EFFECTS OF IMMIGRATION STATUS AND MATERNAL HEALTH BEHAVIORS ON GESTATIONAL WEIGHT GAIN AND ADHERENCE TO INSTITUTE OF MEDICINE GESTATIONAL WEIGHT GAIN RECOMMENDATIONS

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A Dissertation

Presented to

The Faculty of the Department

of Health and Human Performance

University of Houston

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In Partial Fulfillment

of the Requirements for the Degree of

Doctor of Philosophy

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By

Sajeevika Saumali Daundasekara

May, 2018

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ABSTRACT

Gestational weight gain (GWG) is an important consideration during pregnancy as excess weight gains could lead to adverse health conditions in both mother and the child. Immigration status is a potential risk factor of excess GWG. It is important to understand the relationship between immigration status and GWG to design better interventions to control excess GWG. Therefore, the objectives of the current study were 1) to understand the differences between the first and second generation immigrants and non-immigrants with respect to the socio-demographic characteristics and maternal behaviors, 2) to understand whether immigration status is associated with the total GWG and the risk of excess GWG, 3) to determine the socio-demographic and maternal behavior profile of women exceeding the GWG recommendations. The study was conducted as a secondary data analysis using the National Longitudinal Survey of Youth 1979. The study sample included 2823 women (184 first generation, 207 second generation and 2432 non-immigrants) with term, singleton pregnancies reported after 1986. Socio-demographic data, maternal health behaviors, pre-pregnancy weight, GWG and immigration data were extracted from the survey reporting the pregnancy. ANOVA or Chi-square test was performed to determine socio-demographic and maternal behavior differences among the immigration groups. ANCOVA was used to determine differences in total GWG and logistic regression was used to assess the risk of excess GWG among the groups. Finally the characteristic profile of women exceeding GWG recommendations was identified using classification tree analysis. Finding from this study shows that immigration groups in the current study were different on their racial/ethnic composition, employment status, and marital status and education levels. The groups also were different in their smoking and alcohol consumption prior to and during pregnancy.

However, after controlling for the covariates there were no differences in the total GWG among the three immigration groups. Also, there was no difference in the risk of exceeding GWG recommendation between the three immigration groups. According to the CRT analysis, among the first generation immigrants, pre-pregnancy overweight/obese and VISA/residency status indicated risk of excess GWG. Among second generation immigrants those who are overweight and obese prior to pregnancy were most likely to have excess GWG. Among non-immigrants, pre-pregnant overweight/obese, first child, and unplanned pregnancy indicated risk of excess GWG. Also, attempts to reduce caloric intake among non-Hispanic white women further increased the risk of excess GWG, whereas for all other racial/ethnic groups no attempts to reduce caloric intake increased the risk.

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CHAPTER 1

INTRODUCTION

1. Background and Rationale

Pregnancy is a transitional period for many women as they try to modify their lifestyle behaviors positively to ensure a safe and healthy pregnancy. However pre-pregnancy overweight or obesity and excessive weight gain during pregnancy can increase the health risks to both the mother and the child (Ramos & Caughey, 2005; Zera, McGirr, & Oken, 2011). The major complications associated with excessive or inadequate gestational weight gain (GWG) reported in literature includes postpartum weight retention, gestational diabetes, hypertension, pre-term deliveries, cesarean delivery, fetal growth restrictions, fetal macrosomia, large for gestational age babies (LGA), small for gestational age babies (SGA), neonatal hypoglycemia, infant and childhood obesity (Dietrich, Federbusch, Grellmann, Villringer, & Horstmann, 2014; Grieger, Grzeskowiak, & Clifton, 2014; Margerison Zilko, Rehkopf, & Abrams, 2010; Thangaratinam et al., 2012). Unlike pre-existing obesity, GWG could be modified during the course of pregnancy to ensure weight gain is within the recommendations. The most recent GWG recommendations developed by Institute of Medicine (IOM) in 2009 are based on pre-pregnancy Body Mass Index (BMI). The GWG recommendations for overweight and obese women are lower than that of underweight or normal weight women (IOM & NRC, 2009). In order to prevent or minimize inadequate or excess GWG it is important to identify potential modifiable risk factors associated with GWG and women at risk during early stages of pregnancy.

According to nationally representative data, prevalence of overweight and obesity among women of reproductive age has been steadily increasing over the past few decades.

The 2004 Pregnancy Risk Assessment Monitoring System (PRAMS) data shows that among pregnant women, mean prevalence of pre-pregnancy underweight was 13.2%, overweight was 13.1% and obesity was 21.9%. Minority women are more affected by obesity compared to non-Hispanic white women (Headen, Davis, Mujahid, & Abrams, 2012; Ramos & Caughey, 2005). According to the race/ethnicity stratified data from women in 2009–2010, non-Hispanic Black women (58.5%) were significantly more likely to be obese than non-Hispanic white women (32.2%) and Hispanic women (44.9%). Pre-pregnancy obesity is associated with increased risk of gaining excessive GWG. Similar to BMI an upward trend was reported for the prevalence of excess GWG. According to the Centers for Disease Control and prevention (CDC) report using 2012-2013 data the statewide prevalence of inadequate GWG ranged from 12.6% to 25.5%, appropriate GWG ranged from 26.2% to 39.0% and the excess GWG range was 38.2% - 54.7%. Analysis of data from Pregnancy Nutrition Surveillance System has shown that 48% of non-Hispanic black, 43% of Hispanic and 33% of Asian women and more than 50% of non-Hispanic White, American Indian and Multi race women gained excessive GWG (Headen, Davis, Mujahid, & Abrams, 2012).

The United States attracts a large number of immigrants each year (Jimenez, 2011). According to statistical reports by the Migration Policy Institute and Pew Research Center, based on 2015 U.S. census data, about 13.7% of the total U.S. population is foreign born. The foreign born percentages in the U.S. are at an increasing trend (7.9% in 1990, 11.1% in 2000 12.9% in 2012, 13% in 2014, and 13.7% in 2015) and it is projected to almost double by 2065. Health care usage and expenditure is lower among immigrants than U.S. natives and recent immigrants have lower health care expenditure than established immigrants (Ku, 2009; Mohanty et al., 2005). The initial health of immigrants is better than the health status

of the host country (Hunt et al., 2002; Singh & Yu, 1995; Sundquist & Winkleby, 1999; William A. Vega et al., 1998; Wei et al., 1996). This may be due to culturally driven health behaviors among immigrants and strong social support received from the immigrant culture (Landale, Oropesa, Llanes, & Gorman, 1999). However, this trend tends to decrease with increasing length of residency in the host country (Abraido-Lanza, Dohrenwend, Ng-Mak, & Turner, 1999; Scribner, 1996). Therefore, the health of later generations of immigrants is poorer than their parents; which is known as health assimilation.

A number of studies have shown pregnancy outcomes differ between immigrant and native women even after controlling for potential confounding variables (Balarajan, Raleigh, & Botting, 1989; Bollini et al., 2009). There is evidence of a negative association between immigration and maternal mortality, fetal growth restrictions, infections, prenatal care and maternal health. The stress associated with immigration, change in the social networks, lower socioeconomic status and poor access to health care may explain these poorer outcomes. Foreign born women have shown similar or better rates of pre-term birth, low birth weight and health promoting behaviors during pregnancy compared to the native born women (Fuentes-Afflick & Lurie, 1997; Gagnon, Zimbeck, Zeitlin, & The ROAM Collaboration, 2009; Hessol & Fuentes-Afflick, 2000). This is referred to as epidemiological paradox in literature. Protective social and cultural factors may explain positive pregnancy outcomes (Scribner, 1996). Similar to general health positive pregnancy outcomes also tend to decrease with the duration in the host country (Teitler, Hutto, & Reichman, 2012).

There are limited studies about the effects of immigration on the GWG during pregnancy. A Canadian study showed no significant difference in the GWG among recent immigrants and non-immigrants however, the non-immigrant women gained significantly

more weight than women who immigrated to Canada more than 10 years ago (Larouche, Ponette, Correa, & Krishnamurthy, 2010). Another study reported recent immigration is a risk factor for excess GWG among healthy women (Restall et al., 2014). There were no studies evaluating GWG among different generations of immigrants or identifying which generations are at risk of excess GWG. To develop effective methods for controlling weight gain during pregnancy, it is important to understand how different immigrant generations gain weight during pregnancy, and whether immigration status is protective against excess GWG or are immigrants at higher risk of gaining excess GWG independent of their socioeconomic status and ethnicity. This knowledge might help physicians to provide better advice to pregnant immigrant women, and will aid in designing better GWG control interventions for different immigrant groups. This is the main aim of this study.

In this context, identification of modifiable behaviors associated with gestational weight gain and risk factors related to excess GWG is also equally important. The ecological model summarizes the determinants of a health outcome by five different levels. Macro level includes the highest level factors as the culture; exo level includes factors such as neighborhoods, politics and media. Micro level refers to the factors in the immediate surroundings of the individual and meso level explains the interconnections between micro level factors. The final individual level includes the biological, genetic and behavioral factors. According to this model, factors in each level are interrelated and changes in higher level factors such as policy, media, culture, neighborhood and family could potentially change the individual level factors such as attitudes and behaviors. Ultimately this may lead to differences in the health outcome.

According to the literature, GWG is known to be affected by a number of factors including maternal physiological, psychological, behavioral, family, social, cultural, and environmental factors (IOM & NRC, 2009) which represent different levels of the ecological model. Most identified modifiable determinants of GWG are maternal lifestyle and behavioral factors such as dietary behaviors, physical activity (PA) and substance use. Higher maternal energy intake, and lower physical activity have been associated with excess weight gain during pregnancy, and former smokers who quit smoking during pregnancy are shown to gain more weight compared to non-smokers (Kraschnewski et al., 2013; Merkx et al., 2015; Olafsdottir, Skuladottir, Thorsdottir, Hauksson, & Steingrimsdottir, 2006; Olson & Strawderman, 2003; Shin, Lee, & Song, 2016; Strychar et al., 2000). History of alcohol consumption, restraint eating or habitual dieting and concern about weight gain was also shown to be related to GWG (Conway, Reddy, & Davies, 1999; Heery, Wall, Kelleher, & McAuliffe, 2016; Kapadia et al., 2015; Mumford, Siega-Riz, Herring, & Evenson, 2008; Sollid, Wisborg, Hjort, & Secher, 2004). Antenatal depression has been associated with poor diet and both inadequate and excessive GWG. However, the magnitude and direction of the associations are not consistent across the studies. Therefore, identifying the socio-demographic and health behaviors variables that will predict excess GWG among three immigration groups is another aim of this study.

2. Purpose of the study and research aims

The primary goal of this study is to determine the socio-economic status and health behaviors of first generation immigrants, second generation immigrants and non-immigrants in the United States and to understand the effect of immigration generation status on GWG

and risk of excess GWG. This goal will be achieved through the following objectives; 1.) Understand how the first generation immigrants, second generation immigrants and non-immigrants are different on socio-demographic characteristics and health behaviors, 2.) Determine whether there are differences in GWG and risk of excess GWG depending on immigration generation status, and 3.) To determine the most parsimonious way to distinguish women exceeding GWG recommendations and women who do not exceed the recommendations for the three immigration generation groups using the socio-demographic and health behavior variables.

The specific research aims and the hypothesis that this study is built upon are described below.

Study aim 1: Identify the differences between two generations of immigrant women and native born women in regard to their health behaviors and socio demographic status.

There is some evidence of first generation immigrants having better health behaviors and poorer socioeconomic status compared to the native born. However, the evidence also supports the claim that these behaviors change with the length of residency in the host country, country of origin, race/ethnicity and with acculturation to the American culture. My aim is to evaluate these claims among women of three immigration statuses (first generation immigrants, second generation immigrants and non-immigrant women). The purpose of aim 1 is to understand how these three immigration groups differ based on their socio-demographic characteristics (age, parity, education, marital status, employment, annual family income and pre-pregnancy BMI) and health behaviors (diet, physical activity,

smoking, alcohol consumption, prenatal care, unintended pregnancy). This aim was evaluated through the following two hypotheses;

Hypothesis 1: There will be significant differences in socio demographic characteristics among first generation immigrants, second generation immigrants and non- immigrant women

Hypothesis 2: There will be significant differences in the maternal health behaviors of the three groups, first generation immigrants, second generation immigrants and non-immigrants women

Study aim 2: Determining the relationship between the immigration status and gestational weight gain among pregnant women

The study results on the association between immigration status and GWG show that recent immigration is a risk factor for excess GWG and native born women gain more weight during pregnancy compared to women who immigrated >10 years ago. My aim in this study is to evaluate the relationship of GWG and immigration across the three immigration groups after controlling for the potential confounding variables. I evaluated the relationships between the socio-demographic variables and health behaviors with total GWG and excess weight gain. The purpose of research question 1 of aim 2 is to identify the socio-demographic variables and health behaviors that may be confounders for the main regression analysis.

Hypothesis 1: Maternal socio-demographic variables and health behaviors are significantly associated with gestational weight gain

The main research questions of aim 2 are; whether immigration generation status is associated with total GWG and whether it is associated with gaining weight inadequately or

excessively. The purpose is to understand whether the immigration status is a predictor of GWG and whether it is protective against inadequate/excess GWG. The following research hypotheses were developed based on the evidence and theories in related literature to evaluate the main research question.

Hypothesis 2: After controlling for the potential confounding variables, there will be significant differences in total GWG across the three immigration groups.

Hypothesis 3: After controlling for the potential confounding variables, there will be significant differences in rates of excess, inadequate and adequate GWG among the three immigration groups

Study aim 3: To identify the combination of health behaviors and socio-demographic predictors that best distinguish pregnant women who exceed the GWG recommendations and who do not exceed the recommendations, for the three immigration groups.

The final aim of this dissertation is to discover the socio-demographic characteristics and health behavior variables that will classify pregnant women in to two groups; women exceeding GWG recommendations and women who do not exceed the recommendations. The available evidence suggests that the combination of predictors that best distinguish the two GWG groups might be different for the three immigration groups. The analysis was conducted for the three immigration groups separately and will be compared. The purpose of this aim is to understand among different immigration groups the socio-demographic and health behavior variables that will predict excess GWG. This could aid in early identification of at risk groups and educate health care providers about what information should be

collected from different immigration groups to get a better understanding of their level of risk for gaining excess GWG. The hypothesis for the classification tree is given below and a full description of this analytic technique is given in the method section.

Hypothesis 1: The classification tree model based on simple and decision rules can be established to predict the risk of exceeding GWG recommendation.

3. Outline

The **chapter 1** is the Introduction of the dissertation. It will present the background and the rationale for this study emphasizing on the significance of this research. This section also summarizes the purpose of the study, the research questions and the hypotheses.

The **chapter 2** is the Literature Review. This will explains the current research in the field of weight gain during pregnancy and effects of immigration on health and pregnancy outcomes. It will also explain the inconsistencies between the associations of health and immigration with possible theoretical explanations to these results. Finally this chapter will explain the research gaps or the limitations in our knowledge in this field and the need of this study to improve prenatal health.

The **chapter 3** is the method section and this includes a description of the study sample, data collection, and data analysis procedures for each of the study aims. **Chapter 4** is the results section which will in detail explain the study findings. **Chapter 5** is the Discussion of the study results with respect to the current literature and theories. This section will also present the conclusions drawn from this dissertation and the future directions.

4. Potential contribution of the study

Understanding how immigrant women differ from native women and the differences between the first and second generation immigrants will be advantageous when designing

interventions targeting these populations and also when interpreting research findings from multicultural and multiethnic societies such as the United States. Further knowing how immigration is associated with GWG, can lead to the development of better interventions to control unhealthy weight gain during pregnancy. If our findings support the hypothesis that first generation immigrants are less likely to exceed GWG recommendations, it will provide an opportunity to study the cultural and health behavioral factors among these women that are protective and could include these in the future interventions to minimize unhealthy weight gains during pregnancy.

The classification tree results could be used in developing a health behavioral profile of women who might gain excess GWG. This profile could be useful in clinical practice to identify at risk pregnant women and advise them about what they need to do to prevent unhealthy weight gains as early as possible.

Definitions of abbreviations:

GWG: Gestational weight gain

IOM: Institute of Medicine

BMI: Body mass index

PA: Physical activity

PRAMS: Pregnancy risk assessment monitoring system

CDC: Centers for disease control and prevention

CRT: Classification and regression tree

CHAPTER 2

LITERATURE REVIEW

1. Gestational weight gain (GWG)

The commonly used term “gestational weight gain” refers to the amount of total weight gain by a pregnant woman by the time of delivery. Gestational weight gain is an important determinant of the future health of both the mother and the child. According to the Institute of Medicine, the total weight change during pregnancy could vary from weight loss to weight gain of more than 30 kg (66 lb.) (Institute of Medicine, 1992). The pattern of GWG is most commonly described as sigmoidal which means a ‘S’ shaped curve (Hytten and Chamberlain, 1991) although there is evidence of exceptions. Several physiological and environmental factors could contribute to this wide range of observed GWG among healthy pregnant women, including maternal hormones and health habits during pregnancy. In 1971, Hytten and Leitch established physiologic norms for total weight gain, the rate of gain in the last half of pregnancy. According to them physiologic average total weight gain for "healthy primigravid women eating without restriction" is 12.5kg (27.5 lb.), with approximately 1 kg weight gain in the first trimester and remaining weight in the last two trimesters. The most common value for the rate of gain during the last half of pregnancy was between 0.41 and 0.45 kg (~1 lb.) per week, but the range of gain was very wide from less than 0.1 to 0.9 kg (0.2 to 2 lb.) per week (Hytten and Leitch, 1971) These recommendations have been revised and the latest recommendations will be explained later in this chapter.

1.1 Components and composition of GWG

Gestational weight gain is a natural biological phenomenon that ensures and supports the growth and development of the fetus. Weight gain during pregnancy is a function of the maternal physiological changes and the placental metabolism. As pregnancy progresses, protein, fat, water, and minerals are deposited in the fetus, placenta, amniotic fluid, uterus, mammary gland, blood, and adipose tissue. The components of GWG could be categorized into two, maternal tissue accumulations and products of conception which includes placenta, fetus and amniotic fluid (IOM & NRC, 2009). The major components are given in Figure 1 as a percentage of the total weight gain. The largest components of weight gain are the fetus (~25%) and the increased fat and nutrient storage (~27%). Placenta accounts for about 5% of the gain and the amniotic fluid is about 6% (Hytten & Chamberlain, 1991).

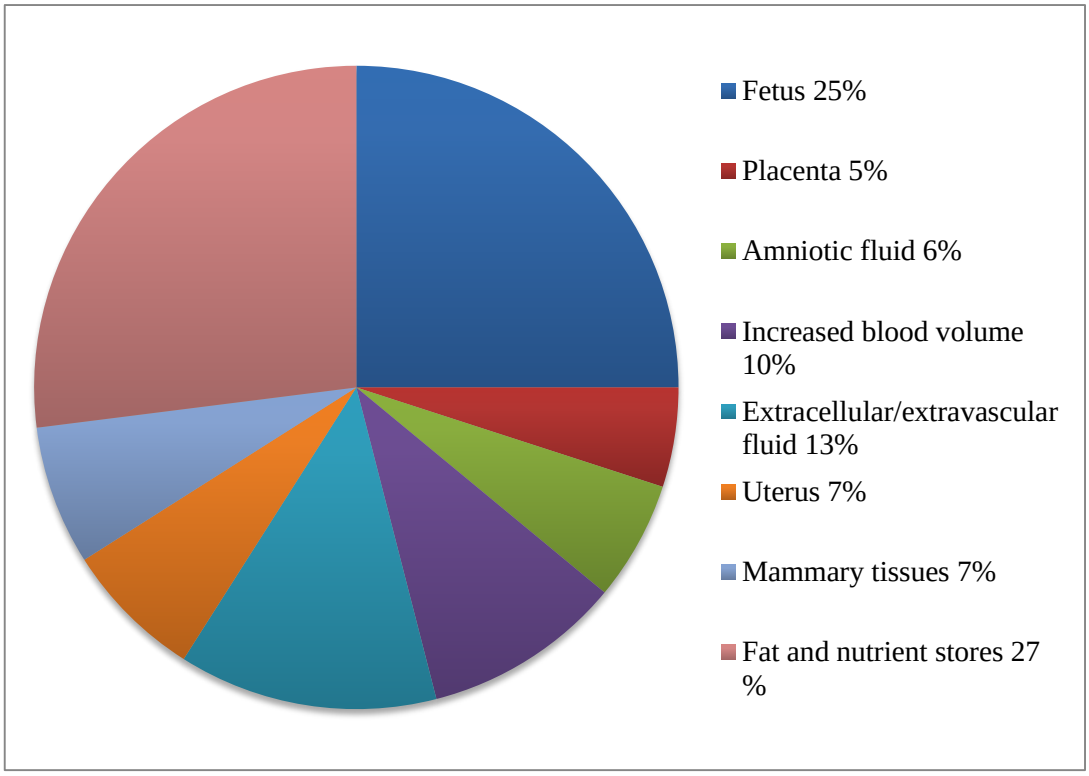

Figure 1. Components of gestational weight gain as a percentage of total weight gain

1.1.1 Maternal components of GWG

Maternal components of GWG include increases in uterine, mammary tissue mass, retained extracellular or extra vascular fluids, increased blood volume, increased fat and fat free mass (nutrient stores). These account for approximately two thirds of the total weight gain and could range 6-10kg (Worthington-Roberts & Williams, 1997). The non-pregnant uterus weight about 50g, which grows to approximately 200g by week 10 and 700g by week 20. The final weight of the uterus at term is approximately 950g. The mean volume of primigravid mammary glands in early pregnancy is about 565ml (9-12 weeks) which increases up to about 775ml at term. The breast volume of multiparous women tends to be greater than the primigravid women. By the 10^{th} week of pregnancy the plasma volume increased above the non-pregnant level by ~50ml and the peak increase is at 34^{th} week (by 1300ml). At term the final blood volume is about 1000ml more than the non-pregnant level (Hytten & Chamberlain, 1991).

