AN INNOVATIVE STRATEGY TO UNDERSTAND AND PREVENT PREMATURE DELIVERY: THE PRE-PREGNANCY HEALTH STATUS OF WOMEN OF CHILDBEARING AGE

DISSERTATION

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ABSTRACT

Rates of preterm delivery in the United States vary by race/ethnicity and socioeconomic status. Previous research has focused on factors during pregnancy which impact the risk for preterm delivery. With little success in reducing overall rates of preterm delivery, focus has shifted to pre-pregnancy health status. Pre-pregnancy health status has a significant impact on pregnancy outcome, including the risk for preterm birth. With disparate rates of preterm birth associated with race/ethnicity and socioeconomic status, this dissertation tests whether subgroups with historically increased rates of preterm delivery also have worse pre-pregnancy health status. In addition, the impact of race/ethnicity and socioeconomic status on the pre-pregnancy health status of women of childbearing age is examined.

This secondary analysis of the National Health and Nutrition Examination Survey (NHANES) 2001-2004 examines the impact of income on douching behavior in women, as well as the impact of race/ethnicity and other sociodemographic factors on pre-pregnancy health status measured as allostatic load. Allostatic load is a theoretical concept operationalized in this dissertation to reflect the impact of life stressors and behavioral responses to stressors on health status of non-pregnant women of childbearing age and quantifies pre-pregnancy health status. It is comprised of ten variables impacted
by stress, that are known to increase the risk for preterm delivery, and to be negatively related to race/ethnicity and socioeconomic status: bacterial vaginosis, trichomonas vaginalis, periodontal disease, systolic and diastolic blood pressures, homocysteine, smoking status, body mass index, iron deficiency anemia, and glycated hemoglobin. A score is produced depending on the number of variables in which the individual scores in the high risk range.

Overall findings indicate that African American women have worse pre-pregnancy health (higher allostatic load scores) than white or Mexican American women. Measures of socioeconomic status impact allostatic load scores differently for each racial/ethnic group. In addition, while African American women have a greater prevalence of douching behavior, decreased income for white women increases their likelihood of douching, suggesting that race is not the only risk factor for douching. This dissertation presents a novel approach of exploring the pre-pregnancy health status of women by specific sub-groups at risk for preterm delivery with the goal of reducing rates of preterm delivery.
Dedicated to the loving memory of my Grandpa, Charles Graham Kiskaddon, Jr., whose life was lived with enthusiasm, vigor, strength, determination and “Happy Days”.
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CHAPTER 1

INTRODUCTION

As a clinician managing normal pregnancies and always on the lookout for abnormal findings, the unexplained nature of preterm birth is both confusing and compelling. Poor birth outcomes including preterm delivery have been associated with minority racial status (Ahern, Pickett, Selvin, & Abrams, 2003; Demissie et al., 2001; Rosenberg, Palmer, Wise, Horton, & Corwin, 2002) and low socioeconomic status (Ahern et al., 2003; Kramer, Seguin, Lydon, & Goulet, 2000; Kramer et al., 2001; Nagahawatte & Goldenberg, 2008; Pickett, Ahern, Selvin, & Abrams, 2002; Reagan & Salsberry, 2005; Savitz et al., 2004). The March of Dimes reports that from 2002-2004 in the United States preterm birth rates were highest for black infants (17.8%) when compared to other racial/ethnic groups (March of Dimes, 2008). In addition, Savitz and colleagues note that poverty and varying educational levels significantly impact the risk for preterm delivery in African American and white women (Savitz et al., 2004).

Much of the work on causes of preterm delivery has focused on those risk factors which occur during pregnancy. For example, Goldenberg and colleagues report on risk factors for preterm delivery such as fetal fibronectin and shortened cervix, both factors which impact the risk for preterm delivery during pregnancy (Goldenberg et al., 1998).
Likewise, in a review of literature on causes of socioeconomic disparity in birth outcomes, Kramer notes that genitourinary infection, incompetent cervix, and cigarette smoking are major risk factors for preterm delivery during pregnancy (Kramer et al., 2000). Nagahawatte remarks that poverty is typically associated with decreased use of prenatal care and increased numbers of medical risk factors which put the woman at risk for preterm delivery (Nagahawatte & Goldenberg, 2008). Specific single health factors have also been examined during pregnancy that increase the risk for preterm delivery. These include periodontal disease (Jeffcoat et al., 2003; Xiong, Buekens, Fraser, Beck, & Offenbacher, 2006), vaginal infections (Hitti et al., 2007; Karinen et al., 2005; Pararas, Skevaki, & Kafetzis, 2006), and hypertension (Samadi & Mayberry, 1998; Sibai et al., 2000) among others.

Although over the last decade general improvement has been made in infant survival after preterm delivery, the disparity between African American and white infant mortality has increased (Hogue & Bremner, 2005). Neither has focusing on risk factors during the pregnancy itself improved pregnancy outcomes to the desired level (Haas et al., 2005). As a result, a shift in focus has been made to pre-pregnancy healthcare, i.e. improving the health of women prior to pregnancy. The concept of pre-pregnancy health improvement is not new. In 1985, the Institute of Medicine noted that “Much of the literature about preventing low birthweight focuses on the period of pregnancy…By contrast, little attention is given to opportunities for prevention before pregnancy.” (p. 119).
Research suggests that pre-pregnancy health status is one of the key predictors of a successful pregnancy outcome and is often impacted by life stress (Conley, Strully, & Bennett, 2003; Haas et al., 2005; Hogue & Bremner, 2005; Lu & Chen, 2004). In her 2005 report, Haas notes that risk factors that occurred prior to pregnancy explained 39.8% of the risk for preterm delivery indicating that pre-pregnancy health has a significant impact on pregnancy outcome including preterm delivery. This leads to the major hypothesis for this dissertation work: given that pre-pregnancy health status has a significant impact on pregnancy outcome, subgroups with high levels of poor birth outcomes will have worse pre-pregnancy health status than other groups. The overall aim of this dissertation work is to explore this hypothesis.

Data from the National Health and Nutrition Examination Survey (NHANES) 2001-2004 are analyzed throughout this dissertation in order to investigate the hypothesis. Started by the National Center for Health Statistics, part of the Centers for Disease Control and Prevention in the 1960’s, each NHANES is cross-sectional and estimates the numbers and percentages of people in the United States population and subgroups with specific diseases and risk factors. When collecting data for the NHANES 2001-2002 and 2003-2004, low-income persons, adolescents 12-19 years, persons 60+ years of age, African Americans and Mexican Americans were over-sampled. A nationally representative sample of the U.S. civilian non-institutionalized population was selected for each survey using a complex, stratified, multistage probability cluster sampling design that allows results to be generalized to the U.S. population (Centers for
Disease Control and Prevention (CDC). National Center for Health Statistics (NCHS), 2004).

Data in the NHANES were collected by interview, examination, and laboratory tests based upon urine and blood samples. Interview data, typically collected in the participant’s home, are based upon self-report. All physical examinations and laboratory tests are conducted in Mobile Examination Centers (MEC) where a specially trained staff performs survey examinations only. Each individual involved in data collection for the NHANES participates in comprehensive training and annual refresher training for quality assurance. In addition, laboratory protocols are extensively reviewed in order to ensure high quality and accuracy. Since 1999 NHANES data have been collected continuously (Centers for Disease Control and Prevention (CDC). National Center for Health Statistics (NCHS), 2004). Part of the data collected by interview for the NHANES is race/ethnicity. The five choices allowed for self-reported race/ethnicity include: Mexican American, Other Hispanic, Non-Hispanic White, Non-Hispanic Black and other, including multi-racial. Included in this dissertation are analyses of Mexican American, Non-Hispanic White and Non-Hispanic Black women. From this point forward, Non-Hispanic White women will be referred to as “white” and because the NHANES dataset does not allow distinction of country of birth for Non-Hispanic Black women, all who self-identify in this group will be referred to as “African American”.

In Chapter 3 and Chapter 4 the racial/ethnic group Mexican American is subdivided by country of birth, either the United States or Mexico, in order to understand the impact of acculturation on the health and health behaviors of the individual.
Acculturation is described as the process of acquisition of the cultural elements of the dominant society (Lara, Gamboa, Kahramanian, Morales & Bautista, 2005) and has been described as a stress-producing process (Farley, Galves, Dickinson & Diaz Perez, 2005). It is important to understand the impact of acculturation because the literature describes a paradox in which Mexico-born Mexican American women (those considered less acculturated), even though they may have low socioeconomic status, have fewer poor birth outcomes, including fewer preterm deliveries and fewer low birth weight deliveries, than U.S. born Mexican American, or non-Hispanic white women (Abraído-Lanza, Chao, & Flórez, 2005; Buekens, 2000; Cervantes, Keith, & Wyshak, 1999; Guendelman, Thornton, Gould, & Hosang, 2006). In addition, Mexico-born Mexican American women are reported to have significantly fewer sexually transmitted infections and are less likely to use substances such as drugs, alcohol or cigarettes (Heilemann, Lee, Stinson, Koshar & Goss, 2000). Lara and colleagues (2005) note that the dietary habits of the less acculturated tend to be better than those who are more acculturated with less fat, more fiber, more protein, folate and vitamins and minerals included in the diet, which may contribute to improved health outcomes.

The underlying cause of these differences in health by acculturative status has not been described. It is possible that low socioeconomic status impacts Mexican American women born in the U.S. or Mexico differently. Farley and colleagues (2005) report that despite their generally better health, Hispanics in the United States tend to have a lower socioeconomic status than whites, experience difficulty accessing healthcare services due to a lack of insurance and language barriers, and through acculturation can experience
greater stress and psychosocial problems. Despite the increased stress, Mexico-born Mexican Americans were least likely to engage in substance abuse as a coping strategy, but were more likely to use positive reframing, denial and religion when compared to U.S.-born Mexican Americans and white women (Farley et al., 2005). The differences noted in coping strategy by country of birth may help explain the differences in health behaviors and health among a group with similar low socioeconomic status. It is possible that these culturally specific coping strategies reduce stress rates and limit the negative effects of stress on the body. By recognizing country of birth in the analyses included in Chapters 3 and 4 as a proxy measure for acculturative status, this dissertation better explains the impact of acculturation on the health, health behaviors, and allostatic load of Mexican American women.

Allostatic load, a theoretical concept reflecting the health status of an individual in light of an accumulation of insults or stressors and the behavioral response to the stressors to which the individual is exposed (McEwen, 1998), is used in this dissertation to quantify pre-pregnancy health status. Although most of the time individuals are able to respond to day-to-day stressors without an accumulation of negative health effects, eventually wear and tear on the body from the repeated stressors impacts the health status of the individual (McEwen, 1998). In the following dissertation, the allostatic load of child-bearing aged women is operationalized by summing indicator scores for health variables for which the individual is in the high risk range. These variables are not only associated with stress related to minority racial/ethnic status and low socioeconomic status, but are also known to increase the risk for premature birth. In light of the aim of
this dissertation to test whether the pre-pregnancy health status of women is worse in subgroups with high rates of poor birth outcomes, Chapter 2 provides a theoretical orientation to the concept of allostatic load by discussing the effects of stress on the body and common stressors, with a specific focus on pre-pregnancy health and preterm delivery. In this chapter, details regarding the variables which comprise the allostatic load score are presented.

In addition to addressing the impact of stress on pre-pregnancy health, specific health behaviors in reaction to stressors can also impact pre-pregnancy health status, measured as allostatic load. Some of these behaviors may be more prevalent in specific sub-groups of the population. Chapter 3 uses the theoretical concept of allostatic load to investigate the impact of low socioeconomic status on a specific behavior, douching. Douching is a behavior which is not only associated with preterm delivery, but also with minority racial/ethnic status, specifically, African American race. The literature does not demonstrate, however, how poverty or low socioeconomic status contributes to douching behavior. It is plausible that poverty may increase the likelihood of douching in women who lack access to healthcare access, resources, or education about the potential harms of douching due to insufficient financial resources. Therefore, it is important to understand the impact that income has on douching behavior in order to understand predictors of douching behavior, especially as they relate to stress associated with low socioeconomic status. 3,522 women representing the experience of 58,306,679 African American, Mexican American and white U.S. women between the ages of 14 and 49 are included in the analysis. Findings suggest that socioeconomic status plays a significant role in
douching behavior, demonstrating that race is not the only risk factor for douching. This chapter provides insight into the disparity in poor birth outcomes for specific subgroups of the population by investigating who douches.

The major aim of this dissertation, to test whether pre-pregnancy health status is worse in subgroups of women with historically worse birth outcomes, is tested in Chapter 4. The pre-pregnancy health status, measured as allostatic load, of child-bearing-aged women by specific subgroup (minority race and socioeconomic status) is presented in detail. In addition, key predictors of increased allostatic load for each racial/ethnic group are presented in this chapter. 1,497 women are included in this analysis, representing the experience of 24,276,859 African American, Mexican American and white U.S. women aged 15 to 35. Findings reveal that African American women have worse overall pre-pregnancy health and the impact of socioeconomic variables on pre-pregnancy health differs for each racial/ethnic group.

In the first four chapters, this dissertation explores the overall theoretical concepts related to allostatic load and pre-pregnancy health, examines the impact of a particular stressor on a negative health behavior with significant impact on pregnancy outcome and then tests the hypothesis regarding varying pre-pregnancy health status by subgroup. Chapter 5 presents findings to a question correlating current allostatic load score with reported history of preterm birth. 460 African American, Mexican American and white U.S. women aged 15-35 who report at least one live birth are included in the analysis. Although cross-sectional, this chapter pilot-tests the assertion that poor pre-pregnancy health is associated with poor birth outcomes.
Chapter 5 also provides an overall summary to the results of this dissertation. Key findings, interpretation of the findings, limitations, and implications for clinical practice and future research are presented. By determining the pre-pregnancy health status of women by specific subgroup with increased risk for poor birth outcomes, clinicians have the opportunity to tailor their care and attempt to reduce rates of preterm delivery. The findings in this dissertation provide a stepping-stone for future research on pre-pregnancy risk factors for preterm delivery, and represent a new way to understand and prevent preterm delivery.


CHAPTER 2

A THEORETICAL APPLICATION OF ALLOSTATIC LOAD TO WOMEN’S HEALTH

Introduction

For many women, pregnancy is not a planned event. In 2001, nearly one-half of all pregnancies in the United States were unintended (Finer & Henshaw, 2006), preventing the opportunity for many women to improve their health prior to the start of the pregnancy, or to seek pre-pregnancy counseling or planning advice. Even among those who do plan their pregnancies, some may try to lead a healthier lifestyle, and may visit a healthcare provider in preparation for pregnancy, but others do not (Barrett & Wellings, 2002). Many professional organizations suggest that every non-pregnancy related visit to a healthcare provider for a reproductive-aged woman ought to address her health in general, with a focus on “pre-pregnancy” health because every woman who is not currently pregnant, but who has the ability to become pregnant may be considered pre-pregnant (American Academy of Pediatrics/ American College of Obstetricians and Gynecologists, 2002; American College of Nurse Midwives, 2007; Braveman, Marchi, Egerter, Pearl, & Neuhaus, 2000; Haas et al., 2005). Because many pregnancies are
unplanned, however, women often have unaddressed or uncontrolled health conditions or high levels of chronic stress that preclude them from carrying a pregnancy to term, or that contribute to an increased risk for pregnancy-associated complications including preterm birth. This review will begin with a brief discussion about stress, behavioral responses to stress, and contributors to stress. Next the effects of stress on immune/inflammatory function, the cardiovascular system, and metabolic function will be discussed, followed by a review of physiological contributors to preterm delivery and application of allostatic load as it relates to stress, women’s health and, in particular, preterm delivery.

Stress

Stress has many physiological effects on the body, both positive and negative (Sapolsky, Romero, & Munck, 2000). During an acute stressful experience, the sympathetic nervous system and the hypothalamic pituitary adrenal axis are activated, leading to increased catecholamine release and increased adrenal secretion of cortisol. As a result, the body experiences the “fight or flight” response including an abrupt increase in blood pressure, anabolic breakdown of foodstores, and a focusing of attention and resources on what is causing the stress – i.e., the stressor and how to respond to it (Sapolsky et al., 2000). For the immediate stressful experience, this response helps the individual manage the stressor(s) presented, perhaps by fleeing the situation. Over time, however, repeated or prolonged stressful situations can cause damage to the individual and contribute to a physiological burden of stress, which is often measured using the concept of allostatic load (McEwen & Lasley, 2003). The effects of stress are seen in
immune/inflammatory, cardiovascular, and metabolic function (Sapolsky et al., 2000), as well as in behavioral responses (McEwen, 1998).

Just as there are both positive and negative effects of stress on the body in general, there are positive and negative effects of stress on immune function and inflammation. Acute stress enhances immune function in anticipation of injury (Vanitallie, 2002). Infectious and non-infectious stressors can cause rapid immune activation including the release of pro-inflammatory cytokines which then contribute to subsequent glucocorticoid release, enhancing the stress response by stimulating the adrenocortical axis (Sapolsky et al., 2000). The immediate effect of enhanced immune and stress responses assists the individual in protection during the acutely stressful situation. Prolonged exposure to stressors, however, can diminish the immune response (Glaser & Kiecolt-Glaser, 2005). Chronically elevated cortisol secondary to increased stress levels decreases immune function and inflammation, making the individual more susceptible to infection and other disease (McEwen & Lasley, 2003). Glaser and Kiecolt-Glaser note that chronic stress can disrupt the production of pro-inflammatory cytokines which are important for wound healing, decreasing the rate of wound repair (Glaser & Kiecolt-Glaser, 2005). In this way, chronically elevated levels of stress can contribute to the physiological burden of stress, in this report operationalized as the allostatic load, by diminishing immune function and inflammatory processes (McEwen & Lasley, 2003). This is observed in the pre-pregnancy health of women with respect to their immune and inflammatory function.
Cardiovascular function is also impacted by stress levels positively and negatively. Acute stressful episodes cause abrupt increases in blood pressure secondary to the release of cortisol and norepinephrine (Sapolsky et al., 2000). Increased blood pressure may enable an individual to flee from a stressful situation. If surges in blood pressure are experienced with frequency due to chronic or repeated stressors, however, damage may occur to blood vessels, setting the stage for atherosclerosis (McEwen & Lasley, 2003). Stress induces cytokine release, which with the major stress hormones and surges in blood pressure causes endothelial damage and adhesion of platelets (Black & Garbutt, 2002). Platelet aggregation can lead to thrombus formation and myocardial infarction or stroke (Vanitallie, 2002). Furthermore, frequent cortisol secretion and increased tone of the sympathetic nervous system in response to stress increases peripheral vasoconstriction leading to chronically increased blood pressure (Vanitallie, 2002) or hypertension. In addition, elevated homocysteine levels, which may be attributable to stress and sympathetic nervous system mediation, contribute to endothelial damage, platelet activation, thrombosis, inflammation and smooth muscle hyperplasia (Black & Garbutt, 2002; Stoney, 1999). In her study, Stoney (1999) found that plasma homocysteine levels were positively correlated with systolic blood pressure during acute stressful episodes, suggesting sympathetic nervous system mediation. The impact of stress on the cardiovascular system is beneficial in the immediate, but over the lifespan, can cause significant injury and morbidity, increasing the physiological burden of stress and allostatic load.
The impact of stress on the metabolic system during an acute stressful situation includes a rapid elevation of blood glucose, partially due to a release of glycogen from storage and an increase in insulin resistance, inhibiting further glucose storage secondary to catecholamines, glucagon and growth hormone (Sapolsky et al., 2000). This allows energy to be diverted to large muscle groups so that the individual can flee the acutely stressful situation. If an individual already has diabetes mellitus, increased insulin resistance and gluconeogenesis can further impair glucose control (Vanitallie, 2002). With chronic stress and subsequent chronically elevated levels of cortisol, insulin resistance leads to increased visceral obesity, weight gain and increased risk for diabetes mellitus (Vanitallie, 2002). The positive benefits of stress on metabolic function during an immediate stressful situation which provide increased availability of glucose for energy can negatively impact an individual over longer periods of time, increasing the physiological burden of stress, contributing to an increased allostatic load. Consideration of immune/inflammatory, cardiovascular and metabolic function is made in this operationalization of allostatic load, as shown in Figure 2.1.

The manner in which an individual responds to stressful situations or daily life stress may be due in part to hypothalamic pituitary adrenal axis (HPA axis) programming received early in life or in utero. For example, long-term Romanian orphans, who did not have emotional support or stimuli while in the orphanage, tend to be high cortisol reactors later in life (Hertzman, 1999). This is likely due to the lack of stimulation in the orphanage that caused an up-regulation of glucocorticoid receptors such that any stimulus which causes a release of cortisol triggers a large stress response. At the same time,
using the Helsinki birth cohort, Kajantie and colleagues found that individuals aged 60 to 70 years with low reported birth weights also had low cortisol concentrations in response to stressful situations (Kajantie, et al., 2007). This provides support for fetal programming of the stress response. In these individuals, stressful situations in utero not only contributed to a decreased birthweight but also likely led to a down-regulation of cortisol receptors, blunting HPA axis function and the stress response later in life.

The behavioral responses to stress. In addition to direct physiological effects of stress on the body, stress also impacts behavior. As shown in Figure 2.1, the behavioral responses to stress included in the model are smoking, physical activity, diet and sexual risk behaviors. As described below, each of these behaviors also impacts a woman’s pre-pregnancy health status. Stressed individuals are more likely to have health habits which enhance their risk for worse health including poorer nutrition, less activity and increased cigarette use (Glaser & Kiecolt-Glaser, 2005; Kristenson, Eriksen, Sluiter, Starke, & Ursin, 2004). In a qualitative study identifying motivators and barriers to healthful eating and physical activity, some low-income, overweight women noted that when they felt stressed they coped by eating high calorie foods (Chang, Nitzke, Guilford, Adair, & Hazard, 2008). The same group of women noted that “if they had time, they would take a walk to relieve their stress” (p. 1026), but that they felt over-burdened and exhausted, making exercise nearly impossible (Chang et al., 2008). As a result, those who eat high calorie foods in order to cope with stress not only experience the negative physiological effects of stress as described above, but are also burdened with the physiological outcome
of increasing body weight. Smoking is another negative health habit that is sometimes identified as a pleasurable behavior used for coping with stress, but it may actually contribute to increased stress levels and increase the impact of stress on mortality (Krueger & Chang, 2008). Again, in this instance, individuals who smoke to cope with the stress in their lives experience negative physiological effects of stress in addition to the negative cardiovascular sequelae associated with smoking.

In addition to diet, activity and cigarette smoking, Brady and Sinha (2005) note that stress stimuli and emotional stress can increase drug-craving in those already dependent upon drugs. Drug use in response to stress can lead to risky sexual behaviors in order to obtain the drugs necessary to manage the drug cravings (Edwards, Halpern & Wechsberg, 2006). Lorvick and colleagues report that female methamphetamine users were more likely than non-methamphetamine injectors to report unprotected anal intercourse, multiple sexual partners and other risky sexual behaviors (Lorvick, Martinez, Gee & Kral, 2006). Bachanas and colleagues (2002) report high rates of risky sexual behavior in African American adolescent girls who also report high rates of substance use and whose peers also engage in risky sexual behaviors. Trichomonas vaginalis infection is one sexually transmitted infection that is more common among African Americans, related to risky sexual behaviors, associated with increased number of sexual partners, increased age, low education, poverty and douching (Sutton et al., 2007). By engaging in risky sexual behaviors, either to obtain drugs used to manage stress or for other reasons, women often are forced to suffer the negative consequences of their actions, including sexually transmitted infections. The health behaviors included in this dissertation (diet,
activity, smoking and sexual risk behaviors) are each influenced by stress, but also increase the physiological burden of stress measured as allostatic load.

