothers in 2011.*

Each individual has their own baseline BMI, or intercept, and all models are random effects. Results support rejecting the null model that a woman's BMI is constant during the reproductive years, suggesting significant variation within women over time.

Age

A woman's age demonstrated an independent effect on BMI that is distinct from time and nonlinear, lessening as a woman ages. The association between age and BMI was best captured by including both the linear and quadratic functions. After adjusting for nonlinearity, the coefficient for age with a random intercept remained stable as covariates were introduced to the model. Overall, the effect of age increases BMI, on average, by 0.40 units and attenuates by -0.1 as a woman ages, about 3.5 and 0.5 pound(s) respectively.

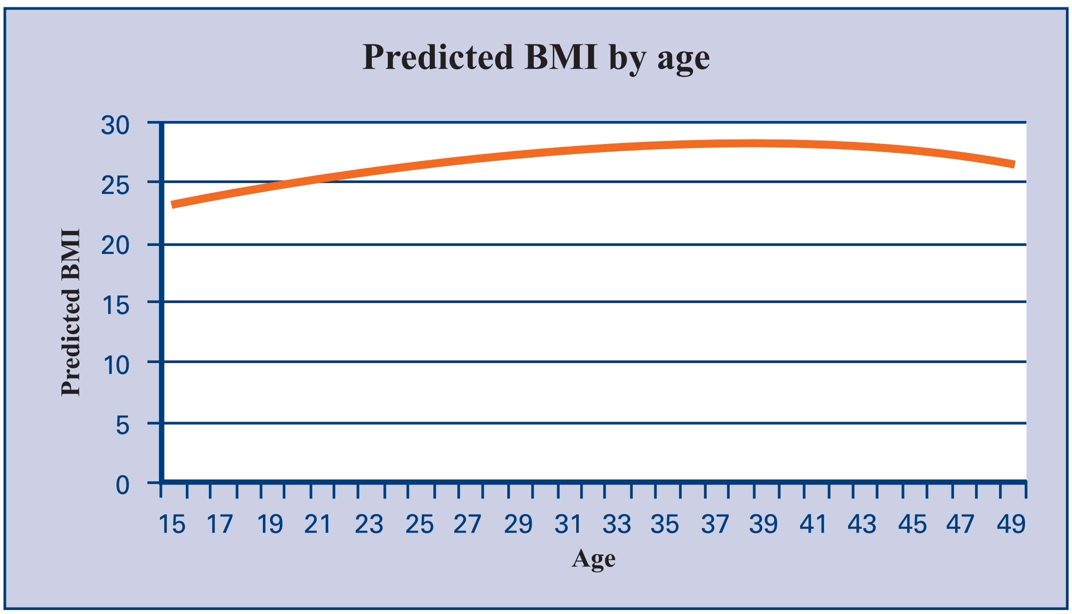

Figure 1: *The effect of age on a woman's BMI is nonlinear.*

Transition to Motherhood

On average, women who became mothers had a lower BMI at baseline than women who remained childless throughout the study period. Net of covariates, results demonstrate that women who transitioned to mothers had a baseline BMI (latent intercept) that was 1.22 BMI units less than women remaining childless ($p<0.001$, 95%CI: -1.94, -0.49), 26.02 and 27.24 respectively. With an unadjusted mean BMI greater than 25 units, both groups were overweight at baseline.

Women who became mothers experienced a significant change in BMI after this transition. On average, a women's BMI increased by 0.69 units with the transition to motherhood ($p<0.004$, 95%CI: 0.23, 1.15). This is consistent with an increase of approximately 4.5 pounds for a 5'4" woman (average height for a female in the United States).[47]   This coefficient remained stable with the introduction of covariates to the model (household income and minority status).

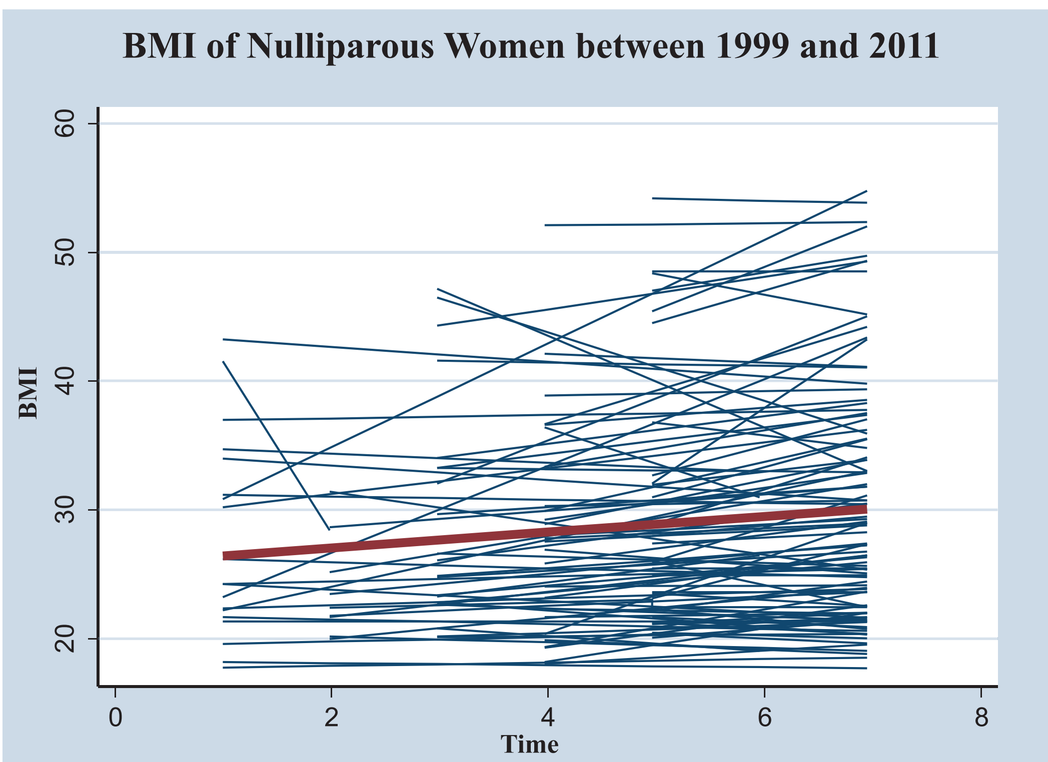

Figure 2: *Nulliparous women had a higher BMI at baseline than women who became mothers.*

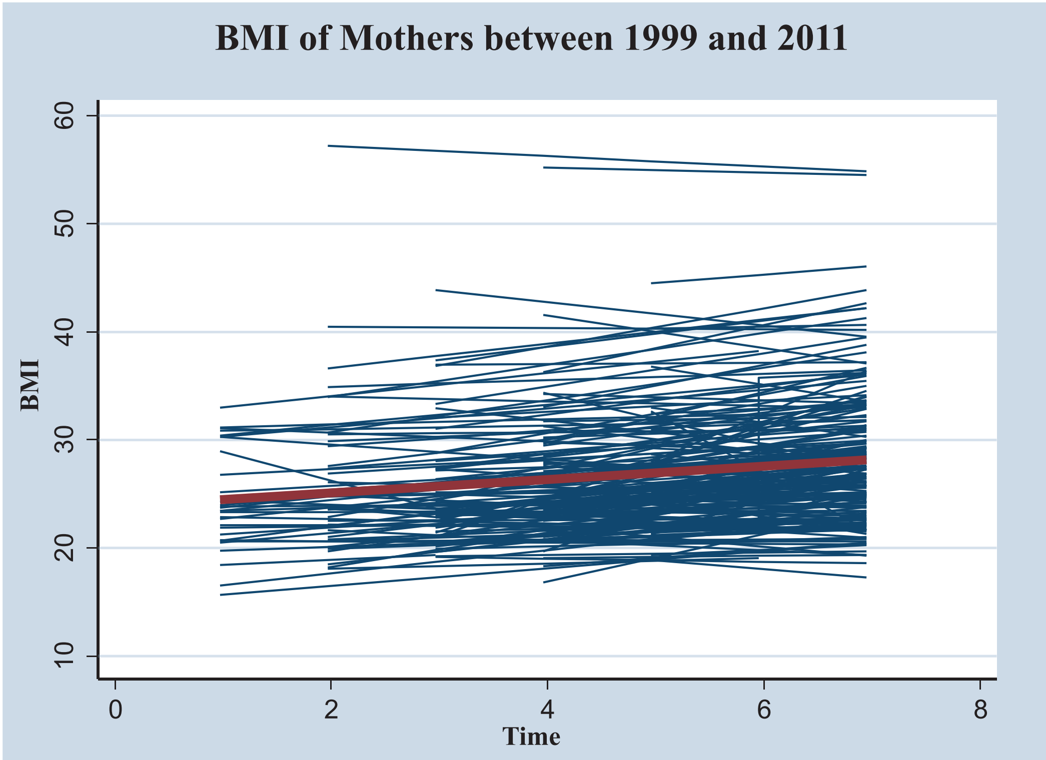

Figure 3: *A woman's BMI increased after the transition to motherhood.*

Household Income and Minority Status

Total household income demonstrated a negative relationship with BMI. For each log increase in household income, BMI decreased by 0.23 units (p=0.08, 95%CI: -0.49, 0.02). This decrease in BMI is equivalent to nearly one pound for a woman of average height in the US. Minority status had a significant positive relationship with BMI and the magnitude of its impact was greater than all other coefficients combined. On average, the BMI of minority women was 3.94 units greater than white women (p<0.001, 95%CI: 2.20, 5.68). Minority women are approximately 23 pounds heavier than white women of average height in the US. Table 3 presents results by each model examined.