1.1.2 The products of conception

The total weight gained by the mother during pregnancy includes the weight of the products of conception. The products of conception includes: placenta, fetus and amniotic fluid. Products of conception are about 8% of total weight gain at 10 weeks and rises to about 30% by 30 weeks. At term 38% of total weight gain compromised of placenta, fetus and amniotic fluid. According to Aberdeen series and Hamilton et.al, normal fetus weighs about 2500g at term (Hytten & Chamberlain, 1991). Placenta, which is an organ developed by mother and child in symbiosis, is a tissue or a structure anchoring the embryo to the walls of the uterus. Usually the final placenta weight of a female fetus is greater than of a male fetus

(Yetter, 1998). Typically the term placenta is about 22 cm in diameter and 2.0 to 2.5 cm thick and generally weighs approximately 470 g. The amniotic fluid could be estimated to be 800ml at term (Hytten & Chamberlain, 1991).

However, the most of the weight gained by the mother is due to the increase in maternal tissues and not fetal tissues. The fetal weight is not directly related to the maternal fat accumulation or the maternal energy intake (Hytten & Chamberlain, 1991).

1.2 Consequences of inadequate and excess GWG

GWG is identified as adequate, inadequate or excess based on Institute of Medicine (IOM) recommendations. It is important to gain weight during pregnancy to ensure a safe and healthy pregnancy. Researchers have been reporting consequences associated with inadequate and excess GWG for decades. The major issues caused by excess GWG includes postpartum weight retention, gestational diabetes, hypertension, cesarean delivery, fetal macrosomia, large for gestational age babies, neonatal hypoglycemia, infant and childhood obesity in child. Inadequate GWG could lead to pre term deliveries, fetal growth restrictions, small-for-gestational-age (SGA) babies, and perinatal mortality (Dietrich et al., 2014; Grieger et al., 2014; Margerison Zilko et al., 2010; Stotland & Cheng, 2006; Thangaratinam et al., 2012). Children born as SGA has a higher risk of abnormal cognitive and psychomotor outcomes than children born as appropriate-for-gestational-age (Li et al., 2017; O'Neill et al., 2017).

1.2.1 Gestational weight gain recommendations

The GWG recommendations were set forth to minimize the adverse health outcomes associated with inappropriate GWGs. Healthy GWG is not equal across different pre-pregnancy BMI categories. All guidelines available up to date recommend underweight women to gain more weight compared to other BMI groups and obese women to gain less weight compared to other BMI groups.

The earliest GWG recommendations available are the IOM 1990 recommendations. These were recommended based on the pre-pregnancy BMI according to the categories derived from the Metropolitan Life Insurance tables. These recommendations place greater emphasize on avoiding the consequences associated with inadequate GWG which might be the most prevailing problem at that time period rather than the excess GWG with respect to the infant adverse outcomes (IOM, 1990). These recommendations were updated in 2009.

Table 1. IOM 1990 GWG recommendations based on pre-pregnancy BMI

Weight category	Pre-pregnancy BMI	Recommended Total GWG (lbs.)	Rate of weight gain in second and third trimester (lb./week)
Underweight	<19.8	28-40	~1.0 (0.5 kg/week)
Normal	19.8-26.0	28-40	1.0 (0.4 kg/week)
Overweight	26.0-29.0	15-25	0.66 (0.3 kg/ week)
Obese	>29.0	At least 15	Not specified

Source: IOM & NRC, 2009

IOM 2009 GWG guidelines are the most recent and widely used recommendations worldwide today. The World Health Organization also uses the IOM weight gain guidelines

to define “normal” weight gain (WHO, 2016). These recommendations were designed to be used among women in United States. However, the IOM recommendations are being used by many other developed and developing countries as the optimal GWG guidelines. The new guidelines are different from the earlier version as the current guidelines are based on the pre-pregnancy BMI category based on the World Health Organization (WHO) BMI cutoff points and provide a relatively narrow GWG recommendation for obese women. The 2009 guidelines identified maternal and infant outcomes that are associated with both excess and inadequate GWG that were based on the Agency for Healthcare research and Quality (AHRQ) systematic review from 2008. Infant outcomes were Small–for-Gestational-Age babies, Large-for-Gestational-Age babies, preterm birth and childhood obesity. Maternal outcomes selected included postpartum weight retention, and caesarean section (IOM & NRC, 2009).

Table 2. IOM 2009 GWG recommendations based on pre-pregnancy BMI

Weight category and Pre-pregnancy BMI	Recommended Total GWG for singletons (lbs.)	Rate of weight gain in second and third trimester (lb./week)	Recommended total GWG for twins (lbs.)
Underweight <18.5	28-40	1.0 (0.5kg/week)	To be discussed with the health care provider
Normal weight 18.5-24.9	25-35	1.0 (0.4kg/week)	37-55
Overweight 25-29.9	15-25	0.6 (103kg/week)	31-53
Obese	11-20	0.5 (0.2kg/week)	25-42

The IOM recommendation for women of short stature (< 157 cm) is to gain at the lower end of the range for their pre-pregnant BMI. The committee revising the IOM recommendations also concluded that there is insufficient evidence to support a modification of GWG guidelines for different racial ethnic groups in US, especially for African American women.

One limitation of this recommendation is that a pregnant adolescent (defined as those between puberty and legal adulthood) might be categorized into a lighter category when using the adult BMI cutoff rather than the adolescent specific BMI guidelines. Thus the GWG recommendation will be higher than would be recommended at the adolescent BMI category. IOM justifies this misclassification stating adolescents need to gain more weight to improve the pregnancy outcomes. According to Harper, Chang, & Macones (2011), when pregnant adolescents gained more than the IOM recommendations, the number of SGA infants and pre term deliveries decreased.

Even though the IOM recommendations are the most widely used and accepted GWG guidelines, these are developed for various racial ethnic women in the US and there are no studies done in US with minority groups to develop optimal GWG recommendations. Therefore, the applicability of the recommendations to populations outside the US is not clear (IOM & NRC, 2009). There are few other recommendations for GWG based on data from other populations. Cedergren (2007) has recommended optimal GWG recommendations based on a large Swedish population-based cohort registry of nearly 300,000 women, almost all Caucasian. Analysis included SGA, LGA, preeclampsia and several short-term maternal and infant complications. Beyerlein al (2009) conducted a study with a German pregnant population based on more than 170,000 deliveries and came up with

GWG recommendations that had wider optimal weight gain ranges than IOM. According to their recommendations the GWG recommendations for underweight and obese women were outside the IOM 2009 recommendations. Their recommendation for overweight and obese women is to reduce or maintain the pre-pregnancy weight with minimal weight gain. Bauer et al. (2016) also reported that among a sample of obese women in US, weight loss during pregnancy significantly decrease or maintain the risk for maternal and neonatal morbidities compared with adequate and excess GWG. This supports the recommendations by Beyerlein et al. (2009). As the original BMI cutoffs were different from the WHO recommended cutoff points for Asian women, Ee et al. (2014) evaluated the GWG recommendations with a multi ethnic Singapore cohort. The summary of above mentioned optimal weight gain ranges are listed in Table 3. These studies are evidence of optimal GWG recommendations vary across diverse populations.

Table 3. Other available optimal weight gain (in kg) recommendations based on pre-pregnancy BMI

BMI category	Cedergren (2007)*	Beyerlein (2009)**	Ee (2014)***
Underweight	4-10	8-25	19.5 (12.9-23.9)
Normal	2-10	2-18	13.7 (7.7-18.8)
Overweight	<9	-7 -12	7.9 (2.6-14.0)
Obese	<6	-15-2	1.8 (-5.0 -7.0)

*Swedish women

**The BMI cutoff of 20. German women

***WHO BMI cutoff for Asians- 18.5 to 23 normal weight, 23 to 27.5 overweight and > 27.5 obese. Multiethnic Singapore women

In almost all GWG literature excess GWG is defined as gaining weight above the IOM GWG recommendations, and inadequate GWG is gaining weight below the IOM GWG recommendations for the women's pre-pregnancy BMI category. Gaining weight beyond the recommendations during pregnancy could lead to negative health outcomes in both the mother and the child. These potential complications could be short term effects that might get corrected with time or long term effects that might create health problems throughout the life span. Therefore it is important to understand possible unhealthy outcomes related to GWG in order to minimize these and to promote healthier weight gains.

1.2.2 Maternal consequences associated with GWG

Cesarean delivery

Excessive GWG increases the risk of emergency cesarean delivery (Arora, Arora, & Patumanond, 2013; Dietz, Callaghan, & Sharma, 2009; Miao et al., 2017; Seligman et al., 2006). According to Johnson's study of evaluating pregnancy outcomes in relation to IOM GWG recommendations, excessive GWG is significantly associated with increased odds of cesarean deliveries among normal weight and overweight women (Johnson et al., 2013). Morken et al. (2013) reported that women with gestational weight gain of ≥16 kg had a significantly increased risk of cesarean delivery. However, there are inconsistencies among the literature on GWG and cesarean delivery. Some studies reported that GWG has no significant effect on cesarean deliveries (Goldstein et al., 2017; Lan-Pidhainy, Nohr, & Rasmussen, 2013).

Gestational diabetes

Gestational diabetes (GD) is defined as impaired glucose tolerance first recognized during pregnancy. It is important to control and prevent onset of GD as this can affect the health of the baby by causing neonatal hypoglycemia and/or infant macrosomia. Women experiencing GD during pregnancy are at increased risk of developing type II diabetes mellitus in 5 to 10 years after delivery. GD is estimated to affect 1% to 14% of pregnancies in the United States annually depending on the population and diagnostic tests used in the study (Chen et al., 2009; Hunt & Schuller, 2007). According to DeSisto et al. (2014) GD prevalence in 2010 was 9.2% among 15 states and New York City as reported on either the birth certificate or PRAM questionnaire [Gestational diabetes information in the birth certificate is based on medical records, and is submitted to the State Department of Health by the health facility where the baby was born (Haghighat et al., 2016; Hosler, Nayak, Radigan, Birth, & Prams, 2010)].

There is evidence relating excess GWG to onset of GD. A recent meta-analysis demonstrates that excessive GWG occurring before GD testing increases the risk of GD by a 40% regardless of the pre-pregnancy BMI (Brunner et al., 2015). According to MacDonald et al. (2017), among normal weight women, every standard deviation increase in weight gain in the first trimester above her predicted gain was associated with a 23% increased odds of gestational diabetes however, second trimester weight gain trajectory was not associated with the onset of GD. Boribonhirunsarn reported that a second trimester weight gain of > 7 kg significantly increased GDM risk 2.6 times in women with negative first trimester GDM screening results, regardless of pre-pregnancy BMI (Boriboonhirunsarn, 2017). GWG has been identified as a modifiable risk factor that could be controlled to minimize the onset of GD and to prevent associated consequences.

Pregnancy induced Hypertensive disorder

Pregnancy induced hypertensive disorders includes gestational hypertension, preeclampsia, and eclampsia. Figure 2 shows that according to CDC data the number of incidents of hypertensive disorders are still at an increasing trajectory which needs to be addressed to minimize pregnancy complications. Several studies have demonstrated an association between excessive GWG and development of hypertensive disorders. According to results from a secondary analysis of a preeclampsia prevention trial among nulliparous carrying singletons 73% of women gained above the IOM guidelines and of those women 32% developed either gestational hypertension or preeclampsia in addition to other adverse pregnancy outcomes including cesarean delivery and large for gestational age (Johnson et al., 2013). Analysis of data from Avon Longitudinal Study of Parents and Children revealed that gaining more than the IOM recommended weight was associated with an increased risk of gestational hypertension and preeclampsia compared with gaining within the recommended range (OR 1.52, 95% CI 1.32-1.73 and OR 2.14, 95% CI 1.46-3.12 respectively) (MacDonald-Wallis, Tilling, Fraser, Nelson, & Lawlor, 2013). Rushtaller et al. (2016) reported that early excessive weight gain was associated with a significantly higher rate of any hypertensive disorder of pregnancy (12.5%) and after adjusting for confounders weight gain above the IOM recommendation was associated with a significant increase in the development of any hypertensive disorder of pregnancy (OR 1.70, 95% CI 1.18–2.44) (Ruhstaller et al., 2016).

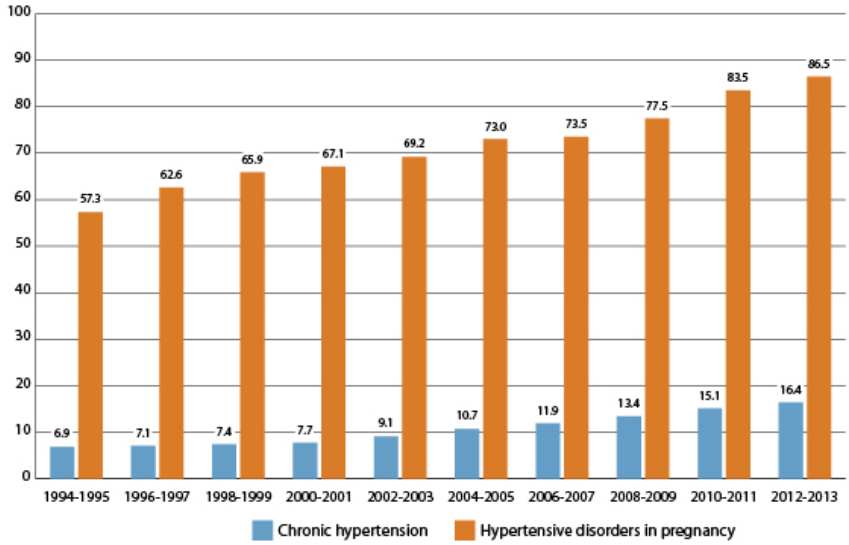

Figure 2. Rate of Hypertensive disorders per 1000 delivery hospitalization

Source: Center for Disease Control and Prevention - data from National In-patient Sample

Post-partum weight retention and increased risk of obesity and metabolic diseases

Obesity research has identified pregnancy as a risk factor for weight cycling in women as pregnancy is a period of women's life where they gain a substantial amount of weight. This might lead to development of obesity in the future. There is evidence indicating that approximately 10% to 15% of women retain the weight they gain during pregnancy, which is referred to as post-partum weight retention (PPWR). One of the major causes of PPWR is excessive GWG.

A recent meta-analysis of observational studies concluded that excessive GWG can significantly increase PPWR risk (OR=2·08, 95 % CI 1·60, 2·70) (Rong et al., 2014). Women with excessive GWG showed a U-shaped trend in weight gain; a decline during the early postpartum time span (year 1) and then an increase in the following period. In the long term these women are at risk of having increased BMI and becoming overweight or obese post-partum. Women with inadequate GWG have significantly lower mean PPWR compared

to women with adequate GWG. This positive association of inadequate GWG and PPWR have shown to fade over time and became insignificant (−1·42 kg; 95 % CI −3·08, 0·24 kg) after ≥15 years (Rong et al., 2014). However, the potential beneficial effect of inadequate GWG on PPWR should be balanced against the potential risks of inadequate GWG.

1.2.3 Infant consequences associated with GWG

Pre-term delivery

Pre-term delivery (born at <37 completed weeks of gestation) increase the risk of infant mortality and long term disabilities compared to infants born at term. During 1981--2006, the U.S. preterm birth rate increased by more than 30%; however this rate was decreased in 2007-2008. According to CDC reports based on 2007, National Vital Statistics System Data, rate of pre-term deliveries among non-Hispanic black was 18.3%, 12.3% in Hispanics, 11.5% in non-Hispanic whites and 10.9% in Asians. The Figure 3 shows the pre-term birth rates in U.S from 1990 to 2008.

Several studies have reported an association between inadequate GWG and increased risk of preterm birth particularly among underweight women. However, Sharma et al. (2015) reported that there was no evidence to support an association between GWG in the first and second trimester and pre-term delivery among underweight and normal weight women.

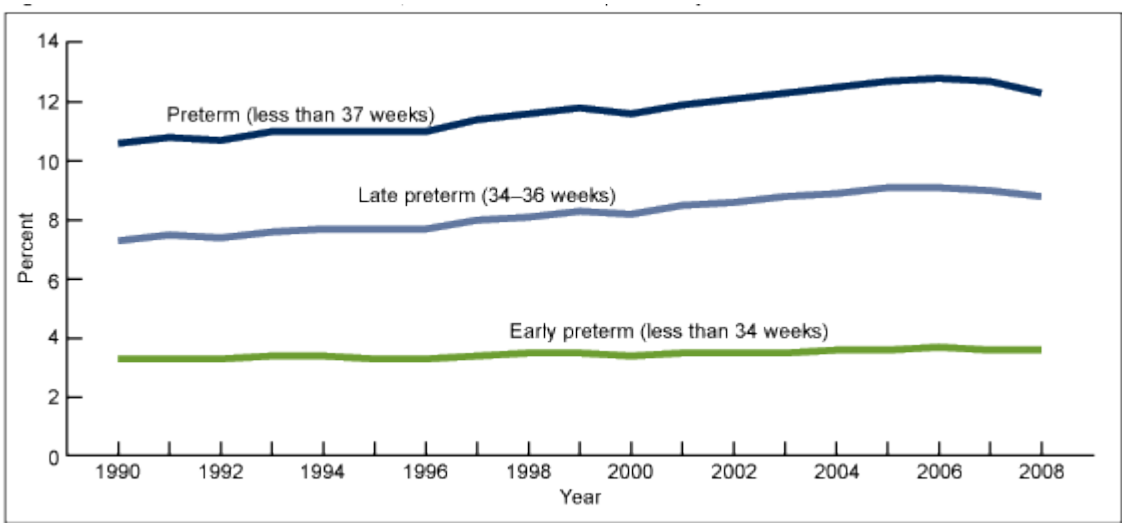

Figure 3. Pre-term birth rates in United States (final 1990-2006 and preliminary 2007 and 2008)

Source: CDC/NCHS, National Vital Statistics system

Fetal growth restrictions

The amount of weight gain during pregnancy and the timing of weight gain influence fetal growth and the programing of the child's health. The associations of weight gain during early, mid, and late pregnancy and fetal growth is different (Hivert, Rifas-Shiman, Gillman, & Oken, 2016). GWG in early pregnancy represents mainly maternal fat depositions and its influence on placental nutrient transfer is different than the influence of later GWG. The later GWG reflects fetal and placental growth and maternal fluid expansion in addition to maternal fat depositions (Hytten & Chamberlain, 1991; IOM & NRC, 2009). Late pregnancy GWG has been consistently reported to be associated with birth weight. According to a prospective study with mother-infant dyads, 2nd trimester weight gain may impact fetal and postnatal growth (Rifas-Shiman et al., 2017). Low GWGs in either second or third trimester was associated with approximately two times higher risk of intrauterine growth retardation

(Strauss & Dietz, 1998). Therefore, appropriate GWG during the right time is important for the long term health and well-being of the child.

Small for gestational age babies (SGA) and low infant birth weight

It is widely reported that GWG is positively associated with birth weight (Akgun, Keskin, Pekcan, & Avsar, 2017; Du et al., 2017; IOM & NRC, 2009) and some studies have reported that the weight gain in the second trimester has the strongest association with birth weight compared with weight gain in other trimesters (Bayer, Ensenauer, Nehring, & Kries, 2014; IOM & NRC, 2009). There is evidence of a strong association between GWG below the IOM recommendations and low birth weight (less than 2500g or 5 pounds 8 ounces) and SGA babies (Siega-Riz et al., 2009). A study using the National Longitudinal Survey of Youth 1979 (NLSY79) and the NLSY79 children and young adult survey showed that each kilogram of GWG was associated with significantly decreased odds of SGA among normal weight and obese women (Margerison Zilko et al., 2010). Inadequate GWG significantly increased the odds of SGA (OR 1.48, 95% CI 1.12-1.96).

According to the National Vital Statistics Report 2017, the rate of low birth weight in 2015 was 8.07%, which is a slight increase from the previous years. The low birth weight rates among non-Hispanic white remained fairly stable over the years, while the rates among non-Hispanic Black and Hispanics increased. Therefore, effective methods to control unhealthy weight gains during pregnancy are important to reduce the incidents of low birth weight especially among the ethnic minority groups.

Large for gestational age babies (LGA)/ fetal macrosomia

According to the literature on maternal outcomes in relation to weight gain, there is strong evidence that high weight gains are associated with an increased risk of LGA infants and GWG above IOM recommendations is shown to be consistently associated with Macrosomia or high birth weight (Johnson et al., 2013; Siega-Riz et al., 2008; Xie et al., 2016). Most of these studies defined LGA as greater than the 90th percentile of birthweight for gestational age and macrosomia defined as birth weight greater than 4500g.

According to Pongcharoen et al. (2016), both higher pre-pregnancy body mass index and excessive gestational weight gain increase the risk of fetal macrosomia. Women who had excessive GWG were eight times (adjusted OR 8.04, 95% CI 1.42- 45.7) more likely to have macrosomic infants compared to women with normal GWG (Pongcharoen, Gowachirapant, Wecharak, Sangket, & Winichagoon, 2016).