Stressors: Minority race/ethnicity and low socioeconomic status. After considering the negative effects of stress on immune/inflammatory, cardiovascular and metabolic function, as well as on behaviors which increase the risk for poor health, it is important to consider contributors to stress. Stressors have been conceptualized in research in many different ways: as negative life events, the experience of daily hassles, psychological distress, and as perceived stress (Gennaro & Hennessy, 2003). Low socioeconomic status (SES) and minority race/ethnicity are often considered chronic stressors (Adler & Newman, 2002; Geronimus, Hicken, Keene, & Bound, 2006; Giscombe & Lobel, 2005). Evidence exists demonstrating that people in low SES groups experience greater stress than those in high SES groups due to economic strain, job insecurity, low levels of control at work and stressful life events (Adler & Newman, 2002; Marmot, 2004; Brunner, 1997). High levels of morning cortisol are associated with lack of social recognition, increased job stress and high levels of perceived stress, which can lead to attenuated stress responses (Kristenson et al., 2004). Stress responses are important for health and protection of the individual in light of a variety of stressors, but increased baseline cortisol levels, in this case elevated due to economic pressures, tend to decrease stress responses in acute situations (Kristenson et al., 2004). In addition, Mirowsky and Ross (2003) note that low levels of education prevent individuals from not only seeking resources necessary for their health and well-being but also prevent these individuals
from recognizing which resources are needed. For this reason, low SES when considered a chronic stressor refers to economic strain, lack of access to resources, lack of knowledge about necessary resources, and other stressful life events associated with poverty.

The effect of socioeconomic stress on health is seen with every measure of socioeconomic status considered, including education, income, occupation and employment status; health increases as socioeconomic status increases (Mirowsky & Ross, 2003). Mirowsky and Ross suggest that while income may grant individuals access to resources, education enables individuals to seek necessary resources and also to make better decisions for health (Mirowsky & Ross, 2003). It is important also to note that while low socioeconomic status can contribute to poor health through these mechanisms, it is also possible that poor health can have a reverse causative effect on socioeconomic status: if an individual is too ill to work or access resources, SES may fall further. Additionally, education may impact the ability of an individual to obtain employment and health insurance, which further influences the ability of an individual to see a healthcare provider. And finally, for much of the United States, SES accounts for much of the variation in racial disparities in health, often making it difficult to separate out causative factors for poor health (Williams, 1999). Low socioeconomic status, when considered in terms of lack of access to resources, lack of access to healthcare or healthcare knowledge, and stressful life events associated with poverty, may be considered a chronic stressor in the lives of many.
Evidence also exists that racism, both individual and structural, as is frequently reported by African Americans and other minority racial/ethnic groups, is stressful (Klonoff, Landrine, & Ullman, 1999). Williams notes that the stress of experiences of discrimination, racial/ethnic bias in health care and residence in poor neighborhoods all contribute to the impact of race/ethnicity on health (Williams, 1999). Giscombe and Lobel suggest that there is ample evidence that African Americans experience individual, structural and other forms of racism and that racism is a form of chronic stress (Giscombe & Lobel, 2005). In an examination of cardiovascular reactivity secondary to discrimination in African American and European American women, African American women who perceived discrimination had increased levels of diastolic blood pressure reactivity than those who did not perceive discrimination, demonstrating that racial discrimination is a chronic stressor with pathophysiological results (Guyll, Matthews, & Bromberger, 2001). For these reasons, minority race/ethnicity is considered a chronic stressor and refers to perceived discrimination, racial/ethnic bias in health care and residence in poor neighborhoods.

Allostatic Load

Allostatic load is theoretical concept contained within the broader framework of stress and physiological responses to stress. It is used to reflect the current health status of an individual in light of an accumulation of insults or stressors to which the individual has been exposed throughout his or her lifetime (McEwen, 1998). That is, allostatic load reflects an individual’s physiological burden of stress that is present as a result of a lifetime of stress. Although most of the time individuals are able to respond to day-to-
day stress without an accumulation of negative health effects, eventually wear and tear on the body from repeated or chronic stress impacts the physiological health of several biological systems of the individual. By combining the impact of stress on several biological systems into one variable, allostatic load assists in understanding the cumulative and synergistic nature of the physiological burden of stress.

Allostatic load increases with time and may be variable depending upon an individual’s resources for managing stress (Goldstein & McEwen, 2002; McEwen & Wingfield, 2003). The theoretical concept of allostatic load, depicted in Figure 2.1, helps to explain the relationship between the chronic stressors minority race/ethnicity and low socioeconomic status (SES), the behavioral response to these stressors, and the impact of the stressors on the health of pre-pregnant women. By considering each of these parts of allostatic load as depicted in Figure 2.1, it is possible to better understand the risk of poor pre-pregnancy health for women.

Figure 2.1 is adapted from a figure by McEwen (McEwen, 1998) in which environmental stressors associated with work, home and neighborhood, as well as major life events, trauma and abuse are considered stressful situations. McEwen describes that an individual’s perception of these stressful events is influenced by individual differences in life experiences, genetics and behaviors. The perception of stress, as helplessness, threat, or the need for vigilance can directly diminish health, initiating physiologic responses. These responses can range from healthy positive responses, allostasis, to negative health effects, measured as allostatic load. With increased negative health effects, allostatic load is increased. The perception of stress can also influence behavioral
responses to the stress such as the fight or flight response, and personal behaviors such as diet, exercise, drinking, and smoking. The individual differences in life experiences, genetics and behavior, as well as the behavioral responses to the stress, can worsen health causing negative physiologic responses and increasing allostatic load. Figure 2.1 was adapted from McEwen’s (McEwen, 1998) figure in order to reflect the impact of life stressors, minority race/ethnicity and low socioeconomic status, on behavioral responses and health status of pre-pregnant women, with a specific focus on pregnancy outcome.

The relationship between race/ethnicity, life stress and the physiological burden of stress measured as allostatic load is evident in the weathering hypothesis put forth by Geronimus (Geronimus et al., 2006). This hypothesis posits that race is a stressor to African American women causing accelerated health deterioration as a result of racism, political marginalization and socioeconomic disadvantage (Geronimus, 1992; Geronimus, 1996; Geronimus et al., 2006). An analysis by Geronimus of singleton births to white and African American Michigan residents in 1989 supports the relationship between race/ethnicity, socioeconomic status, allostatic load and pregnancy outcome (Geronimus, 1996). Linked birth and infant death certificate data demonstrated that among African Americans, but not whites, maternal age beyond 15 years was associated with increased rates of low birth weight delivery (Geronimus, 1996) suggesting that as African American women age, their ability to achieve healthy pregnancy outcomes decreases. This is the opposite of what occurs in general for white women, for whom pregnancy outcome is typically poorer for teenage mothers, improving as women age, until the time of advanced maternal age, i.e., over 35 years. Furthermore, Geronimus found that
African American women living in areas of low income had an even greater risk for low birth weight delivery (Geronimus, 1996) demonstrating that in addition to race/ethnicity, socioeconomic status impacts health and pregnancy outcomes. In addition, Geronimus found that African American women, especially those living in low income areas, experienced worse health profiles in adolescence and young adulthood than white women, that persist and in most cases worsen, with advancing age. These findings have been supported by others (Buescher & Mittal, 2006; David & Collins, 1997).

The weathering hypothesis was also tested in the Mexican American population with evidence that weathering exists for this group as well, particularly for U.S.-born Mexican American women with respect to neonatal mortality and pregnancy-related hypertension (Wildsmith, 2002). In contrast, for Mexican-born women weathering effects were not as prevalent (Wildsmith, 2002). Moreover, as recognized in Chapter 1, a paradox has been described in which Mexican-born immigrants to the U.S., who frequently have very low incomes, but who may live in communities of other immigrants and retain their native nutrition and health promotion behaviors (Callister & Birkhead, 2002), have better birth outcomes, including lower maternal morbidity, fewer preterm deliveries and fewer low birth weight deliveries, than U.S. born Mexican American, or even non-Hispanic white women (Buekens, 2000; Cervantes, Keith, & Wyshak, 1999; Guendelman, Thornton, Gould, & Hosang, 2006). The theory behind this review and inherent in this conceptualization of allostatic load is that in childbearing-aged women, the life stress experienced prior to pregnancy, as a result of an accumulation of life events and stressors including SES and race/ethnicity, as well as individual behavioral responses
to stress, increases the risk for poor birth outcomes such as low birth weight and preterm birth. In particular, preterm birth is a problem contributing to more than one-third of all infant deaths during the first year of life (March of Dimes, 2007) and may be related to pre-pregnancy health status and life stress.

**Preterm Birth**

In the United States, approximately 1 in 8 (12.5%) of all live births occurs prematurely (prior to the 37th week of gestation) (March of Dimes, 2007). Preterm birth is associated with significant societal economic costs (medical, educational and lost productivity) in the United States; in 2005, these costs were at least $26.2 billion (March of Dimes, 2008). The problem of preterm birth is especially significant in some sub-populations, including African Americans and those with low income. From 2002-2004 in the United States, the CDC reports that preterm birth rates were highest for African American infants (17.8%) when compared to other racial/ethnic groups. Hispanics delivered prematurely at a rate of 11.8% and whites at 11.3% (March of Dimes, 2008). Healthy People 2010 recommends that the rate of preterm birth be reduced to no more than 7.6% of live births (Office of Disease Prevention and Health Promotion & U.S. Department of Health and Human Services, 2005). Thus, as emphasized by many professional organizations (American Academy of Pediatrics/ American College of Obstetricians and Gynecologists, 2002; American College of Nurse Midwives, 2007; American College of Obstetricians and Gynecologists, 2005; Brundage, 2002; Johnson et al., 2006), a key first step in reducing premature birth is evaluating and improving the pre-pregnancy health of women. One way to approach this problem is by considering the
burden of stress through the lifespan on physiological contributors known to affect prematurity by using the concept of allostatic load.

*Physiological contributors to preterm birth*

Several maternal health conditions are known to increase the likelihood of preterm delivery, many that may exist prior to the start of pregnancy. Some that increase the risk for preterm delivery are not controllable by the mother including such factors as increased uterine distension with multiple gestation or polyhydramnios, or previous history of preterm delivery (Williams et al., 2000). Other conditions that are often influenced by chronic stress may be controllable by the mother with the help of her healthcare provider. These include infection/inflammation, cardiovascular dysfunction, poor metabolic control, and poor nutrition. Chronic life stress significantly contributes to many of these risk factors. Table 2.1 discusses some of the mechanisms by which the chronic stressors impact the physiological burden of stress as measured by these variables: bacterial vaginosis, trichomonas vaginalis, periodontal disease, systolic and diastolic BP, smoking status, homocysteine, glycosylated hemoglobin, BMI, and iron-deficiency anemia. Each of these ten variables not only increase the risk for preterm delivery, but also contribute to the physiological burden of chronic stress.

Uterine factors. Uterine factors are those over which the mother does not have much control, but which may increase the risk for preterm delivery. For example, multiple gestation which may arise from advanced reproductive technology, has a strong association with increased risk for preterm delivery (Elliott, 2007; Kramer, Seguin, Lydon, & Goulet, 2000). Reasons for this association may be due to an increase in
uterine distension or complications associated with multifetal gestation including hypertension or abruptio placentae (Gabbe, Niebyl, & Simpson, 2002). Another example of a condition non-controllable by a mother is a history of preterm delivery. A previous history of preterm birth increases the risk for a second preterm birth by approximately two-fold (Gabbe et al., 2002).

Infection/ Inflammation pathway to preterm. Infections, both vaginal and systemic increase the risk for preterm delivery (Friese, 2003). If diagnosed, however, infections often can be treated thereby reducing the risk for preterm delivery. In Germany, 40% of preterm births are associated with infection (Friese, 2003). Bacterial vaginosis (BV), an alteration in the vaginal flora in which many gram negative anaerobic bacteria replace the normally predominant lactobacilli (Gabbe et al., 2002), is a relatively common vaginal infection that is strongly associated with preterm delivery (Hillier et al., 1995; Kurki, Sivonen, Renkonen, Savia, & Ylikorkala, 1992). In an analysis of the NHANES data 2001-2004, nearly one-third of the U.S. population was positive for BV, while African American women had 3.13 times the odds ratio of having BV compared to white women in the same study (Allsworth & Peipert, 2007). Kurki and colleagues found that BV was associated with a 6.9-fold (95% CI: 2.5-18.8) risk for preterm birth (Kurki et al., 1992). Another study demonstrated that BV was associated with a preterm low-birth weight delivery with an odds ratio of 1.4 (95% CI 1.1-1.8) (Hillier et al., 1995).

Douching is a vaginal hygiene behavior in which water or a vinegar-based liquid is directed at the vagina. A common practice among African American women,
douching increases the risk for BV significantly (Cottrell, 2003; Culhane et al., 2001; Schwebke, Desmond, & Oh, 2004) thereby contributing to the risk for preterm delivery (Bruce et al., 2002).

The preterm prediction study found that the relationship between African American race, preterm delivery and bacterial vaginosis was mediated by fetal fibronectin (Goldenberg et al., 1998). Fibronectin is a protein that attaches the fetal membranes to the underlying uterine decidua. Normally found in vaginal secretions between 20-22 weeks and then not again until 37-plus weeks of pregnancy prior to the start of labor, the presence of fibronectin in vaginal secretions between 22 and 37 weeks signals a disruption of the decidual-chorionic interface (Gabbe et al., 2002) and often indicates high risk for preterm labor. BV is thought to disrupt the decidual-chorionic interface, which may lead to the release of pro-inflammatory cytokines tumor necrosis factor-alpha (TNFα), interleukin-1 (IL-1), interleukin-6 (IL-6) and interleukin-8 (IL-8), ultimately leading to the continued release of fibronectin, and possibly stimulating premature uterine contractions (Gabbe et al., 2002).

Trichomonas vaginalis is an easily treated sexually transmitted protozoal infection that augments the risk for preterm delivery by increasing the risk for preterm premature rupture of membranes (Cotch et al., 1997). This infection has a higher incidence in African American women (13.3% compared to 1.3% in white and 1.8% in Mexican American women) (Sutton et al., 2007), women of low SES, and in those who engage in risky sexual behaviors (Kramer et al., 2001; Sutton et al., 2007; Weisman et al., 2006). Virtually 100% of women who have sexual contact with an infected partner contract the
The presence of trichomonas vaginalis at mid-gestation is strongly associated with preterm delivery (OR: 1.4, 95%CI, 1.1-1.6) (Cotch et al., 1997). While this condition is easily treated, its presence suggests not only risky sexual behaviors, but also an elevated risk for preterm delivery.

The manner in which trichomonas vaginalis increases the risk for preterm delivery through preterm premature rupture of membranes is by altering the connection between the fetal membranes. Collagen is the connective material that lies between the amnion and the chorion, and collagen maintenance and degradation are closely regulated by the interaction of matrix metalloproteinases and specific tissue inhibitors. The mechanisms of collagen maintenance and degradation may be altered in women with vaginal infections such as trichomonas vaginalis, leading to preterm premature rupture of membranes (Gabbe et al., 2002).

Preterm delivery risk is not only increased by vaginal infections. Periodontal diseases are a group of oral diseases which are caused primarily by gram-negative, anaerobic, and microaerophilic bacteria which colonize in the mouth, and are associated with poor oral hygiene. Lack of access to dental care, which may occur with a lack of dental insurance or income, can increase the likelihood of developing periodontal disease (Xiong, Buekens, Vastardis, & Wu, 2006). Prevalence of periodontal disease in the U.S. population has been reported from 10-60% depending upon diagnostic criteria (Albandar, 2002; Offenbacher et al., 2001; Papapanou, 1996). Radnai and colleagues found that women with periodontal disease had 5.46 times (95%CI: 1.72-17.32) the risk for preterm delivery than periodontally healthy women (Radnai et al., 2004).
With respect to the pathway to preterm delivery, the inflamed periodontal tissue in periodontal disease releases prostaglandin E\textsubscript{2} and pro-inflammatory cytokines such as IL-1\textbeta, IL-6, and TNF-\textalpha (Lopez, Smith, & Gutierrez, 2002). The release of cytokines in response to periodontal infection enhances the production of prostaglandins, endothelins, leukotrienes and proteases in the genital track. These factors are uterotonins, meaning they initiate contractions of the uterus (Gabbe et al., 2002) which then stimulate cervical effacement and dilatation (Offenbacher et al., 2001). The initiation of contractions during pregnancy can lead to rupture of membranes, cervical change and subsequent preterm delivery.

Each of these infections, BV, trichomonas vaginalis and periodontal disease, has been independently described to contribute to the risk for preterm birth and are often the result of stress-caused immune system alterations (Culhane et al., 2001; Kramer et al., 2001; LeResche & Dworkin, 2002). In addition, each of these infections can be managed by the patient with the help of her healthcare provider. If they are treated prior to pregnancy and the infections do not return, the risk for preterm delivery is not theoretically increased. If, however, these infectious agents are present prior to pregnancy, a woman is theoretically more likely to be infected during pregnancy. The following are additional physiological contributors to preterm delivery which have mechanisms not related to infection, but which may be managed by the patient and her provider.

**Cardiovascular dysfunction pathway to preterm.** Cardiovascular dysfunction impacts individual health status notably prior to pregnancy, but also during the pregnancy with
significant effects on pregnancy outcome. Perhaps one of the most common cardiovascular complications of pregnancy which is also prevalent in non-pregnant women is hypertension. In 1999-2000, 28.7% of a sample of US residents in the NHANES dataset had hypertension, while 30.1% of women had hypertension (Hajjar & Kotchen, 2003). Hypertension, or increased blood pressure, is associated with preterm delivery, among other negative birth outcomes (Blackburn, 2003). Chronic hypertension, that is hypertension that exists prior to the start of pregnancy, often augments the risk for indicated preterm delivery due to increased risk of harm to the fetus and the mother (Sibai et al., 2000). In their study, compared with normotensive black women, Samadi and colleagues found that women with pregnancy-induced hypertension were 1.8 (95% CI 1.5-2.2) times more likely and women with chronic hypertension were 1.6 (95% CI 1.3-2.1) times more likely to deliver prematurely (Samadi & Mayberry, 1998).

The mechanism involved in this pathway to preterm delivery is that during pregnancy, hypertension causes fluid to move from the vascular compartment to extravascular spaces, promoting the hemoconcentration of the blood, reducing renal plasma flow and glomerular filtration rate. Because of the reduced glomerular filtration rate, the body suspects dehydration and initiates the renin-angiotensin response, increasing vasoconstriction and sodium and water conservation. Vasoconstriction reduces uteroplacental perfusion, which may retard fetal growth due to lack of blood-flow, increasing the risk for indicated preterm delivery. In extreme situations, vasoconstriction may lead to placental abruption and spontaneous preterm delivery (Blackburn, 2003). If recognized early, hypertension may be managed, and successful pregnancy outcomes are
possible. Hypertension is not the only health factor impacting cardiovascular status and pregnancy outcome, however.

Cigarette smoking or passive tobacco smoke exposure is a relatively well-recognized behavior which increases the risk for cardiovascular dysfunction and lung cancer (Finkelstein, Kubzansky, & Goodman, 2006; Salafia & Shiverick, 1999). In a population-based study of smoking patterns, 29% of women reported smoking in the 12 months prior to delivery, 44% of whom continued to smoke during pregnancy (Kahn, Certain, & Whitaker, 2002). During pregnancy, cigarette smoking can significantly enhance the risk for negative birth outcomes such as low birth weight, preterm delivery, premature rupture of membranes, placenta previa, and placental abruption (Kramer et al., 2000; Windham, Hopkins, Fenster, & Swan, 2000). In a population-based study, smoking was shown to increase rates of preterm delivery with an odds ratio of 1.2 (95% CI, 1.13-1.28) (Hammoud et al., 2005).

During pregnancy, the placentas of women who smoke are larger than the placentas of non-smokers. Placental hypertrophy is thought to occur due to maternal hypoxia associated with smoking (Blackburn, 2003) such that a larger placental surface area exists for oxygen and nutrient transfer. In addition to being larger, the placentas of women who smoke have more calcifications, more fibrin deposits, and an increase in the frequency of necrosis, inflammation and placental lesions, further decreasing oxygen and nutrient transfer to the fetus. Blackburn suggests that these findings indicate that smoking may directly cause damage to the blood vessels of the placenta, which may lead to placental underperfusion (Blackburn, 2003) which can lead to negative birth outcomes
such as low birth weight, preterm delivery, and others. In addition, nicotine, a chemical found in tobacco which readily crosses the placenta, may compete with nutrients for transfer thus inhibiting fetal growth. Catecholamines, which are often released with smoking and with stress, are potent vasoconstrictors which may further decrease uteroplacental perfusion. Furthermore, carbon monoxide, a byproduct of smoking, has a higher affinity for hemoglobin than oxygen, potentially leading to decreased fetal oxygenation (Blackburn, 2003). Each of these factors decreases oxygen and nutrient transfer to the fetus, increasing the risk of intrauterine growth restriction and also the risk for premature delivery due to abruption of the placenta. By quitting smoking and limiting exposure to second-hand smoke, women can decrease the risk for these complications and increase the likelihood of a favorable pregnancy outcome.

A third contributor to cardiovascular dysfunction is homocysteine. Increased levels of this amino acid are associated with atherosclerosis, heart disease, preterm delivery, placental abruption and even spontaneous abortion (Black & Garbutt, 2002; Jacques et al., 1999; Scholl & Johnson, 2000; Vollset et al., 2000). High levels of homocysteine cause the formation of superoxide radicals, which can lead to thrombus formation by damaging endothelial cells (Black & Garbutt, 2002; Gabbe et al., 2002; Kramer et al., 2001; Vollset et al., 2000). Plasma homocysteine levels are nutrition, age and sex dependent (Jacques et al., 1999). When comparing individuals with high levels of homocysteine (10.7-78 μmol/L) to those with lower levels (3.6-7.5 μmol/L), women with high levels were 1.38 times (95% CI 1.09-1.75) more likely to delivery prematurely (Vollset et al., 2000).
Folic acid, vitamin $B_6$, and vitamin $B_{12}$ are necessary for homocysteine to be metabolized to methionine and cystathione (Gabbe et al., 2002). Individuals who have decreased folate levels, especially pre-pregnancy, are at increased risk for hyperhomocysteinemia (Kramer et al., 2001; Scholl & Johnson, 2000). With elevated levels of homocysteine, endothelial dysfunction, smooth muscle cell proliferation and abnormalities of coagulation occur in addition to oxidative stress (Steegers-Theunissen, Van Iersel, Peer, Nelen, & Steegers, 2004), which can lead to thrombus formation and preterm delivery. Often, folic acid supplementation returns homocysteine levels to normal (Scholl & Johnson, 2000), increasing the likelihood of a term pregnancy. Discussion of folic acid supplementation leads to considerations of metabolic control and nutrition on pregnancy outcome.

Poor metabolic control and nutrition. Poor metabolic control, including pre-gestational diabetes mellitus and obesity, and poor nutrition, including underweight and iron-deficiency anemia each impact pregnancy outcomes with mechanisms different from those previously discussed. Pre-gestational diabetes mellitus, a condition which if not controlled leads to chronically elevated blood sugar levels and elevated morbidity and mortality, is associated with significantly higher rates of preterm delivery when compared to women without diabetes or women with gestational diabetes (Ray, Vermeulen, Shapiro, & Kenshole, 2001; Sibai et al., 2000). Diabetes mellitus complicates 3-5% of all pregnancies (Hogan, Dall, & Nikolov, 2003; Rosenberg, Garbers, Lipkind, & Chiasson, 2005). In a prospective study of women with pregestational and gestational diabetes mellitus, women with pregestational diabetes had an odds ratio of 3.8 (95% CI
2.5-2.9) for preterm delivery compared to those with gestational diabetes (Ray et al., 2001), indicating that pre-gestational diabetes mellitus significantly increases the risk for preterm delivery.