Estimated Effects on BMI by Model																		
Parameter	I			II			III			IV			V			VI		
	Est	*SE*	*p-value*	*Est*	*SE*	*p-value*	*Est*	*SE*	*p-value*	*Est*	*SE*	*p-value*	*Est*	*SE*	*p-value*	*Est*	*SE*	*p-value*
BMI	28.10	0.46	**<0.001**	24.87	0.55	**<0.001**	23.63	0.61	**<0.001**	24.02	0.62	**<0.001**	26.43	1.34	**<0.001**	24.21	1.43	**<0.001**
I+Age				0.25	0.02	**<0.001**	0.45	0.05	**<0.001**	0.36	0.06	**<0.001**	0.40	0.06	**<0.001**	0.40	0.06	**<0.001**
II+Age^2							-0.01	0.00	**<0.001**	-0.00	0.00	**0.001**	-0.01	0.00	**<0.001**	-0.01	0.00	**<0.001**
III+ Motherhood										0.74	0.24	**0.002**	0.71	0.24	**0.003**	0.69	0.24	**0.004**
IV+ Household Log Income													-0.26	0.13	**0.04**	-0.23	0.13	**0.08**
V+Minority Status																3.94	0.89	<0.001

Est = coefficient estimate; SE = standard error; p-value = significance level.

Table 3: *The transition to motherhood increases a woman's BMI.*

Nulliparity, Primiparity, and Multiparity

These models consistently demonstrated that parity has an impact on BMI, and the association remained largely unchanged when adjusted for income and minority status. These initial models were limited by constraining the association of parity to be the same regardless of primiparity or multiparity status. An additional model was defined in order to explore potential differences in the association of primiparity and multiparity on a woman's BMI. Results are presented in table 4. Most of the association of childbearing on a woman's BMI occurs with the first birth. BMI increased significantly by 1.35 units after one child (p=0.01, 95%CI: 0.39, 2.32). This is approximately 8 pounds for a woman of average height in the United States. While BMI also increased by 0.64 units with the second or higher order birth (about 4 pounds for a woman of average height), this increase did not reach statistical significance at the 0.05 level (p= 0.12, 95%CI: -0.16, 1.42). It suggests a trend, however, and may reach significance with a larger sample.

Estimated Effects of Primiparity and Multiparity on BMI by Model			
Parameter	*Est*	*SE*	*p-value*
BMI	25.56	1.54	< 0.001
Age	0.40	0.06	< 0.001
Age^2	-0.01	0.00	< 0.001
Primiparity	1.35	-0.49	0.01
Multiparity	0.64	-0.41	0.12
Household Log Income	-0.23	0.13	0.07
Minority Status	3.94	0.89	< 0.001

Est = coefficient estimate; SE = standard error; p-value = significance level.

Table 4: *A woman's BMI increases by more than one BMI unit with the first birth.*

Discussion

Over the past several decades epidemiologic evidence has drawn attention to the large numbers of overweight and obese women in the United States. Although recent data suggest that rates may be stabilizing rather than continuing to increase, the individual and public health challenges of this epidemic remain substantial.[6] Evidence from these analyses suggests that age has a positive association with BMI that attenuates. Early reproductive years may present a period of vulnerability when increasing BMI is more likely. Attention to maintaining BMI in the normal range throughout this period may promote a woman's ability to maintain a healthy BMI over the life course.

While maintaining a normal BMI throughout a woman's reproductive years is ideal, evidence from these analyses suggest that many women may be entering pregnancy already overweight. Women in this study were all nulliparous at baseline and their BMI was classified as overweight. Being overweight or obese prior to pregnancy is concerning as women with an elevated BMI often encounter fertility problems and are more likely to have miscarriages. Compared to women of normal weight, obese women have increased difficulty conceiving and are less responsive to assisted reproductive technologies.[48] The importance of maintaining normal BMI is important for all women. This message also may be emphasized prior to pregnancy as part of preconceptual care.[49]

Being obese during pregnancy also is associated with increased obstetrical risks. The association of increased perinatal complications with obesity make it more likely that pregnancy, a normal life event for most women, may become a complex medical condition. Obese women are more likely to experience complications throughout every stage of pregnancy. During the prenatal period, obese women are diagnosed with gestational diabetes, gestational hypertension, and preeclampsia more frequently.[49] Increased risk of cesarean delivery and poor wound healing complicate their intrapartum experience with greater frequency.[49] After delivery obese mothers encounter greater difficulty breastfeeding and suffer from higher rates of postpartum depression.[49] The infants of obese mothers are also more likely to be macrosomic (intrauterine fetal growth in excess of 4500 grams) and have higher rates of congenital anomalies.[49] Stillbirth and neonatal death also occur more often among obese mothers.[49] While these perinatal complications arise from distinct pathways, their common association with maternal obesity illustrates the far reaching and diverse consequences of becoming obese early in life that are specific to women and present distinctive challenges during the reproductive years.

Results demonstrate a significant baseline difference in BMI between childbearing and nulliparous women at the 0.05 level, with a higher mean among women who remained nulliparous. It is important to consider that the direction of this apparent selection cannot be determined from these analyses, as obesity is associated with difficulty conceiving and infertility. These findings also suggest that age has a positive effect on BMI. Therefore, some weight gain may be observed during the reproductive years irrespective of parity.

Findings are consistent with prior studies that suggest the transition to motherhood is associated with increased BMI.[36] The significant change in the latent intercept after motherhood identified by these analyses is consistent with findings that gestational weight gain and postpartum weight retention are responsible for increased BMI after childbirth. In addition to a change in the latent intercept, Umberson and colleagues found parenthood was associated with an increase in the slope of a woman's BMI trajectory.[36] Encouraging gestational weight gain within recommended guidelines is one potential strategy to mitigate the increase in BMI associated with a transition to motherhood. Greater attention to diet and discussion of optimal pregnancy weight gain is a straightforward and inexpensive intervention that obstetricians and their support staff may incorporate during prenatal visits.[49]

Interventions that encourage women to return to their baseline weight after childbirth also are important. Women who do not return to their pre-pregnancy weight experience adverse cardiovascular and metabolic consequences, which may be identified as early as 12 months after delivery[50]. While analyses for this study were confined to examination of the latent intercept, Umberson and colleagues found parenthood was associated with an increase in the slope of a woman's BMI trajectory.[36] The results suggest that parity changes the rate at which women gain. Additional studies of BMI trajectory may help to distinguish change in weight gain retained from the gestational period itself from a change in a woman's rate of weight gain. A difference in the rate of BMI change after childbirth may have distinct implications for women's health over the life course as compared to retaining gestational weight gain after childbirth. Studies to examine BMI trajectory, cardiac function, and metabolic status after the transition to motherhood are needed.

Findings are consistent with epidemiological data documenting significant obesity disparities between black, Hispanic, and white women. The BMI of minority women in this study was nearly four units greater than white women at baseline. For a woman of average height in the United States (5’4”), this represents approximately 23 more pounds for a minority woman. The mean age at baseline of women in the present study was 19 years, suggesting that many minority women may enter their reproductive years with excessive weight and obesity disparities begin early in life. These findings support the need for early intervention programs among minority youth and young adults. While preventing childhood obesity is an important goal in itself, it may also offer the additional benefit of optimizing reproductive health and perinatal outcomes. Investigating the extent to which obesity disparities during the reproductive years may drive other disparities in perinatal health, such as cesarean section rates, is an important goal for future research.

Findings presented here benefited significantly from the strengths of PSID. PSID is a nationally representative panel with data including height, weight, and birth histories. Whereas most studies of parity and obesity are cross-sectional, the present analyses are longitudinal. Originally purposed to study income and wealth in US households, PSID also provides sophisticated measures of income that make it possible to deal more effectively with confounding. The study design is another strength, as multilevel analysis maximize the benefits of nested data. PSID also provided a contemporary sample. Seven waves of data were included between 1999 and 2011. Study criteria yielded a sample of 257 women with 1799 observations. Nonetheless, analyses of multiparity also may have reached statistical significance with a larger sample. Self-reported height and weight also is a limitation. Under optimal circumstances, measured height and weight would be available for the proposed study as it is more accurate. Nonetheless, despite its limitations, many studies rely upon self-reported height and weight, and it is a frequent source of data for studies that involve BMI.[42]

Evidence from this study adds to the growing scholarship that considers how reproductive events may have long-term impact on women's health, well beyond their reproductive life span. Understanding these linkages offers the opportunity to develop our understanding of reproduction in the context of women's health and wellness over the life course.

Chapter 4 Endnotes

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CHAPTER 5

Is Timing Everything? The Role of Age at First Birth and Obesity Disparities

Abstract

Objective: To examine the association of age at first birth with body mass index (BMI) during the reproductive years.

Methods: This study analyzed data from the Panel Study of Income Dynamics (PSID), a nationally representative longitudinal study of US families that started in 1968. Analyses were conducted using a mixed effects longitudinal linear regression with random intercept. The model examined the association of aging, age at first birth, and minority status using nested data; specifically, multiple BMI values over time for the same woman. Log of total family income was included in the model as a covariate. Exclusion and inclusion criteria yielded a final sample of 146 women with 707 observations, each with at least three waves of data.

Results: The primary outcome was BMI and four models were considered. Age at first birth demonstrated a significant association with BMI in all models that excluded severely obese women and remained stable, ranging from -0.20 in model 1 ($p<0.001$; 95%CI: -0.34, -0.06) to -0.25 in model 2 ($p=0.01$; 94%CI: -0.43, -0.07). Results suggest that for each year beyond age 15 that a woman's first birth is delayed, BMI decreases by about 0.22 units. The association of age at first birth with BMI was greatest for the youngest group of women, 21 years and under. Overall, women who experienced their first birth at 21 years or younger had a BMI five units greater than women who delayed childbearing until at least 30 years (5.02; $p=0.02$, 95%CI: 0.65, 9.40). Adding age at first birth to the models reduced the

coefficient for minority status by about 0.22 BMI units in all models that included obese women (model 1: from 3.74 BMI units, $p<0.001$ 95%CI: 1.80, 5.68 to 3.52 BMI units, $p<0.001$ 95%CI: 1.59, 5.46).

Conclusion: Younger age at first birth may be associated with an increased BMI. This association appears strongest for women who initiate childbearing at 21 years or younger. Minority status demonstrates a significant relation with BMI. Age at first birth merits additional study as a potential mediator of this association.

Introduction

Obesity disparities among minority and white women are well documented.[1] Evidence from survey research also suggest that black and minority women experience increased risk of obesity after childbearing.[2-8] While most studies examining differences in weight gain and obesity after childbearing found increased risk among black as compared to white women, there are limited data on timing of childbearing and maternal age in the context of obesity. This study examined the association of age at first birth, as distinct from the effect of aging, on body mass index (BMI). The primary pathway of interest was timing of childbirth and subsequent BMI among women. Age at first birth is younger among minority women as compared to non-Hispanic whites;[9] therefore, analyses also explored the extent to which evidence may support the hypothesis that age at first birth is a potential mediator of the relation between minority status and BMI.