Infant and childhood obesity

There is a direct but moderate to weak association between total GWG and child obesity. High rates of GWG in early- and mid-pregnancy are known to be associated with increased BMI z-scores and elevated risk of overweight among offspring according to studies done with children between 3-14 years of age. Each additional kilogram increase in GWG is associated with 1% -23% elevated risk of overweight and obesity among the children (Hivert et al., 2016; Oken, Kleinman, Belfort, Hammitt, & Gillman, 2009; Tie et al., 2014; Wrotniak, Shults, Butts, & Stettler, 2008). However, some studies have reported no significant association between GWG and childhood obesity (Gillman et al., 2008; Rooney, Mathiason, & Schauberger, 2011).

1.3 Trends in maternal weight and gestational weight gain in the United States

1.3.1 Body mass index

The pre-pregnancy Body Mass Index (BMI) is related to GWG according to many research findings and the IOM recommendations for GWG are also designed based on the pre-pregnancy BMI. Higher pre-pregnancy BMI is associated with increased risk of exceeding GWG recommendations (Akgun et al., 2017; Rodrigues, Costa de Oliveira, Santos Brito, & Kac, 2010; Rosal et al., 2016; Strychar et al., 2000). Underweight women gain more total gestational weight than overweight or obese women during pregnancy. This is in accordance with the IOM 2009 recommendations. However, among overweight and obese women the rates of excessive GWG is higher compared to underweight and normal weight women (Akgun et al., 2017; Rodrigues et al., 2010). Therefore, it is important to understand the trends in BMI among women of reproducing age when evaluating the GWG trends and problems associated with unhealthy weight gains during pregnancy. Among women of childbearing age, overweight and obesity increase the risk of infertility and adverse outcomes of pregnancy. Research conducted in the past few decades exhibit an alarming increase in overweight and obesity in the United States. According to Cogswell et al. (2001), the prevalence of overweight and obesity has risen more among women of childbearing age than among older women or men.

According to the National Health and Nutrition Examination Survey (NHANES) data from 2009-2010, 33.0% of U.S. adults aged 20 and over are overweight, 35.7% are obese, and 6.3% are extremely obese. When comparing NHANES data from 1960/62 to the most recent data, there is an increase from 24.7% to 27.5% in the rates of overweight, an increase from 15.8% to 36.1% in obesity rates and an increase from 1.4% to 8.5% in extreme obesity

rates among women of 20-74 years. The highest rate changes were observed among women of ages 20-29 years (prevalence of obesity increased from 7% in 1960-1962 to 17% in 1988-1994 and overweight rate increased from 11% in 1960-1962 to 19% in 1988-1994). In 1988–1994, 44% of non-pregnant women 18–49 years old in the United States were overweight (22%) or obese (22%). Both overweight and obesity were highest among minority groups. The 2004 PRAMS data shows among pregnant women, mean prevalence of pre-pregnancy underweight was 13.2%, overweight was 13.1% and obesity was 21.9%.

According to the race/ethnicity stratified data from women in 2009–2010, non-Hispanic Black women (58.5%) were significantly more likely to be obese than non-Hispanic white women (32.2%) and Hispanic women (44.9%). Hispanic women were more likely to be obese than non-Hispanic white women. Similar disparities in obesity were observed in data from 1988–1994, when comparing non-Hispanic white women (22.9%) with non-Hispanic African American women (38.4%) and Hispanic women (35.4%). According to PRAMS data 2004, prevalence of pre-pregnancy underweight was 13.8%, 10.5% and 11.1% among non-Hispanic white, non-Hispanic black and Hispanic women respectively. The prevalence of overweight was 12.2%, 14.7% and 15.9% and obesity rates were 22.9%, 37.9% and 24.7% among non-Hispanic white, non-Hispanic black and Hispanic women respectively.

1.3.2 Gestational weight gain prevalence

According to the recent literature the percentage of women exceeding the GWG recommendations are steadily increasing. The number of US women who exceed the IOM pregnancy weight gain guidelines is noteworthy. In a nationally representative sample of US

women, almost 50% gained weight in excess of the recommended amount (Chu, Callaghan, Bish, & D'Angelo, 2009). According to CDC report analyzing 2013 birth data for U.S. resident women who delivered full-term, singleton infants and 2012 data from Pregnancy Risk Assessment Monitoring System (PRAMS), only 32.1% women had appropriate GWG. The statewide prevalence of inadequate GWG ranged from 12.6% to 25.5%, appropriate GWG ranged from 26.2% to 39.0% and the excess GWG range was 38.2% - 54.7%. The prevalence of excess GWG was > 50% in 17 states. The state wise prevalence of inadequate and excess GWG is given in Figures 4 and 5.

Stratification by pre-pregnancy BMI category indicated that overweight and obese women had the highest prevalence of excessive GWG. The prevalence of inadequate GWG was 32.2% for underweight, 23.6% for normal weight, 12.6% for overweight and 20.65 for obese women. The prevalence of excess GWG was 23.5% for underweight, 37.6% for normal weight, 61.6% for overweight and 55.8% for obese women.

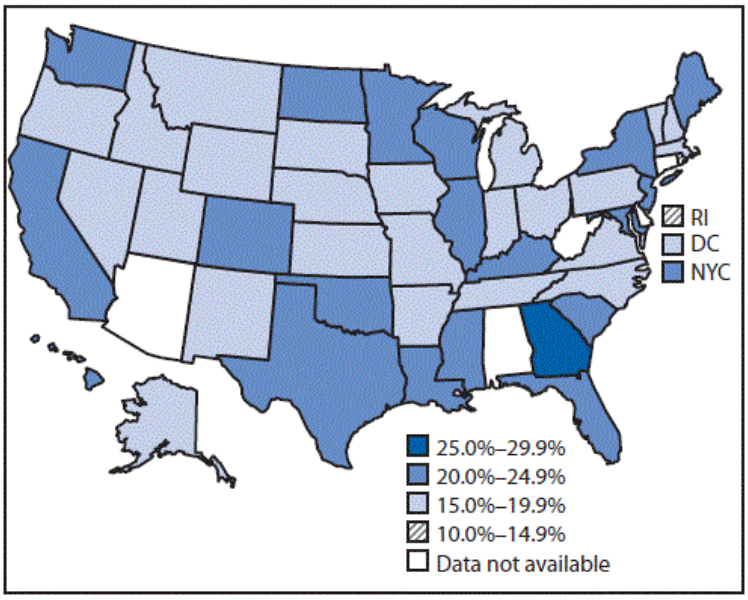

Figure 4. Prevalence of inadequate gestational weight gain (GWG)* — 46 states, New York City, and District of Columbia, 2012–2013 (Deputy et al., 2015)

Sources: 2012 Pregnancy Risk Assessment Monitoring Systems and 2013 birth certificates

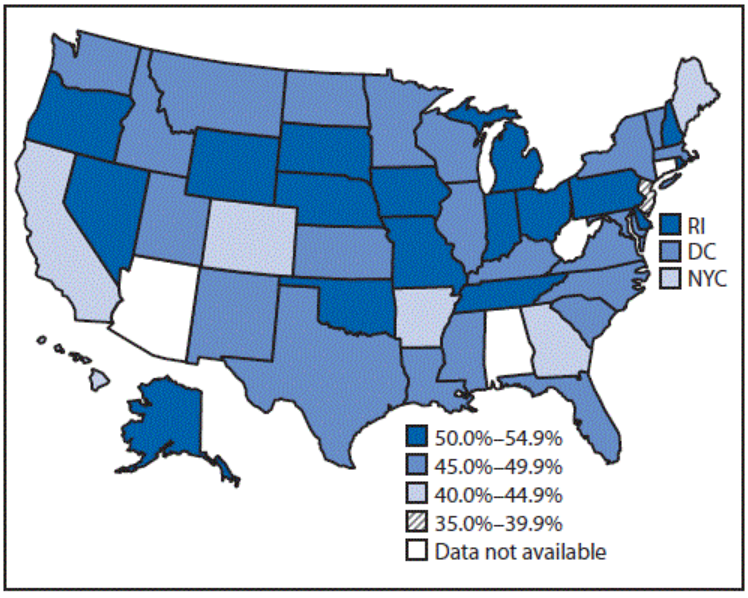

Figure 5. Prevalence of excess gestational weight gain (GWG)* — 46 states, New York City, and District of Columbia, 2012–2013 (Deputy et al., 2015)

Sources: 2012 Pregnancy Risk Assessment Monitoring Systems and 2013 birth certificates

1.3.3 Disparities in trends and patterns of GWG

According to most US reports African American and Hispanic women and children are more affected by adverse pregnancy outcomes and obesity. Analysis data from nationally representative samples have shown that about 48% of non-Hispanic black, 45% of Hispanic and 33% of Asian women and ≥50% of non-Hispanic White, American Indian and Multi race women gained excessive GWG. Inadequate GWG was highest among Asian women (~27%) followed by Hispanic women and non-Hispanic Black women (Headen, Davis, Mujahid, & Abrams, 2012). Figure 6 illustrates the GWG adequacy by Race/Ethnicity, using 2009-2010 PRAMS data.

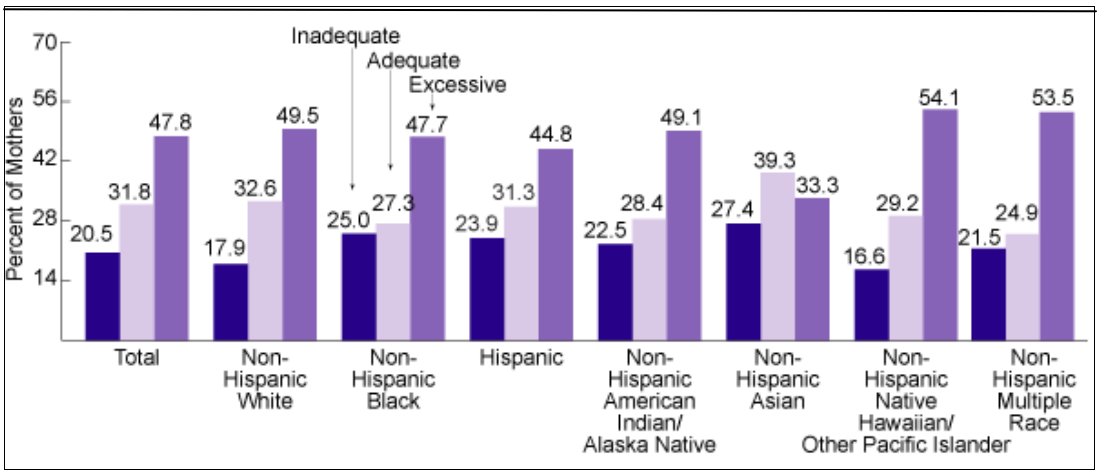

Figure 6. Gestational weight gain adequacy by Race/Ethnicity, 2009-2010

Source: Centers for Disease Control and Prevention, Pregnancy Risk Assessment Monitoring System (PRAMS) 2009-2010.Note: GWG adequacy defined according to IOM GWG recommendations 2009 for women delivering singleton infants at term (37+ weeks gestation).

This shows that except for Asians, the percentage of women who gained excess GWG is higher than the percentages of adequate or inadequate GWG among all racial ethnic groups. Even though there is no difference in the rates of excess GWG among minority women, the rates of overweight and obesity are higher among these groups, therefore, they are at more risk of exceeding GWG recommendations compared to non-Hispanic white women.

1.4 Determinants of GWG

1.4.1 Socio-ecological model

Health is influenced by numerous factors across multiple levels. In the process of understanding health outcomes, and the determinants of the outcome, it is more informative to use the socio-ecological model by Urie Brofenbrenner (shown in Figure 7). This model gives a complete and more comprehensive picture of the situation indicating the complex interplay of factors of various levels. This includes Macro system, Exo system, Meso system, Micro system and individual level factors (Brofenbrenner, 1977; Brofenbrenner & Morris, 1998). This model describes both individual and environmental determinants and the dynamic interrelations among these factors and suggests that in order to prevent a certain outcome it is necessary to influence the multiple levels of the model. The macro system includes the highest level factors such as attitudes and ideology of the culture and the exo system comprises the linkages and processes taking place between two or more settings including factors such as, neighborhood, mass media, politics and social services. The micro system is a pattern of activities, social roles and interpersonal relations experienced by the individual in a given setting. This includes the immediate surrounding of the individual; family, friends. The meso systems comprises the relationships exist between two or more

settings. This could be explained as the connections between the structures of the micro system (Brofenbrenner & Morris, 1998). The individual level factors include the biological or genetic characteristics and behaviors of the individual.

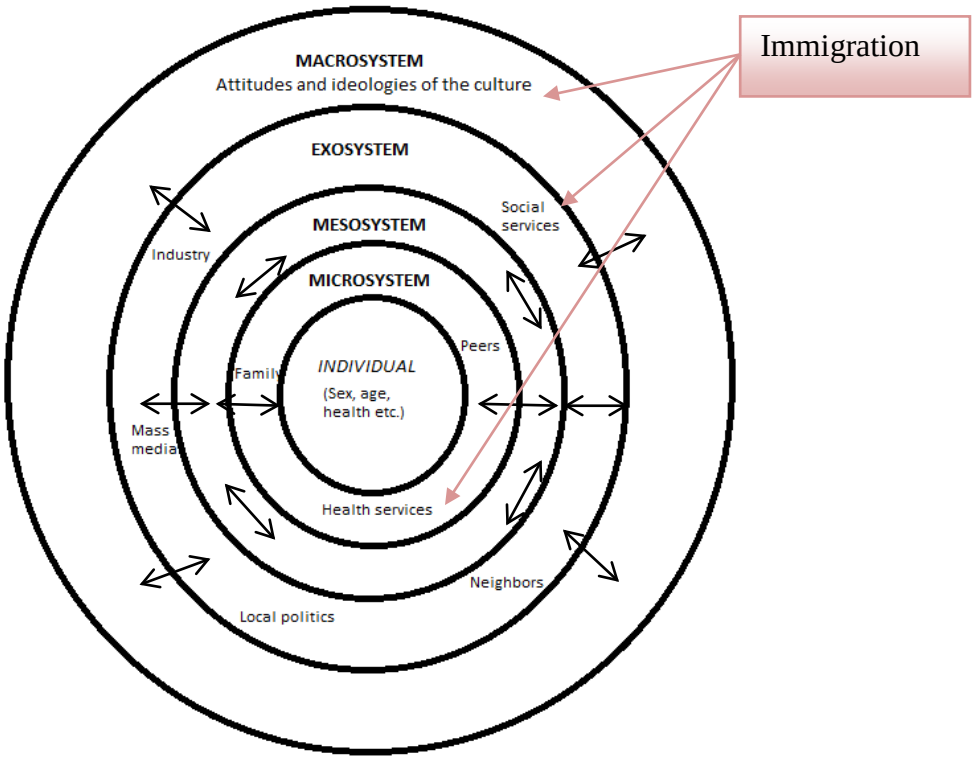

Figure 7. Social ecological model and immigration

According to the theory of ecological model of health, change in any level can affect the outcome directly or indirectly. McLeroy et al. (1988) explains that when using ecological model to explain health outcomes, any changes in the social environment can produce changes in the individual behavior affecting their health.

In the process of developing effective interventions to control GWG it is important to understand these different levels of determinants and their influence on GWG. According to

research on determinants of weight gain during pregnancy, GWG is known to be affected by a number of factors including maternal physiological, psychological, socio-demographic, behavioral factors, society, neighborhood/community and family (IOM & NRC, 2009; IOM, 1990). These determinants align with the different levels explained in the ecological model of health.

1.4.1.1 Individual level factors

Most widely studied determinants of GWG are the maternal factors or the individual level factors that directly influence GWG including socio-demographic, physiological, psychological, and lifestyle factors. These factors are the individual level factors according to the ecological model and some of these are potentially modifiable determinants of GWG. The socio-demographic determinants known to be associated with GWG are maternal age, maternal education and food insecurity (Adams, Grummer-strawn, & Chavez, 2003; Chu et al., 2009; Olson & Strawderman, 2008; Reddy, Ko, & Willinger, 2006). Pre-pregnancy BMI, changes in the hormonal milieu and changes in the basal metabolic rate (BMR) are the maternal physiological factors known to be related to GWG (Goldberg et al., 1993; Prentice, Goldberg, Davies, Murgatroyd, & Scott, 1989). Among the maternal psychological factors, depression is positively associated with lower total GWG (Bodnar, Wisner, Moses-Kolko, Sit, & Hanusa, 2009; Carol A. Hickey, Cliver, Goldenberg, McNeal, & Hoffman, 1995) and stress is also shown to be correlated to lower total GWG (Picone, Allen, Schramm, & Olsen, 1982). Heery et al. (2016) revealed that restrained eating, weight cycling and dieting were associated with higher absolute weight gain, whilst weight cycling only was associated with excessive weight gain.

Among maternal factors the associations between maternal lifestyle factors and GWG are widely reported in literature. Maternal lifestyle behaviors are the most modifiable determinates of GWG. Much research has been done to analyze the relationship between different maternal health behaviors and GWG outcomes. These studies have developed the basis for designing effective interventions to control unhealthy weight gains during pregnancy. The most important maternal behaviors related to GWG identified in literature are dietary intake, physical activity, cigarette smoking, alcohol consumption, drug use and unintended pregnancies (IOM & NRC, 2009).

Nutrition and eating behaviors

Lifestyle factors such as inappropriate diet may play a major role in excessive weight gain during pregnancy. Pregnant women should be guided to have a well-planned, balanced, healthy diet during pregnancy in order to avoid rapid GWG. Higher maternal intake of energy and higher protein and/or lipid intake were associated with increased total weight gain (Bergmann, Flagg, Miracle-McMahill, & Boeing, 1997; Kramer & Kakuma, 2010; Lagiou et al., 2004; Stuebe, Oken, & Gillman, 2009). According to Uusitalo et al. (2009), the 'Fast food' dietary pattern (characterized by higher consumption of sweets, soft drinks, hamburgers, pizza and other fast foods) was positively associated with higher weight gain during pregnancy. Olson and Strawderman (2003) reported that increasing the amount of food intake during pregnancy is associated with greater GWG and an adjusted odds ratio of 2.35 for excess GWG. They also reported that increasing the intake of fruits and vegetables was associated with significant reduction in the total GWG. NHANES data 2003-2006 showed, diets high in meat, dairy products, fruits, vegetables, nut and seeds might be associated with reducing the risk of excess GWG. Consuming more sweets in early

pregnancy was also associated with increased odds of excess GWG (Olafsdottir et al., 2006). There is also evidence of pre-pregnancy dietary behaviors such as restraint or disordered eating being related to excess and inadequate GWG during pregnancy (Conway et al., 1999; Mumford et al., 2008; Sollid et al., 2004). Interventions for pregnant women aim to control unhealthy GWG containing dietary components and/or physical activity components. Many reviews evaluating the effects of GWG control interventions have concluded that dietary interventions were most effective in controlling GWG compared to physical activity interventions or combined interventions (Hill, Skouteris, & Fuller-Tyszkiewicz, 2013; Tanentsapf, Heitmann, & Adegboye, 2011; Thangaratinam et al., 2012). These dietary interventions included either calorie restriction or target macro nutrient distribution for intake and resulted in a mean reduction of GWG by -1.92kg—3.84kg.

Physical activity

Physical activity (PA) is essential for the promotion of health during almost all stages of life. The benefits of PA during pregnancy improves or maintains physical fitness, helps with weight management, reduces the risk of gestational diabetes in obese women, and enhances psychological well-being (Kraschnewski et al., 2013). The American College of Obstetricians & Gynecologist (ACOG) recommends pregnant women perform at least 150 minutes per week of moderate-intensity aerobic activity (i.e., equivalent to brisk walking) which should be spread through- out the week and adjusted as medically indicated. The guidelines advise that pregnant women who habitually engage in vigorous-intensity aerobic activity (i.e., the equivalent of running or jogging) or who are highly active “can continue physical activity during pregnancy and the postpartum period, provided that they remain

healthy and discuss with their health care provider" (American College of Obstetricians and Gynecologists, 2015). There is no evidence of PA during pregnancy being associated with increased risk of low birth weight. However, PA has shown to be related to weight gain and reduced risk of cesarean delivery. There is evidence to support that PA is inversely related to excessive GWG and meeting the PA recommendations is associated with lower odds of excessive GWG (Kraschnewski et al., 2013; Merkx et al., 2015; Stuebe et al., 2009). The participation in leisure-time physical activity (LTPA) during pregnancy is also found to be associated with lower odds of excessive GWG (Juhl, Olsen, Andersen, Nøhr, & Andersen, 2010; Mudd et al., 2012; Owe, Nystad, & Bo, 2009).

Smoking, drugs and alcohol use

It is well established that smoking, drugs and alcohol consumption during pregnancy can cause adverse health effects on the infant (Bailey, McCook, Hodge, & McGrady, 2012). However, there is no consistence evidence of a relation between substance use and GWG. Substance abuse has been identified as a factor contributing to the weight gain during pregnancy (IOM & NRC, 2009).