Normal pregnancy is characterized by a state of insulin resistance and decreased sensitivity to insulin (Gabbe & Graves, 2003). This decreases peripheral maternal glucose use, increasing the amount of glucose readily available to the fetus by crossing the placenta (Blackburn, 2003). The mother compensates for this by using her own fat stores for energy (Herrera, 2000). Due to the easy transfer of glucose to the fetus and relative insulin resistance of the mother, high maternal glycosylated hemoglobin levels (which reflect average blood glucose over the past 2-3 months) associated with uncontrolled diabetes mellitus (gestational or pre-gestational) are associated with fetal hyperglycemia, causing the fetus to produce more insulin, insulin-like growth factors and leptin (Gabbe & Graves, 2003). This can lead to hyperplasia of the fetal islet cells, lipogenesis and increased protein synthesis (Schwartz & Teramo, 2000). These processes contribute to the development of increased fetal body fat, organ size and subsequent fetal macrosomia (Blackburn, 2003). Suspected fetal macrosomia associated with uncontrolled diabetes may indicate the need for cesarean section to prevent traumatic delivery (Gabbe et al., 2002).

Alternatively, poor maternal metabolic glucose control can contribute to reduced utero-placental blood flow (Gabbe et al., 2002; King, 2006). Obesity in pregnancy can lead to a hypoxic state in the fetus if the maternal glycosylated hemoglobin level is increased and an affinity for oxygen is decreased, reducing oxygen transfer and normal
placentation (King, 2006). That is, if blood sugar levels are too high, oxygen transfer is reduced. Reduced blood flow to the fetus can retard growth and development by not providing enough nutrients to the fetus. Growth-restricted fetuses may be delivered prematurely if it is determined that the uterine environment is harmful to their development (Gabbe et al., 2002). Furthermore, fetal hyperinsulinemia which occurs secondary to an increased glucose environment appears to increase the fetal metabolic rate and oxygen requirement. Mothers with diabetes may experience hyperglycemia, ketoacidosis, preeclampsia and maternal vasculopathy as a result of their diabetes, which each further reduce placental blood flow and oxygenation, thereby leading to growth restriction and potentially indicated preterm delivery (Gabbe et al., 2002).

Body mass index (BMI) reflects the metabolic processes of the body but can also reflect poor nutrition. BMI is calculated by dividing an individual’s weight in kilograms by their height in meters squared. Normal BMI lies between 18.5 and 25 kg/m² and reflects a healthy body weight for a given height. A BMI greater than or equal to 25 kg/m² is considered overweight, and greater than 29 kg/m², obese (Schoenborn, Adams, & Barnes, 2002). Roughly 65.1% of Americans older than 20 are overweight with a BMI greater than or equal to 25 kg/m², and nearly one-third are considered obese with a BMI ≥30 kg/m² (Hedley et al., 2004). In one study, when compared to normal weight women (BMI 18.5 -24.9 kg/m²), obese women (BMI ≥ 30 kg/m²) had an unadjusted odds ratio of preterm delivery of 1.83 (95% CI 1.18-2.84) (Haas et al., 2005).

With respect to the mechanism by which BMI impacts pregnancy outcomes, the incidence of, hypertension, thrombophlebitis, preeclampsia, and diabetes mellitus are
increased in obese pregnant women. Each of these conditions predispose a woman to preterm delivery through the mechanisms of vasoconstriction, placental abruption and reduced nutrient transfer (Blackburn, 2003; King, 2006; Sarwer, Allison, Gibbons, Markowitz, & Nelson, 2006; Solomon et al., 1997). In addition, obese women are more likely than normal weight women to enter pregnancy in a state of subclinical inflammation because increased body fat is associated with elevated cytokine levels and inflammation (King, 2006). As was discussed earlier, pro-inflammatory cytokines stimulate the release of uterotonins such as proteases, leukotrienes, prostaglandins and endothelins, initiating the pathway to preterm birth.

At the opposite extreme of the weight spectrum, underweight individuals (BMI <18.5 kg/m^2) are also at increased risk for preterm delivery (Rich-Edwards, 2003; Schieve et al., 2000). In a recent US population based study, roughly 3.7% of women were considered underweight with a BMI <18.5 kg/m^2 (Schoenborn et al., 2002). When compared to normal weight women (BMI 18.5-24.9 kg/m^2), underweight women in one study had an odds ratio adjusted of 2.38 (95% CI 1.04-5.48) for preterm delivery (Haas et al., 2005).

Low body weight is often associated with poor tissue nutrient reserves (Schieve et al., 2000). It is recommended that women who are underweight prior to pregnancy gain more weight during the pregnancy than normal weight or obese women in order to provide the necessary nutrients to the fetus and prevent growth restriction, anemia, malnutrition and preterm delivery (Blackburn, 2003). Using data from the National Maternal and Infant Health Survey, Schieve and colleagues found that women with low
weight gain during pregnancy, especially if they were underweight or average weight initially, were at increased risk for preterm delivery (Schieve et al., 2000). Effects of nutrient deficiency during pregnancy include smaller placentas, inadequate fluid volume expansion, inadequate hormonal responses to pregnancy, and nutrient deficiencies (Viteri, Schumacher, & Silliman, 1989). Smaller placentas coupled with nutrient deficiencies can lead to reduced nutrient transfer to the fetus and growth-restriction, potentially increasing the need for indicated preterm delivery (Blackburn, 2003; Gabbe et al., 2002).

Also a sign of poor nutrition, iron-deficiency anemia has a 9 to 12% prevalence in white women, and nearly 20% in African American and Mexican American women (Killip, Bennett, & Chambers, 2007). Often due to a lack of dietary iron, iron-deficiency anemia is clinically treated with iron supplementation either in dietary or vitamin form (Gabbe et al., 2002). Although the causal relationship between iron deficiency anemia and preterm delivery is not clearly established, Yip reports that moderate to severe anemia is associated with poor pregnancy outcomes (Yip, 2000). Scholl and others reported, in a prospective study of nutrition and pregnancy outcome, that iron-deficiency anemia more than doubled the risk for preterm delivery when compared to no anemia present (Scholl, Hediger, Fischer, & Shearer, 1992).

In a thorough review of the mechanisms by which iron deficiency anemia contributes to preterm delivery, Allen presents three possible mechanisms: 1) hypoxia which subsequently induces maternal and fetal stress thereby stimulating the release of corticotropin-releasing hormone from the placenta and stimulating labor; 2) iron
deficiency can induce oxidative damage to erythrocytes and the feto-placental unit; and 3) iron deficiency may also increase the risk for infections which, as discussed previously, increase the risk for preterm delivery (Allen, 2001). Blackburn supports the hypoxia notion by stating that with severe anemia, maternal arterial oxygen content and oxygen delivery to the fetus are reduced, which, especially before mid-pregnancy, may result in preterm birth due to fetal anoxia (Blackburn, 2003).

The physiological burden of chronic stress (poverty and minority race/ethnicity) including the impact on immune/inflammatory function, cardiovascular function, metabolic control and nutritional status is also associated with an increased risk for poor birth outcomes including preterm delivery. This review has explored ten physiological factors and the mechanisms by which chronic stress increases their likelihood of dysfunction (Table 2.1), as well as their impact on the risk for preterm delivery. An individual’s life stress, poverty and minority race/ethnicity, combined with behavioral responses to stress increases the physiological burden of stress as measured by these ten factors. This in turn increases allostatic load score further impacting the risk for preterm delivery. Infection/inflammation, cardiovascular dysfunction, poor metabolic control and nutrition each result from the impact of chronic stress and contribute to the risk for preterm delivery by different mechanisms (Bruce et al., 2002; Cotch et al., 1997; Hillier et al., 1995; Samadi & Mayberry, 1998; Schieve et al., 2000; Scholl, 2005; Sibai et al., 2000; Williams et al., 2000; Xiong, Buekens, Fraser, Beck, & Offenbacher, 2006). Thus, if one or more of these previously mentioned ten factors are present prior to conception, and especially if several factors are present, not only has the woman experienced
significant chronic life stress, but also, she at increased risk for preterm delivery due to
the mechanisms described above.

**Allostatic Load and Women’s Health: Preterm Birth**

At this time, although a few investigators have utilized allostatic load for specific women’s health issues such as age at menarche (Allsworth, Weitzen, & Boardman, 2005), we know of no studies that have operationalized allostatic load generally for women’s health (Allsworth et al., 2005; Glover, Stuber, & Poland, 2006) or specifically for preterm birth. In addition, previous studies have examined the impact of a particular pre-pregnant health condition on pregnancy outcome (Bruce et al., 2002; Scholl et al., 1992; Xiong, Buekens, Fraser et al., 2006), but few have looked at the overall pre-pregnant health status of child-bearing aged women as an approach to reducing prematurity.

Allostatic load is often calculated as the sum of variables for which the individual scores in the “high-risk” range (Crimmins, Johnston, Hayward, & Seeman, 2003; Geronimus et al., 2006; Seeman, McEwen, Rowe, & Singer, 2001; Szanton, Gill, & Allen, 2005). This high-risk range is either clinically or empirically defined, often as the top quartile of data. Since the late 1990’s when allostatic load was first operationalized, the number of variables in the allostatic load score has ranged from the original ten factors to as many as sixteen factors in an attempt to better elucidate effects of long-term stress on the body (Geronimus et al., 2006; Seeman, Singer, Rowe, Horwitz, & McEwen, 1997; Seeman et al., 2001; Seeman et al., 2004). The original ten variables included in the allostatic load score were systolic and diastolic blood pressures, glycosylated
hemoglobin, total cholesterol, high-density lipoprotein (HDL), epinephrine, norepinephrine, cortisol, dehydroepiandrosterone sulfate (DHEA-S), and waist-hip ratio (Seeman et al., 1997). Several follow-up studies have added to or subtracted from these ten variables, changing the markers of the physiological burden of stress on the body (Allsworth et al., 2005; Geronimus et al., 2006; Seeman et al., 2001). Controversy regarding changing the operationalization of allostatic load for different research studies may simply reflect the newness of the concept of allostatic load and how its operationalization may need to be tailored to measure the physiological burden of stress in specific populations. Seeman and others note that additional biomarkers may need to be added in order to better reflect stress’ effects on multiple organ systems (Seeman et al., 2001).

Looking again at Figure 2.1, the variables included in this operationalization of allostatic load are those variables which were previously identified as being significantly influenced by chronic stressors (minority race/ethnicity and low SES), the behavioral response to stressors, and are significant contributors to preterm delivery. By including measures of immune/inflammatory function, cardiovascular function, metabolism and nutrition, the items included in this operationalization of allostatic load reflect the health of the whole body as it pertains to female reproductive health, impacted by chronic life stress, with a specific focus on preterm delivery. Each of the ten included physiological variables is impacted by stress and then further increases the risk for preterm delivery. Trichomonas vaginalis is the only variable of the ten which is not directly related to the stress response, but rather relates to a health risk behavior, risky sexual practices. Its
inclusion in this operationalization of allostatic load is important in order to understand the risk associated with behaviors that result from stressful life situations. The other variables, either by diminished immune function, increased cardiovascular reactivity, coping mechanisms, sympathetic nervous system stimulation, and dietary intake, are each related to the stress response.

Summary and Limitations

The theoretical concept of allostatic load has been operationalized to represent the impact of stress on the physiological health of women, in an attempt to explain and ultimately improve poor birth outcomes. The focus of this review has been on relating pre-pregnancy allostatic load to possible mechanisms of preterm birth. The present operationalization of allostatic load represents the first time that variables specific for women’s health, particularly for childbearing-aged women, and specifically related to increased risk for preterm birth are investigated in terms of stress, behavioral responses to stress and health outcomes.

Because this is the first time allostatic load has been operationalized using these variables with a specific focus on the risk for preterm delivery, it is necessary to support the reasons why this operationalization represents allostatic load and the cumulative physiological effects of stress on the body. A large body of work has been reported operationalizationing allostatic load with a specific focus on cardiovascular outcomes of older adults in the MacArthur studies of successful aging (Seeman, et al., 2004; Seeman, Singer, Rowe, Horwitz, & McEwen, 1997; Seeman, McEwen, Rowe, & Singer, 2001). Others have operationalized allostatic load to reflect the stress associated with work.
conditions (Schnorpfeil, et al., 2003), age differences in allostatic load (Crimmins, Johnston, Hayward & Seeman, 2003), weathering and age patterns among racial/ethnic groups in the United States (Geronimus, Hicken, Keene, & Bound, 2006), as well as in other situations and populations. While focusing on the effects of stress on the body, each of these studies has operationalized allostatic load to best reflect the effects of stress on their population and the health outcome of interest. Carlson and Chamberlain (2005) note that throughout the literature, even with changing operationalizations of allostatic load, the cumulative nature of allostatic load as an index of physiological wear and tear offers advantages in predicting health risks over evaluation individual physiological factors.

Allostatic load is a concept contained within the broader framework of stress and physiological responses to this stress. Certain societal and environmental factors exert a toll on the body, eliciting a stress response. With chronic activation, through a detailed neuroendocrine response, a cumulative physiological burden of stress is seen in the individual (McEwen & Seeman, 1999). The operationalization of allostatic load in this dissertation is no different: certain factors (minority race/ethnicity, low SES) exert a toll on the body eliciting a stress response which further contributes to the physiological burden of stress, measured as allostatic load. The operationalization of allostatic load continues to change and develop in order to identify parameters that best reflect the impact of stress on the individual. By broadening the notion of allostatic load to include variables other than those originally included in the MacArthur studies of successful aging and by providing a clear rationale for their inclusion and their relationship to the
physiologic stress response, this dissertation work lays the groundwork for future research on the contribution of life stress to allostatic load and pregnancy outcomes. Allostatic load as operationalized in this dissertation serves to reflect the burden of stress on the health of the whole body including: inflammatory/ immune function, cardiovascular function, and metabolic function / nutrition status. Table 2.1 presents the mechanisms by which stress impacts each of the included ten physiological variables, and the review of literature examines the pathways to preterm delivery for each variable. Each of the individual variables represents a piece of the physiological burden of stress that also impacts pregnancy outcome. In combination, however, the ten variables included in this operationalization of allostatic load depict the health of the woman in response to chronic stress, with a specific focus on pregnancy outcomes.

There are numerous potential applications for this concept’s use. For future research, the impact of race/ethnicity and SES on the allostatic load of women could be examined. In addition, alternate variables could be included if they are identified to better reflect the physiological burden of stress on a woman as it relates to pre-pregnancy health. Prospective studies may be performed correlating allostatic load score and pregnancy outcome. Additionally, intervention studies could be performed to determine whether risk reduction involving any or all of these variables positively alters pregnancy outcomes, and if so, in which socioeconomic or racial/ethnic groups (Jeffcoat et al., 2003; Mascagni & Miller, 2004). Clinically, at every pre-pregnancy visit starting at menarche, including annual exams, contraception visits and STD checks, advanced practice nurses and physicians could address the health status variables and risk behaviors. This may
lead to a decrease in risk of adverse pregnancy outcomes. Depending on each woman’s health status, targeted educational interventions could be designed to help improve her health and the health of her pregnancy.

Because this is the first time that allostatic load has been operationalized specifically for women’s health as related to premature birth, the concept’s use must be further explored through prospective investigation. In addition, there are numerous physiological variables which might appropriately reflect the physiological burden of stress in women. The selection of the variables identified in this report was based upon literature review in order to best reflect the impact of life stress on the body, and impact the health outcome, specifically, preterm delivery. This provides an innovative perspective from which new research can grow in an attempt to reduce rates of preterm delivery.
References


http://www.midwife.org/siteFiles/descriptive/Core_Competencies__6_07.pdf


Figure 2.1: Conceptual Framework depicting relationship between perceived stress, behavioral responses to stress and health status, allostatic load and health outcomes. Adapted from (McEwen, 1998).
<table>
<thead>
<tr>
<th>Variable</th>
<th>System Affected</th>
<th>Impact of stressors (race/ethnicity and SES), and behavioral response to stressors</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bacterial Vaginosis</strong></td>
<td>Immune/inflammatory processes</td>
<td>BV is more common among African American women than white women and is strongly associated with douching, a practice of many African American women and women of low SES (Ness et al., 2003). BV is associated with chronic stress due to impaired immunity as evidenced by blunted morning cortisol levels in women with recurrent BV (Ehrstrom, et al., 2005)</td>
</tr>
<tr>
<td><strong>Trichomonas Vaginalis</strong></td>
<td>Immune/inflammatory processes</td>
<td>Risky sexual behaviors, related to stress, drug use, depression, low social support, and a lack of healthcare knowledge or access, which may be more common among low SES women, increase the risk for this and other sexually transmitted infections; (Glaser &amp; Kiecolt-Glaser, 2005; Kramer et al., 2001; Weisman et al., 2006).</td>
</tr>
<tr>
<td><strong>Periodontal Disease</strong></td>
<td>Immune/inflammatory processes</td>
<td>Inability to access dental care services due to low SES can increase poor dental health and risk for periodontal disease (Xiong, Buekens, Vastardis et al., 2006), as can increased psychosocial stress due to a diminished immune response (LeResche &amp; Dworkin, 2002).</td>
</tr>
<tr>
<td><strong>Systolic Blood Pressure</strong></td>
<td>Cardio-vascular</td>
<td>Lower SES is associated with hypertension in the United States (Colhoun, Hemingway, &amp; Poulter, 1998) and may be due to increased sympathetic nervous stimulation and HPA axis alteration as a result of repeated or prolong exposure to stressors (McEwen, 1998). African Americans tend to have higher rates of hypertension and increased blood pressure reactivity to stress (Guyll et al., 2001).</td>
</tr>
<tr>
<td><strong>Diastolic Blood Pressure</strong></td>
<td>Cardio-vascular</td>
<td>People with low SES are known to smoke more frequently than others to cope with stressful situations, and also as a result of high costs of smoking cessation healthcare (Kristenson et al., 2004).</td>
</tr>
<tr>
<td><strong>Smoking Status</strong></td>
<td>Cardio-vascular</td>
<td>Decreased folate levels secondary to a folate-deficient diet, perhaps a result of low SES, can increase homocysteine levels (Kramer et al., 2001). Free homocysteine concentrations may be sympathetically mediated as homocysteine levels rise during acute stress when albumin production is down-regulated (Black &amp; Garbutt, 2002; Stoney, 1999).</td>
</tr>
<tr>
<td><strong>Homocysteine</strong></td>
<td>Cardiovascular/ nutrition</td>
<td>Poor diet and obesity through life, as may occur with low SES or low physical activity, increase the risk for elevated HgA1c levels and subsequent diabetes (Sibai et al., 2000). Increased serum cortisol levels due to stress can contribute to increased blood sugars and subsequent elevated HgA1c levels (Vanitallie, 2002).</td>
</tr>
<tr>
<td><strong>Glycosylated Hemoglobin</strong></td>
<td>Metabolic Processes</td>
<td>Women who lack adequate food sources, perhaps due to low SES, may have decreased BMIs while a diet consisting of primarily processed foods and simple sugars can increase BMI (Blackburn, 2003; Rich-Edwards, 2003). Chronic stress with elevated cortisol levels and insulin resistance leads to visceral obesity and weight gain (Vanitallie, 2002).</td>
</tr>
<tr>
<td><strong>Body Mass Index</strong></td>
<td>Metabolic Processes/nutrient status</td>
<td>Inadequate nutritional intake of iron will lead to iron deficiency anemia (Killip et al., 2007; Terhune, Cogswell, Khan, Will, &amp; Ramakrishnan, 2000). Individuals with infections (as can occur with chronic stress) may also have decreased iron due to iron wasting associated with certain bacterial infections (Maynor &amp; Brophy, 2007).</td>
</tr>
</tbody>
</table>

Table 2.1: Impact of Stressors and Behavioral Response to Stressors on Allostatic Load Variables

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CHAPTER 3

DOUCHING PATTERNS IN WOMEN: SOCIOECONOMIC AND RACIAL CHARACTERISTICS

Introduction

A douche is a stream of water or vinegar-based liquid directed at any part of the body or any body cavity, often into the vagina, for hygiene or medicinal purposes. As a general practice, vaginal douching has been shown to be more harmful than helpful for most women (Cottrell, 2003). Research and practice suggest that vaginal douching contributes significantly to the disruption of vaginal flora, increases rates of bacterial vaginosis (Cottrell, 2003; Culhane et al., 2001), pelvic inflammatory disease (PID) (Ness et al., 2001), ectopic pregnancy (Zhang, Thomas, & Leybovich, 1997), and most significantly, increases the risk of preterm delivery (Bruce et al., 2002).

Preterm delivery (<37 weeks gestation) is a significant cause of perinatal morbidity and mortality in the United States where the incidence has increased 30% in the past two decades with 12% of infants born prematurely in 2003 (March of Dimes, 2007). In addition to douching, there are many other known contributors to prematurity, including advanced reproductive technologies (ART) (Slattery & Morrison, 2002),
multiple gestation (Slattery & Morrison, 2002), maternal stress (Dole et al., 2003; Rich-Edwards & Grizzard, 2005), genetic predisposition (Hoffman & Ward, 1999), periodontal disease (Lopez, Smith, & Gutierrez, 2002), pregestational diabetes mellitus (Sibai et al., 2000), hypertension (Sibai et al., 2000), and of particular interest, bacterial vaginosis (Goldenberg et al., 1998).

In the United States, African American women deliver their infants prematurely roughly 60% more often than white women (Demissie et al., 2001; March of Dimes, 2007). The March of Dimes reports that roughly 18% of African American infants were born preterm between 2003 and 2005 while 11.5% of white infants were born prematurely during the same time period (March of Dimes, 2008). Increased rates of preterm delivery in African American women are present even when accounting for ART. In 2003, 17.7% of African American singleton infants conceived by ART were born preterm while 11.7% of white singletons infants conceived by ART were born preterm (Wright, Chang, Jeng, & Macaluso, 2006). In addition, African American women are 2.8 times as likely to douche as white women (Funkhouser et al., 2002).

Although the racial gap in preterm delivery has decreased slightly in the last 10 years, primarily due to an increase in preterm delivery of white infants, this disconcertingly high rate of prematurity in the African American population deserves further scrutiny, including the examination of douching as a factor in its occurrence (Slattery & Morrison, 2002).

Many of the above-mentioned contributors to preterm delivery are related to stress or to health behaviors that occur in response to stress, of which many are present
prior to pregnancy. Allostatic load has been conceptualized to reflect the burden to the health status of an individual in light of an accumulation of insults or stressors to which the individual is exposed, and the behavioral responses to those stressors (McEwen, 1998a). This concept previously has been used to examine the relationship between stressors, such as minority race/ethnicity and low socioeconomic status, and behavioral responses to these stressors, such as smoking and risky sexual behaviors. Low socioeconomic status and minority race/ethnicity are often considered chronic stressors (Adler & Newman, 2002; Geronimus, Hicken, Keene, & Bound, 2006; Giscombe & Lobel, 2005) which impact health through a variety of means including job strain, economic instability, racism and discrimination (Kristenson, Eriksen, Sluiter, Starke, & Ursin, 2004; Williams, 1999). Furthermore, as discussed in Chapter 2, individuals who experience increased chronic stress may also engage more in negative health behaviors (Glaser & Kiecolt-Glaser, 2005). Funkhouser and colleagues (2002) note that douching is more common among less educated women, indicating that a chronic lack of access to healthcare education increases the likelihood of women douching.

In the following study, the concept of allostatic load is utilized to examine the relationship between the stressors of minority race/ethnicity and low socioeconomic status and the behavioral response of douching. In view of this theoretical concept and the effects of chronic stress, it is hypothesized that women douche as a result of their upbringing with a lack of knowledge about healthy behaviors or as a result of limited access to healthcare resources or healthcare education regarding best health practices (Gazmararian, Bruce, Kendrick, Grace, & Wynn, 2001; Ness et al., 2003). Although not
examined at this time, douching, in turn, is thought to contribute to the health status of a woman by increasing the risk for bacterial vaginosis, thereby putting the woman at risk for certain health outcomes such as preterm delivery. Figure 3.1 visually depicts the theoretical framework, which in the current study, is used to examine the stressors and the douching response to these stressors only.