Although it will not be directly evaluated, chronic disease is the long-term outcome of this study framework. Abundant evidence has established the link between obesity and the onset of conditions such as hypertension and heart disease;[10, 11] genetics, race, and ethnicity also are independent risk factors.[12-14]

Methods

This study analyzed data from the Panel Study of Income Dynamics (PSID), a nationally representative longitudinal study of US families that started in 1968. PSID originally focused on income variability and employed a genealogical sampling frame to follow the children of original family members. It now includes multiple generations and has added information on a range of measures important for public health, including fertility, chronic disease, system utilization, and insurance coverage. The panel response rate remains high and attrition has not become a large problem over the years.[15-18] PSID moved from annual to biannual data collection in 1997.

PSID data for these analyses are publically available through their website. Detailed descriptions of enrollment, consent processes, and data protocols also are available. This study was reviewed by the Institutional Review Board at the Johns Hopkins School of Public Health and determined to not be human subjects research.

In 1999 the panel began collecting self-reported height and weight data, resulting in seven waves of data (between 1999 and 2011) eligible for these analyses. Fertility data were added in 1985 and updated at each wave. Birth information was self-reported and the accuracy of self-reported information related to childbearing is high. In a comparison of self-reported obstetric information to medical records, Gartland and colleagues found greater than 90% agreement.[19] Birth history data included the total number of children delivered by a woman as well as the month and year of each birth. There were 2691 females between 15 and 45 years in 1999. Women with a birth prior to 1999 were excluded (n=2159), as were women with no birth history data (n=27). These exclusion criteria resulted in a potential sample of 505 women. To be included in analyses, a woman needed to experience a birth prior to 2009 data collection. This resulted in a minimum of three waves of BMI data, with at least one BMI measure prior to childbirth and two measures after parturition. These inclusion criteria yielded a final sample of 146 women with 707 observations.

Definition of Study Sample

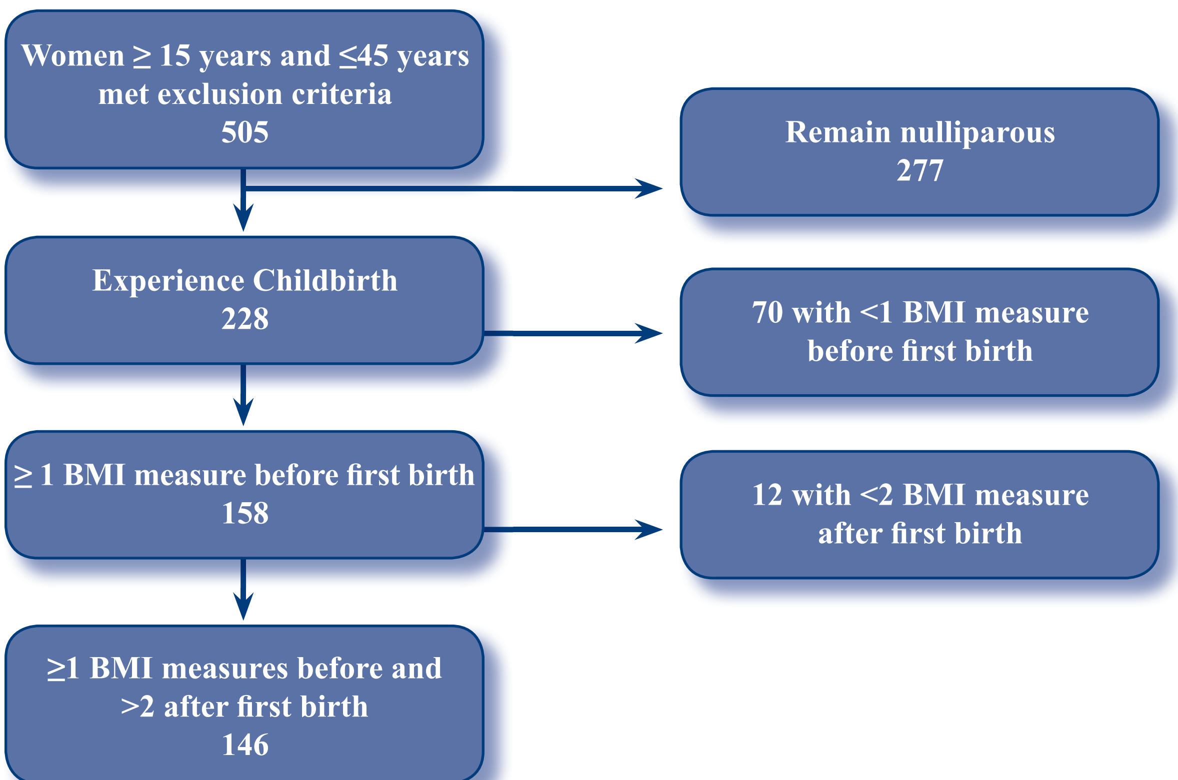

Figure 1: *Exclusion and inclusion criteria defined a sample of 146 women.*

The mean number of observations per participant in the sample was 4.8. Between 1999 and 2011, PSID changed the definition of its race and ethnicity measure to be consistent with advances in demographic classifications. Because panel definitions of race and ethnicity were not consistent over time, they were redefined in order to be consistent during the analysis period, 1999 to 2011. The definitions of race were different between 1999 – 2003 and 2005 – 20011. Ethnicity was part of the race variable between 1999 and 2003. Given these parameters, it was not possible to distinguish both race and ethnicity for all participants during the study period. As a result, minority status was defined as white and other.

Analyses were conducted using a mixed effects longitudinal linear regression with random intercept using *Stata Statistical Software: Release 12*. The model examined change within women using nested data; specifically, multiple BMI values over time for the same woman. The effect of aging, age at first birth, and minority status were of interest. Log of total family income was included in the model as a covariate. It is a measure that sums head of household taxable income; spouse taxable income; head of household transfer income; spouse transfer income; taxable income of other household members, and total social security. Each wave provided a separate measure of total family income in actual dollars for the prior year. Log income was selected due to the nonlinear effect of rising disposable income on household economic decisions, as is commonly done.

The primary outcome was change in BMI. Weight and height in PSID were self-reported. Self-reported height and weight has been validated in national samples.[20-22] PSID also compared its self-reported height and weight data to the self-reported height and weight data of the National Health Information Survey. There were no significant difference between the samples, demonstrating that height and weight responses from PSID are comparable to other nationally representative surveys.[23]

During the reproductive years, change in BMI principally reflects change in weight rather than height; therefore, this dependent variable may be understood as change in body weight over time. An increase in one BMI unit is approximately 6 pounds for a women of average height (5’ 4”) in the United States (US).[24]

The model tested the hypotheses that age at first birth had a positive association with a woman’s BMI, independent of the effect of aging and parity. This is a level two model to examine difference in within-person change between women. Analyses explored possible ceiling effects of obesity on age at first birth. Obesity is defined as BMI greater than 30 units, with additional categories of class one obesity (30-35 BMI units), class two obesity (36- 40 BMI units), and class three obesity (over 40 BMI units). The association of age at first birth with BMI was estimated for all women as well as women with a pre-pregnancy (baseline) BMI less than 50, less than 40, and less than 35. The model may be expressed as:

$$Y_{it} = \beta_0 + \beta_1(A_{it}) + \beta_2(I_{it}) + \beta_3(M_i) + \beta_4(AFB_i) + E_{it}$$

where A_{it} is centered (at 15) age; I_{it} is household income in dollars (not adjusted for inflation) on the log scale; M_i is an indicator variable for minority status; and AFB_i is age at first birth in years. In this model, β_4 may be interpreted as the expected increase in BMI over the entire period, including nulliparous period, associated with a one unit difference in age at first birth.

Age at first birth also was examined as a categorical variable. Using the definition of adolescence by the American Association of Pediatrics,[28] adolescents 21 years and younger were distinguished from women 22 to 29 years and women 30 years and older. The model is may be expressed as:

$$Y_{it} = \beta_0 + \beta_1(A_{it}) + \beta_2(I_{it}) + \beta_3(M_i) + \beta_4(AFB\text{-}CAT_i) + E_{it}$$

Where A_{it} is centered at age 15; I_{it} is household income in dollars (not adjusted for inflation) on the log scale; M_i is an indicator variable for minority status; and $AFB\text{-}CAT_i$ is age at first birth by group (≤ 21, 22-29, and ≥ 30) in years. In this model, β_4 may be interpreted as the expected difference in BMI over the entire period, including nulliparous period, associated with age category.

Experiencing a first birth during adolescence or young adulthood is associated with multiple social and economic challenges[25] and minority women have a younger mean age at first birth as compared to whites.[26, 27] Therefore, analyses also examined the role of age at first birth as a possible mediator of minority status. The main effect of minority status was defined by the following equation:

$$Y_{it} = \beta_0 + \beta_1(A_{it}) + \beta_2(I_{it}) + \beta_3(M_i) + E_{it}$$

where A_{it} is centered at age 15; I_{it} is household income in dollars (not adjusted for inflation) on the log scale; and M_i is an indicator variable for minority status. Here, β_3 is the expected difference in BMI associated with minority status. Results were compared to the model previously defined that considered the association of age at first birth as a continuous variable.

Results

Table 1 presents descriptive information. There were 146 women in the sample with a total of 707 observations and a mean of 4.8 observations per participant. Minority women represented 50% (73 women) of the sample. Mean age at first birth was 23.3 years overall and baseline BMI for women in the sample was 25.86 units. There were significant differences in age at first birth by minority status. Mean age at first birth was 23.8 and 22.8 years for white and minority women ($p<0.001$), respectively. Baseline BMI also was different, 24.04 units for white and 27.68 units for minority women ($p<0.001$). There were significant differences in years of education and total household income in 1999, the first wave of data collection for these analyses.