The literature on smoking and GWG suggests inconsistence results. Some studies showed smoking during pregnancy is related to lower total GWG (Rush 1974), while some reported no associations (Furuno, Gallicchio, & Sexton, 2004; Garn, Hoff, & McCabe, 1979). According to Levine et al. (2015), women who quit smoking during pregnancy gain a higher amount of total gestational weight compared to women who continued to smoke during pregnancy. Hulman has reported that the weekly rate of GWG in second and third trimester was highest in women who quit smoking during pregnancy (0.60kg/week) which is

approximately 20% and 50% higher than women who never smoked and women who smoked during pregnancy (Hulman et al., 2016).

Much lesser information is available for the association between alcohol consumption and GWG. Stevens-Simon & McAnarney reported that among Black adolescent mothers, alcohol use was more frequent among those who showed rapid rates of GWG (Stevens-Simon & McAnarney, 1992). According to Uusitalo et al. (2009) higher alcohol consumption during pregnancy is inversely associated with GWG. Few studies have reported no association of drinking and GWG outside the IOM recommendations (Wells, Schwalberg, Noonan, & Gabor, 2006; Little et al. 1986).

The study by Smith et al. (2006) included a significant proportion of methamphetamine users and among this group those who used the drug in the first two trimesters and ceased use in the third trimester, gained significantly higher GWG than non-users and those who continued to use the drug. However, the study by Graham et al. (1992) with cocaine users, there was no significant difference in the GWG among cocaine users and non-users.

Prenatal care

Accurate knowledge on GWG recommendations among pregnant women are generally lacking, especially among low income ethnic minorities (Ledoux, Berg, Leung, & Berens, 2015; Shulman & Kottke, 2016). Health care provider's advice and information on GWG have been shown to be the main source of information on GWG for pregnant women (Ferrari & Siega-Riz, 2013; Ledoux et al., 2015). However, among those who received advice on GWG from health care providers, about 85% received accurate advice (Phelan et al., 2011). There are conflicting evidence on the association between healthcare providers advice on GWG and the women's' knowledge of GWG recommendations. Some reported

that Health care provider's advice about GWG influences women's total GWG (Stotland et al., 2005; McDonald et al., 2012), while some reported no association between physicians advice and GWG (Brawarsky et al., 2005; McDonald et al., 2011). Ledoux et al. (2015) reported that healthcare providers' advice was not a significant predictor of knowledge of GWG recommendations. The accurate knowledge of IOM recommendations for GWG was associated with appropriate GWG (McPhie, Skouteris, Hill, & Hayden, 2015; Shulman & Kottke, 2016; Strychar et al., 2000). Therefore, use of prenatal care could be a potential contributor to healthy GWG. Yan (2006) reported that onset of prenatal care in second or third trimester was associated with increased risk of inadequate GWG. This study shows that the low frequency of prenatal care visits and inadequate care was also related to the elevated risk of inadequate GWG. However, the association of prenatal care and excess GWG was weak and insignificant.

Unintended pregnancy

There is conflicting evidence on the relationship between the pregnancy intention and GWG. According to Hickey et al. mistimed or unintended pregnancy is associated with increased risk for inadequate GWG (Hickey, Cliver, Goldenberg, McNeal, & Hoffman, 1997). Siega-Riz & Hobel (1997) reported that planned pregnancy is associated with lower risk of inadequate GWG. There are few other studies reporting no association between GWG and planned pregnancy (Kost, Landry, & Darroch, 1998; Wells et al., 2006).

1.4.2. Micro system

The micro system of the ecological model encompasses the relationships and interactions an individual has with his or her immediate surroundings. This includes the interpersonal

determinants of GWG such as marital status and family support. Some studies have reported that friends and family could influence the weight gain during pregnancy even more than health care providers or media sources such as the internet (Brownfoot, Davey & Kornman, 2016; Tovar et.al. 2010). The information and advice given by family and friends has more influence on behavior change because it is provided within the context of a caring and trusting relationship (Glanz, Rimer & Viswanath, 2008). Additionally, social supports can facilitate the coping process and mitigate the effects of health stressors during pregnancy (Hodnett, 2017; Stevens-Simon et.al., 1993).

There is evidence of unmarried women gaining less total weight compared to married women and less rate of excess GWG among married women compared to single or divorced women (Olson & Strawderman, 2003; Ventura, 1994). Even though, there are not much studies looking at the effects of marital status or family support on GWG, there are more evidence of associations between social support and low birth weight. Birth weight could be an indicator of GWG. Doucet et.al. (1989) and Luo et.al. (2004) reported that single women living alone are at a greater risk of low birth weight compared to married women and single women living with a partner or an adult. They concluded that household structure is a more important determinant of birth weight, than marital status. Stevens-Simon et.al. (1993) reported that women's attitudes towards GWG directly related to the perceived family support.

1.4.3. Meso system

Meso system connects two or more systems in which the individual lives. Meso system refers to the interrelations among various settings in which the individual is involved. The meso system is the system of micro systems.

1.4.4. Exo system and macro system

Neighborhood/community determinants of GWG including access to healthy food, and opportunities for physical activities come under the exo level factors in the ecological model. Laraia et al. (2004) reported that increased distance to supermarkets from the residence is associated with reduced diet quality and having social spaces such as parks and sidewalks are associated with reduced odds for inadequate or excess GWG.

The societal determinants of GWG include acculturation/culture and health services which also come under the macro and exo level factors in the ecological model in health. Culture influences women's food preferences, food selections, patterns of eating, preparation of food, and frequency and amount of food consumed in general and also during pregnancy (King, 2000; Fieldhouse, 1986). Food choices of different countries and cultures depend on the established traditions and the availability of food and generally, and for most people food items traditionally consumed in the culture of origin are preferred over other foods (Logue & Smith, 1986; Rozin & Schiller, 1980; Sorokowska et al., 2017). However, among immigrants the traditional food habits could get modified from generation to generation (Bass, Wakefield, & Kolasa, 1979). This can create a difference in the GWG among women of different cultural backgrounds even though they are living in the same society. However, there are no studies reporting how acculturation affects GWG (IOM & NRC, 2009).

The effects of immigration on GWG is not widely studied however, the effects are not solely due to the changes in the exo and micro level determinants. Immigration could affect almost all the levels in the socio-ecological model including changes in woman's immediate environment (family and friends) followed by changes in the individual life style behaviors (diet, physical activity). These changes might occur immediately with moving to a new

location or might take longer time to occur. Therefore, it is important to understand the difference between immigrants and native born women as well as between different generations of immigrants to design better interventions or programs improve the health of the United States. This will be further discussed in the following section.

2. Immigration status and health

Immigration (the international movement of people into a destination country of which they are not natives or where they do not possess citizenship) is a process that could potentially affect almost all the levels of environmental and personal determinants of health as explained by the socio-ecological model. Therefore it is important to understand how this can affect a person's life and the life of future generations.

Most of the studies on immigration and health focus on the behavioral, cultural or structural framework. The behavioral framework focus on the individual level factors such as the individual behavioral choices. The cultural framework looks at shared beliefs, cultural values, traditions linked to race/ethnicity or national origin influencing behavior, shaping choices and behaviors. Structural framework is less frequently used and interprets health outcomes through understanding and accounting for the large-scale social forces that impact health. The societal and institutional level factors such as employment, housing, access to food and social services could also be affected by immigrations (Castaneda et al., 2015). Therefore, immigrations could be considered as a process that affects almost all the levels of determinants of health.

2.1 Immigrants in the United States

United States attracts the largest number of immigrants each year compared to any other country (Jimenez, 2011). An immigrant is someone living in a country who was foreign born (i.e., an immigrant in U.S. is someone who was not born in a state or territory of the United States or was not born abroad to a U.S. citizen). Immigrants join the U.S through avenues such as citizenship, becoming legal permanent residents (LPRs), or by seeking humanitarian protection (Jasso et.al., 2005). There are 3 main types of immigrants in United States:

(1) A naturalized citizen (someone who has lawfully become a citizen of the United States)

(2) A noncitizen who is living in the United States legally (legal permanent residents, i.e., those with "green cards"; refugees; persons seeking asylum; other humanitarian immigrants; and lawfully present temporary immigrants)

(3) A noncitizen that is living in the United States illegally (an undocumented or unauthorized immigrant) (Stimpson, 2012; Udall Center, 2006)

Immigrants are an extremely heterogeneous group with substantial differences across subpopulations such as country of origin, time in U.S. and visa/residency status. In U.S. about 21% of the migrants are illegal border crossers and about 10% are visa abusers (who entered using a valid visa but violate the terms of that visa) (Massay & Malone, 2002). The legal immigrants could enter US with two types of visa; Immigrant visa (those who came to U.S. to become permanent residence, e.g. sponsored by employer, family member) or non-immigrant visa (those who came to U.S. for a temporary visit, e.g. students, temporary

worker visa, business/professional visa or through refugee or asylum status). The main difference between the two groups is that those with immigrant visas may work in U.S. and live with most of the privileges and rights as U.S. citizens while those with non-immigrant visa are restricted to the activities or reasons for which they were allowed entry. There are major differences among immigrants even in the same visa type described above.

Even though the term refugee/asylum used together when describing these immigrants, they are two distinct categories of immigrants. The term "refugee" is used to describe immigrants those who have a reason to fear persecution in their native country due to race, nationality, religious or political beliefs, gender etc. To be qualified as a refugee, they need to reside outside U.S. and should no longer live in their native country (U.S. citizenship and immigration services, 2017; Bureau of Consular Affairs, 2017). Therefore, this group of immigrants has spent some time in refugee camps which could affect both their physical and mental health. However, once refugees come to the United States, they receive support that is not available to other immigrants including cultural orientation, medical care, temporary housing and job placement assistance, as well as loans for travel costs. After being in U.S. for one year they can become permanent residents (Jasso et.al., 2005). Those seeking political asylum either apply when they reach a port of entry into the United States or after they have already entered, often as undocumented immigrants. To be qualifying for asylum they need to prove a well-grounded fear of suffering the death penalty, torture or who need protection due to an internal or external armed conflict or environmental disaster in their native country (U.S. citizenship and immigration services, 2017; Bureau of Consular Affairs, 2017). After granted asylum they also have the same privileges as refugees. These two groups of immigrants could be considered as being forced to immigrate and the reasons for their

decision could be based on emergency situations such as to save their lives. For almost all other immigrants the main reason for migration is for financial benefits and to have a better life.

In general, immigrants with employment related visas have higher level of education and income compared to those with family related visas (Clark & King, 2008). Compared to immigrants with employment related or student visas, illegal immigrants have lower education attainments and lower English language skills. However, compared to immigrants with non-residence visas, illegal immigrants have higher employment rates (Massay & Malone, 2002). The level of education and income are two main determinants of health and related risk factors (Garrett et.al, 2015; Frieden, 2010; WHO, 2018). Therefore, the health status of immigrants with different visa/residency status could expect to be different.

Immigration trends in U.S.

According to statistical reports, in 1970 only 5% of the population was foreign born, but this was approximately 13% in 2009 which is a rapid rise. The Pew research center reports that the foreign born percentage in U.S. population has not much changed since 2009 (13.1% in 2013). The trends in annual immigration numbers from 1850 to 2015 are given in Figure 8. The general trend is the numbers are increasing each year however; the rate of increase has declined in the recent years. The number of refugees entering U.S. has declined sharply in 2017 and the number of unauthorized immigrants has come to a standstill since 2009.

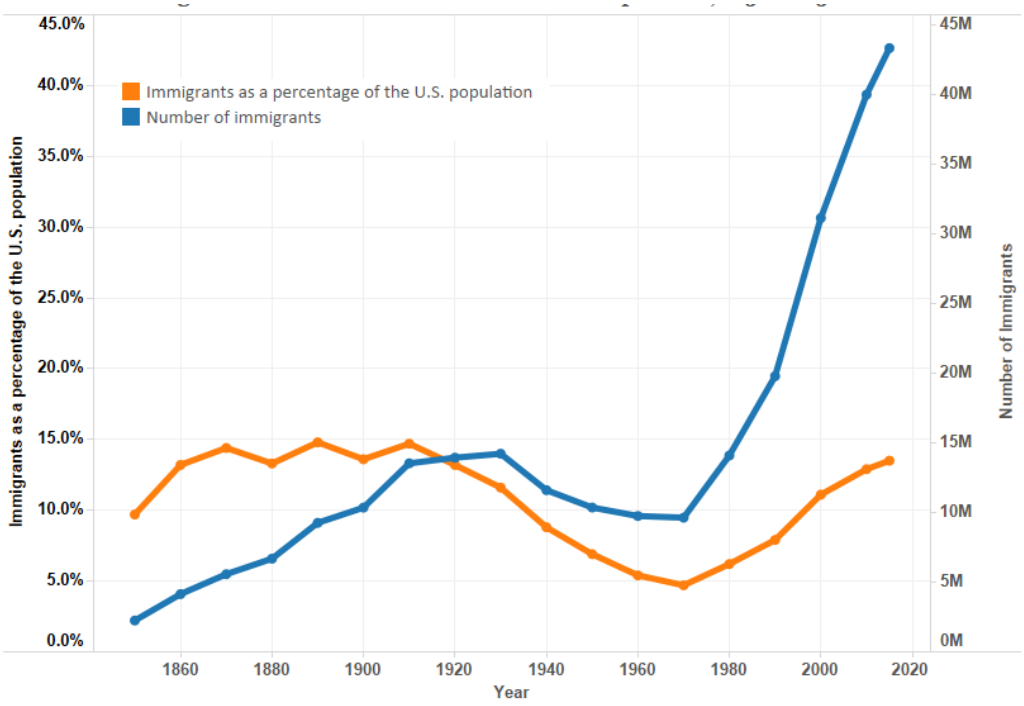

Figure 8. Number of Immigrants and their share of the Total U.S. Population 1850-2015

Source: Migration Policy Institute (MPI) – data of U.S. Census Bureau, 2010-2015 American Community Surveys (ACS), and 1970, 1990, and 2000 Decennial Census. All other data are from Campbell J. Gibson and Emily Lennon, "Historical Census Statistics on the Foreign-Born Population of the United States: 1850 to 1990" (Working Paper no. 29., U.S. Census Bureau, Washington, DC, 1999)

However, the trend of annual immigration numbers differs according to the region of birth. The number of immigrants from Europe continued to show a decreasing trend starting from 1960 (22% in 1990, 15.8% in 2000, and 12.1% in 2010 to 11.1% in 2015). Immigrants from Central and Latin America showed and increasing trend until 2010 (46% in 1990, 54.4% in 2000, and 55% in 2010), currently this trend is decreasing (53% in 2015). The number of immigrant population from Asia and Africa is still at an increasing trend (in 1990,

25% & 1.8%, in 2000, 26.4% & 2.8%, in 2010, 28% & 4.0%, and in 2015, 30.6% & 4.8% of Asians & Africans respectively).

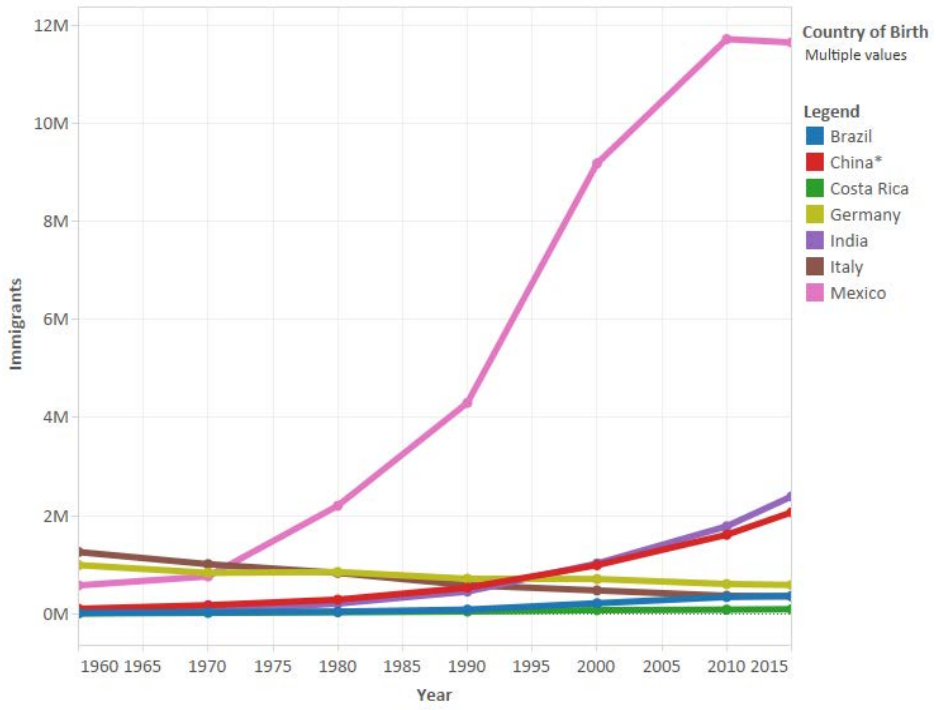

Figure 9. U.S. immigration population by country of birth, 1960-2015

Source: Migration Policy Institute (MPI) tabulation of data from U.S. Census Bureau, 2010 and 2015 American Community Surveys (ACS), and 2000 Decennial Census. 1960 to 1990 data - Campbell J. Gibson and Emily Lennon, "Historical Census Statistics on the Foreign-Born Population of the United States: 1850 to 1990" (Working Paper No. 29, U.S. Census Bureau, Washington, DC, 1999).

Note:* The figure for China excludes both Hong Kong and Taiwan (1990-2015)

Prior to 1965, under the quota system, most immigrants originated from European countries. After 1965, most immigrants came from countries in Latin America, Africa, and Asia. According to data from U.S. Department of Homeland Security, Office of Immigration

statistics, the total number of new Legal Permanent Residents in US during 2015 was 1,051,031. The majority was from Latin and South Americas (41.71%), followed by, 39.89% from Asia, 9.64% from Africa, 8.16% Europe. Most immigrants come from Mexico followed by China and India. Figure 9 shows the changes in number of immigrants from 7 selected countries starting at 1960 until 2015.

2.2 Immigrants and health care

Health care use and expenditure is lower among immigrants than U.S. natives and recent immigrants have lower health care expenditure than established immigrants. According to 1998 Medical Expenditure Panel Survey (MEPS) data the per-capita Emergency Room (ER) expenditures are lower for foreign-born adults than for native born adults while the per-capita ER expenditures are higher for foreign-born children than for native born children (Mohanty et al., 2005). In 1988 even though the immigrant population was about 10% of the total U.S. population, they only accounted for only 7.9% of the health care expenditure (Mohanty et al., 2005).

According to data from a Los Angeles survey in 2000 immigrants incurred a disproportionately smaller share of medical expenses, both government-paid expenses and overall expenses compared to natives (Goldman, Kimbro, Turra, & Pebley, 2006). Figure 10 shows the trend in total health care spending per capita in the U.S., adjusted for age and inflation, stratified by native born, foreign-born naturalized citizens, and foreign-born noncitizens. According to the figure from 1999 to 2006, health care expenditures increased for all groups. However, average expenditures for naturalized citizens were significantly

lower and expenditures for noncitizens were about 50% lower on average, compared to native born (Stimpson, Wilson & Eschbach, 2010).

One of the major reasons for this trend is that U.S. public policy has increasingly restricted access to health care for immigrants over time. Currently, undocumented immigrants and persons who immigrated less than five years ago lacks access to health care through public programs, which results in pay out of pocket or get private insurance to cover medical expenses (Capps et al., 2004). This can limit the health care usage by immigrants compared to U.S. native with similar socio-economic status. Some studies have reported that foreign borne experience health care discrimination especially in rural communities, and have mistrust of health services resulting in avoiding health services and sacrifice their health (Chen & Vargas-Bustamante, Arturo Ortega, 2013; Lopez-Cevallos, 2014). Even though, most of these studies were done with Hispanic/Latinos, similar trends and patterns have being identified with other immigrant groups too. Chen et al. (2013) reported lower health care expenditure among Asian Americans compared to Caucasian. However, there are differences in health care utilization based on the citizenship status, language preferences, English proficiency and ethnic origin among the Asian immigrants.

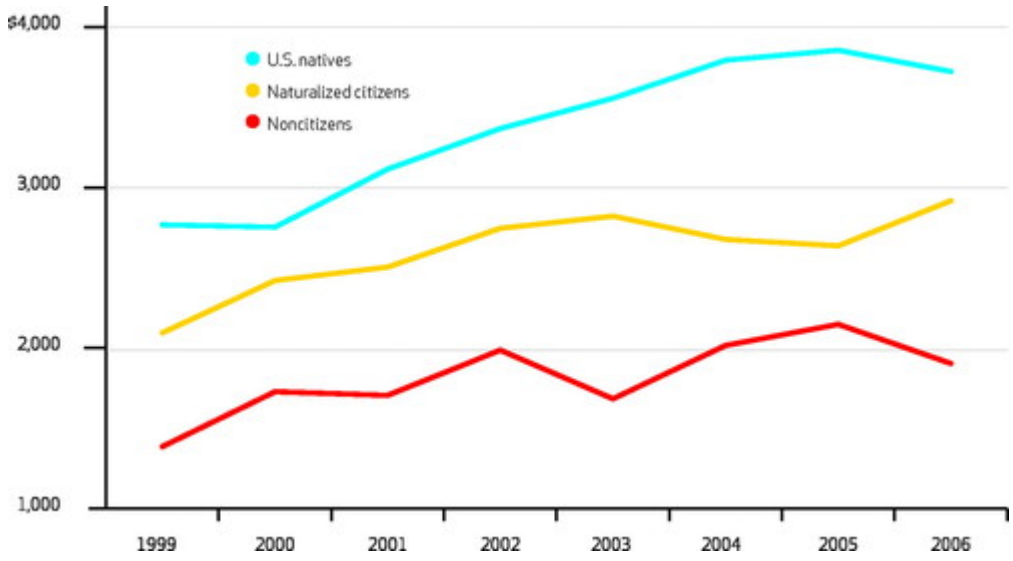

Figure 10. Age-adjusted total per capita health spending (2008 dollars) for U.S. natives, naturalized citizens, and noncitizens, 1999–2006.