Douching

The reasons why women douche are complicated. Many were taught to do so by their mothers or have friends who douche (Annang, Grimley, & Hook EW 3rd, 2006; Funkhouser et al., 2002; Funkhouser, Hayes, & Vermund, 2002; Gazmararian et al., 2001). Women report douching most often after sex, and during or after menses (Annang et al., 2006; Smith et al., 2005). In a telephone survey of adults in five southern states, researchers found that women who douche believe douching is necessary for good hygiene, good for vaginal discharge or itching, can prevent sexually transmitted infections and also prevent pregnancy (Funkhouser et al., 2002). The authors found that the beliefs regarding douching did not differ significantly by race (African American or white), but were more common in older women, less educated women, and among women who douched, either currently or ever (Funkhouser et al., 2002). Similarly, a qualitative study conducted to determine why women douche found that in general, women douche in order to be clean and to get rid of the “unpleasant odor” associated with the vagina (Gazmararian et al., 2001).

Advertising media reinforces douching behavior with advertisements for douching products. Funkhouser and colleagues found in a study of douching practices
among women attending a southern university that encouragement from mothers and also encouragement from media were independently associated with douching behavior, either ever or current (Funkhouser et al., 2002). In a Michigan county health department clinic where women were asked to complete a questionnaire, 30% of African American women and 14% of white non-Hispanic women reported using a vaginal douche at least once per month (Holzman, 2001). In London, England, black women from the Caribbean reported vaginal douching twice as often as white women (Rajamanoharan, Low, Jones, & Pozniak, 1999).

Poverty disproportionately affects minority racial and ethnic groups such as African Americans and Mexican Americans (Kramer, Seguin, Lydon, & Goulet, 2000). Low SES and lack of health insurance may limit a woman’s access to a healthcare provider (Callahan & Cooper, 2005) and therefore may prevent the woman from learning about the long-term harmful effects of douching, including preterm delivery. Similarly, if a woman is taught by her mother that douching is a healthy behavior and she lacks access to healthcare education, the woman is likely to continue douching unless otherwise directed (Funkhouser et al., 2002; Gazmararian et al., 2001; Ness et al., 2003). In addition to reflecting the ability of the individual to obtain resources such as health care, health information, healthy foods or safe housing, SES may also characterize the ability of the individual to make healthy choices. Mirowsky and Ross note that education, one component of SES, enables individuals to seek pathways to health (Mirowsky & Ross, 2003). Not only are individuals with higher education better equipped to seek resources for health, but increased education has been shown to increase
overall health (Marmot, 2004; Mirowsky & Ross, 2003). Another measure of SES is family income, which, perhaps in addition to health insurance status may reflect ability to access healthcare. Since it is known that discouragement of douching behavior from doctors and nurses is effective in changing douching behavior, healthcare access, health insurance and income may be critical issues in determining the likelihood of a woman douching (Funkhouser et al., 2002).

Although African American women are more likely to douche than white women, there are currently no known nationally representative survey studies that examine the interrelationships between socioeconomic status, race, and vaginal douching. It may be, for example, that race/ethnicity is not be the only risk factor for douching, but rather douching may be a practice related to low SES. The specific hypothesis derived from the theoretical model of allostatic load is that women who experience chronic stress associated with minority racial/ethnic status and low SES are more likely to engage in negative health behaviors (Glaser & Kiecolt-Glaser, 2005), such as douching, than other women due to lower levels of health education, healthcare access, and income (Annang et al., 2006; Funkhouser et al., 2002). The purpose of this study is to examine the impact of income on douching patterns of white, African American and Mexican American women.

Materials and Methods

The current study used data from both NHANES 2001-2002 and 2003-2004, described in Chapter 1. The NHANES is a publicly available dataset on the CDC website and has undergone extensive IRB review. Because of this and the fact that this particular study is not specifically human subjects research, institutional IRB review and approval
were not necessary. Women between 14 to 49 years who were both interviewed and examined (n = 4143) were eligible for inclusion in the analysis. This age group was selected because the literature reports that older women report douching more frequently. In addition, while douching impacts pre-pregnancy health and the risk for preterm delivery, the importance of investigating the impact of income on douching behavior led to the decision to include women aged 14-49 years.

The outcome variable of interest in this analysis was douching behavior. Through self-report, women aged 14 to 49 answered whether during the past six months they had douches. The interviewer defined douching as “putting a substance into your vagina either for routine cleansing or for vaginal irritation or signs of infection” (Centers for Disease Control and Prevention (CDC). National Center for Health Statistics (NCHS), 2005). Women responded yes or no to this question. Those women who did not know whether they had doused during the past six months were removed from the analysis (n=251).

Independent variables included age, race/ethnicity, education, income, health insurance status and pregnancy status. Age was self-reported and measured continuously by years. This continuous variable was stratified into four groups with teenagers, twenties, thirties and forties as the categories. Race and ethnicity information was gathered during the interview portion of the survey. As discussed in Chapter 1, only Mexican American, white and African American were included in the analysis. Also as previously discussed, Mexican American women were further categorized by place of birth: Mexico or the United States. Callister and Birkhead recommend that Mexican
American women be differentiated into U.S. born Mexican women and Mexican immigrant women in order to better understand the impact of acculturation on health outcomes (Callister & Birkhead, 2002).

Socioeconomic status was measured with several variables, each of which contributed a different perspective to socioeconomic status. Self-reported education was reported as less than high school, high school graduate (including GED) or more than high school. Education is a reliable variable that is used frequently as proxy for socioeconomic status (Winkleby, Jatulis, Frank, & Fortmann, 1992). Another variable that helped to establish socioeconomic status was the poverty/income ratio (PIR). This variable is the only income-based measure of economic status that adjusts for family size available in the public use NHANES. PIR represents a way to compare across family units of different sizes, using family income and the federal poverty line. Families of a given size with a higher income have a higher PIR. The PIR is reported from 0 to 5 and is determined by dividing an individual’s family income by the federal poverty line for that family size. For example, if the federal poverty line for a family of three is $17,000, a family which earns $8,500 a year has a PIR of 0.5. Likewise, a family of three who earns $34,000 a year has a PIR of 2.0. In this instance, a family of three with an income greater than $85,000 has a PIR top-coded at 5.0. For the logistic regression analysis, PIR was collapsed into four groups: low income, defined as PIR ≤1.3; low middle income, defined as PIR >1.3 and ≤1.85; middle income, defined as PIR >1.85 and ≤3.5; and high income, defined as PIR>3.5.
PIR was stratified in this way based on federal assistance program eligibility criteria (Alaimo, Briefel, Frongillo, & Olson, 1998). The Women, Infants, Children (WIC) program income eligibility criteria dictate that individuals cannot have an income over 185% of the poverty line for their family size (FNS, 2007), which in terms of PIR, equals a $PIR \leq 1.85$. At the same time, food stamp income eligibility requires that an income is less than or equal to 130% of the federal poverty line ($PIR = 1.3$) (FNS, 2008). In 2008 the cut-point at $PIR=3.5$ corresponds to an annual family income for a family of four of $74,200$. This cut-point has been used previously to distinguish between middle income and high income individuals and families (Alaimo, et al., 1998). Individuals whose family incomes fall within the third income group, defined as $PIR >1.85$ and $\leq 3.5$, are not eligible for either the Food Stamp Program or WIC services. Even if the family income is just above the cut-off at $PIR=1.86$, they do not have access to these federal assistance programs and may experience access to fewer resources, including food, than women with a $PIR$ of 1.85.

In addition to education and family income, health insurance status helped to provide insight into the participant’s access to healthcare resources. Participants were asked whether they currently had health insurance coverage and provided a yes or no answer. It is important to note that a differentiation between state-funded and private health insurance was not made. Therefore, assumptions about SES based upon health insurance status cannot be made. Pregnancy status was measured by self-report and also through urine lab test. As a result of both of these measures women were either pregnant, not pregnant, or had unknown pregnancy status at the time of the examination. Although
to this point in the dissertation the focus has been on “pre-pregnancy”, the women included in this analysis are “non-pregnant” as the ages included (14-49) extend beyond the natural child-bearing years. In addition, because douching has been associated with older age, it is important to include women beyond child-bearing years in order to determine the income effects on douching.

The interactions between each of the socio-demographic characteristics (education, PIR and health insurance) and race/ethnicity were statistically different at the $\chi^2 \alpha=0.05$ level. While 45.8% of white women had a PIR $>3.5$, a majority of African American and Mexican American women had a PIR $\leq 1.85$. In addition, more African American and Mexican American women had less than a high school diploma but were older than 19 years of age. The differences in prevalence by race/ethnicity and socio-demographic characteristic demonstrate disparate levels of disadvantage among the racial/ethnic groups. Because of this, it was determined that all remaining statistical analyses ought to be stratified by racial/ethnic group in order to separate the effects of SES and race/ethnicity on douching behavior. Categorical data were compared using $\chi^2$ tests. In order to evaluate the impact of income on douching behavior while controlling for age, education and health insurance, crude and adjusted odds ratios were estimated by using logistic regression for each racial/ethnic group. For self-identified Mexican American women, country of birth was included in the logistic regression analysis as a predictor of douching behavior. Furthermore, all analyses were completed using the appropriate stratum (sdmvstra), PSU designations (sdmvpsu), and 4-year sampling weights (.5*wtmec2yr) estimated by the National Center for Health Statistics to reflect
the entire U.S. population based on the 2000 census data (Centers for Disease Control and Prevention (CDC). National Center for Health Statistics (NCHS)., 2004).

Results

The final sample included data from 3522 women (85% of the eligible sample), which when weighted with population weights, represents the experience of 58,306,679 U.S. women between the ages of 14 and 49. Women were considered ineligible if they did not answer the douching question or answered “don’t know” to the question (n= 415) or if they answered “don’t know” for education (n=1), health insurance status (n=34), or income (n=138). The sum of these is greater than expected as eligible for the final regression because some participants were missing data in more than one variable category. When comparing those eligible for the regression (no missing data) and those ineligible due to missing data using the $\chi^2$ test, there were no significant differences between the groups for douching behavior, education, race, health insurance status, income, or age at the $\alpha=.05$ level.

The prevalence of each variable stratified by race is presented in Table 3.1. Overall, in this analysis, 21% of women in the United States reported douching in the last six months. African American women reported the highest douching prevalence with 47% of the population estimated to douche within the last six months while white women reported a douching prevalence of 17%. Mexican-born Mexican American women reported douching prevalence at 12.5% while U.S.-born Mexican American women reported douching at 19%. With the racial stratification, it is clear that a PIR of greater than 3.5 was more common in the white racial group than in any other group. Nearly
46% of whites reported a PIR of greater than 3.5 while 26.7% of U.S.-born Mexican American women, 4.9% of Mexico-born Mexican American women, and 17.9% of African Americans reported a PIR of greater than 3.5. On the opposite end of the spectrum, U.S.-born and Mexico-born Mexican Americans as well as African Americans demonstrated a larger prevalence in the PIR ≤1.3 group, 33.5%, 53.1%, and 43.3%, respectively, than whites of whom only 19.4% self-identified at this level. The stratification by race helps to elucidate the racial differences in the sociodemographic variables.

In addition to enjoying a higher income as a racial group, nearly 58% of whites reported more than a high school education, while 38.4% of U.S.-born and 16.8% of Mexico-born Mexican American women and 42.6% of African American women reported this level of education. Only 8% of whites older than 19 reported less than a high school diploma while 18% of U.S.-born and 58.3% of Mexico-born Mexican Americans and 21% of African American women older than 19 reported less than a high school education. These findings underline the significant social advantage that whites enjoy as a racial group with higher income and more education than Mexican Americans and African Americans. Such an advantage may also contribute to better health behaviors due to health education and access to resources (Abraído-Lanza, Chao, & Flórez, 2005).

In order to explain the effect of income stratified by racial/ethnic groups, logistic regression with each of the sociodemographic variables was performed for each racial/ethnic group. Table 3.2 displays crude and adjusted odds ratios for douching for
the racial groups, whites, African Americans and U.S.- born and Mexico-born Mexican Americans. For white women, income was a significant contributor to douching behavior in both the crude and adjusted analyses. In the final model, white women with a PIR ≤ 1.3 were 2.33 (95% CI: 1.72-3.16) times more likely to douche than white women with a PIR of greater than 3.5. With respect to education, in the final model white women who were older than 19 but who had not yet completed high school or received a GED were 2.75 (95% CI: 1.03-7.34) times more likely to douche than those with more than a high school education. Interestingly, in this sample, health insurance was a significant predictor of douching behavior. White women without health insurance were 1.90 (95% CI: 1.06-3.37) times more likely to douche than those with health insurance.

As a group, Mexican American women were less likely to report douching than whites or African Americans. As shown in Table 3.2, in the final adjusted model for Mexican American women, the greatest predictors of douching behavior in the last six months were education less than high school but older than 19 years of age, age beyond teenage years, PIR >1.85 and ≤ 3.5, and lack of health insurance. Mexico as a country of birth greatly reduced the risk for douching behavior when compared to those Mexican Americans born in the United States. In the final model, Mexican American women who were born in Mexico were 0.29 (95% CI: 0.20-0.41) times as likely to douche as U.S.- born Mexican American women.

African American women in the 40-49 years age group were 3.58 (95% CI: 1.94-6.61) times more likely to report douching behavior in the past six months than women aged 14-19 after adjusting for the sociodemographic variables. As shown in Table 3.2,
the odds ratios for douching behavior in white women increase as PIR decreased. From this, it can be inferred that douching is not exclusively a behavior of women below the federal poverty line, but that lower income for white and African American women did increase the likelihood of douching behavior. Further, as income increased, African American and white women were less likely to douche. In addition, from this analysis the odds ratios for douching increased for women as they aged beyond 20 years, for women with a lower PIR, and for women with less than a high school diploma or only a high school diploma.

Discussion

Allostatic load was used in this study to address the relationship between chronic stressors (low SES and minority race/ethnicity) and a behavioral response to these stressors, douching. Low income and minority racial status are risk factors for decreased access to healthcare, limited knowledge about health behaviors, increased risk for worse health behaviors, and increased allostatic load and poor health (Giscombe & Lobel, 2005). Consistent with the literature, the results demonstrated that African American women were more likely to report douching behavior than white or Mexican American women. The results also indicated that lower income was a risk factor for douching, as was less than a high school education in women older than 19 years of age. The stressors of low socioeconomic status and minority racial status may have contributed to a lack of access to healthcare services or knowledge about the harmful effects of douching behavior. The concept of allostatic load was useful for addressing the contributing factors to douching behavior in the population sampled by the NHANES dataset.
Although many studies have examined douching behavior and characteristics of women who douche, the National Health and Nutrition Examination Survey provided an estimate of the prevalence of douching behavior in the general U.S. population. The prevalence of douching behavior in multiple studies has ranged from 20% to greater than 60% depending on the population (Annang et al., 2006; Cottrell, 2003; Cottrell, 2006); in this study it is 21%. Possible explanations for the difference noted in prevalence of douching behavior among studies may be due to the operational definition of douching behavior. Some studies asked whether women had ever douched (Bruce et al., 2002) while other studies and the current study only examined douching behavior in the past six months. Funkhouser noted that 40% of the students she interviewed had ever douched while only half of that number reported that they currently douche (Funkhouser et al., 2002). Another explanation for the difference in prevalence estimates is that some clinical studies disproportionately enroll women who are more at risk for douching behavior such as African American women or women in poverty (Annang et al., 2006; Cottrell, 2006).

In addressing the purpose of this study, to examine the income effects on douching patterns within white, African American and Mexican American women, it is important to first discuss who douches with regards to race and ethnicity. Consistent with the literature (Demissie et al., 2001; Funkhouser et al., 2002; Funkhouser et al., 2002; Holzman, 2001; Rajamanoharan et al., 1999; Slattery & Morrison, 2002), African American women were more likely than white women to report douching behavior in the
past six months (47% to 17% in this study). Mexico-born Mexican American women were least likely to report douching (12%).

In the current study, the effects of the socioeconomic status variables of education and PIR on douching status differed among racial groups. While income relative to the poverty line was a significant predictor of douching in white women, notably, it only became significant in African American women in the final model with the adjustment for age, education and health insurance status. For Mexican American women not eligible for federal assistance for food programs (WIC or food stamps), yet not in the high income group, income increased their odds ratio of douching behavior in both the crude and adjusted models. This may be due to a frank lack of resources. If the family income was just above the cut-point for WIC eligibility, the family likely experienced a greater lack of access to resources than those with a lower income who were eligible for federal programs, and may therefore have had to limit healthcare expenditures, limiting healthcare access and knowledge. Furthermore, lack of health insurance as a measure of healthcare access was a significant predictor of douching behavior in white and Mexican American women but not in African American women. This may be due to the lack of distinction between privately-funded and state-funded health insurance. A strong common predictor of douching behavior among each of the racial/ethnic groups was education level less than high school in women older than 19 years of age. While the analyses are stratified by race/ethnicity, in crude and adjusted analyses for each racial/ethnic group, less than a high school education in women older than 19 was a strong predictor of douching behavior. It is likely that these women not only a lack
education, and possibly income associated with their lack of education, but that they also lack access to healthcare.

With Spanish as the primary language of Mexico, those who move to the United States at an older age are at significant disadvantage for obtaining not only education, but also access to healthcare resources due to the language barrier. Callister and Birkhead (2002) recognize that the communication barrier with healthcare providers may discourage women from seeking healthcare services and advice. At the same time, however, Mexico-born Mexican American women were far less likely to douche than U.S.-born Mexican American women. The language barrier may shield women from commercial advertisements for douching or other feminine hygiene products. As discussed in Chapter 1, the lack of acculturation experienced by many Mexico-born Mexican American women may protect them and actually diminish the likelihood of negative health behaviors.

It is worthy to note that just as with white women, income was a significant predictor of douching behavior for African American women after controlling for age, education and health insurance. The greatest predictors of douching in African American women were education levels less than high school in women older than 19, older age and low income. In contrast with white women, health insurance status was not a significant predictor of douching behavior for African American women. Perhaps in African American women, access to healthcare or lack thereof, does not contribute as strongly to douching behavior as it does for white women. As previously noted, generational influences exist for African American women with respect to douching;
perhaps these messages from mothers and grandmothers contribute more strongly to douching behavior than messages received from healthcare providers.

The concept of allostatic load reflects the physiological burden associated with cumulative life stress. The literature suggests that women are likely to douche when they have an unpleasant vaginal odor, or are trying to prevent a sexually transmitted infection (Funkhouser, et al., 2002). Although not tested in this study, it is possible that women with risky sexual behaviors are also those who are more likely to douche, in order to prevent infections or manage discharge and odors associated with infections. Chapter 2 presents a discussion on the association of risky sexual behaviors and stress. This study suggests that women who experience minority racial/ethnic status and/or low socioeconomic status would be more likely to engage in douching behavior, perhaps due to a lack of education about health behaviors or a lack of access to healthcare services which may educate women about other ways to maintain vaginal hygiene. Across racial groups with the NHANES data we confirm that older women, and more specifically women older than 19 with less than a high school diploma are more likely to douche than younger women. This is consistent with the literature which reports that the least frequent group to douche is teenage women (Cottrell, 2003). Interestingly, U.S.-born Mexican American women were more likely to douche than Mexico-born Mexican American women. In addition, African American and white women with lower poverty income ratios were more likely to douche than women with higher PIR values, which is also consistent with what is previously known. This income effect was not noticed with Mexican American women. Socioeconomic disadvantage, including low PIR and lower
education, is a major predictor for douching. In addition, while douching seems more prevalent in African American women, it is important to remember that more African American women are in lower income groups than white women.

Mexico-born Mexican American women douche less than African American women (47.3%) and slightly less than white women (17.3%) at a rate of 12.5%. While the income effect for douching behavior is not the same for Mexican American women as it is for African American and white women, the effect of education on douching behavior is similar. It is also interesting that Mexican American women born in Mexico are far less likely to douche than those born in the United States. In a related study on risk factors for small-for-gestational age infants, Collins and Martin noted that traditional sociodemographic risk factors for small-for-gestational age infants (SGA) for U.S.-born Mexican American mothers such as maternal education, parity, prenatal care and community income were not associated with SGA in Mexican-born mothers, suggesting that protective cultural effects exist prior to acculturation (Collins & Martin, 1998). It is possible that socioeconomic disadvantage only impacts birth outcomes when immigrant women are no longer practice their cultural diets and behaviors (Callister & Birkhead, 2002).

The impact of douching on health status needs to be considered. First, many studies have identified the high association between douching behavior and BV (Allsworth & Peipert, 2007; Cottrell, 2003; Holzman, 2001; Schwebke, Desmond, & Oh, 2004). For example, Holzman and colleagues reported a significant increase in BV prevalence in women who began douching before 20 years of age and in women who
described themselves as frequent douchers (more than once a month) (Holzman, 2001). Likewise, Schwebke and colleagues reported that women who douche after menses were more likely to receive a diagnosis of BV compared to women who did not douche after menses (OR: 5.11, 95% CI: 1.99-13.15) (Schwebke et al., 2004). Second, many authors have reported a relationship between BV and preterm delivery including Kurki and colleagues who found that BV is associated with a 6.9-fold increased risk (95% CI 2.5-18.8) for preterm birth (Kurki, Sivonen, Renkonen, Savia, & Ylikorkala, 1992). And finally, the link between douching and BV and between BV and preterm labor was reported by Cottrell (2006), who found in her sample that 87% of 409 women in eight Florida panhandle counties with preterm deliveries who doused regularly prior to pregnancy had a history of BV (Cottrell, 2006). Overall, Allsworth and Peipert report that nearly one-third of the U.S. population tests positive for BV, with rates varying by age, race/ethnicity, education and poverty (Allsworth & Peipert, 2007).

The association between douching and BV reported in the literature may be addressed by clinicians when a woman tests positive for BV, by asking whether the woman is douching. This is especially important if the woman is pregnant, given the association between BV, douching and preterm labor and delivery (Cottrell, 2006; Kurki et al., 1992). The opportunity to educate a woman regarding douching behavior could help prevent morbidity for a future pregnancy. Results from the current study suggest that, in particular, older women, women of low SES, and African American women should be queried as to their douching behavior, with the goal of reducing ectopic pregnancy, PID and importantly, BV and preterm delivery in these at-risk groups.
Limitations of this study include missing data which allowed for only 85% of the eligible sample to be included in the analysis. There were, however, no differences on any of the measured variables between women who were included for analysis and those who were not. Future iterations of the NHANES will help to further describe douching behavior among American women. By describing who douches, it may be possible to design interventions that specifically target women who douche in an attempt to reduce rates of negative sequelae of douching, including BV, PID, ectopic pregnancy, and preterm labor and delivery.
References


Figure 3.1: Conceptual Framework depicting relationship between Stressors, Behavioral responses to stress and health status, allostatic load and health outcomes. Adapted from McEwen (1998).