White women had nearly one year greater education than minority women, 9.2 years and 8.4 years respectively (p=0.02). White women reported total household income nearly $30,000 higher than minority women. Mean total unadjusted household income was $68,094 for whites and $39,602 for minorities (p<0.001).

Descriptive Characteristics at First Wave (1999) by Minority Status				
	Total	White	Minority	
	n = 146	n = 73 (50%)	n = 73 (50%)	
	Mean (SE, range)	Mean (SE)	Mean (SE)	p value
Age in 1999	18.1 (0.10; 15 – 37)	18.1 (0.12)	18.2 (0.16; 15 – 37)	0.78
Age First Birth	23.3 (0.13; 16 – 39)	23.8 (0.16)	22.8 (0.21; 16 – 39)	< 0.001
Baseline BMI	25.86 (0.20; 16.44 – 55.84)	24.04 (0.21)	27.68 (0.33)	< 0.001
Years Education 1999	8.8 (0.16; 0 – 17)	9.2 (0.22)	8.4 (0.22)	0.02 (8.5)
Total Household Income 1999	$53,948 ($2233; $4000 – $770,900)	$68,094 ($4183)	$39,602 ($1203)	<0.001

n = sample size; SE = standard error; CI = confidence interval; p = significant value.

Table 1: *Mean age at first birth, baseline BMI, years of education, and total household income in 1999 were significantly different among white and minority women.*

Estimated Association of Age at First Birth with BMI						
Sample	Total (n=146) (total observations 707)			Baseline BMI<40 (n=140) (total observations 681)		
	Model 1			*Model 2*		
Parameter	*est*	*se*	*p (95%CI)*	*est*	*se*	*p (95%CI)*
BMI	27.08	3.22	<0.001 (20.77 – 33.39)	26.65	2.64	<0.001 (21.47 – 31.83)
Age	0.58	0.09	<0.001 (0.40 – 0.76)	0.59	0.09	<0.001 (0.41 – 0.76)
Age^2	-0.01	0.00	0.001 (-0.02 – -0.00)	-0.01	0.00	0.001 (-0.02 – -0.00)
Log Total Income	-0.11	0.15	0.46 (-0.41 – 0.19)	-0.07	0.15	0.65 (-0.36 – 0.22)
Minority Status	3.53	0.99	<0.001 (1.59 – 5.46)	2.79	0.77	<0.001 (1.27 – 4.30)
Age at First Birth	-0.22	0.12	0.06 (-0.45 – 0.01)	-0.25	0.09	0.01 (-0.43 – -0.07)

Estimated Association of Age at First Birth with BMI						
Sample	Baseline BMI<35 (n=135) (total observations 633)			Baseline BMI<30 (n=118) (total observations 579)		
	Model 3			*Model 4*		
Parameter	*est*	*se*	*p (95%CI)*	*est*	*se*	*p (95%CI)*
BMI	26.97	2.52	p<0.001 (22.03 – 31.90)	24.81	2.20	<0.001 (20.49 – 29.13)
Age	0.58	0.09	p<0.001 (0.41 – 0.75)	0.60	0.09	<0.001 (0.42 – 0.77)
Age^2	-0.01	0.00	0.001 (-0.02 – -0.00)	-0.01	0.00	<0.001 (-0.02 – -0.01)
Log Total Income	-0.12	0.15	0.42 (-0.41 – 0.17)	-0.06	0.15	0.70 (-0.36 – 0.24)
Minority Status	2.04	0.73	0.01 (0.61 – 3.46)	1.34	0.59	0.02 (0.18 – 2.50)
Age at First Birth	-0.24	0.09	0.01 (-0.40 – -0.07)	-0.20	0.07	0.04 (-0.34 – -0.06)

n = sample size; est = Estimate of the coefficient; se = standard error; p = significance value.

Table 2: *Age at first birth demonstrated a significant association with BMI.*

The first set of analyses considered the association of age at first birth on BMI and included age, log total household income, and minority status as covariates. Recognizing the association of obesity with fertility issues and altered metabolic function,[29, 30] results were stratified. Model 1 included all women in the sample; model 2 excluded women with class III obesity at baseline; model 3 excluded women with classs II and class III obesity at baseline; and model 4 excluded all women who were obese at baseline. Age at first birth demonstrated a significant association on BMI in all models that excluded severely obese women. Model 1, that included severely obese women, was marginally significant ($p = 0.06$; 95%CI: -0.45 – 0.01). The association of age at first birth remained stable across the models, ranging from -0.20 in model 1 ($p<0.001$; 95%CI: -0.34 – -0.06) to -0.25 in model 2 ($p=0.01$; 94%CI: -0.43 – -0.07). Results suggested that for each year beyond age 15 years that a woman's first birth is delayed, BMI decreases by about 0.22 units. This is about one pound per year for a woman of average height (5'4") in the US. Results are available in Table 2.

The effect of age on BMI was nonlinear, indicating that its effect decreased as women became older. It was significant for all models and the coefficient remained stable. The log of total household income failed to reach significance in any model. The coefficient for minority status changed considerably in each model, ranging from 3.53 in model 1 ($p<0.001$; 85%CI: 1.59 – 5.46) to 1.34 in model 4 ($p=0.02$; 95%CI: 0.18 – 2.50). As each model became increasingly restrictive by baseline obesity, results indicate that minority women were more likely to have class II and class III obesity.

Association of Early Childbearing on BMI for Young Women as Compared to Women over 30 Years						
Sample	Total (n=146) (total observations 707)			Baseline BMI<40 (n=140) (total observations 681)		
	Model 1			*Model 2*		
Parameter	*est*	*se*	*p (95%CI)*	*est*	*se*	*p (95%CI)*
BMI	17.31	2.65	<0.001 (12.12 – 22.50)	17.14	2.23	<0.001 (12.73 – 21.52)
Age	0.57	0.09	<0.001 (0.40 – 0.75)	0.59	0.09	<0.001 (0.41 – 0.78)
Age^2	-0.01	0.00	0.001 (-0.02 – - 0.00)	-0.01	0.00	0.001 (-0.02 – -0.00)
Log Total Income	-0.12	0.15	0.43 (-0.42 – 0.18)	-0.08	0.15	0.61 (-0.37 – 0.21)
Minority Status	3.80	0.99	<0.001 (1.85 – 5.74)	2.99	0.79	<0.001 (1.45 – 4.53)
Age at First Birth<=21	5.02	2.23	0.02 (0.65 – 9.40)	4.44	1.73	0.01 (1.04 – 7.84)
Age at First Birth 22-29	4.62	2.20	0.04 (0.31 – 8.93)	3.65	1.71	0.03 (0.30 – 7.00)

Association of Early Childbearing with BMI for Young Women as Compared to Women over 30 Years						
Sample	Baseline BMI<35 (n=135) (total observations 633)			Baseline BMI<30 (n=118) (total observations 579)		
	Model 3			*Model 4*		
Parameter	*est*	*se*	*p (95%CI)*	*est*	*se*	*p (95%CI)*
BMI	18.23	2.16	<0.001 (14.00 – 22.46)	18.30	1.95	<0.001 (14.47 – 22.12)
Age	0.58	0.09	<0.001 (0.41 – 0.76)	0.60	0.09	<0.001 (0.43 – 0.78)
Age^2	-0.01	0.00	0.001 (-0.02 -- -0.00)	-0.01	0.00	<0.001 (-0.02 – -0.01)
Log Total Income	-0.13	0.15	0.39 (-0.42 – 0.16)	-0.08	0.12	0.61 (-0.38 – 0.22)
Minority Status	2.17	0.74	0.004 (0.71 – 3.62)	1.37	0.61	0.03 (0.17 – 2.58)
Age at First Birth<=21	4.05	1.61	0.01 (0.89 – 7.20)	2.50	1.27	0.05 (0.01 – 4.99)
Age at First Birth 22-29	3.03	1.59	0.06 (-0.08 – 6.15)	1.83	1.24	0.14 (-0.61 – 4.26)

n = sample size; est = Estimate of the coefficient; se = standard error; p = significance value; 95%CI = 95% confidence interval.

Table 3: *Age at first birth has the greatest association among women under 21 years.*

An additional set of analyses was completed to estimate the association of early childbearing as compared to initiating childbirth at or after age 30. Once again, four models were considered and results are presented in Table 3. Model 1 included all women in the sample; model 2 excluded women with class III obesity at baseline; model 3 excluded women with class II and class III obesity at baseline; and model 4 excluded all women who were obese at baseline. The association of age at first birth with BMI was greatest for the youngest women. Overall, women who experienced their first birth at 21 years or younger had a BMI five units greater than women who delayed childbearing until at least 30 years (5.02; p=0.02, 95%CI: 0.65 – 9.40). Women experiencing their first birth between ages 22 and 29 also had a higher BMI than women delaying their first birth to age 30 years or more (4.62; p=0.04, 95%CI: 0.31 – 8.93). In models 3 and 4, women experiencing their first birth between 22 and 29 years were not significantly different at the 0.05 level from women who initiated childbearing at 30 years or older and the confidence intervals overlap (model 3 p=0.06, 95%CI: -0.08 – 6.15 and model 4 p=0.14, 95%CI: -0.61 – 4.26). Nonetheless, given sample size considerations and the consistent direction of coefficients within the models, these groups may be different albeit with an effect size that is too small to detect with these analyses.

The effect of age was consistent with prior models. Log of total household income failed to reach significance in any of the models, which was consistent with the first set of analyses. Minority status was significant in all four models and displayed the same pattern of decreasing magnitude as the models were increasingly restrictive of more obese women.