Source: Stimpson, Wilson, & Eschbach (2010). Trends in Health care spending for immigrants in the United States.

As immigrant health care utilization declines, the general health and health status of immigrants might be affected leading to health disparities. Hamilton et al. (2011) reported that access to health care is one of the explanations for increasing prevalence of child health conditions such as asthma, allergies and learning disabilities across generations of immigrants. Achieving health equity, eliminating disparities and improve the health of all groups is one of the “Health People 2020” goals. Therefore, it is important to invest more on research on understanding these health disparities.

2.3 Immigration and health

Most of the research on immigration and health has shown that despite the low socio-economic status and limited access to healthcare, immigrants have better health outcomes than the native populations in terms of mortality rates, chronic conditions and mental health (Hunt et al., 2002; Singh & Yu, 1995; Sundquist & Winkleby, 1999; Reichman et al., 2008; William A. Vega et al., 1998; Wei et al., 1996). This is known as "epidemiological paradox" when applied to child outcomes such as low birth weight and pre-term births. These studies are mostly done in the United States with Hispanic immigrants and even though the immigrants are mostly assimilated in to the lower socio-economic status, there is much evidence of racial/ethnic minority immigrants having better mental health than their counter-parts born in the United States (Burnam, Hough, Karno, Escobar, & Telles, 1987; Golding & Burnam, 1990; Harker, 2001; Rumbaut, 1994; Vega & Rumbaut, 1991; Vega et al., 1998). However, this trend tends to decrease with increasing length of residency in the host country (Abraido-Lanza et al., 1999; Scribner, 1996). Dey and Lucas (2006) reported that Hispanic immigrants in the U.S. for fewer than 5 years have lower rates of obesity, hypertension, diabetes and cardiovascular diseases than the Hispanic immigrants who have lived in U.S. for more than 5 years.

There are two possible explanations to this observation, "Healthy migrant hypothesis" and "Salmon bias hypothesis/selective return migration" (Lu & Qin, 2014). The healthy migrant hypothesis explains that migrants represent a positively selected group of individuals with respect to health, relative to the general population of their country (Chiswick, Lee, & Miller, 2008; Palloni & Morenoff, 2001). This selection makes them standout in terms of health level when compared with the population of the host country even though they are

from a under developed country (Scribner, 1996). The salmon bias hypothesis explains that unhealthy immigrants or immigrants with deteriorating health having a higher tendency to return to their origin communities compared to healthy migrants (Abraido-Lanza et al., 1999).

There is evidence to show immigration could lead to a change in the level of risk of some diseases associated with obesity, such as cardiovascular disease, diabetes, and cancer (Goulao, Santos, & Do Carmo, 2015). Studies done with U.S. immigrants have shown that the initial BMI of the immigrants are lower than the American population and with increasing length of residency their BMI reaches the level of the American population. According to Kain et.al. (2014) when comparing obesity rates among adults in U.S. to other North/Latin American countries, Mexico and Chile present similar high rates of obesity (around 35 %), whereas in Brazil and Colombia, the rates are around 20 % and 16.5 %, respectively. In general, the highest prevalence occurs in low-income women. In Asia the rates of obesity is 2.2% in India, 3.2% in Korea, 4% in China and 6.8% in Thailand (Ramachandran & Snehalatha, 2010). The susceptibility to obesity also increases with immigration and length of residence in the host country (Goulao et al., 2015; Tsujimoto, Kajio, & Sugiyama, 2016).

Immigrants with ages ≤ 20years at arrival and being in U.S. for ≥15 years were 11 time more likely to be overweight or obese than immigrants who were ≤ 20 years at arrival and being in U.S. for a ≤1 year (Roshania, Narayan, & Oza-Frank, 2008). A study done with Puerto Rican immigrants showed that recent immigrants exhibit better health outcomes than childhood immigrants & U.S. born women of same ethnicity (Landale et al., 1999). One of the main reasons for the health deterioration is the change in the diet. Immigration can reduce

the quality of the food consumed while increasing the intake of convenient foods and fast foods. Two main reasons for these observed changes are the availability of food and the income. There are inconsistencies in results on the risk of mental health outcomes by nativity due to differences among immigrants in their age of arrival to U.S., length of residency in U.S. and country of origin (Alegria, Sribney, Woo, Torres, & Guarnaccia, 2007). The later arrival to U.S. was associated with later onset of psychiatric disorders. This study also reported that all the protective effects experienced by immigrants appeared to occur while they were in their country of origin and there were no protective effects after arrival to U.S. Their explanation is the protective factors such as familism (sense of familial obligation to provide material and emotional support) and affiliative obedience (children raised with strong values towards parental respect and difference to elders) are hard to retain after leaving their country.

The health deterioration is more visible among the later generations of the immigrants (Bates, Acevedo-garcia, Alegría, & Krieger, 2008). It is important to research more about the health status of the second and plus generations as their numbers grow sharply and will continue to growing the future. Second generation immigrants (who are born in the U.S. to foreign born parents) generally have an advantage of better health at birth compared to children of U.S. born parents. Immigrants of later generations gradually replace their old cultural and behavioral patterns with those of the host countries and with each generation they move closer to the host society and improve their socio-economic status. There is research evidence supporting higher acculturation being associated with less healthy diets, increased tobacco, alcohol and drug usage (Viruell-Fuentes, 2007). The rate of obesity also

increases across the generations of immigrants similar to the adverse health behaviors (Bates et al., 2008).

2.4 Effects of immigration status during pregnancy

Pregnancy outcomes differ between immigrant and native born white women even after controlling for the potential confounding variables (Balarajan et al., 1989). However, the results on the perinatal health of immigrants are conflicting (Gagnon et al., 2009). Some studies report that the outcomes are better than the average of the host country while some show worse outcomes. These results vary based on the maternal country of origin, the host country, socioeconomic status, length of residency in the host country, age at arrival, visa/residency status and the specific perinatal outcomes analyzed (Pedersen, Mortensen, Gerster, Rich-Edwards, & Andersen, 2012). There is evidence of a negative association between immigration and maternal mortality, fetal growth restrictions, infections, prenatal care and maternal health. Immigrated women have shown similar or better rates of pre-term birth, low birth weight and health promoting behaviors during pregnancy compared to women born in the host country (Gagnon et al., 2009; Hessol & Fuentes-Afflick, 2000; Cervantes, Keith, & Wyshak, 1999; Cho, Frisbie, Hummer, & Rogers, 2004; Fuentes-afflick, Hessol, Pe, & Deangelis, 1999; Fuentes-Afflick & Lurie, 1997; Scribner, 1996). In most of these studies the comparison group was identified as women in the host country regardless of the ethnicity and some as non-Hispanic white women of the host country. According to the *Morbidity and Mortality Weekly Report* by CDC (2002) women born outside the 50 states of U.S. and DC had better birth outcomes than their state-born racial/ethnic counterparts.

Most of the research on immigration and pregnancy outcomes is done with Hispanic/Latino immigrants in the United States as they are the largest immigrant group in the US at present. The study populations in these studies are women who immigrated before becoming pregnant including women who migrated as adults as well as children or adolescents. According to the U.S. natality statistics birth outcomes of foreign born Hispanic mothers are similar to or more favorable than the native born non-Hispanic white mothers despite their low SES (Sylvia Guendelman et al., 1999; Hessol & Fuentes-Afflick, 2000; Peak & Weeks, 2002). Latina women of Mexican origin have similar risk of low birth weight and a lower risk of infant mortality compared to white women born in the US (Hessol & Fuentes-Afflick, 2000; Cho, Frisbie, Hummer, & Rogers, 2004; Fuentes-afflick, Hessol, Pe, & Deangelis, 1999). A series of Belgian studies on pregnancy outcomes among immigrants, showed that except for Sub-Saharan African and European immigrant mothers, all other immigrants groups had better rates of low birth weight compared to Belgians but, the risk of perinatal mortality was higher among immigrants. However, after adjusting for the SES the immigrants showed no excess risk of perinatal mortality (Racape, De Spiegelaere, Dramaix, Haelterman, & Alexander, 2013; Racape, Schoenborn, Sow, Alexander, & Spiegelaere, 2016; Racape, Spiegelaere, Alexander, Buekens, & Haelterman, 2010). According to Singh and Yu foreign born status was associated with 7% and 20% lower risk of low birth weight and infant mortality respectively and these effects were larger among African, Cuban, Mexican and Chinese immigrants than other ethnic groups (Singh & Yu, 1995).

The length of residency in the host country and age at arrival are two of the factors that are closely related to immigration that could explain the differences in the pregnancy outcomes among immigrants. According to Pedersen et al., in general the association of the

length of residency and preterm birth for most immigrant groups is a "U" shaped curve (Pedersen et al., 2012). The highest risk was for most recent immigrants and for long term immigrants. The age at immigration and preterm birth risks also had a similar U shaped curve with the highest risk for those immigrated at early ages (0-14 years) and at ≥ 25 years. They also reported that for immigrants reside for 5-15 years in the host country had the lowest odds of SGA babies compared to recent or long term immigrants. Among Puerto Rican immigrant mothers, the length of residency in the mainland U.S. is associated with increased risk of infant mortality (Landale et al., 1999). Through evaluating national data sets Teitler, Hutto & Reichman (2012) reported that among all immigrants, the lowest rates of low birthweight occurred to those who were in the U.S. between 3 and 10 years. Similar to general health outcomes among both overall and Hispanic immigrants in U.S. the rates of low birth weight decline over the first few years in U.S. and then increases.

The stress associated with immigration, change in the social networks, lower socioeconomic status and poor access to health care are possible explanations for poorer health outcomes for immigrant women compared to non-Hispanic white women in the host country and women of same race or ethnicity who were born in the host country (Almeida, Caldas, Ayres-De-Campos, Salcedo-Barrientos, & Dias, 2013; Caplan, 2007; Derose, Escarce, & Lurie, 2007; Landale et al., 1999; Markides & Coreil, 1986). The healthy immigrant effect and protective social and cultural factors may explain the positive pregnancy outcomes. According to the Linked Birth-Infant Death Data Sets for the 1989-91 birth cohorts, show foreign-born women are less likely to smoke, use alcohol or drugs during pregnancy than native-born women of same country of origin or white women (Sylvia Guendelman et al., 1999; Landale et al., 1999), and limited evidence suggests that nutritional

intake also worsens with time in the U.S. (Guendelman & Abrams, 1995). The family and community networks may provide information about pregnancy and resources available to pregnant women, encourage healthy behaviors during pregnancy, and reduce stress by providing psychological support (Guendelman, English, & Chavez, 1995).

There are inconsistencies in the finding on the relationship of immigration and pregnancy outcomes however; the drastic differences among different immigrant populations could be one of the potential explanations for this. Still there is not enough research to conclude how immigration affects GWG during pregnancy and how this varies across different generations of immigrants.

2.4.1 Immigration and GWG

Among current literature there was only one published study examining the effects of immigration on GWG. This study was done among immigrants in Canada to evaluate the effect of recent immigration on GWG. They reported that immigration status and ethnicity independently influence GWG and the association immigration status and GWG could be partly due to the interaction between the immigration status and hypertension (Larouche et al., 2010). There were no significant differences in GWG among recent immigrants and non-immigrants but the non-immigrant women gained more weight than women who immigrated to Canada more than 10 years ago. The women of Latin origin gained more weight than the women from South Asia (Larouche et al., 2010). In the study by Restall et al. (2014) evaluating the risk factors for excessive GWG, recent immigration was found to be a significant risk factor. In contrast, Pawlak et al. (2015) even though the minority women are at greater risk of excess GWG, the risk decreases if they were foreign born.

The above study suggests that immigrants may have different rates of or level of risks of adverse pregnancy outcomes than expected based on their individual level factors such as SES. Some studies showed that the health related behaviors of immigrants are different from those of the host country population. Immigration should be treated as a health determinant itself (Castaneda et al., 2015).

The ecological model explains that changes in the meso and macro system can change individual level factors and directly or indirectly affects the health outcome. However the individual level changes and change of believed cultural values occur with time. The behavioral and lifestyle changes are higher among the immigrants being in the host country for longer time periods and also among later generations of immigrants. So these influences of environment could create the changes in pregnancy outcomes observed among different immigrant groups.

More research is needed to understand how immigrants are different from the general population of the host country and how behavior and lifestyles changes after immigration affect their health. As health during pregnancy and pregnancy outcomes could affect the lives of both the mother and the child it is more important to know how immigration affects health behaviors of pregnant mothers. It is likely that factors associated with immigration as age at immigration, country of origin, time in the host country, visa/residency status and immigration generation status could make differences among immigrants, so research is needed to distinguish how these different groups of immigrant are affected by changes associated with immigration and how much is the level of risk of adverse pregnancy outcomes. In-depth understanding of the life of immigrants could possibly help the health

care providers to provide better advice to immigrant pregnant women and researchers to develop better targeted interventions to improve pregnancy outcomes.

3. Summary

According to the current literature review on GWG it is understandable that gaining healthy amount of weight during pregnancy is important to the health of both mother and the child. Majority of women in U.S. exceeds the GWG recommendations despite their SES or ethnicity. Overweight and obese women are more at risk of exceeding the GWG recommendations compared to normal weight women. Research on GWG are focused more on identifying factors associated with excess GWG and most GWG interventions target try to influence behavioral changes to promote healthy GWG. These interventions have shown minimal success in preventing excess GWG. To increase the effectiveness of the interventions it is important to identify the behaviors and characteristics of women exceeding the GWG recommendations. This could help to design more targeted interventions and to identify behaviors that need to be addressed through the interventions. One objective of my study is to develop a characteristic and behavioral profile for women exceeding GWG recommendations and those adhering to GWG recommendations.

In the U.S. about 51% of the foreign born population are female and among them about 80% are of the reproducing age. Therefore, it is important to understand how immigration affects pregnancy. There are many studies done with immigrant women to understand how immigration affects pregnancy outcomes such as pre-term birth or low birth weight. Even though most of these outcomes are associated with GWG there are no studies looking at how different generations of immigrants gain weight during pregnancy or their

risk of excess GWG compared to natives. If immigrants are at more risk of excess GWG compared to natives, then policy should target this group and help improve their pregnancy outcomes. To address this gap in research, current study is trying to understand the effects of immigration on GWG and risk of excess GWG across two generations of immigrants.

CHAPTER 3

METHOD

1. Dataset:

The data for the study were extracted from the National Longitudinal Survey of Youth 1979 (NLSY79), which is sponsored by the Bureau of Labor Statistics (BLS) of the U.S. Department of Labor. The NLSY79 includes a sample of 12,686 men and women, who were born between 1957 and 1964, and who were living in the United States when the survey began in 1979. The purpose of the original survey was to collect information on labor market activities and other significant life events at multiple time points and to be used by economists, sociologists and other researchers. Types of information gathered in the survey included labor market behavior, educational experiences (high school, college, and training), family background, Armed Services Vocational Aptitude Battery (measures knowledge and skills including reading and mathematics), high school information received from schools and school transcripts, government program participation, family life (marital status, fertility, and child care), health issues and assets and income.

The study was authorized under Title 29, Section 2, of the United States Code. The Center for Human Resource Research at The Ohio State University and the National Opinion Research Center at the University of Chicago conducted this study under a contract with the Department of Labor. The U.S. Office of Management and Budget (OMB) have approved the questionnaires used to collect data.

1.1 Sampling procedure

A list of housing units in selected areas of U.S. was created in 1978 for the first interview and the interviewers went to a random sample of these houses to perform a screening interview to collect information on all residents of the household. This included 75,000 dwellings and group quarters. A random sample of Department of Defense records was used to include members of the military. These two processes provided basic information of more than 155,000 people. Data from screening interviews was used to identify all individuals ages 14 to 21 as of December 31, 1978 and were invited to participate in the first NLSY79 interview. A set of supplemental samples designed to oversample civilian Hispanic or Latino, black and economically disadvantaged, nonblack, non-Hispanics born in the same time period was also included into the sample to yield proper population proportions of various racial, ethnic and income groups in the cohort (Frankel et.al. 1983). All participants completed the first interview are considered as a member of the 1979 NLSY cohort.

1.2 Data:

The sample of participants in the cohort was selected to yield a data base of youth that represent the entire US population born in 1957 through 1967. The respondents were ages 14 to 22 when initially interviewed and were 47 to 56 years of age at the time of the 2012 interviews. The characteristics of the initial NLSY79 cohort are given in the Table 4.

Table 4. Characteristics of the initial NLSY79 cohort in 1979 (N=12,686)

Characteristic	Number (%)
Gender	
Male	6,403(50.5)
Female	6,283(49.5)
Race/Ethnicity	
Non-Hispanic, white	7,510(59.2)
Black	3,174(25.0)
Hispanic or Latino	2,002(15.8)
Age (years)	
14-16	4,074(32.1)
17-19	4,819(38.0)
20-22	3,793(29.9)
Country of birth	
U.S.	11,812(93.1)
Other	873(6.9)
North/South America	422(80.4)
Asia	34(6.5)
Africa	5(1.0)
Europe	64(12.2)
Employment	
Employed	4,579(37.3)

Unemployed	1,867(15.2)
Student	3,387(27.6)
In active forces	1,217(9.9)
Homemaker	473(3.8)
Other	762(6.2)
Highest grade completed	
None	5(0.03)
Elementary	70(0.55)
Middle school	6,082(48.5)
High school	4,917(39.2)
Some college education	1,421(11.3)
College graduate or higher	37(0.42)
Marital status	
Single	11,117(87.6)
Married	1,352(10.7)
Separated/divorced	214(1.0)
Widowed	1(0)
Annual family income	
< $10,000	4,655(47.8)
$10,000-$19,999	2,660(27.3)
$20,000- $49,999	2,173(22.3)
≥ $50,000	258(2.6)

1.3 Data collection:

The cohort was interviewed annually through 1994 and then biannually until present. In the initial years, the interviews were conducted in the first six months of the year and more recently surveys have typically begun in winter and ended the following winter. Retention rates for NLSY79 cohort participants from 1979 to 1993 was above 90% percent, rates from 1994 until 2000 was above 80% and rates from 2002 until 2012 have been around 73%.

Prior to the interview, participants were sent a short, informative letter reminding them of the upcoming interview and confirming the current address and phone number. In-person interviews were done to collect data in the initial years. However, when the participant resided in a remote area, the field staff determined that phone contact was the preferred method of interview, or in the years with limited funding, telephone interviews replaced in-person interviews. At present, phone interviews have become the main mode of data collection and the participants were instructed to call and set up an appointment for their interview.

Until 1989, the NLSY79 was conducted using only paper-and-pencil interviews (PAPI- where the interviewer used paper and pencil to record the responses), thereafter Computer-assisted personal interviews (CAPI) were designed and used to minimize errors and complications associated with PAPI. The average length of a personal interview is approximately one hour.

2. Sample and data extraction for the current study:

In the NLSY79 Survey, data on women's pregnancies began to be collected in 1986. Data were collected retrospectively for pregnancies before 1986. The sample for the current

study included all women participants in the NLSY79 cohort who have complete data for at least one pregnancy after 1985 and reported in a survey after 1986. The data on pregnancies before 1985 and the pregnancies reported >3 years after the delivery was excluded from the current analysis because of recall bias and/or lack of information on health behaviors during each of those pregnancies. Wise et al., (2017) also removed the pregnancies reported >3 years after the delivery in their study after proving no difference in the analysis with and without this group.

The eligible sample for this study included all women with at least one singleton birth and complete information to calculate pre-pregnancy BMI and GWG. Data was extracted from all surveys from 1986- 2014. For women with data for more than one pregnancy during this time period, the information on only the first reported pregnancy that met the inclusion criteria was used in the current study. This was done to prevent having more than one set of information for any participant which could add within subject variation to models. Women with multiple pregnancies (twins/triplets), delivered preterm (delivered <37 weeks gestational age), and women without complete information to calculate pre-pregnancy BMI were excluded from the study. These women were excluded because the IOM 2009 GWG recommendations are given for full-term, singleton deliveries, based on the pre-pregnancy BMI. The women born abroad to U.S. citizen parents were also excluded because the possible health and early childhood factors that cannot be controlled for given their foreign born and they are different from both the first generation immigrants and U.S. born women. Women born in U.S. with parent's birth places unknown was excluded from the analysis as their immigration generational status could not be accurately determined. The selection of study sample is given in Figure 11.