*: Other behavioral responses to stress included in the model of allostatic load adapted by Arbour, but not considered in this analysis: Smoking, Activity, Diet, Sexual risk behaviors

†: Other factors in addition to BV considered in health status in the model of allostatic load as adapted by Arbour, but not considered in this analysis: Systolic and diastolic blood pressure, body-mass index, glycated hemoglobin, homocysteine, trichomonas vaginalis, smoking status, periodontal disease, iron-deficiency anemia
<table>
<thead>
<tr>
<th>Sample</th>
<th>White Sample n (Population %)</th>
<th>African American Sample n (Population %)</th>
<th>U.S.-born Mexican American Sample n (Population %)</th>
<th>Mexican –born Mexican American Sample n (Population %)</th>
<th>χ² p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>221 (17.3)</td>
<td>355 (47.3)</td>
<td>54 (19.3)</td>
<td>47 (12.5)</td>
<td>&lt;.0001</td>
</tr>
<tr>
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<td>598 (52.7)</td>
<td>483 (80.7)</td>
<td>402 (87.5)</td>
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</tr>
<tr>
<td>Income (Poverty Income Ratio)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤1.3</td>
<td>380 (19.4)</td>
<td>447 (43.3)</td>
<td>192 (33.5)</td>
<td>260 (53.1)</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>&gt;1.3 to ≤1.85</td>
<td>138 (9.1)</td>
<td>126 (14.7)</td>
<td>93 (13.7)</td>
<td>87 (22.2)</td>
<td></td>
</tr>
<tr>
<td>&gt;1.85 to ≤3.5</td>
<td>401 (25.7)</td>
<td>229 (24.1)</td>
<td>131 (26.0)</td>
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<td>151 (17.9)</td>
<td>121 (26.7)</td>
<td>17 (4.9)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than HS* teenager</td>
<td>382 (13.3)</td>
<td>389 (14.6)</td>
<td>295 (25.9)</td>
<td>111 (8.1)</td>
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<tr>
<td>Less than HS older</td>
<td>139 (8.3)</td>
<td>153 (21.5)</td>
<td>65 (18.0)</td>
<td>218 (58.3)</td>
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</tr>
<tr>
<td>HS Grad or GED†</td>
<td>275 (20.6)</td>
<td>147 (21.3)</td>
<td>60 (17.7)</td>
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<td>More than HS</td>
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<td>264 (42.6)</td>
<td>117 (38.4)</td>
<td>54 (16.1)</td>
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<td>Health Insurance Status</td>
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<td></td>
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</tr>
<tr>
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<td>1364 (84.9)</td>
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<td>167 (34.8)</td>
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</tr>
<tr>
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<td>161 (17.8)</td>
<td>135 (28.8)</td>
<td>282 (65.2)</td>
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</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14-19</td>
<td>453 (15)</td>
<td>468 (17.4)</td>
<td>333 (29.1)</td>
<td>143 (10.5)</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>20-29</td>
<td>406 (24.7)</td>
<td>173 (27.1)</td>
<td>91 (33.7)</td>
<td>114 (31.9)</td>
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<td>30-39</td>
<td>397 (27.7)</td>
<td>147 (28.5)</td>
<td>47 (17.8)</td>
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<td>40-49</td>
<td>324 (32)</td>
<td>165 (27.0)</td>
<td>66 (19.4)</td>
<td>87 (21.7)</td>
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<td>Pregnancy Status</td>
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<td>Pregnant</td>
<td>242 (4.3)</td>
<td>99 (7.7)</td>
<td>58 (7.5)</td>
<td>79 (10.2)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Not pregnant</td>
<td>1309 (94.1)</td>
<td>830 (89.3)</td>
<td>470 (90.9)</td>
<td>355 (87.2)</td>
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<td>29 (1.6)</td>
<td>24 (3.0)</td>
<td>9 (1.6)</td>
<td>15 (2.6)</td>
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</tr>
</tbody>
</table>

* High school
† General equivalency diploma

Table 3.1: Sample Prevalence and Population Percentages of Race/Ethnicity and Sociodemographic Characteristics in Women 14-49 Years of Age
<table>
<thead>
<tr>
<th>White</th>
<th>Final Adjusted Model *:</th>
<th>African American</th>
<th>Final Adjusted Model *:</th>
<th>Mexican American</th>
<th>Final Adjusted Model *:</th>
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<td><strong>Education</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Less than high school teenager</td>
<td>0.22 (0.14-0.33)</td>
<td>0.72 (0.27-1.93)</td>
<td>0.24 (0.16-0.37)</td>
<td>0.51 (0.25-1.02)</td>
<td>0.12 (0.06-0.21)</td>
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<tr>
<td>Less than high school older</td>
<td>12.38 (6.86-22.32)</td>
<td>2.75 (1.03-7.34)</td>
<td>8.73 (6.21-12.27)</td>
<td>3.65 (2.06-6.50)</td>
<td>8.85 (6.10-12.85)</td>
</tr>
<tr>
<td>High school grad or GED †</td>
<td>2.29 (1.63-3.20)</td>
<td>1.93 (1.36-2.74)</td>
<td>1.41 (0.98-2.02)</td>
<td>1.29 (0.90-1.85)</td>
<td>1.28 (0.66-2.48)</td>
</tr>
<tr>
<td>More than high school</td>
<td>-------</td>
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<tr>
<td>20-29</td>
<td>3.83 (2.38-6.17)</td>
<td>2.89 (1.28-6.55)</td>
<td>3.06 (2.05-4.55)</td>
<td>1.77 (0.95-3.28)</td>
<td>5.95 (3.64-9.73)</td>
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<td>30-39</td>
<td>4.79 (2.79-8.25)</td>
<td>4.07 (1.61-10.31)</td>
<td>4.00 (2.63-6.10)</td>
<td>2.50 (1.5-4.17)</td>
<td>6.55 (3.94-10.89)</td>
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<td>40-49</td>
<td>3.71 (2.28-6.04)</td>
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<td><strong>Income (Poverty Income Ratio)</strong></td>
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<tr>
<td>≤1.3</td>
<td>2.91 (2.24-3.77)</td>
<td>2.33 (1.72-3.16)</td>
<td>1.59 (0.90-2.81)</td>
<td>1.84 (1.05-3.24)</td>
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<td>&gt;1.3 to ≤1.85</td>
<td>2.73 (1.63-4.58)</td>
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<td>&gt;1.85 to ≤3.5</td>
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<td>&gt;3.5</td>
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<td><strong>Health Insurance</strong></td>
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<tr>
<td>No</td>
<td>2.85 (1.69-4.80)</td>
<td>1.90 (1.06-3.37)</td>
<td>1.15 (0.65-2.06)</td>
<td>1.01 (0.54-1.89)</td>
<td>1.20 (0.81-1.78)</td>
</tr>
</tbody>
</table>

* Adjusts for education, age, income and health insurance, and for Mexican Americans, country of birth.
† General equivalency diploma
‡ Poverty/income ratio

Table 3.2: Crude and Adjusted Odds Ratios and 95% Confidence Intervals for Selected Demographic Characteristics Among Women 14-49 Years Of Age for Douching in the Past 6 Months
CHAPTER 4

ALLOSTATIC LOAD IN WOMEN: AN INNOVATIVE STRATEGY TO UNDERSTAND AND PREVENT PRETERM DELIVERY

Introduction

Pre-pregnancy Health

Pregnancy is an important time for a woman because the outcome of pregnancy, whether good or bad, can impact her, her family and society for many years. One of the key predictors of a successful pregnancy outcome is a woman’s pre-pregnancy health status (Conley, Strully, & Bennett, 2003; Geronimus, 1996; Haas et al., 2005). Pre-pregnancy health status refers to the health of a woman who is not currently pregnant, but who has the ability to become pregnant. Some examples of pre-pregnancy health conditions which are known to negatively impact pregnancy outcomes are hypertension (Samadi & Mayberry, 1998), diabetes mellitus (Ray, Vermeulen, Shapiro, & Kenshole, 2001), obesity (Haas et al., 2005), and periodontal disease (Radnai et al., 2004). In addition to these, many other conditions exist that are known to negatively impact pregnancy outcomes including the outcome of preterm delivery. With the knowledge that pre-pregnancy health status has the ability to impact pregnancy outcomes such as preterm delivery, many professional organizations suggest that a key first step in
reducing premature birth is evaluating and improving the pre-conception health of
women (American Academy of Pediatrics/ American College of Obstetricians and
Gynecologists, 2002; American College of Nurse Midwives, 2007; American College of
Obstetricians and Gynecologists, 2005; Brundage, 2002; Johnson et al., 2006).

*Preterm Delivery*

Preterm birth (less than 37 weeks gestation), which occurs at a rate of 1 in 8
(12.5%) of all live births in the United States, is a serious cause of infant morbidity and
mortality, and contributes to more than one-third of all infant deaths during the first year
of life (March of Dimes, 2007). African Americans have a higher prevalence of preterm
birth than other racial/ethnic groups (March of Dimes, 2008). For infants who survive,
prematurity is associated with an increased risk for long-term disability including
cerebral palsy, blindness and developmental delay (Ward & Beachy, 2003). With a
significant impact to the individual, family, and society, premature birth has considerable
societal economic costs (medical, educational and lost productivity): $26.2 billion in
2005 (March of Dimes, 2008). Unfortunately, the incidence of singleton preterm birth
has increased, not decreased over the last decade (March of Dimes, 2007). Healthy
People 2010 recommends that the rate of preterm birth be no higher than 7.6% of all live
births (Department of Health and Human Services, 2007) calling researchers and
clinicians to take a fresh look at what is driving this epidemic. Several researchers have
suggested that one way to do this is by examining the impact of life stress on pre-
pregnancy health status (Hogue & Bremner, 2005; Shannon, King, & Kennedy, 2007).
The Impact of Stressors on Pre-Pregnancy health

Pre-pregnancy health status is often reflective of a lifetime of stressful events, including those associated with poverty and minority race/ethnicity (Lu & Chen, 2004). An acute stressful experience triggers the sympathetic nervous system and the hypothalamic pituitary adrenal axis stimulating a release of catecholamines and cortisol. This leads to a sudden increase in blood pressure, increased blood glucose and a shift of attention and focus to the acute stressor, a series of events known as the “fight or flight” response (Sapolsky, Romero, & Munck, 2000). This response helps the individual in the immediate circumstance by allowing him or her to manage the stressor, perhaps by fleeing the situation. Repeated or prolonged exposure to stressors can, however, over time, lead to wear and tear on the individual and increase the physiological burden of stress, measured as allostatic load (McEwen & Lasley, 2003).

Stressors

Minority racial status and poverty are often associated with increased levels of chronic stress impacting health (Adler & Newman, 2002; Geronimus, Hicken, Keene, & Bound, 2006; Giscombe & Lobel, 2005). Evidence exists that racism, as frequently reported by African Americans, contributes to life stress (Klonoff, Landrine, & Ullman, 1999). The stress of discrimination, racial bias in health care and residence in poor neighborhoods all contribute to the impact of race on health (Williams, 1999). In addition, poverty disproportionately affects racial minorities such as African Americans and Mexican Americans (Kramer, Seguin, Lydon, & Goulet, 2000). Multiple reports provide evidence that demonstrate that people in low SES groups experience greater
stress than those in high SES groups (Adler & Newman, 2002; Marmot, 2004). Mirowsky and Ross note that for every measure of socioeconomic status considered, including education, income, occupation and employment status, health increases as socioeconomic status increases (Mirowsky & Ross, 2003).

The incidence of preterm birth is higher among the socially disadvantaged than among other groups (Kramer et al., 2001). Because race/ethnicity and socioeconomic status are closely related, the disparities in pregnancy outcome according to socioeconomic status are often associated with pregnancy outcome disparities by race/ethnicity (Kramer et al., 2000). One example of a risk factor for preterm delivery that is related to both race/ethnicity and socioeconomic status is bacterial vaginosis (BV). BV is associated with an increased risk for preterm delivery (Friese, 2003) and is also more common among African American individuals and those living in poverty (Allsworth & Peipert, 2007). Aside from individual contributors to preterm delivery, socioeconomic disadvantage limits access to care, healthcare knowledge and education, thereby increasing the risk for poor pregnancy outcomes (Kramer et al., 2000).

In the weathering hypothesis put forth by Geronimus, the relationship between race/ethnicity, life stress and the physiological burden of stress measured as allostatic load is apparent (Geronimus et al., 2006). The weathering hypothesis suggests that African Americans suffer accelerated health deterioration as a result of the stress related to racism and political marginalization (Geronimus, 1992; Geronimus, 1996). As evidence for this hypothesis, African American women tend to have better birth outcomes (fewer low birth weight and preterm deliveries) when they deliver in their
teens, rather than during later years such as the twenties and thirties after they have accumulated more effects of life stress (Geronimus, 1996). This suggests that as African American women grow older, their ability to achieve healthy pregnancy outcomes decreases. The weathering hypothesis has also been tested in Mexican American women with evidence that weathering exists for these women as well, at least for those born in the United States, although perhaps not for those born in Mexico (Wildsmith, 2002).

As reviewed in Chapter 2 and specifically Table 2.1, the effects of exposure to chronic life stress associated with minority racial status and low socioeconomic status are seen in immune/inflammatory responses, cardiovascular, metabolic function, and nutritional intake (Sapolsky et al., 2000). Several infections that reflect immune/inflammatory function, including bacterial vaginosis (BV) and periodontal disease are each impacted not only by life stress as described in Table 2.1, but are also implicated in increased risk for preterm delivery (Cotch et al., 1997; Culhane et al., 2001; Hillier et al., 1995; Kramer et al., 2001; Kurki, Sivonen, Renkonen, Savia, & Ylikorkala, 1992; LeResche & Dworkin, 2002; Radnai et al., 2004; Weisman et al., 2006). Trichomonas vaginalis is a vaginal infection that is implicated in increased risk for preterm delivery, but more importantly, is associated with risky sexual behaviors. Increased levels of stress and depression, as well as low social support are associated with risky sexual behaviors (Mazzaferro, et al., 2006). Similarly, systolic and diastolic blood pressures, homocysteine and cigarette smoking are additional variables which impact a woman’s pre-pregnancy health and risk for preterm delivery, and are impacted by life stress (Blackburn, 2003; Colhoun, Hemingway, & Poulter, 1998; Guyll,
Stress also impacts metabolic function and nutritional status with effects on body mass index (BMI), glycated hemoglobin levels and iron deficiency anemia. These each increase the risk for preterm delivery and can significantly impact a woman’s pre-pregnancy health status (Haas et al., 2005; Killip, Bennett, & Chambers, 2007; Ray et al., 2001; Sapolsky et al., 2000; Vanitallie, 2002; Yip, 2000).

These ten variables (BV, trichomonas, periodontal disease, systolic and diastolic blood pressures, homocysteine, cigarette smoking, BMI, glycated hemoglobin and iron deficiency anemia) are those which are considered in the present study as measures of pre-pregnancy health status and are evaluated to conceptualize the total body effects of stress, i.e., the allostatic load. The risk for preterm delivery increases as problems occur prior to pregnancy, either in isolation or clusters. For example, a woman with hypertension and obesity is at greater risk for poor pregnancy outcomes than a woman who is simply obese. Chapter 2 includes a detailed review of the literature surrounding the effects of stress on the body. In addition, the impact of stress on pregnancy and pregnancy outcomes is discussed in terms of these ten variables and the manner in which each increases the risk for preterm delivery.

Theoretical Concept: Allostatic Load

The theoretical concept of allostatic load helps to explain the impact of life stress and behavioral responses to stress on the pre-pregnancy health status of women.
Allostatic load reflects the health status of an individual in light of an accumulation of stress to which the individual has been exposed, as well as behavioral responses to stress (McEwen, 1998). Individuals are typically able to respond to day-to-day stressors without negative effects on the body. When the stressors are too much or too frequent, however, the individual experiences wear and tear on the body as a result (Goldstein & McEwen, 2002; McEwen & Wingfield, 2003). As stated previously, a woman’s pre-pregnancy health status is theorized to result from the accumulation of chronic life stress including minority race/ethnicity and low SES (Adler & Newman, 2002; Geronimus et al., 2006; Giscombe & Lobel, 2005), as well as her behavioral responses to these stress such as smoking, diet, decreased physical activity, increased sexual risk behaviors (Glaser & Kiecolt-Glaser, 2005; Kristenson et al., 2004; Mazzaferro, et al., 2006) and douching as explored in Chapter 3. Pre-pregnancy health status is reflected in a woman’s allostatic load score, which is theorized to impact the health outcome, in this case, pregnancy outcome. See Figure 4.1.

Since the 1990’s when the concept of allostatic load score was first introduced, the number of variables counted in the score has ranged from ten to sixteen, with alterations in operationalization designed to better reflect the life stress an individual has experienced (Geronimus et al., 2006; Seeman, Singer, Rowe, Horwitz, & McEwen, 1997; Seeman, McEwen, Rowe, & Singer, 2001; Seeman et al., 2004). An individual’s allostatic load score is often calculated by summing the number of variables in which the individual scores in the “high risk” range (Crimmins, Johnston, Hayward, & Seeman, 2003; Geronimus et al., 2006; Seeman et al., 2001; Szanton, Gill, & Allen, 2005). Table
4.1 lists high risk cut points for the variables included in the current study. The high-risk cut points selected for these variables are clinically relevant levels, meaning treatment or management is expected to occur in a clinical setting if an individual consistently has a value in the high risk range.

One way to view pre-pregnant health status is through a combination of variables reflecting the function of many body systems, as with allostatic load. Previous uses of allostatic load have not been specifically designed to evaluate conditions that place women at risk for poor birth outcomes. In order to address this gap and assess the impact of stress on total body pre-pregnancy health status, measured as allostatic load, the following variables were selected for allostatic load measurement: bacterial vaginosis, trichomonas vaginalis, periodontal disease, systolic and diastolic blood pressures, homocysteine, smoking status, body mass index, glycated hemoglobin, and iron-deficiency anemia. These variables, associated with the effects of stress on the body as well as preterm delivery, are influenced by poverty and minority race/ethnicity, as well as health behaviors. Each is known to individually contribute to preterm birth, but the additive effects of more than one variable are unknown.

Gap/ Purpose

Although previous studies have examined the impact of a particular pre-pregnant health condition on pregnancy outcome (Bruce et al., 2002; Khoury, Henriksen, Christophersen, & Tonstad, 2005; Scholl, Hediger, Fischer, & Shearer, 1992; Xiong, Buekens, Fraser, Beck, & Offenbacher, 2006), few studies were found during this research that looked at the overall health status of a woman during her reproductive years
as an approach to reducing prematurity. Haas and colleagues prospectively examined chronic medical conditions pre-pregnancy and the risk for preterm delivery but only included chronic diseases such as anemia, asthma, lung diseases, diabetes, hypertension, epilepsy, HIV, cancer, thyroid and heart disease, as well as height, weight and smoking status in their measure of pre-pregnancy health status (Haas et al., 2005). In addition to not looking at variables specifically associated with preterm delivery, these authors did not examine the impact of socioeconomic conditions on health status. While some have looked at SES (Ahern, Pickett, Selvin, & Abrams, 2003; Craig, Thompson, & Mitchell, 2002; Kramer et al., 2000; Kramer et al., 2001) and minority race/ethnicity (Dole et al., 2003; Hogue & Bremner, 2005; Lu & Chen, 2004; Rosenberg, Palmer, Wise, Horton, & Corwin, 2002) as stressors increasing the risk for preterm delivery, no studies were found during this research that looked at both low SES and minority race/ethnicity as potential stressors that impact pre-pregnancy health status (allostatic load), and subsequent pregnancy outcome (Shannon et al., 2007). In order to address these gaps, this study tests the hypothesis that: Subgroups with historically high levels of poor birth outcomes will have worse pre-pregnancy health status (allostatic load) than other groups. This hypothesis is tested in pre-pregnant childbearing-aged women, with consideration of racial/ethnic background and SES, with the use of population-based data from the National Health and Nutrition Examination Survey (NHANES). In addition, sociodemographic risk factors for increased allostatic load will be examined.
Materials and Methods

Current Sample

Data from both the NHANES 2001-2002 and 2003-2004 data sets, described in Chapter 1, are used in the current study. Because the NHANES is a publicly available dataset on the CDC website, this research is not specifically human subjects research and therefore IRB review and approval is not necessary. Mexican American, African American, and white women aged 15-35 who completed both the examination and interview portions of the survey and who were not pregnant at the time of the survey were eligible for inclusion in the analysis (n=2,108). This age group was selected to represent women of child-bearing age.

Variables

Dependent. Allostatic load is the dependent variable for this analysis. It includes 10 physiological variables that are not only influenced by life stress, but are also known to impact the risk for preterm delivery. Frequently in other studies (Crimmins et al., 2003; Geronimus et al., 2006; Seeman et al., 2001; Szanton et al., 2005) and in the current study, allostatic load is calculated by summating the number of variables in which the individual scores in the “high risk” range. Table 4.1 lists high risk cut points for the variables included: BV, trichomonas vaginalis, periodontal disease, systolic and diastolic blood pressures, homocysteine, smoking status, BMI, glycated hemoglobin, and iron-deficiency anemia. The high-risk cutoffs selected for these variables are clinically-based levels, meaning treatment or management is recommended to occur in a clinical setting if an individual has a value in the high risk range. For each variable with a value outside of
the clinically acceptable range, a point is assigned to the woman’s individual allostatic load score. The score may range from 0-10 with 10 indicating worse health status than 0.

As part of the NHANES dataset, periodontal disease and body mass index (BMI) were collected by examination only, while glycated hemoglobin, homocysteine, BV, trichomonas, and iron-deficiency anemia were collected by laboratory analysis. Systolic and diastolic blood pressures were measured as part of the exam and by questionnaire. For purposes of this analysis, if a woman answered that she had been told by a medical provider that she had high blood pressure, but was normo-tensive during the clinical examination or was missing blood pressure data altogether, she was still considered to have elevated systolic and diastolic blood pressures. Smoking status information was collected by both self-report of current smoking behavior and serum cotinine in laboratory analysis. If a woman stated that she smoked cigarettes everyday but had missing serum cotinine values, she was considered to be a current smoker for the purposes of this analysis. Likewise, if she reports a non-smoking status, but has cotinine levels above the cut-off level indicative of smoking behavior, she is considered to be a current smoker in this analysis.

Independent. The independent variables in this study include several sociodemographic variables: poverty/income ratio, educational level, health insurance, race/ethnicity, age, and country of birth for Mexican Americans, each of which is be discussed below. In the publicly available NHANES dataset, the only income-based measure of economic status that adjusts for family size is the 1) poverty/income ratio (PIR). PIR represents a way to compare family income across family units of different sizes, using the federal poverty
guidelines. Families of a given size with a higher income have a higher PIR. PIR is ranked continuously from 0 to 5 where 1 is considered 100% of the federal poverty line for a family of that size. For example, if the federal poverty guideline for a family of three is $20,000 per year, a family with an income of $0 would have a PIR of 0, while a family income of $30,000 for 3 people would indicate a PIR of 1.5. Data are top-coded at 5 or 500% of the federal poverty line; in the current sample, 188 women have income top-coded at 5. For the purposes of logistic regression analysis, PIR was collapsed into four groups: low income, defined as PIR \leq 1.3; low middle income, defined as PIR >1.3 and \leq 1.85; middle income, defined as PIR >1.85 and \leq 3.5; and high income, defined as PIR>3.5. The Materials and Methods section of Chapter 3 describes the rationale for this grouping of PIR. Income reflects the ability to access material needs and health resources, making it an important measure when considering the socioeconomic status of women. 2) Educational level, answered by questionnaire, is coded as less than high school, high school or graduate equivalency diploma (GED) completion, or more than high school. Education reflects the ability of an individual to gather information and needed resources and is an important part of socioeconomic status. 3) Health insurance status is self-reported at the time of interview in answer to the question: “Do you currently have health insurance?” A follow-up question asks whether the insurance is private or public. Health insurance status reflects the ability of an individual to seek healthcare and contributes to socioeconomic status. 4) Race/ethnicity is self-reported (only non-Hispanic blacks (African American) and whites, and Mexican Americans are included). For Mexican American women, a follow-up question regarding their country
of birth (the United States or Mexico) is included, as discussed in Chapter 1. With the racial disparity noted in birth outcomes, it is crucial to know the race/ethnicity of individuals in this analysis. 5) Age is self-reported in years. Women aged 15 to 35 who are included in the analysis are grouped by age from 15 to <20, ≥20 to <25, ≥25 to <30, and ≥30 to 35 years in order to facilitate analysis. As women age, their allostatic load generally increases. This is accelerated for some subgroups (Geronimus et al., 2006). For this reason, age is an important variable to consider with respect to pre-pregnancy health status measured as allostatic load.