Association of Age at First Birth with Minority Status as Predictor of BMI

Sample	Total (n=146) (total observations 707)						Baseline BMI<40 (n=140) (total observations 681)					
	Model 1a			*Model 1b*			*Model 2a*			*Model 2b*		
Parameter	*est*	*se*	*p*	*est*	*se*	*p*	*est*	*se*	*p*	*est*	*se*	*p*
BMI	21.87	1.68	<0.001 (18.59 – 25.16)	27.08	3.22	<0.001 (20.77 – 33.39)	20.96	1.58	<0.001 (17.86 – 24.06)	26.65	2.64	<0.001 (21.47 – 31.83)
Age	0.59	0.09	<0.001 (0.41 – 0.77)	0.58	0.09	<0.001 (0.40 – 0.76)	0.60	0.09	<0.001 (0.43 – 0.78)	0.59	0.09	<0.001 (0.41 – 0.76)
Age^2	-0.01	0.00	0.001 (-0.02 – 0.01)	-0.01	0.00	0.001 (-0.02 – -0.004)	-0.01	0.00	<0.001 -0.02 – -0.01)	-0.01	0.00	0.001 (-0.02 – -0.004)
Log Total Income	-0.12	0.15	0.41 (-0.42 – 0.17)	-0.11	0.15	0.46 (-0.41 – 0.19)	-0.09	0.15	0.55 (-0.38 – -0.20)	-0.07	0.15	0.65 (-0.36 – 0.22)
Minority Status	**3.74**	0.99	<0.001 (1.80 – 5.86)	**3.52**	0.99	<0.001 (1.59 – 5.46)	**3.02**	0.79	<0.001 (01.48 – 04.56)	**2.78**	0.77	<0.001 (1.27 – 4.30)
Age at First Birth				-0.22.	0.12	0.06 (-0.45 – 0.01)				-0.25	0.09	0.001 (-0.43 – -0.07)

Association of Age at First Birth with Minority Status as Predictor of BMI

Sample	Baseline BMI<35 (n=135) (total observations 663)						Baseline BMI<30 (n=118) (total observations 579)					
	Model 3a			*Model 3b*			*Model 4a*			*Model 4b*		
Parameter	*est*	*se*	*p*	*est*	*se*	*p*	*est*	*se*	*p*	*est*	*se*	*p*
BMI	21.57	1.58	<0.001 (18.48 – 24.67)	26.97	2.52	<0.001 (22.03 – 31.90)	20.39	1.58	<0.001 (17.30 – 23.48)	24.81	2.20	<0.001 (20.49 – 29.13)
Age	0.60	0.09	<0.001 (00.43 – 0.77)	0.58	0.09	<0.001 (0.41 – 0.75)	0.62	0.09	<0.001 (0.45 – 0.79)	0.60	0.09	<0.001 (0.42 – 0.77)
Age^2	-0.01	0.00	<0.001 (-0.02 – -0.01)	-0.01	0.00	0.001 (-0.02 – -0.004)	-0.01	0.00	<0.001 (-0.02 – -0.01)	-0.01	0.00	<0.001 (-0.02 – -0.01)
Log Total Income	-0.15	0.15	0.33 (-0.44 – 0.15)	-0.12	0.15	0.42 (-0.41 – 0.17)	-0.10	0.15	0.53 (-0.40 – 0.20)	-0.06	0.15	0.70 (-0.36 – 0.24)
Minority Status	**2.25**	0.74	0.002 (0.79 – 3.70)	**2.04**	0.73	0.01 (0.61 – 3.46)	**1.38**	0.61	0.03 (0.18 – 2.58)	**1.34**	0.59	0.02 (0.18 – 2.50)
Age at First Birth				-0.24	0.09	0.01 (-0.40 – -0.07)				-0.20	0.07	0.004 (-0.34 – -0.06)

n = sample size; total obs= total data observations for sample; est = Estimate of the coefficient; se = standard error; p = significance value.

Table 4: *Age at first birth may yield new insights regarding the association between minority status and BMI.*

The last set of analyses examined the role of age at first birth as a possible mediator of minority status. As with the prior analyses, four models were examined and results are in Table 4. Model 1 considered all women, model 2 excluded women with class III obesity at baseline, model 3 excluded women with class II and class III obesity at baseline and model 4 excluded all women who were obese at baseline. Introducing age at first birth to the models had a small effect on the estimate of the coefficient of minority status, with the exception of model 4. The estimate of the effect of minority status on BMI among women who were not obese at baseline was statistically significant but close to 1 (1.38, p=0.03; 95%CI: 0.18 – 2.58) and remained essentially unchanged after age at first birth was introduced to the model (1.34; p=0.02, 95%CI: 0.18 – 2.50). For all models (1, 2, and 3) that included women who were obese at baseline, the coefficient for minority status decreased by approximately 0.22 BMI units when age at first birth was introduced. This is about one pound per year for a woman of average height (5'4") in the US and is consistent with the association of delaying first birth for each year beyond age 15 years.

Discussion

These analyses stemmed from the overarching hypothesis that timing of childbirth is important. Most studies of childbearing and obesity consider the role of gestational weight gain and subsequent maternal BMI. Few studies have considered the role of maternal age and obesity. Scholarship in this area typically considers teen pregnancy and obesity. Among women who became mothers in adolescence, Herman and Yu found that BMI prior to pregnancy was the most significant predictor of obesity after childbearing.[31]

In addition to greater gestational weight gain when compared to adults [32], adolescent mothers also appear to develop more central adiposity.[33] Young mothers (age 14-22) were more likely to be obese five years after delivery than young women who did not have children, suggesting that early childbearing may have unique implications for long-term weight status among women.[2] Findings from other studies suggest that younger age at menarche and short interval from menarche to first birth may increase the likelihood of developing obesity.[34, 35]

A recent study by Robinson and colleagues used propensity score matching to compare multiparous and nulliparous women and consider the role of maternal age and obesity among slightly older, non-adolescent, mothers.[36] With data from the National Longitudinal Study of Adolescent Health, they used logistical regression models to estimate both incidence and prevalence of obesity among mothers and childless women with a mean age of 28.4 years. Results found no significant difference between nulliparous and parous women, suggesting no association between childbearing and obesity. The study by Robinson differs from this study in two important ways. One, Robinson and colleagues did not consider age at first birth as an explicit variable. Two, their study participants have an older mean age at first birth than participants included in the present work.

The association of age at first birth with BMI on an annual basis may appear modest. Estimates of the association ranged from 0.20 to 0.25 less BMI units for each year a first birth was delayed, depending on the model. This represents a little over a pound a year for a woman of average height in the US and is roughly half the estimated effect of aging itself. While some evidence suggests that elevated BMI before pregnancy is most predictive of obesity after childbirth,[31] this association was significant even when considering only women with a BMI in the normal and overweight range prior to pregnancy. The cumulative association of age at first birth is more easily appreciated when comparing younger mothers (21 years or less) to older mothers (30 years or more). Among all women in the sample, women who experienced the transition to motherhood at 21 years or younger were five BMI units heavier than women 30 years and older when they become first-time mothers.

Findings suggest that increased BMI, and by extension obesity, may be an underappreciated factor of adolescent pregnancy. Additional studies are needed to explore this research question. Age-specific analyses also are important to inform public health policy and to support intervention strategies that are appropriately tailored to mothers. Current guidelines for recommended weight gain during pregnancy are adapted according to pre-gestational maternal weight. Obstetrical providers also may wish to consider maternal age among first-time mothers as another parameter to direct individual counseling and recommendations.

Four models were examined to consider possible ceiling effects of age at first birth, and to explore the role of baseline BMI. When treated as a continuous variable, the estimate of the association of age at first birth with BMI remained stable across all models. It was marginally significant, inclusive of all baseline BMI values, reaching statistical significance at the 0.05 level in other models. Overall, these findings are insufficient to support the presence of a ceiling effect of BMI on age at first birth. Examining the association of age at first birth by baseline BMI also established the effect was significant among women who were normal and overweight but not obese before pregnancy.

When comparing the four models, the effect of minority status consistently decreases as baseline BMI is restricted to lower classifications. This finding suggests that minority women were more likely to report BMIs in the overweight, obese, and extremely obese range. Other estimates in the model remained largely stable. Of note, household income was not significant in any model. Other studies have found a negative association between income and BMI in the US, with higher incomes generally associated with lower BMI .[37-39] One of the strengths of the PSID is the sophistication with which income data are collected, and these findings may reflect the robust nature of income measures available in the panel. As this is a contemporary sample of data from waves collected between 1999 and 2011 inclusive, findings also may reflect a dynamic association between income and BMI, where income is becoming less strongly associated with BMI.

Although the mechanisms are poorly understood, minority women experience increased risk of obesity after childbearing. Analyzing National Health and Nutrition Examination Survey (NHANES) data, Wolfe and colleagues reported that black women were more likely to experience weight gain ten years after pregnancy than white women.[5] Parker and Abrams also examined relations between race and postpartum weight retention using the 1988 National Maternal and Infant Health Survey.[8] Results suggest black women are twice as likely as white women to retain weight after childbearing (adjusted OR 2.20, 95% CI 1.50 – 3.22). Minority women, on average, also experience childbirth at younger ages than white women. The National Survey of Family Growth (NSFG) reported the mean age at first birth between 2006 and 2010 was 24.1 years for non-Hispanic white women, 21.2 years for Hispanic women, and 20.9 years for non-Hispanic black women. Whereas the probability of a first birth before age 20 among Non-Hispanic black women and Hispanic women was 32% and 30% respectively, it was just 14% among white women.[9] Minority women are not only more likely to experience a first birth during adolescence and young adulthood but also to be obese.

Analyses suggest that younger age at first birth increased a woman's BMI. Therefore, age at first birth might be expected to partially mediate minority status. Analyses tested for evidence of mediation using the approach formalized by Baron and Kenny by investigating the relationship between minority status and BMI both in the presence and the absence of age at first birth.[40] When applying this approach, there is evidence of mediation when the relationship between the independent and dependent variable is different when the mediating variable is included in the analysis. The coefficient for minority status decreased by approximately 0.22 BMI units when age at first birth was introduced, for all models except when restricting baseline BMI to normal and overweight. While the magnitude of this change may not be significant at the individual level, it may be meaningful at the population level. The limited sample size also makes it difficult to evaluate the evidence for possible mediation. Additional studies to better understand the co-occurrence of younger mean age at first birth and increased risk of obesity among minority women may advance our understanding of obesity disparities.

Few studies of obesity and childbearing have conducted longitudinal analyses. Findings from this study begin to address this gap in our understanding of the complex and dynamic linkages between reproductive decisions and a woman's long-term health. It also is a contemporary sample, with its last wave of data collected just three years ago. As the overall prevalence of obesity has changed dramatically in the US over the past several decades, it is important to draw upon recent data. Decisions based upon studies using data more than ten years old may no longer be relevant to the current forces shaping the obesity epidemic. Nonetheless, this study also presents limitations. Optimally, height and weight data would be objectively measured rather than self-reported. A larger sample with more measures before and after pregnancy also would lend more confidence to interpretation of findings.