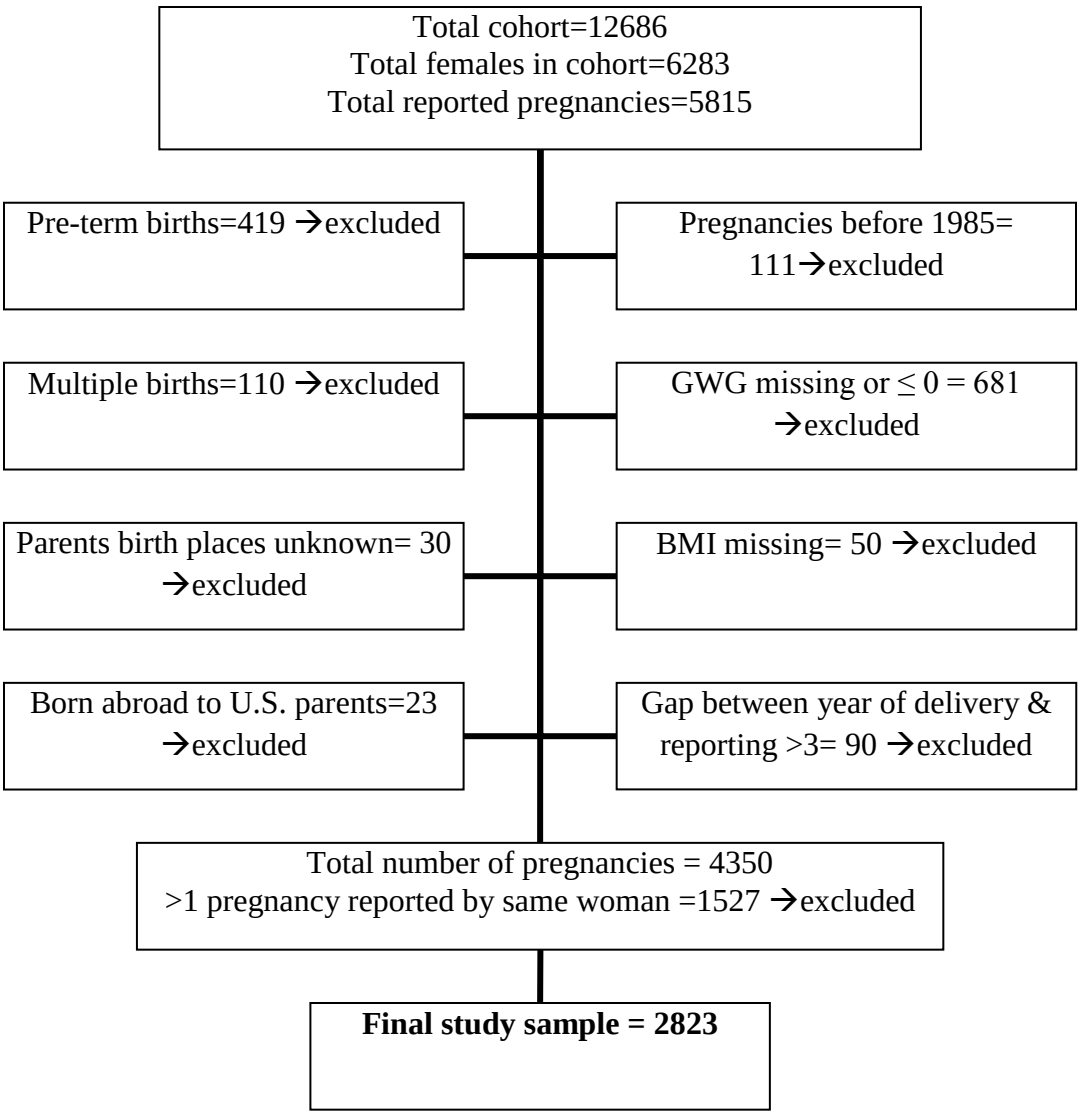

Figure 11. The study sample selection process

2.1 Socio-demographic information:

The socio demographic data were extracted from the survey responses. All the available socio demographic data in the NLSY79 was used in the current study. Nationality/Origin, birthplace (in U.S., in other country), date of birth (to calculate age) and ethnicity (non-Hispanic/white, black, Hispanic), whether a foreign language was spoken at home during childhood (yes/no, and if yes the language- Spanish, French, German or other)

data were extracted from the initial survey in 1979. Information on education (highest grade completed [1-12 grade or 1-8 or more years in college], highest degree ever received [high school diploma, associate, bachelor's degree, master's degree, doctoral degree, professional degree and other]), employment status (employed, unemployed, out of labor force, in active forces), marital status (married, single, separated, divorced and widowed), annual total family income, type of residence (own dwelling or other), poverty status (in poverty or not in poverty), urban/ rural residency, parity, and region of residency (Northeast, North central, south, west) was collected from the survey of the year closest to the time of pregnancy. The year of pregnancy was recoded as before 1990, 1990-2006 and after 2006 (due to the GWG recommendations used in these time periods were different). However, there was only one pregnancy reported after 2006, so the year of pregnancy was dichotomized as ≤1990 and after 1990.

2.2 Immigration status:

The immigration status used in the current study is the immigration generation, which includes first generation immigrants, second generation immigrants and non–immigrants. The generational status was defined using the classification used by the U.S Census Bureau and in many studies with immigrant populations (Alkerwi et al., 2012; David et al., 2015; Hamilton, van der Maas, Boak, & Mann, 2014; Mcdonald et al., 2009; Svensson & Hagquist, 2010). According to the U.S Census Bureau, the term generational status is used to refer to the place of birth of an individual or an individual's parents. Information on place of birth and parental place of birth are used to define the first generation, second generation, and non-immigrants. The first generation refers to those who are foreign born. The second generation refers to those with at least one foreign-born parent. The non-immigrants include those with

two U.S. native parents. In this study the non-immigrant group includes both the native born and the third or higher generations of immigrants.

The reported birthplace of women (in U.S, in other country) and the birthplaces of their parents (in U.S., in other country) were used to identify immigration generational status. This variable had three categories, first generation immigrants, second generation immigrants and non–immigrants. Women born outside the U.S. were coded as first-generation immigrants; women born in the U.S. with at least one biological parent born outside the U.S. were coded as second-generation immigrants. Women born in U.S. with both parents born in U.S. were coded as non-immigrants. As the grandparents birth places were not reported in this survey, this group includes all third plus generations of immigrants.

The self-reported year the immigrant women entered to the U.S., country of citizenship when immigrated, immigration or visa status (refugee, diplomat, entry on temporary visa, entry for permanent residence sponsored by relative, entry for permanent residence sponsored by employer, other) were also collected from the immigrant women. The number of years in U.S. by the time of pregnancy was calculated and coded as being in U.S. for less than 5 years, 5-10 years or more than 10 years.

2.3 Pre-pregnancy BMI:

Women self-reported their weights in every survey beginning in 1981, when the average respondent was 19.7-year-old. Height data were self-reported in 1981, 1982, 1983, 1985 and collect in every survey after 2006. In this study the height reported in 1985 was used to compute BMI as all women were at least age 20 and had attained their adult height (Smith, Bogin, & Bishai, 2005).

In the NLSY79 survey, pre-pregnancy weight was reported for each pregnancy from 1986 onwards (question in the survey- "what was your weight just before you became pregnant with your youngest child?"). The self-reported pre-pregnancy weight was verified by comparing with the weight reported at the closest previous survey prior to that pregnancy. Pre-pregnancy BMI (weight [kg]/height [m^2]) was calculated using the height reported during the interview conducted closest to the pregnancy and recalled pre-pregnancy weight. Pre-pregnancy BMI status was categorized as underweight <18.5, normal weight 18.5-24.9, overweight 25-29.9 and obese >30.

2.4 Gestational weight gain:

Women self-reported their weight just before delivery (question in the survey- "What was your weight just before you delivered?") in every survey beginning 1986. Total GWG is calculated by subtracting the recalled pre-pregnancy weight from the reported weight just before delivery and is a variable available in the NLSY79 data set (Ranchod et al., 2016). Women with implausible weight values such as zeros and negative values were removed from the final data set for the current study. Women were categorized as inadequate GWG, adequate GWG and excess GWG based on the IOM 2009 GWG guidelines for their pre-pregnancy weight status.

2.5 Health behaviors:

The pregnancy and fertility section of the survey includes data on pregnancy health behaviors. This includes information on prenatal care, alcohol and cigarettes consumption, vitamin/mineral supplement intake, caloric and salt intake, involvement in different physical activities three months prior to pregnancy and in each trimester of pregnancy (each activity

was included as a separate variable), and pregnancy intention. The questions asked in the survey and all possible response options are given in Table 5.

The pregnancy intention of both mother and father were recorded as “planned pregnancy” if they answered yes to the question “just before you become pregnant with your youngest child did you want to become pregnant when you did?” and all other answers were recorded as “unplanned pregnancy”.

Table 5. The health behavior items from the NLSY79 used in the current study.

Construct	Survey question(s)	Response options
Prenatal care	When did you first visit a doctor or nurse for prenatal care, during which month of your pregnancy?	1 through 12 – actual month
Alcohol and cigarette consumption	Did you drink any alcoholic beverages including beer, wine or liquor during the 12 months before the child was born?	Yes/No
	During your pregnancy, did you reduce or stop alcohol intake?	Yes/No/Not applicable
	Did you smoke tobacco cigarettes at all during the 12 months before the child was born?	Yes/No
	During your pregnancy, did you reduce or stop smoking?	Yes/No/Not applicable

Nutrition and diet related behaviors	During your pregnancy, did you cut down on the amount of calories in the food you ate?	Yes/no
	During your pregnancy, the reason you cut down on the amount of calories in the food you ate is medical advice?	Yes/no/not applicable
	During your pregnancy, did you cut down on the amount of salt you used?	Yes/no
	During your pregnancy, the reason you cut down on the amount of salt you used is medical advice?	Yes/no/not applicable
	During your pregnancy, did you use diuretics to help eliminate water?	Yes/no
	During your pregnancy, did you use diuretics to help eliminate water on medical advice?	Yes/no/not applicable
	During your pregnancy, did you take a	

	vitamin/mineral supplement?	Yes/no
Physical activity	Which of the activities listed on this card you did on most days during the ___ (three months before pregnancy/ first trimester/ second trimester/ third trimester)	
	-climbed 3 or more flights of stairs each day	Yes/no
	-stood for more than 3 hours at a time	Yes/no
	-carried loads of more than 20 pounds	Yes/no
	-engaged in strenuous household acts for 1 hour or more per day	Yes/no
Pregnancy intention	Just before you become pregnant with your youngest child did you want to become pregnant when you did?	Yes/ Didn't matter/ No, not at that time/ No, none at all
	What about your husband or partner when you became pregnant when you did?	Yes/ Didn't matter/ No, not at that time/ No, none at all

2.6 Interview information:

The data on interview language used (English, Spanish or other), understanding of the survey questions (good, fair or poor) and attitudes towards the interview (friendly and interested, cooperative but not interested, impatient and restless, hostile) were also collected from the survey.

3. Data analysis:

3.1 Missing values:

Women with GWG data was compared with women without GWG data to identify potential bias introduced by removing the group without GWG data. There were 265 women with no GWG data out of the sample of 3278 (8.08%) who were excluded from the analytic sample. GWG missing group had significantly higher percentage of black women (32.1% vs. 23.9%, p=0.001), higher percentage of women in poverty (30.0% vs. 21.1%, p=0.003) and higher percentage of unmarried women (24.2% vs. 16.8%, p<0.001) compared to women with GWG data. GWG missing group also had significantly higher percentage of women without using prenatal care (9.6% vs. 0.6%, p<0.001) or taking vitamin/mineral supplements (17.2% vs. 4.6%, p<0.001) and a higher percentage of non-alcohol users (73.2% vs. 54.0%, p<0.001) compared to women with GWG data. Most of interviews among women with no GWG data were done in Spanish (3.8% vs. 1.1%, p=0.001), with higher percentage of not interested (22.4% vs. 17.1%, p=0.006) and impatient (6.1% vs. 3.2%, p=0.006) behaviors during interviews and a significantly higher percentage of women with fair level of understanding of interview questions (10.6% vs. 6.2%, p=0.025) compared to women with GWG data.

Fifty women were excluded due to missing BMI values (1.7%). This group was compared with the group with BMI data (N=2979) to identify potential biases. BMI missing group had significantly higher percentage of births occurred prior to 1990 (76% compared to 56.5%, p=0.006) and married women (84% compared to 71.3%, p=0.048) compared to women with BMI data.

In the analytic sample 2210 (78.3%) women had no missing values on socio-demographic variable and only 567 (20.8%) had no missing values for any of the study variables (i.e., complete cases). However, the majority were missing data on pregnancy intention of mother (planned the pregnancy or not) which was 71.9%. The percentages of missing values for all study variables are given in Table 6. The Little's MCAR test was performed with all study variables except for physical activity data and found that the data appear to be missing completely at random (MCAR chi square =0.801, df =1, p= 0.371). The physical activity data was not collected in some years such that 56.3% was system missing. Therefore, physical activity data was not included in the comparison tests or the decision tree analysis.

Table 6. Percentage of cases with missing values for each study variables (N = 2823)

Variable	Missing %
Interview characteristics	
Language of interview	0.5
Attitudes towards the interview	19
Understanding of the questions	0.6

Socio demographics	
In poverty	16.43
Region of residence	1.0
Urban/Rural residence	3.7
Employment status	1.55
Foreign language use at home	0.1
Marital status	0.4
Education	0.2
Country of origin	0.9
Annual family income	16.43
Health behaviors	
Pregnancy intention of mother	71.9
Pregnancy intention of spouse	29.4
Use of pre-natal care	0.1
Month starting prenatal care	2.5
Alcohol consumption 12 months prior	0.1
Smoking 12 months prior	0.2
Vitamin/Mineral supplement intake	0.4
Cut down calories	0.4
Cut down salt	0.4
Use of diuretics	0.7
Use of alcohol during pregnancy	0.5
Smoking during pregnancy	0.5

Reason for caloric cut down	0.5
Reason for cut down in salt	0.6

3.2 Statistical analysis

All analyses were conducted using SPSS, version 22.0 (IBM, Inc., New York, NY). Descriptive analyses were computed for all study variables stratified by the immigration generation status. All the subsequent statistical testing was performed after evaluating the test assumptions.

Aim 1: Determination of the differences between the three immigration groups in socio-demographic variables and health behaviors

The first aim was statistically evaluated using either univariate ANOVA, or chi square test based on the level of variable (i.e. continuous or categorical). The independent variable was the three immigration status; first generation immigrants, second generation immigrants and non-immigrant women. Separate ANOVA tests were done with each continuous demographic variables or health variables as the dependent variable and chi-square tests were done with the categorical variables. If there were statistically significant group differences, each test was followed by a post-hoc analysis using Scheffe's test to determine how groups differed from one another. The missing values were case-wise removed in each analysis.

Aim 2: Determination of the relationship of Immigration generational status and GWG

The association between immigration generational status and total GWG was evaluated using an Analysis of Covariance (ANCOVA) where the potential confounding socio-demographic and interview related variables were controlled for. Pearson's correlation coefficients, t test or univariate ANOVA were used to identified the potential confounding socio-demographic variables that are significantly ($p<.05$) correlated with the dependent variable (i.e., total GWG) for the subsequent analyses. The dependent variable was the total GWG just before the delivery as a continuous variable and the categorical independent variable was the three immigration generation groups (first generation immigrant, second generation immigrant and non-immigrant). The cases with missing values were list-wise excluded in the analyses.

To evaluate whether the three immigration generations have significantly different rates of inadequate, adequate and excess GWG a multinomial logistic regression analysis was performed. The GWG categories (inadequate, adequate and excess) were the dependent variable and the immigration generation status was the independent variable. Adequate GWG was used as the reference variable and the potential confounding socio-demographic and interview variables identified in chi-square or ANOVA test was entered as covariates in this analysis. The cases with missing values were list-wise excluded in the analysis.

Aim 3: To identify the combination of health behaviors and socio-demographic predictors that best distinguish pregnant women who exceed the GWG recommendations and who do not exceed the recommendations, for the three immigration groups.

The purpose of this aim is to understand the socio-demographic and health behavior profile of pregnant women who exceeds the GWG recommendations, so this could be used in clinical practice to identify at risk women. I used one of the decision tree algorithms, the classification and regression tree analysis (CRT) to derive a model to predict risk of exceeding GWG recommendations using the available socio-demographic and maternal health behaviors. CRT is a non-parametric classification technique developed by Breiman, Friedman, Olshen, & Stone in 1984 (Strobl, Malley, & Tutz, 2009). The purpose of CRT is to explore potentially non–linear relationships between variables and identifying population subgroups that are homogeneous with respect to outcomes of interest (Venkatasubramaniam et al., 2017). This method is different from the general linear regression based methods as it is a way of learning from the available information on all the variables to estimate an unknown relationship rather than relying on a specified model to summarize the effects of predictors on the outcome variable (Argesti, 2013). Classification tree analysis uses recursive partitioning of the data space and fits a simple prediction model within each partition (Strobl et al., 2009). Each partition is created such that the observations with similar responses are grouped together. This method is designed for dependent variables that have finite number of unordered values (Loh, 2011). Classification tree analysis has been widely used in medical research in diagnosing conditions such as osteoarthritis, eating disorders and identifying the need for cesarean birth (Gabriel, Crowson, & O'Fallon, 1996; Stice, Marti, & Durant, 2011; Stivanello, Rucci, Lenzi, & Fantini, 2014). Only one study has used this method to evaluate risk of excess GWG based on pre-pregnancy BMI and a range of psychosocial risk factors (Fuller-Tyszkiewicz, Skouteris, Hill, Teede, & McPhie, 2016).

The reason for selection of this method is it allows using a large number of both categorical and continuous predictors, and can be used when the assumptions of general regression are violated (e.g., multivariate normality, linearity). It has the ability to detect interactions without having to make a priori decisions about which interaction terms to include, and does not have the sample size limitations for statistical power to detect effects as regression analysis. Another advantage of using this method is that the results could be easily understand and applied by practitioners who have little understanding of basic statistics.

CRT analysis:

Three classification trees were generated for the three immigration groups and one tree for the total sample. All the socio demographic and maternal behavioral variables mentioned in the method section above were entered in to the model as potential predictors of excess GWG. For the first generation immigrants the country of birth (categorized as North/South American, Asian, African, and European), visa/residency status and time in U.S. was also entered as predictors. For both immigration groups "whether a foreign language was used at home" was a potential predictor. Each immigration group as a whole (parent node) was split into two subgroups (daughter nodes) by the predictor which best discriminate the GWG. Each daughter node was further split in to subgroups until a predefined stopping criterion is met. In the current analysis the stopping criteria was Gini index <0.001 (Fuller-Tyszkiewicz, Skouteris, Hill, Teede, & McPhie, 2016) and minimum number of cases in parent node and each daughter node was set to 50 and 10 respectively for a split to take place (for the total sample this was set to 100 and 50 respectively to prevent over fitting of the tree). Gini index is the impurity measure used to build the decision tree.

In CRT analysis, for cases with missing values for a certain variable, classification is done using other variable that have high associations with the original variable of interest. The alternative predictors used are called the surrogates.

Even though the classification tree is a low bias method, there is high variance if the classification trees are produced using different random samples from a common population. Therefore, *k*-fold cross validation (with 10 folds) was used to enhance the robustness of the solution. In this cross validation process the original sample is randomly partitioned in to *k* equal sized subsamples; from these 10 subsamples a single subsample will be retained as the validation data for testing the model. The remaining subsamples are used for the CART analysis and the cross validation will be repeated *k* (10) times. The resulting classification trees are averaged to produce a single estimation. The current knowledge and understanding of GWG and immigration is used in interpreting the classification trees.

CHAPTER 4

RESULTS

1. Study sample characteristics

The final sample for the current study was 2823 women with pregnancies reported after 1986. There are 184 first generation immigrants, 207 second generation immigrants and 2432 non- immigrants.

The majority of the interviews were done in English. The interviewers have reported most of the participants were friendly and interested in the interviews and had a good understanding of the questions asked. This improves the reliability of the collected data. The majority of the sample was non- Hispanic, white married and employed women. About half of the sample had explained their origin as European. The complete list of sample characteristics for the total study sample and each immigrant group is given in Table 7.

The maternal health behaviors during pregnancy for the total sample and each immigration group are summarized in Table 8. Almost all the women had some prenatal care and majority started prenatal care visits between 2nd and 3rd month of pregnancy. Ninety-six percent of women took the recommended vitamin/mineral intake, 13.2% smoked during pregnancy and only 9.7% had alcohol during pregnancy.

Table 7. Socio-demographic characteristics and interview information of the study sample (given as number of women (%) or mean (SD)*).