PIR, educational level and health insurance status are three measures of socioeconomic status that are used. Each reflects a different mechanism by which an individual may experience advantage or disadvantage that can impact health. PIR reflects the financial status of the family and the ability to access material goods; education reflects an individual’s educational level and ability to access information (Mirowsky & Ross, 2003); and health insurance status reflects and ability to access healthcare services as needed. Again, as described in Chapter 1, country of birth for Mexican American women, the United States or Mexico, was entered into the regression in order to better understand the impact of acculturation on health outcomes (Callister & Birkhead, 2002).

Statistical Methods

The different measures of SES and race/ethnicity were compared using the $\chi^2$ statistic and differing interactions between race/ethnicity and SES were noted for each group. The interactions between each of the sociodemographic characteristics and
race/ethnicity were statistically significant at the $\alpha=0.05$ level. For example, while white women were fairly evenly dispersed among the four income groups, a majority of African American and Mexican American women populated the lowest income group. In addition, more African American and Mexican American women had less than a high school diploma but were older than 19 years of age. The differences in prevalence by race/ethnicity and sociodemographic characteristic demonstrating disparate levels of disadvantage among the racial/ethnic groups led to the decision to separate the analyses by racial/ethnic group. That is, the analyses were stratified by racial/ethnic group in order to determine which factors most augmented the risk for increased allostatic load for each group. Categorical data were compared using the $\chi^2$ statistic. In order to determine the impact of PIR, education and health insurance on reaching or surpassing the overall median allostatic load score while controlling for age, crude and adjusted odds ratios were estimated by using logistic regression (Seeman, Singer, Ryff, Dienberg Love, & Levy-Storms, 2002). The overall median allostatic load score was used as the outcome score for logistic regression in order to differentiate between high and low allostatic load scores. All analyses were completed using the appropriate stratum (sdmvstra), PSU designations (sdmvpwu), and 4-year sampling weights (.5*wtmec2yr) estimated by the National Center for Health Statistics in order to reflect the entire U.S. population based on the 2000 census data.

Results

The final sample includes data from 1497 women (71% of the eligible sample), which when weighted represents the experience of 24,276,859 U.S. women aged 15 to
35. Women were considered ineligible if they were missing data or answered “don’t know” to variables on education (n=2), income (n=112), health insurance (n=3), bacterial vaginosis (n=232), trichomonas vaginalis (n=224), periodontal disease (n=177), blood pressure- missing systolic and/or diastolic blood pressures and no answer to blood pressure questionnaire (n=35), smoking- missing serum cotinine and no answers to smoking questionnaire (n=106), homocysteine (n=91), body mass index (n=21), glycated hemoglobin (n=85) and iron-deficiency anemia variables (n=80). The sum of these is greater than expected as eligible for the final analysis because some participants were missing data for more than one variable. In addition, two women were excluded as outliers with allostatic load scores of 8 and 9 respectively. They were both African American in the lowest income group (PIR <1.3); one was a teenager and the other was in the oldest group (30-35 years of age) but without a HS diploma; they both had health insurance.

With respect to demographic data (education, income and health insurance), when comparing those eligible for the analysis (no missing data) and those ineligible due to missing data using the $\chi^2$ test, there were no significant differences between the groups for education, race, health insurance status, or income at the $\alpha=.05$ level. With respect to the variables which comprise the allostatic load score (BV, trichomonas vaginalis, periodontal disease, blood pressures, smoking, homocysteine, BMI, glycated hemoglobin and iron deficiency anemia), when comparing those eligible for the analysis (no missing data) and those ineligible due to missing data using the $\chi^2$ test, more African American women were missing data for smoking, glycated hemoglobin and iron-deficiency anemia.
than white or Mexican American women at the $\alpha=.05$ level. In addition, more Mexican American women than white or African American women were missing blood pressure information at the $\alpha=.05$ level. Based upon systolic and diastolic blood pressure readings only, there were no significant differences between missing and non-missing groups at the $\alpha=.05$ level, but with the inclusion of the blood pressure questionnaire variable, more Mexican American women were missing blood pressure data. Also, more women in the lowest two income groups (PIR $\leq 1.85$) were missing periodontal disease data than the other income groups. Because none of the variables were different by race/ethnicity and income, complete case analysis was used, bringing the analytic sample to 1497.

In order to ensure that income and education were not strongly correlated in each racial/ethnic group and were actually measuring different components of socioeconomic status, Pearson’s correlations were calculated between income and education by race/ethnicity. Although the correlations were statistically significant at $p<0.05$ for most groups, the correlations were small: U.S.-born Mexican American ($r=0.07, p=0.26$); Mexico-born Mexican American ($r=0.21, p=0.0064$); White ($r=0.09, p=0.024$); African American ($r=0.17, p=0.0003$); entire sample ($r=0.19, p<.0001$). Because the correlations were small, albeit statistically significant, support remains to include both income and education in the analysis. Income reflects the ability of an individual to access material goods while education enables an individual to understand and think about what she needs in order to maintain or improve her health.

The prevalence of each sociodemographic variable stratified by race is presented in Table 4.2. The racial stratification into white, African American, U.S.-born Mexican
American and Mexico-born Mexican American helps to disentangle the race/ethnicity and SES relationship, revealing the differences in health for racial/ethnic group. Of the women who self-identified as African American, roughly 6% were born in a country other than the United States. Roughly 40% of self-identified Mexican American women in this analysis were born in Mexico with the remaining being born in the United States. Overall, more white women (38.6%) report a PIR in the highest income group (PIR>3.5) than African American (15.6%) or Mexican American women (26.3% U.S.-born and 4.4% Mexico-born) ($\chi^2 p<.0001$). In addition, African American and Mexico-born Mexican American women report the highest prevalence in the lowest income group, (PIR≤1.3), 47.9% and 52.9% respectively ($\chi^2 p<.0001$). Besides a high income, more white women report greater than a high school diploma (53.3%) than African American (44.0%), U.S. –born Mexican American (41.4%) or especially Mexico-born Mexican American women (16.6%) ($\chi^2 p<.0001$). These findings help to highlight the significant advantage that white women have as a racial/ethnic group with higher income and more education than African American or Mexican American women, which may contribute to better health as a result of increased access to healthcare providers and increased health education (Mirowsky & Ross, 2003).

As may be suspected with the varying socioeconomic profiles of each of the racial/ethnic groups, and as is later presented as part of the logistic regression, allostatic load score for each racial/ethnic group varies by sociodemographic characteristic. Mean and median allostatic load scores by racial/ethnic group and sociodemographic characteristic (PIR, education, health insurance and age) were calculated and are...
presented in Table 4.3. Differences between mean allostatic load scores for each racial/ethnic group and sociodemographic characteristic were tested using the analysis of variance (ANOVA) procedures with \( \alpha=0.05 \) and the Bonferroni correction for experimental error. The overall mean allostatic load score for the population is 2.40 suggesting that on average, women have two or more conditions prior to pregnancy which may impact their risk for preterm delivery. White, U.S.-born Mexican American and Mexico-born Mexican American women have median allostatic load scores of 2.0, and the overall median allostatic load score for these women is also 2.0. African American women have a higher median allostatic load score at 3.0. This means that 50% of white and Mexican American women, and 50% of the overall sample have two or more risk factors for preterm delivery but that 50% of African American women have three or more risk factors. The impact of income and race/ethnicity on allostatic load, and age and race/ethnicity on allostatic load are visually depicted in Figures 4.2 and 4.3 respectively. ANOVA and the Bonferroni correction were used to determine whether differences at a given age or income between racial/ethnic groups were statistically significant at \( \alpha=0.05 \). In Figure 4.2, mean allostatic load for African American women is statistically significantly different from all other racial groups at the first and second income groups. In the fourth income group, mean allostatic load for African American women is different from white and U.S.-born Mexican American women but not Mexico-born Mexican American women due to the small number of women represented in this cell. Figures 4.2 and 4.3 visually reveal that age and income do not impact mean allostatic load score in exactly the same manner for each racial/ethnic group.
With the understanding that the effect of sociodemographic variables impact allostatic load score differently for each racial/ethnic group, it is important to consider the mean and frequency of each clinically significant risk factor for each racial/ethnic group. Mean values by risk group and racial/ethnic group were calculated for each of the ten risk factors except those which are dichotomous in nature, BV, trichomonas vaginalis, and periodontal disease. These appear in Table 4.4. This indicates that while all included in the high risk smoking group are current smokers, the white and African American women smoked more heavily. Mean values of glycated hemoglobin for individuals in the high risk group were not terribly different by racial/ethnic group, but hemoglobin levels for those with anemia were different by racial/ethnic group. While white and African American women with iron deficiency anemia had mean hemoglobin levels at 10.9 g/dL and 10.7 g/dL respectively, U.S.-born Mexican American women had mean hemoglobin levels at 11.1 and Mexico-born Mexican American women at 9.98 g/dL. From this it appears as though the Mexico-born Mexican American women included in this analysis were much more anemic than women with iron deficiency anemia in the other racial/ethnic groups, perhaps due to a dietary deficiency of iron. Mean homocysteine and blood pressures in the high risk category did not vary much by racial/ethnic group, but BMI did. In agreement with the literature, while African American women had a mean BMI of 32 kg/m², every other racial/ethnic group in the high risk BMI category had a lower mean BMI of 29 kg/m².

As previously mentioned, the ten variables which comprise the allostatic load score (BV, trichomonas vaginalis, periodontal disease, blood pressures, smoking,
homocysteine, BMI, glycated hemoglobin and iron deficiency anemia) have differing clinical high-risk prevalence in the stratified racial/ethnic groups. The frequency of the high risk variables is noted in Table 4.5 and the population prevalence is visually depicted in Figure 4.4. Prevalence for each variable is significantly different for the four racial/ethnic groups at $\chi^2 p < .05$. Interestingly, African American women have an increased prevalence of vaginal infections (BV: 51.13%, trichomonas vaginalis: 8.41%) when compared to white (BV: 20.35%, trichomonas vaginalis: 0.61%) or Mexican American women (U.S.-born BV: 33.6%, trichomonas vaginalis: 0.95%; Mexico-born BV: 31.45%, trichomonas vaginalis: 2.77%). African American women also have a higher prevalence of increased systolic and diastolic blood pressures and iron deficiency anemia when compared to the other racial/ethnic groups. African American and Mexico-born Mexican American women have the highest prevalence of elevated glycated hemoglobin levels (76.94% and 73.16% respectively) while white women have the lowest rates of BMI outside the clinically normal range (46.43%).

In order to explain the effects of the sociodemographic variables (age, PIR, education, health insurance, and country of birth for Mexican American women) on allostatic load score at or above the median, logistic regression was performed calculating crude and adjusted odds ratios. Results of the logistic regression analysis are presented in Table 4.6. Interestingly, in the final analysis controlling for education, age, health insurance status, PIR, and for Mexican American women, country of birth, education was only an important predictor allostatic load $\geq 2$ for white and Mexican American women, not for African American women. White women with only a high school diploma or
GED were 2.14 (95% CI 1.06-4.32) times more likely to have an allostatic load score of ≥2 than women with more than a high school diploma. Teenaged white women, not yet finished with high school, were 2.34 (95% CI 1.24-4.41) times more likely than women with more than a high school diploma to have an allostatic load score of ≥2. Alternatively, white women with less than a HS diploma and who were older than 19 were not at increased risk for increased allostatic load. Mexican American women with only a high school diploma or GED were 2.47 (95% CI 1.19-5.10) times more likely to have an allostatic load score of ≥2 than women with more than a high school diploma.

For African American women in the final model adjusting for age, PIR, health insurance and education, only a complete lack of health insurance was a significant predictor of allostatic load score ≥ 2 when compared to women with privately funded health insurance. Lack of health insurance status compared to private health insurance was a significant predictor of allostatic load score ≥2 for all women in the final model: White OR: 2.46 (95% CI 1.51-4.01); Mexican American OR: 2.11 (95% CI 1.02-4.34); African American OR: 3.23 (95% CI 1.43-7.32).

Importantly, income was not a significant predictor of allostatic load score at or above the median for white or African American women in either the crude or adjusted analyses. In crude analyses, income increased the risk for allostatic load score ≥2 for Mexican American women, but this risk did not persist in adjusted analyses. For Mexican American women, Mexico as a country of birth as a sole predictor increased the risk for allostatic load score ≥2 when compared to women born in the United States: crude OR 1.68 (95% CI 1.02-2.77); but in the final adjusted analyses, country of birth did...
not contribute significantly to increased risk: adjusted OR: 0.69 (0.43-1.11). Age increased the risk for allostatic load score ≥2 for white and Mexican American women, but not African American women. For white women, age 25-29 years increased risk for increased allostatic load when compared to women aged 15-19 (Adjusted OR: 3.39 (95%CI 1.95-5.90), as did age 30-35 (Adjusted OR: 4.54 (95%CI: 2.79-7.40). For African American women, age was not a significant predictor of allostatic load score ≥2. For Mexican American women aged 30-35 years, increased risk for allostatic load score of ≥2 was seen when compared to teenaged women (adjusted OR: 4.98 (95%CI: 1.65-14.99). These analyses demonstrate that the impact of the sociodemographic predictors on risk for allostatic load score ≥2 varies for each racial/ethnic group. These findings highlight the importance of understanding risks for increased allostatic load score as different for different racial/ethnic groups in order to understand the pre-pregnancy risk for preterm delivery.

Discussion

In addressing the purpose of this study to test the hypothesis that subgroups with high levels of poor birth outcomes will have worse pre-pregnancy health status than other groups, this discussion examines the sociodemographic predictors overall and then addresses the pre-pregnancy health status of each racial/ethnic group separately. Overall, the risk factors for increased allostatic load score were not the same between the different racial/ethnic groups. Generalizing the results to the U.S. population of women aged 15-35 a median allostatic load score of two indicates that 50% of women have at least two or more risk factors for preterm delivery prior to pregnancy. The high rates of preterm
delivery in the United States may be due, in part, to this finding, where the pre-pregnancy health of women has a significant impact on pregnancy outcome (Haas et al., 2005).

As was discussed previously in this chapter, disparate levels of socioeconomic disadvantage are often experienced by minority racial/ethnic groups in the United States. This was also the case with the findings in this chapter in which more African American and Mexican American women than white women were represented in the lower income groups. Kramer and colleagues note that socioeconomic disadvantage limits access to healthcare, healthcare knowledge, and healthcare education, thereby increasing the risk for poor pregnancy outcomes (Kramer, et al., 2000). As a result, it might be anticipated that the impact of the sociodemographic predictors on allostatic load scores may vary by racial/ethnic group, or that the greater socioeconomic disadvantage experienced by African American and Mexican American women would have a greater impact on health status than for white women. As reported, however, in the final analyses income was not a significant predictor of allostatic load score ≥ 2 for any of the racial/ethnic groups at any level of income. One response to this surprising finding is that although income is thought to represent access to resources in a way not considered by education or health insurance status, perhaps for health, education and health insurance are more important than the access to material resources afforded by increased income. Another response is that perhaps low income does not increase chronic stress levels initiating the stress response as previously discussed in this chapter. Perhaps families who have lived at particular income levels for extended periods of time have found coping mechanisms for accessing the material goods needed for their health and their families, thereby virtually
eliminating income as a stress-producing factor. Further examination and exploration into this phenomenon should be made.

Unlike the lack of impact due to income, a lack health insurance increases the risk for elevated allostatic load scores among each of the three racial/ethnic groups studied in this analysis. For African American and Mexican American women, having non-private health insurance did not convey any more risk for elevated allostatic load scores than having private health insurance. A frank lack of health insurance, however, significantly increased the risk for allostatic load scores ≥ 2. This may be because health insurance, whether public or private, yields access to healthcare, but a lack of health insurance severely limits an individual’s access to healthcare knowledge, education, and treatment. For white women, conversely, non-private health insurance increased the risk for elevated allostatic load when compared to white women with private insurance. Perhaps the quality of healthcare varies by type of insurance (private or non-private) for white women, but not for African American or Mexican American women. This is unclear based upon these results and deserves further examination.

Education is the third piece of the socioeconomic puzzle and is thought to reflect “learned effectiveness” (Mirowsky & Ross, 2003), or the ability of an individual to know and understand what she needs to improve her health and well-being, as well as how to access those needs. Based upon this description of education, it may seem as though education would be the most important factor for determining an individual’s health. Additionally, it may seem that a lack of education would severely impact an individual’s health, raising their allostatic load score. This was not the case. Education less than a
high school diploma in women older than 19 was not a significant risk factor for elevated allostatic load scores in any of the three racial/ethnic groups. In fact, educational status did not matter at all for African American women. These findings do not suggest that we should discourage education, but rather, these findings add more question to the puzzle as to what actually determines increased risk for allostatic load scores ≥ 2. Perhaps for African American women, there is something unique about their life experience that increases their risk for poor health (high allostatic load scores) that goes beyond sociodemographic predictors. Alternatively, it is possible that those with a limited income have found other mechanisms by which to take care of themselves and do not experience the stress associated with low income or socioeconomic disadvantage. The remainder of this discussion will address the findings specific to each racial/ethnic group, and then will conclude with overall recommendations and limitations.

**White Women**

With a mean allostatic load score of 2.18, white women as a group experience better health status compared to Mexican American and African American women. In addition to better health, white women experience economic advantage when compared to the other racial/ethnic groups included in this analysis. More white women (38.6%) are represented in the high income group (PIR>3.5) than any other racial/ethnic group. Furthermore, more white women than any other racial/ethnic group have more than a high school degree (53.3%). At the same time, very few white women are older than 19 without a high school diploma (8.2%). Applied to the theoretical concept of allostatic load the findings of this analysis indicate that white women experience less
socioeconomic stress, and may have better health as a result of this. With respect to the ten variables measured here as components of allostatic load, white women had the highest rates of smoking when compared to Mexican American and African American women. This finding agrees with the literature which suggests that smoking prevalence is higher among whites than African American or Hispanic individuals (Barbeau, Krieger, & Soobader, 2004; Shavers, Lawrence, Fagan, & Gibson, 2005). Additionally, across racial/ethnic groups among those who either admit to smoking daily or were found to smoke regularly based upon their serum cotinine levels, white women had the highest mean serum cotinine levels indicating that they were the heaviest smokers of all the analyzed groups. White women also had a higher prevalence of hyperhomocysteinemia than African American or Mexican American women. This may be due to limited dietary folic acid intake, or perhaps to a higher prevalence of a genetic mutation in methylenetetrahydrofolate reductase (MTHFR) which causes elevated levels of homocysteine (Kramer et al., 2001).

In the crude analyses, white women 25 years of age or older were at increased risk for having an allostatic load score ≥2 when compared to teenaged white women. These findings persisted in the adjusted final analysis with women aged 30-35 years 4.54 (95%CI 2.79-7.40) times as likely as teenaged women to have an allostatic load score ≥2. Although white women typically do not experience “weathering” as described by Geronimus (Geronimus et al., 2006), it appears that when white women age their health status decreases. Perhaps the decrease in health status is not as drastic and fast as it is for African American women, but it does appear that in general, with age, the health of white
women declines. The theoretical concept of allostatic load has an assumption that with time (and age), allostatic load increases as the ability to respond to daily stressors decreases (McEwen & Seeman, 1999). Also in the crude analyses, a lack of private health insurance increased the risk for increased allostatic load score for white women when compared to those with privately funded health insurance. Again, these risk factors persisted in the adjusted analysis. Interestingly, education was a significant predictor of allostatic load score $\geq 2$ in white women in the final analysis. Teenaged women who had not yet finished high school and women with only a high school diploma or GED were more likely to have increased allostatic load score compared to women with greater than a high school degree. An allostatic load score of 2, the median score for white women, would, although differing by individual woman, include such high risk variables as elevated glycated hemoglobin and abnormal BMI or periodontal disease.

Based upon these findings, clinical implications for the pre-pregnancy health of white women include the critical need to address smoking cessation for women who smoke at every healthcare visit. Because white women were found to be the heaviest smokers among the racial/ethnic groups studied here (highest mean serum cotinine levels as seen in Table 4.4), special attention needs to be made for smoking reduction and cessation. Specific smoking cessation strategies targeted to this population should be investigated. Furthermore, as with any woman, questions regarding plans for future pregnancy should be discussed and measures to improve individual health should be taken in an attempt to achieve better pregnancy outcomes. In addition, because private health insurance and education beyond high school are important to the pre-pregnancy
health of white women, societal strategies to ensure healthcare coverage and advanced education for all, regardless of socioeconomic status, ought to be investigated. Alternatively, investigation into the differences in quality of healthcare for those with private, non-private and a lack of health insurance should be made in a quality control effort to improve the healthcare quality for everyone.

African American Women

In acceptance of this study’s hypothesis, in general the results of these analyses indicate that African American women have worse overall pre-pregnancy health with higher mean (2.94) and median (3.0) allostatic load scores than white or Mexican American women, a finding that echoes Geronimus’ weathering hypothesis (Geronimus, 1992; Geronimus, 2001; Geronimus et al., 2006). The weathering hypothesis posits that African Americans suffer accelerated health deterioration as a result of socioeconomic stress and political marginalization (Geronimus, 2001). To understand this in light of the theoretical concept of allostatic load as pictured in Figure 4.1, African American women in general have likely suffered more cumulative life stress, which subsequently decreased pre-pregnancy health, increased their allostatic load, and by extension, increased their risk for preterm delivery. Giscombé and Lobel (Giscombe & Lobel, 2005) note that African American women experience increased stress as a result of racism and may have different (negative) health behaviors as a result of their socioeconomic status, thereby increasing their risk for adverse birth outcomes.

With respect to the sociodemographic variables, more African Americans (47.9%) are represented in the low income group (PIR ≤1.3) than in any other income group.
Only 15.6% of African American women in the United States have an income in the highest group (PIR>3.5). More African American than white women are older than 19 but lack a high school diploma (17.2% compared to 8.2% in white women), and fewer have private health insurance (49.6% in African American compared to 72.7% in white women). These findings highlight the significant disadvantage experienced by African American women in general, suggesting increased life stress, which could impact their health status and allostatic load. In addition to experiencing increased disadvantage, in this analysis African American women have an increased prevalence of bacterial vaginosis, trichomonas vaginalis, increased systolic and diastolic blood pressures, elevated glycated hemoglobin, body mass index outside the normal range and increased prevalence of iron-deficiency anemia when compared to white or Mexican American women. The findings of the analyses agree with those in the literature which suggest that African American women have increased rates of BV, perhaps related to the increased practice of douching in African American women (Annang, Grimley, & Hook EW 3rd, 2006) as noted in Chapter 3, as well as increased rates of vaginal infections (Hitti et al., 2007; Schwebke, Desmond, & Oh, 2004). Also as recognized in the literature, African American women are at increased risk for high blood pressure, elevated glycated hemoglobin and body mass index (Buescher & Mittal, 2006; James, Keenan, Strogatz, Browning, & Garrett, 1992; King, 2006). In fact, in this analysis, African American women in the high risk body mass index group had higher overall mean BMI’s than high risk women in any of the other racial/ethnic groups as shown in Table 4.4. This suggests that while all the women in the high risk BMI group were outside the normal range for
their BMI, African American women were heavier on average. In addition, these findings agree with the literature that African American women have increased rates of iron-deficiency anemia when compared to Mexican American and white women (Killip et al., 2007).

In the crude analyses, as might be suspected with the weathering hypothesis of accelerated health deterioration (Geronimus et al., 2006), increasing age was a significant predictor of allostatic load score ≥2. Interestingly, this did not persist in the final model. In the adjusted logistic regression model only a complete lack of health insurance impacted the risk for allostatic load score ≥2. Education was not a significant contributor to allostatic load score in either the crude or adjusted analyses for African American women, nor was income. This finding is critical. Economic effects do not play a significant role in the allostatic load score ≥2 for African American women.