The preceding analyses are grounded in the life course perspective. This approach integrates the ways that situation, culture, time, and social organization affect and are affected by individual developmental processes.[41] Recently, Davis and colleagues brought the life course perspective to their consideration of stress, childbearing, and obesity.[42] Their model draws upon the weathering hypothesis [43] and frames disparities in obesity among whites and blacks as the result of differences in responses to stress and reproductive events. Davis' conceptual framework recognizes exogenous factors within the social, cultural, and physical environment and stress as processes that occur across time. Obesity disparities among women are seen as the result of "a combination of genetic risk, suboptimal living environment (e.g. social and physical), differential exposure and response to chronic stress, coping ability, and health risk behaviors."

In their framework, Davis and colleagues advance the idea that how women respond to stress affects the manner in which these various factors may influence maternal weight and obesity. Their model assumes the stress-response system operates between puberty and menopause in the same way irrespective of when childbearing occurs. Experiencing childbirth at younger ages is associated with multiple social and economic challenges, which may promote frequent activation of the stress-response system and thus result in higher BMIs at younger ages. Prior research has established that other factors involved in the stress-response system, such as sleep patterns[44] and mental health,[45] also differ systematically by age. Younger women also are less likely to be married[46] and more likely to experience unintended pregnancy.[47] Additional bio-behavioral studies to explore these pathways are needed. Timing of childbearing is an important aspect of life course events that merits additional attention from clinical researchers interested in obesity and health disparities.

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Chapter 5 Endnotes

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CHAPTER 6:

Implications for Public Health Research, Policy and Practice

6.1 Summary

The overarching goal of this dissertation is to better understand the ways in which reproductive decisions may shape a woman's overall health status over the life course. Particularly, the impact of childbearing on body mass index (BMI) is explored, with attention to factors that may contribute to obesity disparities between minority and white women.

Specific aim one is to describe how allostatic load provides a framework to understand the contributions of reproductive events to BMI over the life course. The first article, chapter three, completed this specific aim by presenting the conceptual framework linking childbearing and BMI. It outlined pathways through which childbearing patterns may contribute to obesity by influencing a woman's BMI. The conceptual framework is supported by life course theory and draws upon three models, including weathering, allostatic load and the environmental affordances model. While presenting distinct orientations, these models shared the substantive argument that stress modifies neuroendocrine structure and function in ways that are detrimental to health.[1, 2] The conceptual framework introduces age at first birth as a possible marker of stress that connects childbearing and obesity, highlighting the significance of timing as a key factor to consider when examining this linkage.

Specific aim two is to determine if the transition to motherhood impacts BMI after childbirth. The second article, chapter four, completed this specific aim. Women in the study that experienced a transition to motherhood had a mean BMI that was 1.22 units less at baseline than women who remained childless. This is a difference of about seven pounds for a woman of average height in the US. The mean BMI of both mothers and women who remained childless exceeded 25 units, making both groups overweight at baseline. It suggests that many women enter their reproductive years already overweight and possibly obese. Women experienced a significant increase in BMI after the transition to motherhood that was equivalent, on average, to about 4.5 pounds for a woman of average height. As expected, household income was negatively related to BMI and minority status demonstrated a significant positive relationship to BMI. Analyses also considered the association of multiparity with BMI. Although results suggest that most of the association with childbearing occurs with the first birth, a larger sample might also identify significant effects of higher order births. The change in the latent intercept after childbearing lends evidence to the premise that elevated BMI after pregnancy may be driven by gestational weight gain and postpartum weight retention.

Specific aim three is to determine if the association between the transition to motherhood and subsequent BMI differs by age at first birth and minority status. The last article, chapter five, completed this specific aim. Findings suggest young age at first birth may be a marker for elevated BMI. For each year that a woman's first birth is delayed beyond age 15, BMI decreases by about 0.22 units. The association of young age at first birth with obesity is best appreciated when comparing women who were 21 years or younger to women 30 years or older. Overall, women experiencing the transition to motherhood at 21 years or younger had a BMI five units greater than women who delayed the transition to motherhood until at least 30 years (5.02; p=0.02, 95%CI: 0.65 – 9.40). Although household income was inversely related to BMI in models related to specific aim two, there was no significant relationship in analyses related to specific aim three. As expected, minority status was significantly associated with elevated BMI. Adding age at first birth to the models changed the coefficient for minority status marginally. In light of these findings, younger age at first birth merits additional study as a possible mediator of the relation between minority status and obesity.

6.2 Implications for Public Health Research

Obesity is a complex condition to manage at the population level due to the magnitude of the epidemic and its associated co-morbid conditions. It is a difficult condition to treat at the individual level because there are few effective therapies other than surgical interventions.[3] While pharmacological options are increasing, adverse effects often limit utilization of medications.[4] These and other challenges associated with secondary prevention make finding ways to support primary prevention of obesity critically important.

Findings suggest that many women already are overweight or obese before they become pregnant, suggesting that primary prevention needs to start prior to pregnancy. Preconceptual counseling offers an important opportunity for health care providers to encourage women to address issues of excess nutrition. Nonetheless, given the large number of pregnancies in the US that are unplanned, this approach is likely to be insufficient.[5] Furthermore, even women who plan pregnancies seldom present specifically for preconceptual counseling and health care. Identifying optimal points of intervention during adolescence, young adulthood and throughout the rest of the reproductive years and well as the interventions that have the most impact is a priority.

The difference in baseline BMI between women who transitioned to motherhood and women remaining childless was just over one unit, or roughly seven pounds for a women of average height in the US.[6] BMI among mothers increases almost five pounds after childbearing. As these changes were associated with the latent intercept, these results are limited to associations with the transition to motherhood and do not provide information about trajectories. The life course perspective encourages consideration of both transitions and trajectories, making investigation of BMI trajectories a compelling and appropriate progression of the work presented. PSID is expected to release data from the 2013 wave within the first quarter of 2015, at which point I will update my sample with the additional observations and continue with this succession plan. I will re-run the analyses presented and expect to have more precise estimates. With the anticipation of both a larger sample and more observations, I also plan to examine BMI trajectory. Information about the trajectories of mothers and women without children may help refine the hypotheses related to the impact of stress after early childbearing. It also will provide a more complete narrative of systematic changes in the pattern of BMI changes after childbearing, as well as between mothers and women without children.

6.3 Implications for Public Policy

Policy discussions more typically relate obesity prevention to diabetes or cardiovascular disease and unintended pregnancy prevention to adolescent reproductive health. Nonetheless, findings suggest that policy relating obesity and unintended pregnancy prevention activities may be beneficial. Greater understanding of the relations between childbearing and subsequent overweight and obesity among US women is a priority as many pregnancies in the US are unintended. Mosher and colleagues reviewed National Survey of Family Growth (NSFG) data from 1982 to 2010 and estimated that 37% of births were unintended.[5] Further, adolescents and young women experience a large proportion of the unintended pregnancies. Among adolescent and young adult (age 20 to 24) mothers, 77% and 50% of births were unintended, respectively.[5] In contrast, just 25% of births were reported as unintended among women age 25 to 44 years. While unintended pregnancy is an important public health outcome in its own right, increasing the proportion of planned pregnancies among young women may also yield benefits for obesity prevention and the chronic diseases associated with it. Findings support the need for continued investments in family planning and prevention of unintended births among adolescents and young adults.

Policy initiatives to support intensive monitoring of gestational weight gain and aggressive weight management after childbirth appear indicated. Public and commercial insurance plans do not typically cover routine nutritional counseling during prenatal care. Adding this service may prove beneficial to individual women during their reproductive years, as well as yield broader public health benefits over time. At present, most women receive one post-partum visit after childbirth. Extending follow-up to include nutritional monitoring and weight management also offers the potential to benefit women. Initial goals for clinical management may be returning to pre-pregnancy BMI. Longer term goals may include achieving and maintaining a BMI in the normal range.

6.4 Implications for Practice and Program Interventions

At a most basic level, the problem of overweight and obesity may be defined as one of caloric consumption and expenditure. Interventions to address these parameters often target reducing caloric intake, increasing caloric expenditures, or both. Unfortunately, effective behavioral interventions are few and pharmacological options often present the potential for significant adverse effects, leaving surgical interventions as the most promising option at this point.[3, 4]

Findings from these analyses suggest that another approach to interventions targeting overweight and obesity may be beneficial. Rather than focusing on diet and exercise, attending to life course transitions offers potential benefits. Pregnancy is a time when women may be prompted to attend to their own health in new ways. Evidence that maternal diet during pregnancy may influence the risk of obesity and other adverse outcomes among offspring offers the potential to motivate women to adopt dietary and lifestyle behaviors they previously evaded. Investigations of these pathways are needed.

The role transition to motherhood may have on obesity also compels us to reexamine the high proportion of pregnancies in the US, particularly among younger women, that are unintended. Public health arguments to prevent unintended childbearing have traditionally drawn upon evidence related to the negative social and economic consequence for women, children and families. Findings from these analyses point to potential negative consequences for women's health due to elevated BMI and its attendant co-morbid conditions such as cardiovascular disease and diabetes. Such an approach represents a fundamentally different context for unintended pregnancy prevention and merits additional consideration.

6.5 Limitations

Studies comparing measured height and weight data to self-reported height and weight consistently find the mean error is small and the variability is large.[7-9] Research also finds individuals over report height and underreport weight.[7] Differences by race and ethnicity have been identified, primarily in studies from 2003 forward.[10, 11]

Under optimal circumstances, measured height and weight would be available for the proposed study. Barriers to obtaining height and weight data are several. Cost is one factor, as settings in which measured height and weight data may be collected require equipment and trained personnel. Confidentiality is paramount in all data collection efforts; however, collecting anthropometric information requires privacy accommodations that are more expansive than surveys and interviews. Being weighed is sensitive for many women and may be approached with more reluctance than simply providing the information verbally. As a result women who are willing to participate in data collection that involves measured height and weight may be different from women in studies that collect self-reported parameters.