Characteristic	Total sample (N=2823)	First generation immigrants(N=184)	Second generation immigrants (N= 207)	Non-immigrants (N=2432)
Interview characteristics				
Language-				
English	2779 (98.9%)	58 (86.8%)[a]	207 (100%)[b]	2414 (99.8%)[b]
Spanish	29(1.0%)	23 (12.6%)[a]	0[b]	6 (0.2%)[b]
Other	1(0)	1 (0.5%)[a]	0[a,b]	0[b]
Attitudes towards interview				
Friendly and interested	1814 (80.1%)	112 (78.9%)[a]	155 (86.1%)[a]	1547 (79.6%)[a]
Cooperative but not interested	386 (17.0%)	26 (18.3%)[a]	19 (10.6%)[a]	341 (17.5%)[a]
Impatient and restless	63(2.8%)	4 (2.8%)[a]	6 (3.3%)[a]	53 (2.7%)[a]
Hostile	3(0.1%)	0[a]	0[a]	3 (0.2%)[a]
Understanding of the questions				

Good	2623 (93.5%)	162 (89.0%)[a]	197 (95.2%)[a,b]	2264 (93.7%)[b]
Fair	170 (6.1%)	18 (9.9%)[a]	10 (4.8%)[a]	142 (5.9%)[a]
Poor	13 (0.5%)	2 (1.1%)[a]	0[a]	11 (0.5%)[a]
Socio demographics				
Race/ethnicity				
Hispanic	530 (18.8%)	129 (70.1%)[a]	115 (55.6%)[b]	286 (11.8%)[c]
Black	668 (23.7)	19 (10.3%)[a]	8 (3.9%)[b]	641 (26.4%)[c]
Non-Hispanic, White	1652(57.6)	36 (19.6%)[a]	84 (40.6%)[b]	1505 (61.9%)[c]
Ethnicity/ Origin				
Black	646(23.2%)	15(8.1%)[a]	6(2.9%)[a]	625(26.0%)[b]
Asian	30(1.1%)	12(6.5%)[a]	7(3.3%)[a]	11(0.5%)[b]
European	1357(48.7%)	25(13.6%)[a]	70(33.8%)[b]	1262(52.5%)[c]
Latin/South American	415(14.9%)	94(51.7%)[a]	103(50.0%)[a]	218(11.4%)[b]
North American	222(7.9%)	0[a]	7(3.3%)[a]	214(8.9%)[b]
Other Hispanic /Spanish	49(1.7%)	27(14.7%)[a]	6(2.9%)[b]	16(0.7%)[c]

Other	73(2.5%)	10(5.4%)[a]	8(3.8%)[a,b]	55(2.2%)[b]
Own dwelling	2614 (92.6%)	172 (93.7%)[a]	190 (91.8%)[a]	2252 (92.6%)[a]
In poverty	488 (20.7%)	33 (23.1%)[a]	24 (14.0%)[a]	431 (21.1%)[a]
Region of residence				
Northeast	486 (17.4%)	39 (23.1%)[a]	35 (17.2%)[a]	412 (17.0%)[a]
North Central	673 (24.1%)	14 (8.3%)[a]	29 (14.3%)[a]	630 (26.0%)[b]
South	1056 (37.8%)	36 (21.3%)[a]	66 (32.5%)[b]	954 (39.2%)[b]
West	579 (20.7%)	80 (47.3%)[a]	73 (36.0%)[a]	426 (17.6%)[b]
Urban residence	2139 (78.8%)	156 (94.0%)[a]	183 (91.5%)[a]	1800 (76.6%)[b]
Employment				
Employed	1576 (56.7%)	81 (44.3%)[a]	132 (65.7%)[b]	1363 (56.9%)[c]
Unemployed	144 (5.2%)	11 (6.0%)[a]	5 (2.5%)[a]	128 (5.3%)[a]
Out of labor force	1046 (37.6%)	89 (48.6%)[a]	63 (31.3%)[b]	894 (37.3%)[b]
In active forces	13 (0.5%)	2 (1.1%)[a]	1 (0.5%)[a]	10 (0.4%)[a]

Married	2010 (71.5%)	147 (80.3%)[a]	152 (74.1%)[a,b]	1711 (70.6%)[b]
Education				
Less than high school	278 (9.9%)	42 (23.0%)[a]	17 (8.2%)[b]	219 (9.0%)[b]
High school	1294 (46.0%)	69 (37.7%)[a]	79 (38.2%)[a]	1146 (47.3%)[b]
Some college or higher	1243 (44.2%)	72 (39.3%)[a]	111 (53.6%)[b]	1060 (43.7%)[a]
Annual family income				
≤$10,000	447 (18.9%)	25 (17.5%)[a]	26 (15.2%)[a]	396 (19.4%)[a]
Above $10,000	1912 (81.1%)	118 (64.1%)[a]	145 (84.8%)[a]	1649 (80.6%)[a]
Foreign language spoken at home during childhood	673 (23.9%)	166 (90.2%)[a]	152 (73.4%)[b]	355 (14.6%)[c]
Parity				
Primiparous	1189 (42.1%)	76 (41.3%)[a,b]	106 (51.2%)[b]	1007 (41.4%)[a]
Multiparous	1634 (57.9%)	108 (58.7%)[a,b]	101 (48.8%)[b]	1425 (58.6%)[a]

Pre-pregnancy BMI				
Underweight	173 (6.1%)	8 (4.3%)[a]	12 (5.8%)[a]	153 (6.3%)[a]
Normal	1819 (64.4%)	124 (67.4%)[a]	136 (65.7%)[a]	1559 (64.1%)[a]
Overweight	529 (18.7%)	36 (19.6%)[a]	39 (18.8%)[a]	454 (18.7%)[a]
Obese	302 (10.7%)	16 (8.7%)[a]	20 (9.7%)[a]	266 (10.9%)[a]
Year of child birth				
Before 1990	1577 (55.9%)	107 (58.2%)[a]	89 (43.0%)[b]	1381 (56.8%)[a]
1990-2006	1245 (44.1%)	77 (41.8%)[a]	118 (57.0%)[b]	1050 (43.2%)[a]
After 2006	1 (0)	0[a]	0[a]	1 (0)[a]
Family size*	3.96 (1.40)	4.28 (1.52)[a]	3.78 (1.40)[b]	3.95 (1.39)[b]
Age*	28.77 (3.98)	28.79 (4.10)[a,b]	29.65 (4.44)[a]	28.70 (3.93)[b]

Note: Similar superscripts show groups that are not significantly different (i.e., homogenous subsets) at the 0.05 level.

*given as mean (SD)

Table 8. Maternal health behaviors during pregnancy (given as number of women (%) or mean (SD)*).

Characteristic	Total sample (N=2823)	First generation immigrants(N=184)	Second generation immigrants (N= 207)	Non-immigrants (N=2432)
Pregnancy intention of mother				
Planned pregnancy	98 (12.3%)	7 (14.6%)[a]	10 (21.3%)[a]	81 (11.6%)[a]
Unplanned	696 (87.7%)	41 (85.4%)[a]	37 (78.7%)[a]	618 (88.4%)[a]
Pregnancy intention of father				
Planned pregnancy	1391 (69.8%)	96 (72.7%)[a]	111 (72.5%)[a]	1184 (69.3%)[a]
Unplanned	602 (21.3%)	36 (27.3%)[a]	42 (27.5%)[a]	524 (30.7%)[a]
Use of prenatal care	2805 (99.5%)	182 (98.8%)[a]	204 (99.0%)[a]	2419 (99.5%)[a]
Month starting prenatal care*	2.41 (1.712)	2.47 (1.721)[a]	2.27 (1.726)[a]	2.42 (1.710)[a]
Alcohol- 12 months before pregnancy	1326 (47.0%)	49 (26.6%)[a]	97 (47.1%)[b]	1180 (48.6%)[b]
Smoking 12 months before pregnancy	806 (28.6%)	20 (10.9%)[a]	42(20.3%)[b]	744 (30.7%)[c]

Alcohol use during pregnancy	273 (9.7%)	33 (18.1%)[a]	19 (9.3%)[b]	221 (9.1%)[b]
Smoking during pregnancy	371 (13.2%)	38 (20.8%)[a]	23 (11.2%)[b]	310 (12.8%)[b]
Vitamin/mineral supplement intake	2696 (95.9%)	174 (95.1%)[a]	195 (94.7%)[a]	2327(96.0%)[a]
Use of diuretics during pregnancy				
Yes, due to medical advice	27 (1.0%)	2 (1.1%)[a]	3 (1.5%)[a]	22 (0.9%)[a]
Yes, but no medical advice	7 (0.2%)	0[a]	0[a]	7 (0.3%)[a]
Did not use	2768 (98.8%)	178 (98.9%)[a]	202 (98.5%)[a]	2388 (98.8%)[a]
Cut down calories during pregnancy				
Yes, due to medical advice	406 (14.4%)	29 (15.8%)[a]	31 (15.0%)[a]	346 (14.3%)[a]
Yes, but no medical advice	278 (9.9%)	22 (12.0%)[a]	21 (10.2%)[a]	235 (9.7%)[a]
Did not cut down	2126 (75.7%)	132 (72.1%)[a]	154 (74.8%)[a]	840 (76.0%)[a]
Cut down salt intake during pregnancy				
Yes, due to medical advice	775 (27.6%)	50 (27.3%)[a]	60 (29.1%)[a]	665 (27.5%)[a]
Yes, but no medical advice	661 (23.6%)	36 (19.7%)[a]	44 (21.4%)[a]	581 (24.0%)[a]

Did not cut down	1369 (48.8%)	97 (53.0%)[a]	102 (49.5)[a]	1170 (48.4%)[a]
Physical activity 3 months prior to pregnancy				
Climbed ≥3 flights of stairs daily	449 (15.9%)	32 (17.4%)[a]	24 (11.6)[a]	393 (16.2%)[a]
Stood for more than 3 hrs. at a time	590 (20.9%)	37 (20.1%)[a]	36 (17.4%)[a]	517 (21.3%)[a]
Carried loads of >20 lbs.	678 (24.0)	36 (19.6%)[a]	33 (15.9%)[a]	609 (25.0%)[a]
Engaged in strenuous household acts for 1 hour or more per day	625 (22.1)	42 (22.8%)[a]	40 (19.3%)[a]	543 (22.3%)[a]
Physical activity during 1st trimester				
Climbed ≥3 flights of stairs daily	404 (14.3%)	25 (13.6%)[a]	25 (12.1%)[a]	354 (14.6%)[a]
Stood for more than 3 hrs. at a time	528 (18.7%)	32 (17.4%)[a]	28 (13.5%)[a]	468 (19.2%)[a]
Carried loads of >20 lbs.	566 (20.0%)	36 (16.3%)[a]	30 (14.5%)[a]	506 (20.8%)[a]
Engaged in strenuous household acts for 1 hour or more per day	515 (18.2%)	34 (18.5%)[a]	35 (16.9%)[a]	446 (18.3%)[a]

Physical activity during 2nd trimester				
Climbed ≥3 flights of stairs daily	373 (13.2%)	22 (12.0%)[a]	24 (11.6%)[a]	327 (13.4%)[a]
Stood for more than 3 hrs. at a time	452 (16.0%)	24 (13.0%)[a]	27 (13.0%)[a]	401 (16.5%)[a]
Carried loads of >20 lbs.	442 (15.7%)	23 (12.5%)[a]	25 (12.1%)[a]	394 (16.2%)[a]
Engaged in strenuous household acts for 1 hour or more per day	420 (14.9%)	26 (14.1%)[a]	32 (15.5%)[a]	362 (14.9%)[a]
Physical activity during 3rd trimester				
Climbed ≥3 flights of stairs daily	322 (11.4%)	16 (8.7%)[a]	18 (8.7%)[a]	288 (11.8%)[a]
Stood for more than 3 hrs. at a time	334 (11.8%)	22 (12.0%)[a]	15 (7.2%)[a]	297 (12.2%)[a]
Carried loads of >20 lbs.	316 (11.2%)	15 (8.2%)[a]	18 (8.7%)[a]	283 (11.6%)[a]
Engaged in strenuous household acts for 1 hour or more per day	326 (11.5%)	20 (10.9%)[a]	24 (11.6%)[a]	282 (11.6%)[a]

Note: Similar superscripts show groups that are not significantly different (i.e., homogenous subsets) at the 0.05 level.

*given as mean (SD)

In the analysis all first generation immigrants, regardless of country of origin, time in U.S., age at arrival, and immigrant visa status, were combined together due to the lower sample size of first generation immigrants. The description of the first generation immigrants used in the study is given in Table 9. The majority of the first generation immigrants used English as the interview language crudely indicating they may be more acculturated. Most of these immigrants were in the U.S. by age of 14 years and had been in the U.S. for more than 10 years. The origin of the majority of the immigrants was Central or North America.

Table 9. Characteristics of the first generation immigrants (n=184)

Characteristic	n	%
Foreign language spoken at home	166	90.2
Type of language used		
Spanish	125	75.8
French	9	5.5
German	3	1.8
Other	28	17.0
Residence at age 14		
In the US	125	68.3
In other country	58	31.7
Residency/visa status		
Refugee/Asylee	8	5.3

Temporary visa	16	10.5
Permanent residence sponsored by	96	63.2
relative	3	2.0
Permanent residence sponsored by	7	4.6
employer		
Permanent residence sponsored with	2	1.3
labor certification	18	11.8
Other entry for permanent residence	2	1.3
Without permission		
Other		
Country of citizenship		
North/South America	123	81.4
Mexican citizens	69	56.1
Africa	2	1.3
Europe	14	9.3
Asia	12	7.9
Number of years in US		
10 years or less	17	12.9
More than 10 years	115	87.1

2. Study Aim 1:

The study aim one was designed to understand demographic and behavioral differences between the three immigrations groups of the study; first generation, second generation and non-immigrants. The comparison between immigration groups are included in Table 7 and 8. Similar superscripts indicate groups that are not significantly different (i.e., homogenous subsets).

According to the results there were significant associations between the immigration groups and race/ethnicity (χ^2=591.16, p<0.001), country of origin (χ^2=1446.99, p<0.001), region of current residence (χ^2=139.97, p<0.001), urban/rural residency (χ^2=49.03, p<0.001), year of child birth (χ^2=15.339, p=0.004), marital status (χ^2=8.37, p=0.013), employment status (χ^2=17.11, p<0.001), level of education (χ^2=45.62, p<0.001), family size (F=6.604, p=0.001), parity (χ^2=7.57, p=0.023) and age at child birth (F=5.45, p=0.004). However, type of residency, income category or poverty status and pre-pregnancy BMI was not associated with immigration group.

There was a higher number of Hispanics among first generation immigrants (70.1%) compared to other two group and the second generation immigrants (55.6%) had more Hispanics than non-immigrants (11.8%). These differences were statistically significant at α=0.05.

Among non-immigrants there were a higher percentage of women from North central (26.0%) and south (39.4%) regions of the U.S. and rural residences (23.2%) compared to first generation immigrants (p<0.05). Among first generation and second generation immigrants there were a higher percentage of women from the West regions (47.3% & 36.0% among 1st

generation and 2nd generation respectively) of the U.S. and from urban residences (94.0% & 91.5% among 1st generation and 2nd generation respectively) compared to non-immigrants. These differences were statistically significant at α=0.05.

The second generation immigrants had a lower percentage of pregnancies prior to 1990 (43.0%) compared to other two groups (58.2% & 56.8%, 1st generation and non-immigrants respectively). A greater percentage of first generation immigrant women (80.3%) were married compared to non-immigrants (70.6%). The percentage of women who were employed was highest among second generation immigrants (66.2%) followed by non-immigrants (57.3%). The first generation immigrant group had a significantly higher percentage of women who were not high school graduates (23.0%), the second generation immigrants had a significantly higher percentage of women with college level education (53.6%) and non-immigrants had a significantly higher percentage of women who were high school graduates (47.3%) compared to the other two groups. All these differences were statistically significant at α=0.05.

The mean family size was significantly higher among the first generation immigrants (4.28±1.52) compared to the 2nd generation 3.78 ± 1.40 (p=0.002) and non-immigrants 3.95 ± 1.38 (p=0.009). The mean parity was highest among the first generation immigrants (2.04 ± 1.16), followed by the non-immigrants (1.95 ± 1.03). The mean age at pregnancy was highest among the second generation immigrants (29.65 ± 4.44).

Most of the interviews of the first generation immigrants (12.6%) were done in Spanish compared to the other two groups (0% & 0.2%, 2nd generation and non-immigrants respectively).

When comparing the maternal health behaviors of the three immigration groups only the alcohol (χ^2=33.08, p<0.001) and smoking (χ^2=40.40, p<0.001) habits prior to pregnancy and alcohol (χ^2=15.89, p<0.001) and smoking (χ^2=10.16, p=0.006) habits during pregnancy were significantly different. The percentage of women, who were consuming alcohol and smoking prior to pregnancy, was lowest among first generation immigrants (26.6% alcohol users & 10.9% smokers). The second generation immigrants had a lower percentage of smokers (20.3%) compared to non-immigrants (30.7%). However, during pregnancy the percentage of women, using alcohol and smoking was highest among first generation immigrants (18.1% alcohol users & 20.8% smokers) compared to the other two groups (9.3% alcohol users & 11.2% smokers among 2nd generation and 9.1% alcohol users & 12.8% smokers among non-immigrants).

3. Study aim 2:

3.1 Correlations between socio-demographics, maternal health behaviors and GWG

Correlation coefficients between various socio-demographic and maternal health behavior variables and the total GWG and GWG categories identified potential confounding variables that were controlled in future analyses.

Family size (r= -0.078, p<0.001), parity (r= -0.089, p<0.001) and pre-pregnancy BMI (r= -0.129, p<0.001) were significantly correlated with total GWG, and the age at child birth was not correlated with total GWG (r= -0.020, p=0.291). According to the ANOVA results interview language was significantly associated with GWG (F=3.887, p=0.021). Among the socio-demographic variables, race/ethnicity (t=3.578, p <0.001), income category (t= -2.321, p=0.020) and current region of residency (F=3.665, p=0.012) were the only variables

significantly associated with total GWG. Among the maternal health behaviors, use of prenatal care (t=2.952, p=0.003), alcohol consumption 12 months prior to pregnancy (t=2.365, p=0.018), caloric reduction during pregnancy (F=13.596, p<0.001), reducing salt intake during pregnancy (F=4.916, p=0.007) and smoking during pregnancy (t=1.965, p=0.049) were the only variables significantly associated with total GWG.

Race/ethnicity (χ^2=7.551, p=0.023), income category (χ^2=16.611, p<0.001), year of pregnancy (χ^2=13.353, p=0.001), level of education (χ^2=11.945, p=0.018), marital status (χ^2=9.767, p=0.008), poverty status (χ^2=15.437, p<0.001), family size (F=6.087, p=0.002), parity (F=14.415, p<0.001) and pre-pregnancy BMI (F=42.968, p<0.001) were significantly associated with the GWG category. Among the maternal health behaviors, use of prenatal care (chi=18.099, p<0.001), spouse's pregnancy intention (chi=9.747, p=0.008), smoking 12 months prior to pregnancy (chi=6.606, p=0.037), vitamin/mineral supplement intake (chi=10.749, p=0.005), reducing caloric intake during pregnancy (chi=12.873, p=0.012), reducing salt intake (chi=29.725, p<0.001) and smoking during pregnancy (chi=8.769, p=0.012) were significantly associated with GWG category.

3.2 Association between GWG and immigration generation status

ANCOVA test results – determining association between total GWG and immigration generation status

ANCOVA was conducted to test the difference between first generation, second generation and non-immigrant groups on total GWG controlling for the covariates. Prior to conducting the analysis it was determined that none of the assumptions of ANCOVA

analysis appeared to be violated. Pre-pregnancy BMI parity, race/ethnicity, income category and interview language were included as covariates in the model. The race/ethnicity (dichotomized as non-Hispanic White and Black/Hispanic), and interview language (dichotomized as English and non-English including Spanish and other languages) was dichotomized because of small sample sizes in some of the original categories of those variables.

The overall model for total GWG containing all the covariates (pre-pregnancy BMI, parity, race/ethnicity, income, interview language) and predictor (immigrations groups) was statistically significant ($F=7.375$, $p<0.001$) but explained only 2.2% of the variance in the total GWG ($R^2=0.022$). Pre-pregnancy BMI ($F=24.605$, $p<0.001$) and parity ($F=11.930$, $p=0.001$) were the only significant predictors of total GWG. According to this model pre-pregnancy BMI and parity are inversely related to total GWG. Lower the BMI and fewer children are associated with lower total GWG. One-unit increase in pre-pregnancy BMI was associated with reduction in the total GWG by 0.28 lbs. ($B= -0.28$) and when parity increased by 1 birth, total GWG decreased by 0.98 lbs. ($B= -0.98$). The predicted main effect of immigration groups was not significantly associated with the total GWG ($F=0.115$, $p=0.891$) in this model, indicating no difference in the total GWG between the three immigration groups after accounting for the other variables. The effects of interview language ($F=2.962$, $p=0.085$), race/ethnicity ($F=1.139$, $p=0.286$) and income ($F=1.985$, $p=0.159$) were also not statistically significant. The results of the ANCOVA analysis is given in Table 10 as adjusted mean values (SD) of total GWG and pairwise comparison results for mean differences using Bonferroni-adjusted tests.

Table 10. Adjusted means of total GWG (SD) and mean differences among the immigrations groups, controlling for confounding socio-demographic variables.

Variable	Adjusted Mean (SD)	Mean difference$^{(A-B)}$	Sig. (Bonferroni)
Interview Language			
English^{A}	32.581 (0.61)		
Other^{B}	27.187 (3.07)	5.394	0.085
Race/Ethnicity			
Black/Hispanic^{A}	29.550 (1.57)		
non-Hispanic, White^{B}	30.218 (1.62)	-0.668	0.286
Income			
<$10,000^{A}	29.356 (1.65)		
≥$10,000^{B}	30.411 (1.56)	-1.055	0.159
Immigration category			
First generation^{A}	30.311 (1.73)	0.717^{A-B}	0.999
Second generation^{B}	29.595 (1.90)	0.567^{A-C}	0.999
Non-immigrants^{C}	29.745 (1.60)	-0.150^{B-C}	0.999

The adjusted mean values are given for parity = 1.93 and pre-pregnancy BMI=23.821.

Adjustment for multiple comparisons: Bonferroni

Superscripts are used to indicate the calculation of mean differences.