In Figure 4.2, African American women in the second income group have a higher mean allostatic load score (3.49) than at any other income level. The cut-points of this income group indicate that while these women are eligible for WIC assistance, they are likely not eligible for other federal assistance including food stamps. Perhaps African American women experience greater disadvantage in this income group, with a larger impact on their health than African American women in the other income groups. As may be expected, African American women with a PIR >1.85, have a much lower mean allostatic load score (2.31) than women with a PIR ≤1.85.

With health insurance as the only statistically significant predictor of increased allostatic load score for African American women in the final model, it is clear that other
factors must be measured to determine increased allostatic load score in this population. Perhaps education and income are not good or sensitive enough measures of disadvantage or stress experienced by African American women. Perhaps stress as measured by low SES and race/ethnicity in proxy is not the major factor for African American women; maybe environment plays a greater role. Or, is it possible that since most African American women have allostatic load scores \( \geq 2 \) (87.73% of the population) that these sociodemographic risk factors are not able to differentiate between the few with an allostatic load score of 0 (1.91%) or 1 (10.37%) and those with a score of 2 or higher?

When the analyses were run using an allostatic load score \( \geq 3 \) (median for African American women) as the outcome variable for this racial/ethnic group, different sociodemographic predictors arose. Education remained an insignificant predictor and a lack health insurance no longer proved to be a significant predictor of allostatic load score above the median, 3 in this case. Interestingly, African American women aged 30-35 had an increased odds ratio of allostatic load score \( \geq 3 \) (adjusted OR: 3.19, 95% CI: 1.67-6.09) compared to women aged 15-19 years of age. Also, women in the lowest income group were at increased risk for an allostatic load score \( \geq 3 \) (adjusted OR: 2.53, 95% CI: 1.007-6.331). By using allostatic load score \( \geq 3 \) as the outcome measure for the analysis for African American women, suddenly, women in the lowest income group who likely experience the greatest amount of poverty-associated stress, as well as women in the oldest age group who have likely have the greatest cumulative life stress are at risk for increased allostatic load scores. This does not answer why African American women are sicker on the whole, but it does provide some information to differentiate between
African American women with allostatic load scores above and below 3. Perhaps as health worsens, age and income play a more significant role. The questions remain, however, why and how African American women’s health deteriorates more rapidly than other racial/ethnic groups, even when considering sociodemographic predictors. Are there other stress-producing situations not measured in these analyses that worsen African American women’s health more rapidly than income, age, education and health insurance? It is possible that, as Geronimus (1992) suggests, racism and political marginalization contribute significantly to the accelerated health deterioration in African Americans. Measures of these variables were not available in the NHANES dataset used, but may need to be included in future research.

After considering these findings, one question that might arise is whether it is important to evaluate health of all women at an equal level. These analyses were conducted to analyze risk factors for all women to reach an allostatic load score ≥2 and this author feels it is more important to evaluate health of all women on an equal level rather than to evaluate health at a worse level for African American women, simply because their overall health is worse. This remains true even if only one of the predictors for allostatic load score ≥2 for African American women was statistically significant. For the average African American woman included in this sample, an allostatic load score of 2 would likely be comprised of elevated glycated hemoglobin and an abnormal BMI or bacterial vaginosis.

Because a lack of health insurance was the only significant finding in the logistic regression, clinical implications of these findings for African American women highlight
the need for increased health insurance for all. In addition, clinicians can address many of the risk factors higher for African American women (bacterial vaginosis, trichomonas vaginalis, increased systolic and diastolic blood pressures, elevated glycated hemoglobin, body mass index outside the normal range and increased prevalence of iron-deficiency anemia) at healthcare visits for related or unrelated concerns. At every visit to a healthcare provider, these issues should be addressed, whether the woman is planning pregnancy or not (American College of Nurse Midwives, 2007). Only by addressing pre-pregnancy health is it possible to reduce risk for preterm delivery that exists prior to pregnancy.

**Mexican American Women**

Mexican American women, like white women, had a median allostatic load score of 2, with Mexico-born Mexican Americans at a slightly higher mean allostatic load score (2.37) than U.S.-born Mexican American women (2.06). Mexican American women in this analysis had a greater prevalence in the low income groups than in the high income groups, similar to African American women. In addition, fewer Mexican American women, especially Mexico-born, had more than a high school degree than white or African American women. This group of women also is more likely to lack health insurance than either white or African American women. Despite their low socioeconomic status, Mexican American women who have a similar low socioeconomic profile to African American women, in this analysis have lower allostatic load scores. This reflects the Mexican Paradox, described in Chapter 1, in which Mexican American women with low socioeconomic profiles have generally better health outcomes, including
better birth outcomes with fewer preterm deliveries than African American women (Hummer, Powers, Pullum, Gossman, & Frisbie, 2007; Xiong, Buekens, Vastardis, & Wu, 2006).

In spite of their lower mean and median allostatic load scores than African American women, Mexican American women did have several variables in which they had a higher prevalence than other women. Significantly more Mexico-born Mexican American women had periodontal disease than the other groups, perhaps reflecting a lack of dental care or access to dental care. This is different than what has been reported in the literature which suggests that Mexican Americans, as a whole, have lower rates of periodontal disease than African American women (Xiong, Buekens, Vastardis et al., 2006). It is possible that the separation of Mexican Americans into groups based upon country of birth revealed these differences. Also, both U.S.-born and Mexico-born Mexican American women had elevated rates of high glycated hemoglobin and BMI outside the normal range. This is consistent with the literature which demonstrates higher rates of diabetes mellitus in Mexican American women when compared to white women (Cowie et al., 2006). Significantly fewer Mexican American women than African American or white women had high levels of homocysteine. This may be due to the high levels of folate found in beans, which are common in the Mexican American diet (Suarez et al., 2000). Interestingly, Mexico-born Mexican American women in the high risk anemia group had much lower mean hemoglobin levels than the other high risk women of the additional racial/ethnic groups, suggesting worse anemia. This agrees with the literature which suggests that Mexican American women, although not differentiated into
country of birth by Frith-Terhune and colleagues (2000), have increased rates of iron-deficiency anemia compared to white women.

In the logistic regression analysis, education at the level of a high school diploma or GED increased the risk for allostatic load score ≥2 when compared to Mexican American women with more than a high school diploma. A recent study by Acevedo-Garcia and colleagues suggests that education has a greater impact on health outcomes (in their study, low birth weight) for U.S.-born Mexican American women than for foreign-born Mexican American women (Acevedo-Garcia, Soobader, & Berkman, 2007). For U.S.-born Mexican American women acculturated to the mainstream U.S. society, education is a significant part of daily life, an expectation of success and well-being (Acevedo-Garcia et al., 2007). It is possible that through their acculturative process, education became important for health in these women. In the regression analysis, Mexican American women were not separated into groups by country of birth, but rather, country of birth was added as a predictor for allostatic load score. In crude analyses, it significantly contributed to allostatic load score ≥2, but in the final analysis, country of birth did not contribute significantly to allostatic load score. This suggests that the sociodemographic predictors included, age, PIR, health insurance and education, comprise that which was represented in the variable “country of birth” in the crude analyses.

In the present study, more U.S.-born Mexican American women were found to have health insurance than Mexico-born Mexican American women, which in addition to increased health knowledge as a result of education, affords greater access to healthcare.
The logistic regression analysis demonstrated that a lack of health insurance for Mexican American women significantly increased allostatic load scores when compared to women with private health insurance. Lara and colleagues note that “foreign-born Latinos” living in the United States were more likely to be uninsured that white individuals (Lara et al., 2005) and discusses the negative implications on health as a result of a lack of healthcare access. Age beyond 30 years was also a significant predictor of increased allostatic load score for Mexican American women when compared to teenaged women. An average Mexican American woman included in this analysis with an allostatic load score of 2 likely experiences an elevated glycated hemoglobin, and an abnormal BMI or periodontal disease. Clinical implications for this group include addressing BMI and risk for diabetes and periodontal disease at every health care visit. In addition, society needs to increase healthcare coverage for Mexican American women, whether U.S.-born or Mexico-born, in order to improve birth outcomes and pre-pregnancy health overall.

Summary

With an interest in reducing rates of preterm delivery, this paper sought to test whether subgroups with historically high levels of poor birth outcomes also have worse pre-pregnancy health status than other groups. The theoretical concept of allostatic load was used throughout this research to examine this hypothesis. Each of the three racial/ethnic groups, white, African American and Mexican American, had different risk factors for preterm delivery and the sociodemographic predictors impacted each group’s health differently. Clinical implications of the findings here are that healthcare providers ought to consider every visit to a healthcare provider made by a currently non-pregnant
but child-bearing-aged woman as a pre-pregnancy visit and ought to provide appropriate counseling (American College of Nurse Midwives, 2007). If pre-pregnant women seen at a healthcare provider’s office have one or more of the ten health conditions included in this analysis, at a very minimum, the provider should include education about the woman’s health in general and how to improve health if a pregnancy is possible, planned or otherwise. In addition, women should be empowered to improve their own pre-pregnant health in order to reduce their risk for preterm delivery or other negative birth outcome. This may include short-term interventions to simply lose weight or increase dietary iron. Alternatively, the woman may undertake interventions to reduce life stress and increase healthy coping skills, which may have a long-term positive benefit on the woman’s health and the health of her future children. Additional studies ought to be conducted investigating interventions which may help to decrease life stress and improve health, addressing the long-term effects of stress on the body, increased allostatic load.

Although this study represents a novel approach in examining pre-pregnant health through the use of allostatic load and a composite score of ten variables related to women’s health and life stress, no study is without limitations. One question that presents and may be considered a limitation to the concept of allostatic load is whether variables should be weighted when considering their impact on health outcomes. Admittedly, while some variables may have a greater physiologic impact on health and in this case the risk for preterm birth, the application of equal weights to the allostatic load score has been used throughout the literature as a conservative estimate of the size of the relationship between the individual’s allostatic load and health outcomes (Karlamangla,
Singer, McEwen, Rowe & Seeman, 2002). This approach, however, may limit the applicability and usefulness of allostatic load in predicting health outcomes by using variables that do not carry the same gravity in health consequences. For example, blood pressure may represent more of a risk to future health than homocysteine levels. If weights were to be applied to allostatic load scoring, research would be needed not only to determine the best composition of variables for the given population and health outcome of interest, but also to determine the severity of impact for each variable individually on the health outcome. Additionally, some variables may synergize with each other more than other variables and this would need to be considered should weights be applied to the score as a whole.

Further limitations include possible underestimation of allostatic load scores due to exclusion of women with missing data, more of whom were African American and Mexican American, as well as in the lowest two income groups. When interpreting the results, it is important to be mindful of this possible underestimation. Furthermore, the data are cross-sectional and therefore no cause-and-effect relationships can be studied between stresses over the lifespan, pre-pregnancy health and pregnancy outcome. Also, as mentioned by Seeman and colleagues, the composition of variables for allostatic load score may need to change to better reflect the total body effects of stress for the population of interest (Seeman et al., 1997). Perhaps changes or additions to the ten variables included here as representative of total body effects of stress with implications for preterm delivery could be made that would improve outcomes. More research is needed in this area.


Sibai, B. M., Caritis, S. N., Hauth, J. C., MacPherson, C., VanDorsten, J. P., Klebanoff, M., et al. (2000). Preterm delivery in women with pregestational diabetes mellitus or chronic hypertension relative to women with uncomplicated pregnancies. the national institute of child health and human development maternal- fetal medicine


Figure 4.1: Conceptual Framework depicting relationship between perceived stress, behavioral responses to stress and health status, allostatic load and health outcomes. Adapted from (McEwen, 1998).
Figure 4.2: Impact of Income and Race/Ethnicity on Mean Allostatic Load Score in U.S. Women aged 15-35

* Mean AL for African American women significantly different from all other groups at ANOVA $\alpha=0.05$ with Bonferroni correction

† Mean AL for African American women significantly different from white and U.S.-born Mexican American women at ANOVA $\alpha=0.05$ with Bonferroni correction
Figure 4.3: Impact of Age and Race/Ethnicity on Mean Allostatic Load Score in U.S. Women aged 15-35

* Mean AL for African American women significantly different from all other groups at ANOVA $\alpha=0.05$ with Bonferroni correction

† Mean AL for African American women significantly different from white women at ANOVA $\alpha=0.05$ with Bonferroni correction
Figure 4.4: Population Prevalence of Allostatic Load Variables by Race/Ethnicity in U.S. Women Aged 15-35*

*All variables significantly different at $\chi^2 p < .05$. 
<table>
<thead>
<tr>
<th>Variable</th>
<th>High Risk Cut-off</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bacterial Vaginosis</td>
<td>Positive diagnosis by Nugent’s Score</td>
</tr>
<tr>
<td>Trichomonas Vaginalis</td>
<td>Positive Diagnosis</td>
</tr>
<tr>
<td>Periodontal Disease</td>
<td>Clinical attachment loss or probing depth ≥ 4 mm at one or more sites</td>
</tr>
<tr>
<td>Systolic Blood Pressure</td>
<td>&gt;140 mmHg or individual report of diagnosis of high blood pressure</td>
</tr>
<tr>
<td>Diastolic Blood Pressure</td>
<td>&gt;90 mmHg or individual report of diagnosis of high blood pressure</td>
</tr>
<tr>
<td>Smoking Status</td>
<td>Serum Cotinine &gt;10 ng/mL or self-report of smoking everyday</td>
</tr>
<tr>
<td>Homocysteine</td>
<td>&gt;8.1 µmol/L</td>
</tr>
<tr>
<td>Body Mass Index</td>
<td>&lt;18.5 or ≥25 kg/m²</td>
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<tr>
<td>Glycated Hemoglobin</td>
<td>&gt;5%</td>
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<tr>
<td>Iron-deficiency anemia</td>
<td>If HGB &lt;12 g/dL, RDW &gt;14.5% AND MCV &lt; 80 fL</td>
</tr>
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</table>

Table 4.1: Allostatic Load Score Variables and Their Cut-offs
<table>
<thead>
<tr>
<th><strong>Income (Poverty Income Ratio)</strong></th>
<th><strong>Sample n</strong> (Pop. %)</th>
<th>White Sample n (Pop. %)</th>
<th>African American Sample n (Pop. %)</th>
<th>U.S.-born Mexican American Sample n (Pop. %)</th>
<th>Mexico-born Mexican American Sample n (Pop. %)</th>
<th>χ² p</th>
</tr>
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<tbody>
<tr>
<td>≤1.3</td>
<td>167 (24.0)</td>
<td>207 (47.9)</td>
<td>102 (38.3)</td>
<td>101 (52.9)</td>
<td>&lt;.0001</td>
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<tr>
<td>&gt;1.3 to ≤1.85</td>
<td>68 (11.8)</td>
<td>55 (15.6)</td>
<td>44 (14.9)</td>
<td>31 (20.4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;1.85 to ≤3.5</td>
<td>157 (25.5)</td>
<td>93 (20.8)</td>
<td>55 (20.5)</td>
<td>35 (22.4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;3.5</td>
<td>252 (38.6)</td>
<td>64 (15.6)</td>
<td>61 (26.3)</td>
<td>5 (4.4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Education</strong></td>
<td></td>
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<tr>
<td>&lt; HS* teenager</td>
<td>195 (16.7)</td>
<td>201 (18.1)</td>
<td>151 (26.5)</td>
<td>57 (9.6)</td>
<td>&lt;.0001</td>
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<tr>
<td>&lt; HS older</td>
<td>40 (8.2)</td>
<td>37 (17.2)</td>
<td>14 (14.3)</td>
<td>68 (58.6)</td>
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<td>HS or GED†</td>
<td>131 (21.8)</td>
<td>72 (20.7)</td>
<td>40 (18.1)</td>
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<tr>
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<td>278 (53.3)</td>
<td>109 (44.0)</td>
<td>57 (41.1)</td>
<td>22 (16.6)</td>
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<td>76 (33.4)</td>
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<td>191 (33.3)</td>
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<td>≥30 to 35</td>
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<td>14 (12.1)</td>
<td>45 (41.4)</td>
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</table>

* High school
† General equivalency diploma

Table 4.2: Sample Prevalence and Population Percentages of Race/Ethnicity and Socio-demographic Characteristics in Women Aged 15-35 (n=1497)
<table>
<thead>
<tr>
<th></th>
<th>White Mean AL</th>
<th>White Median AL</th>
<th>African American Mean AL</th>
<th>African American Median AL</th>
<th>U.S.-born Mexican American Mean AL</th>
<th>U.S.-born Mexican American Median AL</th>
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<th>Mexico-born Mexican American Median AL</th>
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<td>Overall Income (Poverty Income Ratio)</td>
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<td>Median AL</td>
<td>Mean AL</td>
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<td>Median AL</td>
<td>Mean AL</td>
<td>Median AL</td>
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<td>≤1.3</td>
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<td>2.0</td>
<td>2.94†</td>
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<td>2.06</td>
<td>2.0</td>
<td>2.37</td>
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<td>2.0</td>
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<td>2.31</td>
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<td>1.0</td>
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<td></td>
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<td>2.51</td>
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<td>2.0</td>
<td>2.14</td>
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<tr>
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<td>2.68</td>
<td>3.0</td>
<td>3.25</td>
<td>3.0</td>
<td>2.38</td>
<td>3.0</td>
<td>2.47</td>
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<td>Age (years)</td>
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<tr>
<td>15 to &lt;20</td>
<td>1.86</td>
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<td>2.55</td>
<td>2.0</td>
<td>1.87</td>
<td>2.0</td>
<td>2.10</td>
<td>2.0</td>
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<tr>
<td>≥20 to &lt;25</td>
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<td>3.23</td>
<td>3.0</td>
<td>2.35</td>
<td>3.0</td>
<td>2.19</td>
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<td>3.5</td>
<td>2.69</td>
<td>3.0</td>
<td>2.52</td>
<td>2.0</td>
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<tr>
<td>≥30 to 35</td>
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<td>4.10</td>
<td>4.0</td>
<td>2.86</td>
<td>3.0</td>
<td>2.84</td>
<td>3.0</td>
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</tbody>
</table>

* Allostatic Load Score

For each racial/ethnic group and each socio-demographic predictor, means with same superscript letter are statistically different from one another at the ANOVA *p* < 0.05 level with Bonferroni correction

† Overall mean AL for African Americans is statistically different from mean AL for other racial/ethnic groups at the ANOVA *p* < 0.05 level with Bonferroni correction

Table 4.3: Mean and Median Allostatic Load Scores by Race and Selected Demographic Characteristics
<table>
<thead>
<tr>
<th>Risk group</th>
<th>L*</th>
<th>H†</th>
<th>L</th>
<th>H</th>
<th>L</th>
<th>H</th>
<th>L</th>
<th>H</th>
<th>L</th>
<th>H</th>
<th>L</th>
<th>H</th>
<th>L</th>
<th>H</th>
<th>L</th>
<th>H</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S. born</td>
<td>0.3</td>
<td>88.0</td>
<td>4.9</td>
<td>5.3</td>
<td>13.6</td>
<td>11.1</td>
<td>106</td>
<td>117</td>
<td>63</td>
<td>69</td>
<td>21</td>
<td>29</td>
<td>5.6</td>
<td>11.7</td>
<td>5.7</td>
<td>9.1</td>
</tr>
<tr>
<td>M.A. ‡</td>
<td>0.1</td>
<td>85.5</td>
<td>4.9</td>
<td>5.5</td>
<td>13.4</td>
<td>9.98</td>
<td>107</td>
<td>111</td>
<td>62</td>
<td>68</td>
<td>21</td>
<td>29</td>
<td>5.6</td>
<td>9.9</td>
<td>5.7</td>
<td>9.2</td>
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<tr>
<td>White</td>
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<td>176.5</td>
<td>4.9</td>
<td>5.3</td>
<td>13.7</td>
<td>10.9</td>
<td>107</td>
<td>118</td>
<td>64</td>
<td>76</td>
<td>21</td>
<td>29</td>
<td>6.1</td>
<td>9.8</td>
<td>6.3</td>
<td>9.5</td>
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<tr>
<td>African American</td>
<td>0.7</td>
<td>153.7</td>
<td>4.9</td>
<td>5.4</td>
<td>12.9</td>
<td>10.7</td>
<td>110</td>
<td>124</td>
<td>64</td>
<td>75</td>
<td>21</td>
<td>32</td>
<td>6.1</td>
<td>9.8</td>
<td>6.1</td>
<td>9.4</td>
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</tbody>
</table>

* Low risk group  
† High risk group  
‡ M.A. refers to Mexican American

Table 4.4: Mean Values of Allostatic Load Risk Factors by Racial/Ethnic Group and Risk Category

<table>
<thead>
<tr>
<th>Component</th>
<th>White sample (Pop. %)</th>
<th>African American sample (Pop. %)</th>
<th>U.S.-born Mexican American sample (Pop. %)</th>
<th>Mexico-born Mexican American sample (Pop. %)</th>
<th>( \chi^2 )</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bacterial Vaginosis</td>
<td>122 (20.35)</td>
<td>189 (51.13)</td>
<td>87 (33.6)</td>
<td>60 (31.45)</td>
<td>&lt;.0001</td>
<td></td>
</tr>
<tr>
<td>Trichomonas Vaginalis</td>
<td>4 (0.61)</td>
<td>39 (8.41)</td>
<td>3 (0.95)</td>
<td>3 (2.77)</td>
<td>&lt;.0001</td>
<td></td>
</tr>
<tr>
<td>Periodontal Disease</td>
<td>257 (41.80)</td>
<td>185 (49.28)</td>
<td>99 (42.26)</td>
<td>86 (56.09)</td>
<td>.0387</td>
<td></td>
</tr>
<tr>
<td>Systolic Blood Pressure</td>
<td>38 (7.11)</td>
<td>44 (15.33)</td>
<td>12 (8.59)</td>
<td>11 (6.65)</td>
<td>.0092</td>
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<tr>
<td>Diastolic Blood Pressure</td>
<td>38 (7.08)</td>
<td>43 (14.93)</td>
<td>11 (7.85)</td>
<td>11 (6.65)</td>
<td>.0095</td>
<td></td>
</tr>
<tr>
<td>Smoking</td>
<td>187 (29.89)</td>
<td>88 (26.55)</td>
<td>31 (16.40)</td>
<td>10 (7.73)</td>
<td>&lt;.0001</td>
<td></td>
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<tr>
<td>Homocysteine</td>
<td>108 (18.00)</td>
<td>62 (17.62)</td>
<td>14 (7.27)</td>
<td>14 (10.80)</td>
<td>&lt;.0001</td>
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<tr>
<td>Glycated Hemoglobin</td>
<td>358 (53.83)</td>
<td>313 (76.94)</td>
<td>146 (60.32)</td>
<td>116 (73.16)</td>
<td>&lt;.0001</td>
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<tr>
<td>Body Mass Index</td>
<td>287 (46.43)</td>
<td>247 (67.79)</td>
<td>135 (62.53)</td>
<td>93 (64.47)</td>
<td>&lt;.0001</td>
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<tr>
<td>Iron Deficiency Anemia</td>
<td>6 (0.61)</td>
<td>23 (5.23)</td>
<td>3 (1.34)</td>
<td>4 (1.91)</td>
<td>&lt;.0001</td>
<td></td>
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Table 4.5: Sample Prevalence and Population Percentages of Clinically Significant Allostatic Load Score Components by Racial/Ethnic Group

158
<table>
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<tr>
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<th>White*</th>
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<th>African American *</th>
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<th>Mexican American*</th>
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<tr>
<td></td>
<td>Crude</td>
<td>Final Adjusted Model†</td>
<td>Crude</td>
<td>Final Adjusted Model †</td>
<td>Crude</td>
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<tr>
<td><strong>Education</strong></td>
<td></td>
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<td></td>
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<tr>
<td>Less than high school teenager</td>
<td>0.84 (0.53-1.34)</td>
<td>2.34 (1.24-4.41)</td>
<td>0.40 (0.20-0.81)</td>
<td>0.54 (0.27-1.10)</td>
<td>0.60 (0.33-1.01)</td>
</tr>
<tr>
<td>Less than high school older</td>
<td>3.67 (0.85-15.82)</td>
<td>3.36 (0.76-14.57)</td>
<td>4.6 (0.66-31.88)</td>
<td>3.11 (0.50-19.46)</td>
<td>2.46 (1.08-5.65)</td>
</tr>
<tr>
<td>High school grad or GED</td>
<td>1.97 (1.08-3.67)</td>
<td>2.14 (1.06-4.32)</td>
<td>0.65 (0.31-1.35)</td>
<td>0.56 (0.26-1.27)</td>
<td>5.65 (2.47-11.93)</td>
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<tr>
<td>More than high school</td>
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<td><strong>Age (years)</strong></td>
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<tr>
<td>20-24</td>
<td>1.25 (0.73-2.14)</td>
<td>1.76 (0.97-3.18)</td>
<td>2.23 (1.18-4.23)</td>
<td>1.27 (0.50-2.36)</td>
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<td>1.97 (1.26-3.10)</td>
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<td>2.60 (1.40-4.81)</td>
<td>2.50 (1.14-5.52)</td>
<td>2.76 (0.86-8.88)</td>
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<td>No</td>
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<td>1.88 (1.04-3.37)</td>
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<td>3.23 (1.43-7.32)</td>
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<td>≤1.3</td>
<td>1.74 (1.04-2.93)</td>
<td>1.31 (0.69-2.50)</td>
<td>1.61 (0.53-4.92)</td>
<td>1.25 (0.34-4.62)</td>
<td>2.34 (1.18-4.64)</td>
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<td>&gt;1.3 to ≤1.85</td>
<td>1.08 (0.57-2.05)</td>
<td>0.83 (0.41-1.69)</td>
<td>3.02 (0.82-11.09)</td>
<td>2.70 (0.67-10.84)</td>
<td>2.45 (1.17-5.12)</td>
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<td>&gt;1.85 to ≤3.5</td>
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<td>1.23 (0.71-2.12)</td>
<td>0.46 (0.17-1.28)</td>
<td>0.59 (0.18-1.88)</td>
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</table>

* Crude and adjusted odds ratio of allostatic load score greater than or equal to 2.
† Final model adjusted for age, PIR, health insurance status and education.
‡ Country of birth (Mexico or U.S.) included in final model for Mexican Americans.