Self-reported weight, even when a woman desires to be forthcoming, still may suffer from reporting bias. A woman may provide an inaccurate weight because she has not weighed herself recently. In homes without scales, women may rely on the weight they remember from their most recent visit to a health care provider. Making accurate reporting dependent, in turn, on the ease with which she may access health care and the frequency with which she may be able to do so. Finally, it may be difficult for women to remember their most current height and weight, resulting in recall bias. Digit preference for reporting numbers that end in "5" or "0" also may occur among women regardless of how forthcoming or reluctant she may be about reporting her height and weight.

Nonetheless, despite these limitations, self-reported height and weight is the conventional source of data for studies that involve BMI.[7] Given the frequency with which self-reported height and weight data is used, it is important to consider the influence of misreported height and weight data on results. If the reporting error is systematic and consistently in the same direction, then misreporting will result in misclassification bias. Women commonly over report height and underreport weight, which biases results toward lower BMI classifications. Stommel and Schoenborn found that the majority of misclassified BMI by self-reported data are "within one unit of category boundary in question" and occur most often at the extremes of weight.[9]

Estimating the degree of misreporting, recall, and misclassification bias present in these analyses is difficult. Given the ages of women in the sample, height is not expected to change during the study period. It is reassuring, therefore, that height as reported in the sample remained stable over the seven waves of data. Nonetheless, examination of the data does reveal digit preference.

Internal validity is another potential concern with data from the Panel Study of Income Dynamics (PSID). PSID is one of the longest running panel studies in the US with some families participating for over 45 years. While panel duration offers rich longitudinal information, length of participation and responding to repeated survey questions over time also may result in response habituation and participant conditioning. As mentioned in chapter two, PSID conducted a study to validate its height and weight data. Andreski compared PSID height and weight data to self-reported height and weight data of the National Health Information Survey (NHIS).[12] Results are provided in chapter 2, Figure 3 and demonstrate that self-reported height and weight in PSID is comparable to other nationally representative surveys. Although these results do not address concerns about bias in self-reported height and weight data, it does provide reassurance that height and weight data from PSID are at least as robust as other large survey studies conducted in the US. It also may suggest that the multigenerational sample and exceptionally long study duration, forty-six years, may actually contribute to a greater willingness to disclose sensitive information over time.

6.6 Strengths

In situations where conditions cannot be randomly assigned, such as motherhood, it is scientifically important to examine research questions from perspectives that are methodically distinct. PSID is a nationally representative sample, whereas many studies of obesity and childbearing have drawn upon cross-sectional surveys and clinical samples. A key strength of this work, therefore, is contributing findings from a population-based panel to the investigation of obesity and childbearing. It is an advantage to have data that presents different strengths and limitations than those of cross-sectional surveys and clinical samples.

The impact of attrition is an important consideration for all panel studies. Fitzgerald and colleagues completed two expansive evaluations of attrition in the PSID. In 1998, they concluded that while overall accumulative panel attrition from 1968 was roughly 50%, authors found “no strong evidence that attrition has seriously distorted the representativeness of the PSID through 1989, and considerable evidence that its cross-sectional representativeness has remained roughly intact (p. 251).”[13] The second study considered attrition between generations through 2007.[14] They tested several attrition models and found “little evidence of attrition bias for female intergenerational models (p. 21).[14]

Attrition of less healthy participants is an important concern for studies that consider health outcomes. In his review, Fitzgerald refers to a study of selective attrition in PSID by health status completed by Halliday and Kimmitt in 2008 (p.2).[14] Their findings confirmed that individuals of poor health may be more likely to drop out but also found evidence that they are easier to track over time. Importantly, Fitzgerald also refers to two papers that used PSID to investigate health outcomes and specifically tested for selective effects of attrition on their findings (p.3).[13] Both studies concluded that selective attrition by health status did not alter their results. Overall, studies are reassuring that attrition in PSID is not a large problem.

PSID also is a contemporary sample. The waves included in these analyses are 1999 to 2011. Prevalence of overweight and obesity has changed significantly over the past five decades in the US but appears to be stabilizing in recent years among adults and decreasing among children.[15] In order to inform current policy decisions appropriately, studies need to draw upon the most recent data possible.

Finally, one of the principal sources of confounding in studies of overweight and obesity as well as health disparities is economic status. Since the original purpose of PSID was to study income and wealth in US households, this study benefited from some of best measures of income available. As a result, these analyses were able to address confounding more effectively. The study design also is a strength. Using multilevel analysis maximized the benefits of nested data. Incorporating pregestational BMI and the length of follow-up after childbearing are additional benefits.

6.7 Closing

The overarching goal of this dissertation is to promote our understanding of the pathways through which reproductive health events may contribute to women's long-term health status. It is motivated by the goal of understanding the impact of the transition to motherhood on obesity, with attention to the role of age at first birth. Findings point to a positive association between childbearing and increasing BMI, with the most substantial impact occurring with the first birth and among women who experience the transition to motherhood at 21 years or younger. By extension, these findings would suggest that by giving rise to an earlier onset of obesity, early childbearing may also result in earlier onset and longer duration of chronic diseases associated with obesity. While the present analyses provide weak evidence of age at first birth as a mediator of the association between minority status and BMI, it merits additional exploration with a sample that is capable of appropriately addressing this research question.

Chapter 6 Endnotes

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Loral Patchen, CNM
Curriculum Vitae

PERSONAL INFORMATION

Date of Birth: August 23, 1968

Home Address: 15 Jefferson Street NE
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LICENSURE

District of Columbia
License: RN960088
Issued: 1999
Renewal: June 1, 2010

Maryland
License: R144716
Issued: 1999
Renewal: August 31, 2010

Connecticut
License: E60671
Issued: 1998
Renewal: August 31, 2010

CERTIFICATION

American College of Nurse Midwives
Written Boards: 1999
Recertification: 2014

EDUCATION

Undergraduate	**Brown University** Providence, RI 1986 – 1990 Bachelor of Arts, Portuguese and Brazilian Studies
Graduate	**Johns Hopkins University** School of Advanced International Studies Washington, DC 1994 – 1996 Masters of Arts, International Economics
Nursing	**Yale University** School of Nursing New Haven, CT 1996 – 1999 Masters of Nursing, Midwifery
Doctorate Candidate	**Johns Hopkins University** Department of Population, Family and Reproductive Health Baltimore, MD 2010 – present

APPOINTMENTS

Adolescent Family Life Research Program
Office of Population Affairs Expert Work Group
Chair: Lorraine Klerman, DrPh
Participants: Melanie Brown, Sarah Brown, Blake Dohrn, Sumru Erkut, Alice Frye, Lynne Haverkos, Evelyn Kappeler, Douglas Kirby, Laurie Nsiah-Jefferson, Pat Paluzzi, **Loral Patchen,** John Santelli, Diana Schneider, Alison Spitz, and Maria Torres.
2009 – 2010

Clinical Faculty
Department of Obstetrics and Gynecology
Washington Hospital Center, Washington, DC
1999 – Present

LANGUAGES

- Native Speaker English
- Fluent Spanish
- Basic Portuguese

PROFESSIONAL EXPERIENCE

Washington Hospital Center
Director, Section of Midwifery

- 2008 – Present
- The Section of Midwifery brings comprehensive health care to women in the areas of normal obstetrics; reproductive health; contraceptive utilization; and sexual health. Responsible for strategic and operational leadership for midwifery services, as well as delivery of educational services that include academic research and grant activities.

Staff Attending

- 1999 – Present
- Washington Hospital Center is the largest hospital in the District of Columbia and serves as a tertiary care and referral center, averaging 4,500 deliveries annually. Responsibilities include providing obstetric and gynecologic care for patients, as well as supervising and teaching medical students, nursing students and residents in both inpatient and outpatient settings.

Executive Director, Center for Adolescent Women, Teen Alliance for Prepared Parenting (TAPP)

- 1999 – Present
- TAPP is a comprehensive program that provides clinical and psychosocial services to improve the well-being of pregnant and parenting adolescents age 17 and under. Over one-third of all pregnant adolescents in DC enroll in program services annually; at present, total active enrollment exceeds 500 clients, including teen mothers, fathers and their children. Responsible for overall implementation, management, and service delivery.

Provider, Unity Health Care, Nurse-Midwife

- 1999 – 2009
- Unity Health Care is the largest federally qualified health center in the District of Columbia, and provides medical and social services to uninsured and underserved residents, including a large immigrant population. Provided comprehensive obstetric and gynecologic care as well as family planning services for adolescents two days a week as part of a broad community initiative of Washington Hospital Center.

Consultant, 1996
The Partnership for Child Health Care, Inc. Washington, DC
Prepared report that summarized lessons learned to improve case management practices of non-formal health care practitioners.

Consultant, 1995 – 1996
World Bank, Washington, DC
1996: Researched and analyzed the social dimensions of economic development, the determinants of sustainability, and the role of local initiatives in project interventions. Topics included increased morbidity and mortality; food insecurity; and social disarticulation.
1995: Part of a team to assess environmental health in Africa, with a focus on Sub-Saharan Africa infrastructure operations. Wrote three annotated bibliographies for inclusion in the two-volume World Bank document Environmental Health in Africa.

Field Research Associate, 1990
National Institute of Health, Samoa
Drafted and implemented project plan for data collection in local villages for study that enrolled more than 1500 Samoan men and women. Coordinated study recruitment with local officials and village chiefs.

HONORS

Professional

- National Health Service Corps Scholarship, 1999

Nursing

- Sigma Theta Tau International Honor Society of Nursing, 1999

Undergraduate

- Minnie Helen Hicks Prize for undergraduate scholarship, Brown University, 1990

PROFESSIONAL SOCIETIES

Member, American College of Nurse-Midwives
1996 – Present

PUBLIC SERVICE

Member, MedStar Resident Research Day

- 2006 – 2009, This committee is responsible for judging resident research projects.

Midwifery Integration and Staff Midwife, 1998 – 2000
Prince George's Hospital Center, MD
Clinical training focused on providing care to economically marginalized populations. Obstetrical practice included management of advanced repairs, abnormal third stage, and physician co-management.

Clinical Volunteer, 1997
Community Health Care Van, New Haven, CT
Assisted the Clinical Director to provide primary care. The van served primarily IV drug users, sex workers, and the homeless.

Volunteer, 1991 – 1993
Peace Corps, Honduras
Assigned to work as a hill-side agricultural specialist. Wrote project plan, defined five-year goals, and developed an implementation strategy to establish a rural agricultural program in three subsistence villages.

INVITED LECTURES

Medstar Washington Hospital Center Department of Obstetrics & Gynecology Grand Rounds. *No Glove, No Love: Preventing Sexually Transmitted Infections among Youth in the Age of LARC*. December 20, 2012, Washington, DC.

DC Campaign to Prevent Teen Pregnancy. *The More You Know, The More You Can Help: A Roundtable for Frontline School Staff.* December 9, 2009, Washington, DC.

DC Public Schools Summer Institute for School Nurses. *When Mom Is Still A Kid*. August 14, 2008, Washington, DC.

Superior Court of the District of Columbia Annual Family Court Conference. *Adolescent Reproductive and Sexual Health: Prevention of High Risk Behaviors*. October 11, 2006, Washington, DC.

Office of Adolescent Pregnancy Prevention Annual Prevention Grantee Conference. *The Continuum of Adolescent Development*. September 25, 2006, Pittsburgh, PA.

Office of Adolescent Pregnancy Prevention Annual Adolescent Family Life Grantee Conference. *The Changing Landscape: New Developments in Contraception with Special Implications for Adolescents*. January 11, 2006, Washington, DC.

Office of Adolescent Pregnancy Prevention Annual Adolescent Family Life Grantee Conference. *Evaluation of OAPP Care Grantee Projects: Making the Partnership Work*. January 11, 2006, Washington, DC.

Washington Hospital Center Department of Obstetrics and Gynecology Grand Rounds. *Subsequent Pregnancy Prevention Among Teen Mothers: Does a Competency Building Approach Work?* January 3, 2006, Washington, DC.

Superior Court of the District of Columbia Annual Family Court Conference. *Depression in Pregnant and Parenting Adolescents*. October 4, 2004, Washington, DC.

DC Campaign to Prevent Teen Pregnancy. *Healing the Hurt Roundtable: Grief, Loss and Teen Pregnancy*. June 23, 2004, Washington, DC.

National Organization of Adolescent Pregnancy, Parenting, and Prevention National Conference. *Counseling Adolescents on Utilization of Contraception*. November 11, 2003, Washington, DC.

National Organization for Adolescent Pregnancy Prevention National Conference. *Using Best Practices for Subsequent Adolescent Pregnancy Prevention*. August 18, 2001, Washington, DC.

Society of Adolescent Medicine Annual Conference. *Gynecologic Challenges among Adolescents*. June 16, 2000, Washington, DC.

Washington Hospital Center Department of Obstetrics and Gynecology Grand Rounds. *Vertical Transmission of HIV-1 among Woman-Infant Pairs Who Received ZDV Intrapartum Only: What Do Pediatric Outcomes Tell Us?* November 28, 1999, Washington, DC.

SCHOLARSHIP AND RESEARCH

Active Grants

CMS 1D1CMS331151-01-00 *National Capital Strong Start*
Co-Principal Investigator: **Loral Pachen, CNM**. Total Project Period Award: $135,699 (02/15/13 – 02/17/13.

NICHD/NIH 1R43HD072823-01 *Sexually Active Adolescent Focused Education*, Co-Principal Investigator: **Loral Patchen, CNM**. Total Project Period Award: $150,000 (09/01/12 – 08/31/13).

Previous Grants

CHA-BSA-RFA-030609 *Pregnancy Prevention through Teen Empowerment.* Principal Investigator: **Loral Patchen, CNM**. Total Project Period Award: $230,000 (04/01/12 – 06/31/13).

OAPP/OPA/DHHS 1 APHA006064-01-00 *Adolescent Family Life Demonstration Projec*t: *Teen Alliance for Prepared Parenting-SPIN Parent Child Connectedness Enhanced Services Intervention*. Principal Investigator: **Loral Patchen, CNM**, co-Principal Investigator: W. Douglas Evans, PhD. Total Project Period Award: $1,500,000 (09/01/2010 – 02/28/13).

NICHD/NIH 2U01HD044253-04 *Community Child Health Research in Washington, DC*. Principal Investigator: Sharon L. Ramey, PhD; co-Principal Investigator: **Loral Patchen, CNM**; co-Principal Investigator: Robin G. Lanzi, PhD, MPH. Total Project Period Award: $2,500,000 (07/01/07 – 06/30/12).

CHA-BSA-RFA-030609 *Pregnancy Prevention through Teen Empowerment.* Principal Investigator: **Loral Patchen, CNM**. Total Project Period Award: $230,000 (12/01/10 – 11/30/11).

CHA-BSA-RFA-070109 *Perinatal Health Outcomes, District of Columbia.* Principal Investigator: **Loral Patchen, CNM**; co-Principal Investigator: Melissa Fries, MD. Total Project Period Award: $250,000 (09/30/09 – 09/30/10).

OAPP/OPA/DHHS 5 APHA002026-05-00 *Adolescent Family Life Demonstration Projec*t: *Teen Alliance for Prepared Parenting*. Principal Investigator: **Loral Patchen, CNM**, co-Principal Investigator: Barbara Sugland, ScD. Total Project Period Award: $1,450,000 (07/15/2001 – 07/14/06).

Publications in Refereed Journals

Patchen, L, LeTourneau, K, Berggren, E. *Evaluation of an Integrated Services Program to Prevent Subsequent Pregnancy and Birth among Urban Teen Mothers*. Soc Work Health Care. 2013 Aug; 52(7):642-55.

Patchen, L; Lanzi, RG. *Maternal depression and rapid subsequent pregnancy among first time mothers.* MCN The American Journal of Maternal Child Nursing. 2013 Jul-Aug;38(4): 215-20.

Evans, W.D., **Patchen, L**., Pease, T.E., Nestle-Patt, J.P. & Wallace, J. (2012). Teen Pregnancy Prevention Among At-Risk Urban Youth: Improving Parent-Child Connectedness. In S.R. Notaro (Ed.), *Health Dispartities Among Under-Served Populations: Implications for Research, Policy and Praxis* (pp. 177-206). United Kingdom: Emerald.

Lanzi, R., **Patchen, L**., Bert, S.C. (2011). Experiences with childhood trauma and prenatal depression among first-time adolescent and young adult mothers: Risk factors for subsequent pregnancy within twelve months. Free Inquiry in Creative Sociology, 39(2), 35-44.

Berggren, E., **Patchen, L.** *Prevalence of Chlamydia trachomatis and Neisseria gonorrhoeae and Repeat Infection Among Pregnant Urban Adolescents*. Sex Transm Dis. 2011 Mar;38(3):172-4.

Patchen, L., Berggren, E. Use of the Copper T380A Intrauterine Device by Adolescent Mothers: Continuation and Method Failure. J Pediatr Adolesc Gynecol. 2011 Apr;24(2):71-3.

Patchen, L., Caruso, D., Lanzi, R.G. *Poor Maternal Mental Health and Trauma as Risk Factors for a Short Interpregnancy Interval among Adolescent Mothers.* Journal of Psychiatric and Mental Health Nursing 2009; 16:401-403.

Patchen, L., Beal, M. *Preventing Perinatal Transmission of HIV: An Evidence-Based Update for Midwives*. Journal of Midwifery and Women's Health 2001; 46:354-365.

Patchen, L., Khoshnood, K. *Risk of Perinatal Transmission with Treatment Combinations of Intrapartum and Newborn Zidovudine Monotherapy*. The AIDS Reader 2001; 11:233-277.

Scientific Presentations

Ramey, SL., Lanzi, R., **Patchen, L**. *Inter-birth Intervals, Parent Relationships, and Maternal and Child Outcomes*. Oral presentation, #1528931, in symposium "Do Developmental Vulnerability Begin Before Conception?" 2013 SRCD Biennial Meeting April 18th, Seattle, Washington.

Lanzi, R., Waggoner, M., Timraz, N., Klerman, L., Ramey, S., **Patchen, L.** *Pregnancy Intentions, Contraceptive Use, and Subsequent Births among Adolescent and Adult Mothers.* Oral presentation, Abstract #205149, American Public Health Association 137th Annual Meeting, November 10th, 2009, Philadelphia, PA.

Lanzi, R., Lefever, J., Guest, K., **Patchen, L.** *Early Maternal Depression in Relation to Parenting and Child Outcomes among Adolescent and Adult Mothers.* Oral presentation, Abstract #205178, American Public Health Association 137th Annual Meeting, November 11th, 2009, Philadelphia, PA.

Berggren, E., Andrus, A., Conroy, E., **Patchen, L.,** Lanzi, R. *Shortened Inter-pregnancy Intervals among Adolescent Mothers: The Influence of Maternal Depression.* Oral presentation, Abstract #207114, American Public Health Association 137th Annual Meeting, November 10th, 2009, Philadelphia, PA.

Abstracts

Lanzi, R., Bert, S., **Patchen, L.** *Adolescent and young adult maternal depression, childhood trauma experiences, and children's social/emotional development: Findings and implications from a multi-site, longitudinal, prospective study.* Poster presentation, Abstract #*292661*, American Public Health Association 141th Annual Meeting, November 4th, 2013, Boston, MA.

Lanzi, R., Ramey, S., **Patchen, L**., Lefever, J. Longitudinal Effects of

Chronicity and Severity of Maternal Depression on Family and Child Functioning: Cross-Study Findings. Society for Research in Child Development Biannual Meeting, March 31, 2011, Montreal, Quebec, Canada.

Patchen, L., Berggren, E., Conroy, E., Amini, D., Miodovnik, M., Umans, J. *Weight Retention in Teen Mothers: Do Nine Months Stay with You Forever?* Society for Gynecologic Investigation 57th Annual Meeting, March 27th, 2010, Orlando, FL.

Shveiky, D., **Patchen, L.**, Amini, D., Landy, H., Miodovnik, M., Umans, J. *Are Primiparous Women at Extremes of Age at Increased Risk for Vaginal and Perineal Tears?* Society for Gynecologic Investigation 57th Annual Meeting, March 25th, 2010, Orlando, FL.

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