Table 4.6: Crude and Adjusted Odds Ratios and 95% Confidence Intervals for Selected Demographic Characteristics among Women 15-35 Years of Age for Allostatic Load Score ≥2
The overall purpose of this dissertation has been to address the hypothesis that if pre-pregnancy health status has a significant impact on pregnancy outcome, then subgroups with historically high levels of poor birth outcomes will have worse pre-pregnancy health status than other groups. The theoretical concept of allostatic load was operationalized throughout this work to reflect the health status of women as it results from cumulative life stress and behavioral responses to life stressors (McEwen, 1998). A theoretical review of this concept comprised Chapter Two while an investigation of the impact of income and race/ethnicity on douching behavior using the concept of allostatic load comprised Chapter Three. Chapter Four explored the effects of minority race/ethnicity and low socioeconomic status on pre-pregnancy health status testing the hypothesis that subgroups with historically worse birth outcomes would have worse pre-pregnancy health.

As reviewed in Chapter 2 and then supported by data presented in Chapters 3 and 4, subgroups with historically worse birth outcomes do have worse pre-pregnancy health in general. One question not addressed through the course of the previous three chapters is “What is the relationship between current allostatic load score and reported history of a
preterm delivery?” To date, no research has addressed the correlation between these two variables. Haas and colleagues investigated pre-pregnancy health status and the risk of preterm delivery prospectively, but only included chronic diseases such as anemia, asthma, lung diseases, diabetes, hypertension, epilepsy, HIV, cancer, thyroid and heart disease, as well as height, weight and smoking status in their measure of pre-pregnancy health status (Haas et al., 2005). They did not focus their investigation on factors specifically related to pregnancy outcome, nor did they include all the measures included within the concept of allostatic load, especially income measures. Finally, they did not focus specifically on the effect of stress on health status and pregnancy outcomes. The Chapter Two theoretical review of allostatic load shows that each of the ten components studied as part of this dissertation research (bacterial vaginosis, trichomonas vaginalis, periodontal disease, systolic and diastolic blood pressures, homocysteine, smoking status, body mass index, iron deficiency anemia and glycated hemoglobin ) is not only associated with preterm delivery, but also reflects the physiological burden of chronic stress associated with minority race/ethnicity and low SES (Cotch et al., 1997; Haas et al., 2005; Hammoud et al., 2005; Hillier et al., 1995; Kurki, Sivonen, Renkonen, Savia, & Ylikorkala, 1992; Radnai et al., 2004; Ray, Vermeulen, Shapiro, & Kenshole, 2001; Sibai et al., 2000; Vollset et al., 2000; Yip, 2000). The summation of these factors used to quantify allostatic load has never been prospectively associated with preterm delivery or correlated with a reported history of preterm delivery. For this reason, the start of this chapter will address this question prior to discussing the dissertation findings as a whole.
Methods and Materials

Data from the NHANES 2001-2004 were analyzed for this question. White, African American and Mexican American women who were not pregnant at the time of the survey, aged 15-35 with a reported history of at least one live birth and complete, current, allostatic load score information were included in the analysis (N=460). Essentially, the sample for this analysis is a sub-sample of the women included in Chapter 4; i.e., those women who report at least one live birth. Independent variables included race/ethnicity, income measured as poverty/income ratio (PIR), health insurance status, education and computed allostatic load score. The dependent measure was self-reported history of a preterm delivery. Descriptive statistics were calculated for demographic data and history of preterm delivery. Categorical data were compared using the Pearson’s $\chi^2$ statistic. A Pearson’s correlation between reported history of a preterm delivery and allostatic load score was performed with $\alpha=0.05$. Appropriate 4-year sampling weights (.5*wtmec2yr), PSU designations (sdmvpwu), and stratum (sdmvstra) estimated by the National Center for Health Statistics in order to reflect the entire U.S. population based on the 2000 census data were applied to all analyses except the Pearson correlation, which was not able to be weighted.

Results

The final sample includes the data from 460 women which when weighted, represents the experience of 9,844,175 U.S. women aged 15-35. For this entire group, only 44 women, 7.6%, report a history of preterm birth. More African American women (19.86%) than Mexican American (4.67%) or white (5.00%) women report a history of
preterm delivery ($\chi^2 p<0.05$). In addition, women with non-private health insurance, compared to private or a complete lack of health insurance have an increased prevalence of reported preterm delivery ($\chi^2 p<0.05$). At the same time, reported history of preterm delivery does not vary by income group or educational status. See Table 5.1. The frequency of reported history of preterm birth varies significantly by allostatic load score ($\chi^2 p<0.05$). See Figure 5.1. At the allostatic load score with the highest reported prevalence of reported history of a preterm delivery (allostatic load score=5) roughly 21.5% of women report a history of preterm delivery while at allostatic load score=1, only 1.25% of women report a history of preterm delivery, the lowest reported prevalence. Overall, there is a small but statistically significant positive Pearson’s correlation between allostatic load score and reported history of a preterm birth ($r=0.102$, $p=0.0283$), suggesting that increased allostatic load score is associated with reported history of preterm delivery.

Discussion

Addressing the purpose of this small question, there is a small but statistically significant positive relationship between allostatic load score and reported history of a preterm delivery. It is important to remember that the NHANES is cross-sectional and cannot be used for cause and effect relationships. Therefore, we cannot establish whether poor pre-pregnancy health contributes to a woman’s risk for preterm delivery, or whether the stress of a child who was born prematurely causes a woman to have subsequently poor health. Consistent with the literature, significantly more African American women reported a history of preterm birth than Mexican American or white women (Demissie et
al., 2001; Lu & Chen, 2004; March of Dimes, 2008). It would be of interest in future research to prospectively examine the relationship between pre-pregnancy health status (allostatic load) and subsequent pregnancy outcomes.

Discussion of Dissertation Findings

This dissertation presents findings on the pre-pregnancy health status of child-bearing aged women by race and socioeconomic status. By testing whether women in subgroups with historically elevated rates of preterm delivery have worse pre-pregnancy health status, this research provides ground for future advances in reducing rates of preterm delivery. Overall the findings in this dissertation highlight the health significant disparity that is associated with minority race/ethnicity and low SES in the United States with respect to health behaviors and health outcomes. White women in both Chapters 3 and 4 were not only found to have higher socioeconomic profiles, but also had lower allostatic load scores and reported douching less frequently than African American women. The sociodemographic predictors of poor health and poor health behaviors were not the same for each racial/ethnic group, and as may be anticipated, neither were they the same predictors between Chapters 3 and 4. For example, in Chapter 3, education less than a high school diploma in women older than 19 significantly increased the risk for douching behavior in white, African American and Mexican American women. In this instance, the lack of education in older women is thought to represent the lack of healthcare education and knowledge that these women have access to, putting them at increased risk for the negative health behavior of douching. One might suspect that this group of women would also have worse health, and subsequently elevated allostatic load
scores. In Chapter 4, however, education less than a high school diploma in women older than 19 years was not a significant predictor of allostatic load score ≥ 2 for any of the racial/ethnic groups. How can this education/age category be an important predictor of the health behavior of douching, but not an important predictor of allostatic load score, or health status? In addition, Mexico as the country of birth for Mexican American women was protective against douching in Chapter 3, but did not significantly contribute to allostatic load scores ≥2 in Chapter 4. Perhaps, as suggested for Chapter 3, this education/age category and lack of acculuration represents access to healthcare education and knowledge, but does not contribute to increased life stress that would increase the physiological burden of stress as measured in Chapter 4. Perhaps there is something additional and unique about the African American experience that increases the risk for poor health behaviors (such as douching) and poor health overall. Is the intergenerational transmission of poor birth outcomes and health a contributing factor (Marmot, 2004)? More research is necessary to identify why, even when considering socioeconomic disadvantage, the poor health of African American women remains unexplained.

Chapter 2 provides a detailed theoretical review for the concept of allostatic load and its application to women’s health and preterm delivery. The impact of stress on the body is discussed in detail with respect to immune/inflammatory function, cardiovascular function and metabolic function/nutritional status, as is the theoretical concept of allostatic load and its components. Each of the ten components of allostatic load chosen here and related to women’s health is explored in detail with respect to the impact of stress, behavioral responses to stress and risk for preterm delivery. This chapter
describes an innovative use of allostatic load specifically aimed at understanding women’s health and preterm delivery and provides a rationale for why it is important to consider the whole health of a woman during her child-bearing years.

As discussed in Chapter 2, allostatic load is a concept contained within the broader framework of stress and physiological responses to stress. The stress response is elicited by certain stress-producing societal and environmental factors. With chronic activation of the stress response, a cumulative physiological burden of stress develops in the individual (Seeman, et al., 2004). The present operationalization of allostatic load is no different in this regard from previous and more commonly-used operationalizations: certain factors (minority race/ethnicity, low SES) exert a toll on the body, contributing to a stress response and further increasing the physiological burden of stress measured as allostatic load. The operationalization of allostatic load continues to change and develop from study to study in order to identify physiological parameters that best reflect the impact of stress on the individual. By broadening the notion of allostatic load to include variables other than those originally included in the original allostatic load studies, this dissertation work lays the groundwork for future research on the contribution of life stress to allostatic load and pregnancy outcomes.

Chapter 3 tests the appropriateness of using the concept of elevated allostatic load to evaluate the impact of minority race/ethnicity and low SES on a behavior known to negatively influence a woman’s reproductive health. This chapter examines the impact of income on douching patterns of white, African American and Mexican American women using the theoretical concept of allostatic load. Douching behavior is important
to examine because this behavior is known to be more prevalent among African American women and also increases the risk for pre-term birth. Prior to this analysis, however, it was not clear what the impact of poverty or other socioeconomic factors would have on douching behavior. Including an analysis of 3522 women in the NHANES 2001-2004 datasets, Chapter 3 describes which socio-demographic factors are most predictive of douching behavior in each of the three racial/ethnic groups. By providing support for the idea that socioeconomic disadvantage limits healthcare access and education thereby increasing rates of the negative health behavior of douching, the results suggest that the concept of allostatic load is appropriate to use to evaluate the impact of chronic stress based upon minority race/ethnicity and low SES on the health and health behaviors of women. Results of the analysis suggest that race is not the only risk factor for douching and that socioeconomic status plays a significant role. For African American and white women, as income decreases, rates of douching behavior increase. This chapter highlights the complexity of separating the effects of race/ethnicity and socioeconomic status on health and behavior through the use of allostatic load as a theoretical concept. Implications of this research include the need for open discussion of douching behavior between a healthcare provider and any woman of child-bearing age with BV, in order to prevent future pregnancy complications. Discussions of this nature should not be limited to African American women.

Chapter 4 presents the main findings of this dissertation, describing the pre-pregnancy health status of women by race/ethnicity and socioeconomic status. African American women in general have worse health (higher allostatic load scores) than
Mexican American or white women with higher mean and median allostatic load scores. African American women also have the highest prevalence of a majority of the ten risk factors identified as important to the pre-pregnancy health of women and influenced by stress included in the allostatic load score measurement. In addition, African American and Mexican American women have lower socioeconomic profiles than white women in general. For African American women, the risk factors with the highest prevalence are abnormal body mass index, elevated glycated hemoglobin and bacterial vaginosis. For white women, the risk factors with the highest prevalence are elevated glycated hemoglobin, abnormal body mass index and periodontal disease. Mexican American women also have a high prevalence of elevated levels of glycated hemoglobin, abnormal body mass indexes and periodontal disease. The socio-demographic predictors for allostatic load score are different for each racial/ethnic group. Health insurance is the only statistically significant predictor common among the three racial/ethnic groups. In this chapter, strategies are discussed to improve pre-pregnancy health for each racial/ethnic group based upon risk factors identified and socio-demographic predictors. As a clinician it is important to screen women of child-bearing age for any of the ten conditions described here, in order to prevent future health complications with pregnancy.

Clinicians may be assisted in assessment of their patients using allostatic load by focusing on the factors that are highly prevalent in each racial/ethnic group, but should also realize that each of these factors could ultimately impact pregnancy outcome. If the ten variables were monitored individually, however, their cumulative and synergistic
nature would not be considered as readily in the risk for future preterm delivery.

Allostatic load relies upon the ability to evaluate the health of the individual as a whole in response to stress, and not focus on single health factors. Chapter 4 discussed issues surrounding weighting of the allostatic load variables to better reflect the impact of the specific ten variables on the health outcome, and to better predict the health outcome. As was mentioned at that time, the algorithm for allostatic load throughout the literature has not included weighting of specific variables. Rather, a system of equal weights has been used to calculate allostatic load scores, with the explanation that the equal weights provide a conservative estimate of the health of the individual, and that this is useful and predictive in health outcomes (Karlamangla, Singer, McEwen, Rowe & Seeman, 2002). Future research, however, should provide information regarding the ideal composition of factors for predicting preterm birth risk, as well as the severity of impact of each of the ten variables on the health outcome. This will allow weights to be applied to the algorithm and perhaps more efficiently predict health outcomes.

Chapter 1 discussed the Mexican Paradox in which Mexico-born Mexican Americans with low socioeconomic profiles have better birth outcomes than African Americans who also have low socioeconomic profiles. The data presented in Chapters 3 and 4 support the Mexican paradox. That is, Mexican American women were far less likely to douche than African American women as reported in Chapter 3, and the mean and median allostatic load scores of Mexican American women in Chapter 4 were lower than those of the African American women included in the analysis. These findings indicate that Mexican American women have better pre-pregnancy health than African
American women in the United States. Perhaps these results which indicate that Mexican American women begin pregnancy with better health are part of the reason for their better birth outcomes.

The weathering hypothesis, discussed in Chapter 2, suggests that African Americans suffer accelerated health deterioration as a result of political marginalization and discrimination. The evidence presented in Chapters 4 also supports the weathering hypothesis. African American women had higher mean and median allostatic load scores at all age levels, as well as by all measures of socioeconomic status. Although income did not contribute significantly to prediction of allostatic load score ≥2, descriptive statistics demonstrate that African American women had higher allostatic load scores at each of the income, education and health insurance levels. African American women in this analysis had worse health sooner than white or Mexican American women, lending support to the weathering hypothesis.

Roughly 6% of African American women in the Chapter 4 analysis report a country of birth outside of the United States. As with the Mexican paradox where Mexican American women born in Mexico have better birth outcomes and better health than U.S.-born Mexican American women, a similar paradox has been reported in the literature for African women born outside of the United States. Pallotto, Collins and David (2000) report that maternal nativity (country of birth) is associated with infant birth weight with Caribbean-born black women demonstrating lower rates of low birth weight than U.S.-born black women. Similarly, in a study conducted on New York City births to self-identified black women, nativity was associated with low birth weight and
preterm birth, with foreign-born women less likely to deliver preterm or low birth weight infants than U.S.-born women (Howard, marshall, Kaufman, & Savitz, 2005). An analysis of this sort was not feasible with the data in this dissertation due to the low percentage of African American women who report a country of birth outside of the United States (6%). Future research, however, should look further into a possible “immigrant paradox” to determine what factors improve birth outcomes for immigrant women, and also to determine whether the paradox is truly a “Mexican Paradox” or whether it applies to many immigrant groups.

This dissertation represents a novel approach to investigating the risk for preterm delivery using allostatic load and more research is needed prior to clinical application. In order to understand the relationship between allostatic load for women of child-bearing age and the risk for future preterm delivery, prospective studies need to be done to evaluate how allostatic load conservatively estimates the relationship between the individual’s health and their risk for preterm delivery. Measures in an ideal assessment of pre-pregnancy health status, quantified as allostatic load, with respect to the health outcome of preterm delivery might include evaluation of some hormones that are directly attributable to the stress response. For example, 12-hour urinary cortisol excretion levels as well as 12-hour urinary epinephrine and norepinephrine levels may provide a direct measure of hypothalamic pituitary adrenal axis function, as well as sympathetic nervous system function (Seeman, et al., 2004). Additional biomarkers that need to be addressed are urinary toxicology levels to assess drug use and abuse, as well as a questionnaire regarding alcohol intake and regular consumption. Moreover, a detailed history of
previous pregnancies and birth outcomes, as well as complications would be included to assess risk factors for outcomes of an upcoming pregnancy. In order to more appropriately measure the chronic life stress that individuals experience, a detailed racism and discrimination questionnaire, an evaluation of coping strategies for stress, a measure of perceived stress, as well as a more descriptive measure of acculturation would be included. By obtaining more detailed information regarding an individual’s life experience of stress, as well as more direct measures of the stress response prospectively during the pre-pregnancy period, and then following the cohort through delivery, the operationalizion of allostatic load may be more closely tied to birth outcomes and its use may be more developed.

Limitations

No study is without limitations. This dissertation is built around the theoretical concept of allostatic load, reflecting the health status of women in response to cumulative life stress and behavioral responses to the stress (McEwen, 1998). Since the late 1990’s when allostatic load was first operationalized, the number of variables in the allostatic load score has ranged from 10 factors in the initial study to as many as 16 factors, in an attempt to better elucidate the total body effects of stress (Geronimus, Hicken, Keene, & Bound, 2006; Seeman, McEwen, Rowe, & Singer, 2001; Seeman et al., 2004). Seeman and others note that the composition of variables for allostatic load score may need to change to better reflect the total body effects of stress for the population of interest (Seeman, Singer, Rowe, Horwitz, & McEwen, 1997). While the ten variables included in this operationalization of allostatic load are based upon extensive literature review, are
impacted by stress and further impact pregnancy outcomes, it is possible that other variables may better reflect the impact of stress on the body or may better measure allostatic load in childbearing-aged women with a focus on pregnancy outcome.

In addition, while the concepts of allostasis and allostatic load have gained significant popularity since the late 1990’s, they are not without controversy. Trevor Day states that defining and describing the concepts of allostasis and allostatic load is little more than an exercise in renaming the concept of homeostasis (Day, 2005). While there does seem to be some overlap between the definitions of allostasis and homeostasis, allostatic load is a useful concept because it refers specifically to the negative effects acquired as a result of the body’s struggle to maintain a constant internal milieu in the face of chronic or repeated stressors. Additionally, the cumulative measure of health provided by an allostatic load score provides a healthcare provider with a conservative estimate of the health of the individual in relationship to the health outcome.

Another limitation of this dissertation is that while the NHANES provides a wealth of information and data for studying relationships, it is important to remember that the data are cross-sectional. No longitudinal data exist in this dataset which means that no cause and effect relationships can be established. In addition, much of the demographic data are gathered by self-report, but the survey is strengthened by laboratory analysis and examinations in the mobile exam center. For the NHANES, respondents must live in a house in order to be eligible for participation, leaving homeless and institutionalized out of the dataset. In addition, Mexican American and
African American individuals are over-sampled in the dataset, but with the application of sampling weights, no groups are over-represented in the final analyses.

In Chapters 3 and 4, missing data are a source of limitation. In Chapter 3, 85% of eligible sample were included in the final analysis due to missing data. No significant differences were noted for any of the measured variables between those included and not included, however. In Chapter 4, only 71% of eligible sample were included in the final analysis due to missing data. In this chapter, there were significant differences between those with and without missing data by income and race/ethnicity. As a result, underestimation of allostatic load scores due to exclusion of women with missing data, more of whom were African American and Mexican American, as well as in the lowest two income groups may result. Because there are significant differences between those missing and not missing data, the data are not considered missing completely at random. Therefore, possible under representation of responses from sub-populations and a bias in the results may exist (Raghunathan, 2004).

A limitation of secondary data analysis is a lack of control over quality and integrity of data collection procedures. This does not appear to be of concern in this instance because of the great rigor with which the data were collected and quality control measures which were implemented (Centers for Disease Control and Prevention (CDC). National Center for Health Statistics (NCHS)., 2004).

This research provides important information regarding the impact of race/ethnicity and socioeconomic status on the pre-pregnancy health of women in order to better understand risk for pre-term delivery. Future studies could examine
prospectively the impact of each of these pre-pregnancy variables and allostatic load score on pregnancy outcome. Furthermore, prospective studies to determine the relationship between pre-pregnant allostatic load score and risk for preterm delivery could be performed. Intervention studies examining ways to reduce the risk for preterm delivery based upon these findings are an essential future step in the research process. These findings are important to nursing and nursing practice, as healthcare providers attempt to reduce the disparity in birth outcomes and reduce the overall rate of preterm delivery (Department of Health and Human Services, 2007).
References


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<th>Negative History of Preterm</th>
<th>Positive History of Preterm</th>
<th>( \chi^2 ) p</th>
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<td>Overall</td>
<td>416 (92.4%)</td>
<td>44 (7.6%)</td>
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<td>131 (95.3%)</td>
<td>9 (4.7%)</td>
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<td>White</td>
<td>180 (95.0%)</td>
<td>12 (5.0%)</td>
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<tr>
<td>African American</td>
<td>105 (80.1%)</td>
<td>23 (19.9%)</td>
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<td>17 (5.0%)</td>
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<td>18 (18.2%)</td>
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<td>135 (92.8%)</td>
<td>9 (7.2%)</td>
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<td>100 (84.7%)</td>
<td>16 (15.3%)</td>
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<td>108 (92.8%)</td>
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<tr>
<td>&gt; HS</td>
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* High school
† General equivalency diploma

Table 5.1: Sample Prevalence and Population Percentages of History of Preterm Birth and Socio-demographic Characteristics in Women Aged 15-35 (n=460)
Figure 5.1: History of Preterm Delivery by Current Allostatic Load Score ($\chi^2$ $p<0.05$)