Multinomial logistic regression results- determining association between immigration generation status and GWG category

Multinomial logistic regression was conducted to determine the effects of immigration generation status on the GWG categories controlling for the covariates; pre-pregnancy BMI (Overweight or obese and Normal weight), parity (primiparous and multiparous), race/ethnicity (Black/Hispanic and non-Hispanics, white), poverty status, marital status, and year of pregnancy. Adequate GWG category was the reference group. Even though the total model was statistically significant (χ^2=197.180, p<0.001), BMI (χ^2=149.654, p<0.001) and parity (χ^2=18.430, p<0.001) were the only significant unique predictors of GWG. There was no difference among the immigration groups in GWG categories. Since 29.0% of the cells had zero frequencies the goodness of fit of the model and the coefficients could not be interpreted.

Therefore, to better understand the association between immigration groups and GWG categories, I decided to do a logistic regression using excess GWG as the dependent variable (categories; excess GWG and adequate/inadequate GWG) and immigration groups as the independent variables after controlling for the covariates.

The correlation analysis using socio-demographic variables and excess GWG showed that family size (t=-3.422, p=0.001), parity (primiparous and multiparous) (χ^2=21.35, p<0.001), pre-pregnancy BMI category (χ^2=156.411, p<0.001) and year of pregnancy (χ^2=5.299, p=0.021) were significantly related to excess GWG. These variables were entered as covariates in the logistic regression analysis. Prior to conducting the analysis the

assumptions of logistic regression were tested and confirmed that none of the assumptions were violated.

Logistic regression results- determining relationship between immigration generation status and risk of excess GWG

The total model including all the covariates and immigration groups was statistically significant (χ^2=187.601, p<0.001). The model explains only 8.6% of the variation (Nagelkerke R^2) in excess GWG and correctly classified only 62.9% of the cases. However, there was no significant difference in the likelihood of exceeding GWG among the three immigration groups (Wald z= 0.606, p= 0.738) and parity (Wald z=12.019, p=0.001) and pre-pregnancy BMI (Wald z=154.042, p<0.001) were the only unique predictors of excess GWG.

Table 11 summarizes the results of the logistic regression analysis. Primiparous women are more likely to gain excess GWG compared to multiparous women (odds ratio=1.38). Underweight and normal weight women have a lower likelihood of gaining excess GWG compared to obese women (odds ratio of 0.26 and 0.45 for underweight and normal weight respectively). However, overweight women are more likely to gain excess GWG compared to obese women (odds ratio=1.34).

Table 11. Logistic regression results summary – parameter estimates for association between excess GWG and immigration generation status controlling for confounding socio-demographic variables.

Factor	B	SE	Wald z	Exp(B)	sig.
Year of pregnancy	0.004	0.081	0.002	1.004	0.960
Parity	**0.320**	**0.092**	**12.019**	**1.377**	**0.001**
BMI(underweight)	**-1.344**	**0.211**	**40.772**	**0.261**	**<0.001**
BMI(normal)	**-0.807**	**0.127**	**40.322**	**0.446**	**<0.001**
BMI(overweight)	**0.295**	**0.148**	**3.961**	**1.343**	**0.047**
Family size	-0.061	0.033	3.372	0.941	0.066
Immigration group(1st Gen)	-0.125	0.161	0.600	0.883	0.439
Immigration group(2nd Gen)	-0.020	0.151	0.018	0.980	0.892

Note: GWG category (excess GWG and not excess GWG) was the dependent variable and immigration group (1st generation, 2nd generation & non-immigrant) was the independent variable (non-immigrant group-reference category).

4. Study aim 3

Classification tree analysis

Separate classification tree analyses were completed for the total sample of women and for women of each immigration group to identify the most important socio-demographic and health behavior variables that would predict excess GWG.

The optimal classification tree for the total sample is presented in Figure 14. Pre-pregnancy BMI, parity, level of education, reduction of calories during pregnancy, age and race/ethnicity were the variables used to separate individuals. There were 43.9% women with excess GWG in the total sample, and 61.3% of overweight or obese women had excess GWG. Only 36.6% of underweight or normal weight women exceed the GWG recommendations. Both of the BMI groups were further divided by parity. Among the overweight/ obese women, 69.2% of primiparous women and 56% of multiparous women had excess GWG. This primiparous group was further divided by the factor whether they cut down calories during pregnancy. Seventy seven percent of women who did not reduce caloric intake during pregnancies exceeded the GWG recommendation. Among women who reduced caloric intake during pregnancy 55.7% exceeded GWG recommendations and this group was further divided by race/ethnicity. About 68% of non-Hispanic, white women who reduced calories during pregnancy exceeded the GWG recommendations. Among the underweight/normal weight women, only 41.1% of primiparous and 33.2% of multiparous women had excess GWG. This primiparous group was divided by education and then age. As shown in Figure 1 only 37% of primiparous women with college education exceed GWG recommendations and when further subdivided using age about 39% < 33.5 years had excess

GWG compared to 25.5% of excess GWG among women > 33.5 years of age. Quantitatively, 63.1% of the women were correctly classified through the decision rules of this model (with 0.383 risk estimate and 0.009 standard errors).

In general those who were least likely to gain excess GWG were >33.5 years old, had some college or higher education, pregnant with their first child, and had normal or underweight status pre-pregnancy. Those who were most likely to gain excess GWG were white, had not reduced calorie intake during pregnancy, were pregnant with first child, and were overweight or obese before pregnancy.

The optimal classification tree for the first generation immigrant women is presented in Figure 15. Among the first generation immigrant only 40.8% exceeded the GWG recommendations and majority 59.2% did not exceed the recommendations. Visa/residency status and pre-pregnancy BMI were the variables used to separate excess GWG group. Only 13.8% of immigrants who were refugee/Asylee, illegal immigrants, or enter for permanent residence sponsored by employer had excess GWG, and 45.8% of immigrants with temporary visa, enter for permanent residence sponsored by relative or enter for permanent residence with labor certification. The latter group was further divided using the pre-pregnancy BMI and 64.3% of overweight or obese women had excess GWG compared to 38.9% of underweight or normal weight women. Using the decision rules of this model 65.8% of women were correctly classified as excess GWG or not (with 0.495 risk estimate and 0.037 standard errors).

Among first generation immigrants, those who were least likely to gain excess GWG had immigrated to the US under visa/residency status that could be categorize as emergency

situations or, those came for permanent residency sponsored by employer. This includes the groups of immigrants that could be considered as impoverish and the group of immigrants with highest recourses and facilities. The first generation immigrants who were most likely to exceed GWG recommendations were overweight or obese before pregnancy and immigrated to the US with visa/residency status that could be defined as for non-emergent reasons (e.g.: came for family reunion, temporary visa and green card holders).

Figure 16 illustrates the optimal classification tree for second generation immigrant women. Pre-pregnancy BMI, level of education, age and race/ethnicity are the variable used to separate women exceeding GWG recommendations from those who do not. The prevalence of excess GWG among second generation women is 44.4 % and 69.5% of overweight or obese women exceed the GWG recommendations. Only 34.5% of underweight or normal weight women had gained weight excessively. The proportion who gained excessively could not be improved by splitting the overweight or obese group further. In contrast, underweight or normal weight group was spilt further by level of education. Among this BMI group, women with below high school level education or college level education (highest and lowest education groups) had slightly more risk of excess GWG (40.6%), than the low BMI group as a whole (34.5%). Low BMI women with below high school level or college level education could be further divided based on their age. Women below 33.5 years of age were more likely to exceed GWG recommendations (46.8%), than women who were more above 33.5 years of age (15.8%). This younger group was split again using the race/ethnicity and Hispanic women had higher risk of excess GWG (56.4%) compared to non-Hispanics (36.8%). This model was able to correctly classify 69.1% of women correctly as exceeding GWG or not (with 0.401 risk estimate and 0.034 standard errors).

Among second generation immigrants those who were least likely to gain excess GWG were more likely to be 1) more than 33.5 years in age, have some college education or less than high school education, and have normal pre-pregnancy weight, or 2) have high school education and have normal pre-pregnancy weight. Those who were more likely to exceed GWG recommendations were most likely to be overweight and obese pre-pregnancy.

The classification tree for the non-immigrant women is given in Figure 17. There are 44.1% women exceeding the GWG recommendation among non-immigrant women. Pre-pregnancy BMI, reduction in salt intake during pregnancy, pregnancy intention, parity, reduction in caloric intake during pregnancy, smoking prior to pregnancy and during pregnancy and race/ethnicity are the variables used to separate excess GWG group. Sixty one percent of overweight or obese women had excess GWG, and only 36.9% of underweight or normal weight women had excess GWG. Among the high BMI group, women who were not expecting pregnancy had higher risk of excess GWG (61.8%). This group was further divided using parity and among the high BMI women who did plan pregnancy primiparous women 69.5% have excess GWG. There is higher risk of excess GWG among primiparous women who did not reduce caloric intake during pregnancy (75.9%) compared to primiparous women who reduce caloric intake for any reason (58.4%). Among the latter group the risk of excess GWG increased if they are non-Hispanic white (71.4%). Among the high BMI women who did plan pregnancy multiparous women 56.8% have excess GWG, and this risk is higher for non-smokers (59.0%) compared to smokers (40.0%).

The low BMI group was further divided by salt intake, mother's pregnancy intention, parity and pre-pregnancy smoking behavior. Women who were advised by the health care provider to reduce salt intake had slightly higher risk of excess GWG (43.6%). Among the

women who did not reduce salt intake or who reduce salt intake as a personal choice, the group who planned pregnancy had a higher risk of excess GWG (44.5%) compared to non-planned pregnancies (34.4%). The latter group was further subdivided and among them the primiparous women who were smokers prior to pregnancy were the most at risk group (49.2%). This model was able to correctly classify 63.4% of women correctly as exceeding GWG or not (with 0.384 risk estimate and 0.010 standard errors).

Among non-immigrants those who were least likely to gain excess GWG were more likely to be multiparous, did not wanted to become pregnant, did not reduce calories or reduce calories due to medical advice and were normal weight before pregnancy. Those who were more likely to exceed GWG recommendations were most likely to not reduce caloric intake during pregnancy, having the first child, did not wanted to become pregnant and were overweight and obese pre-pregnancy or were non-Hispanics, white women who did not reduce calories during pregnancy and having the first child, did not wanted to become pregnant and were overweight and obese pre-pregnancy.

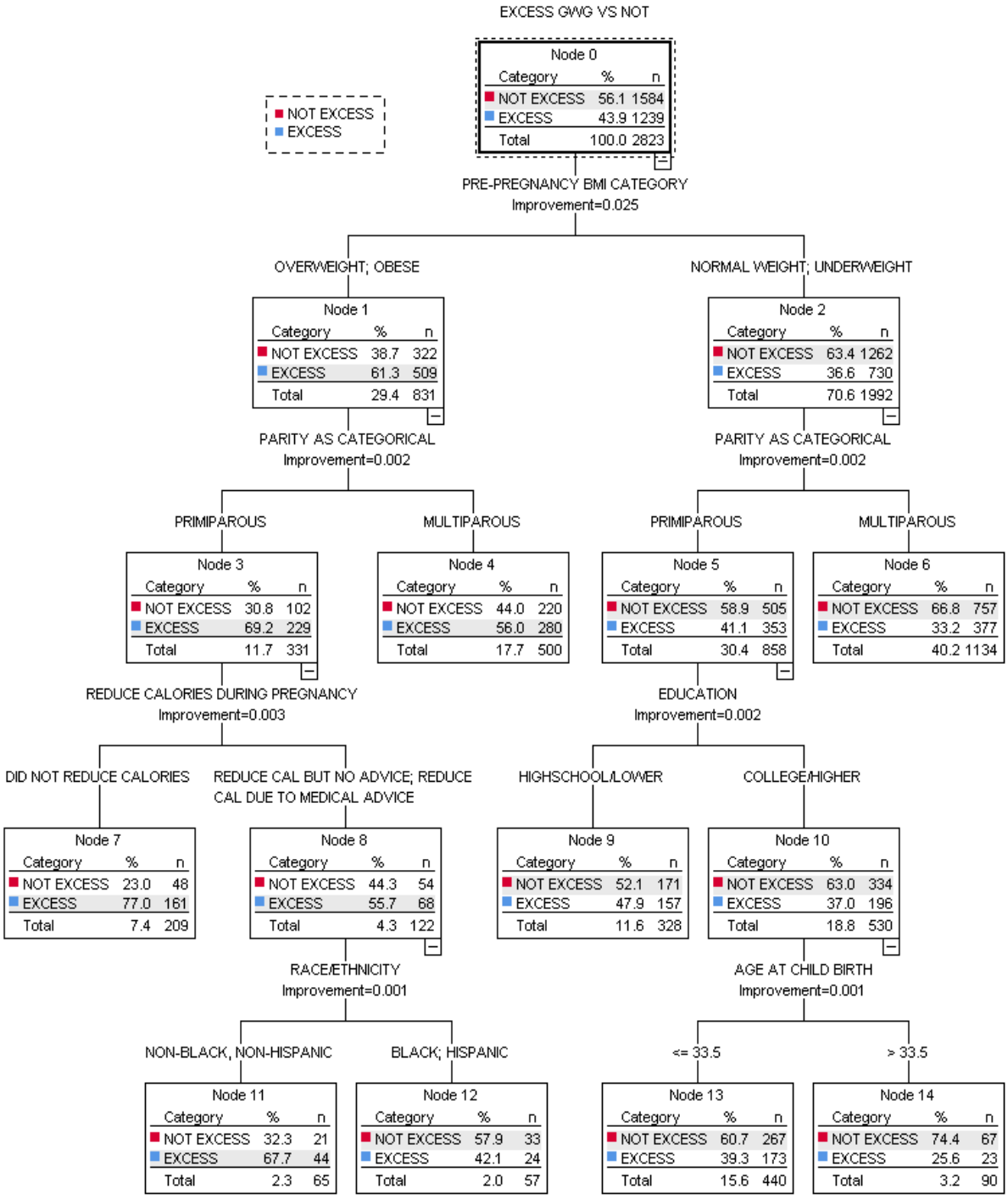

Figure 12. Classification tree for predicting excess GWG for the total study sample

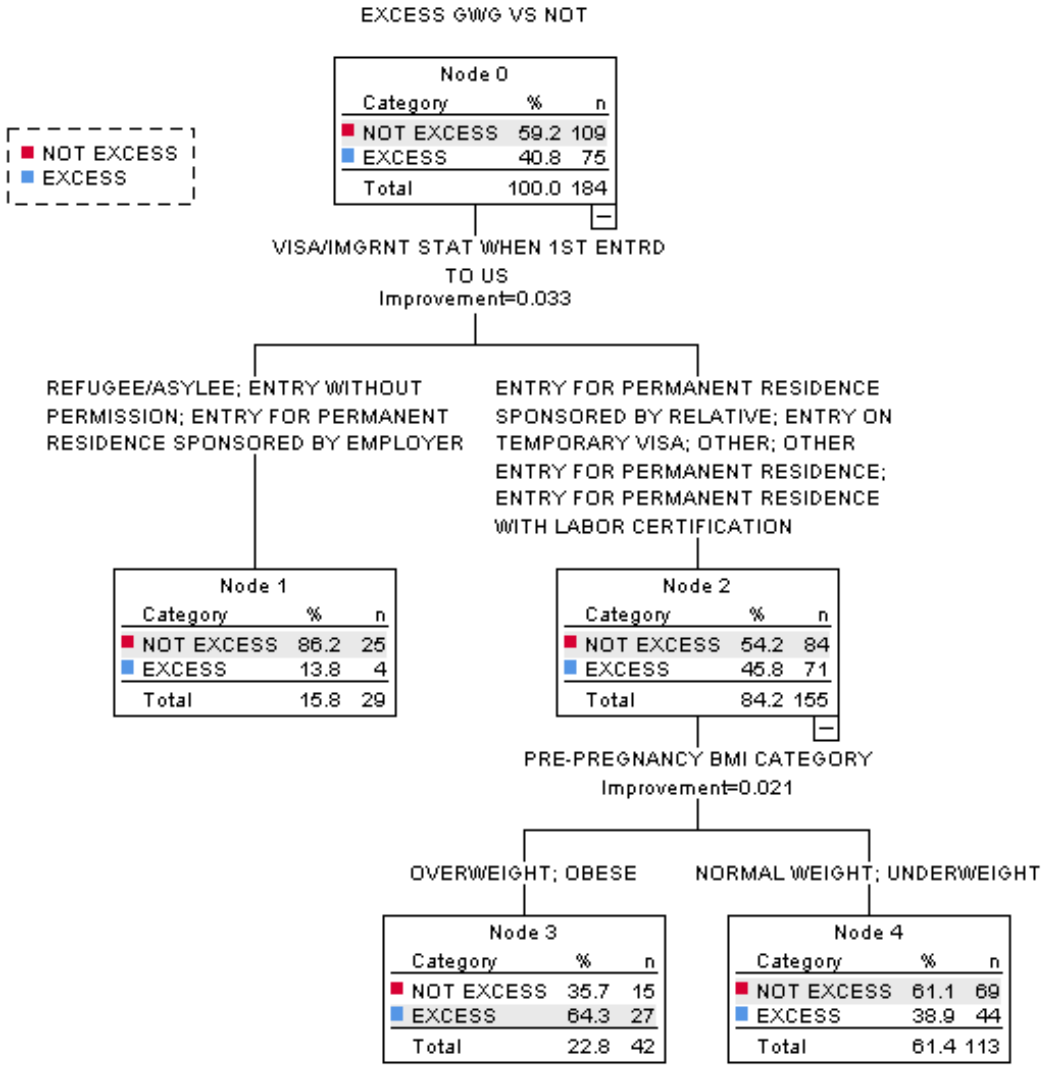

Figure 13. Classification tree for predicting excess GWG among first generation immigrants.

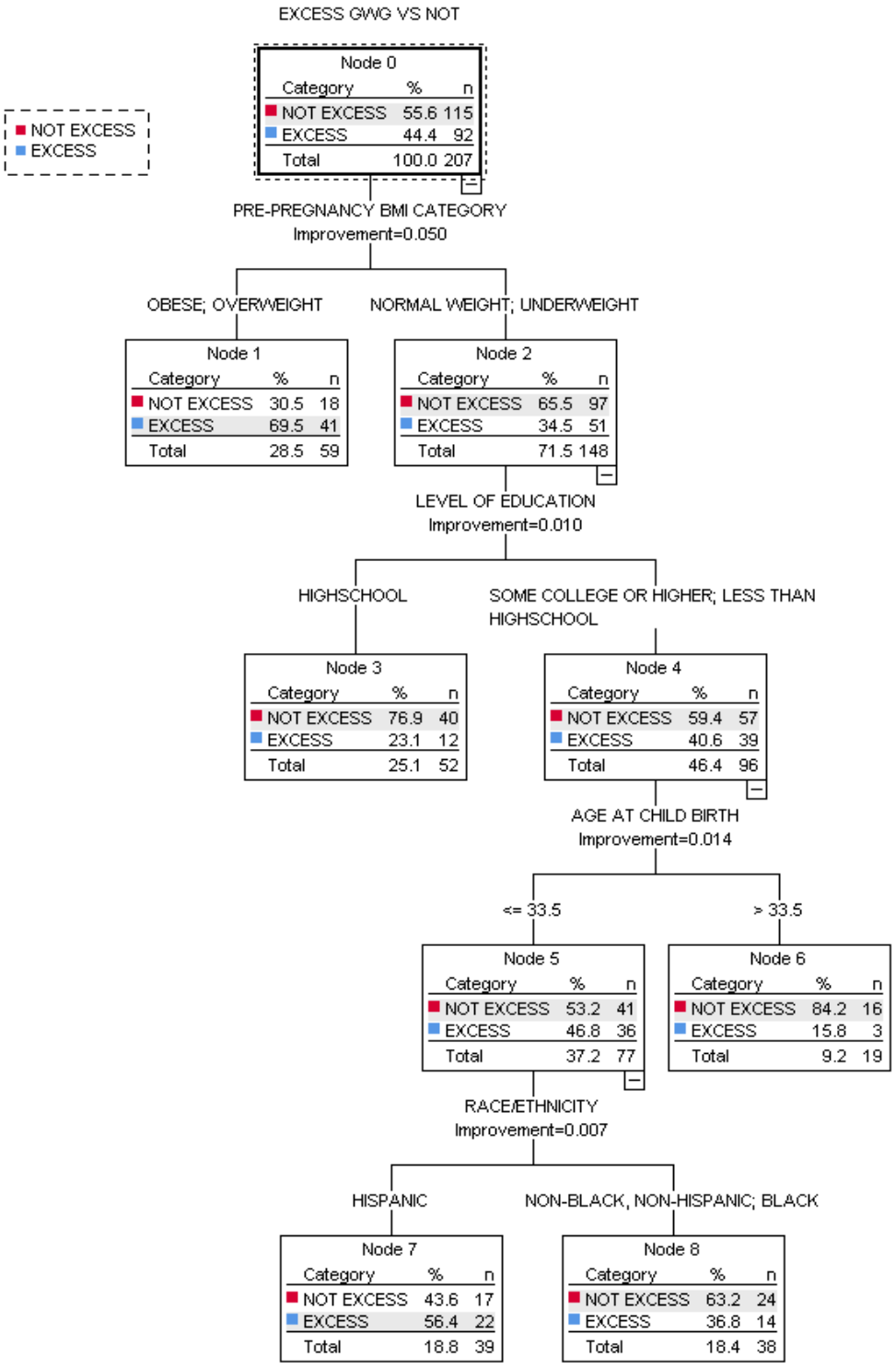

Figure 14. Classification tree for predicting excess GWG among 2nd generation immigrants

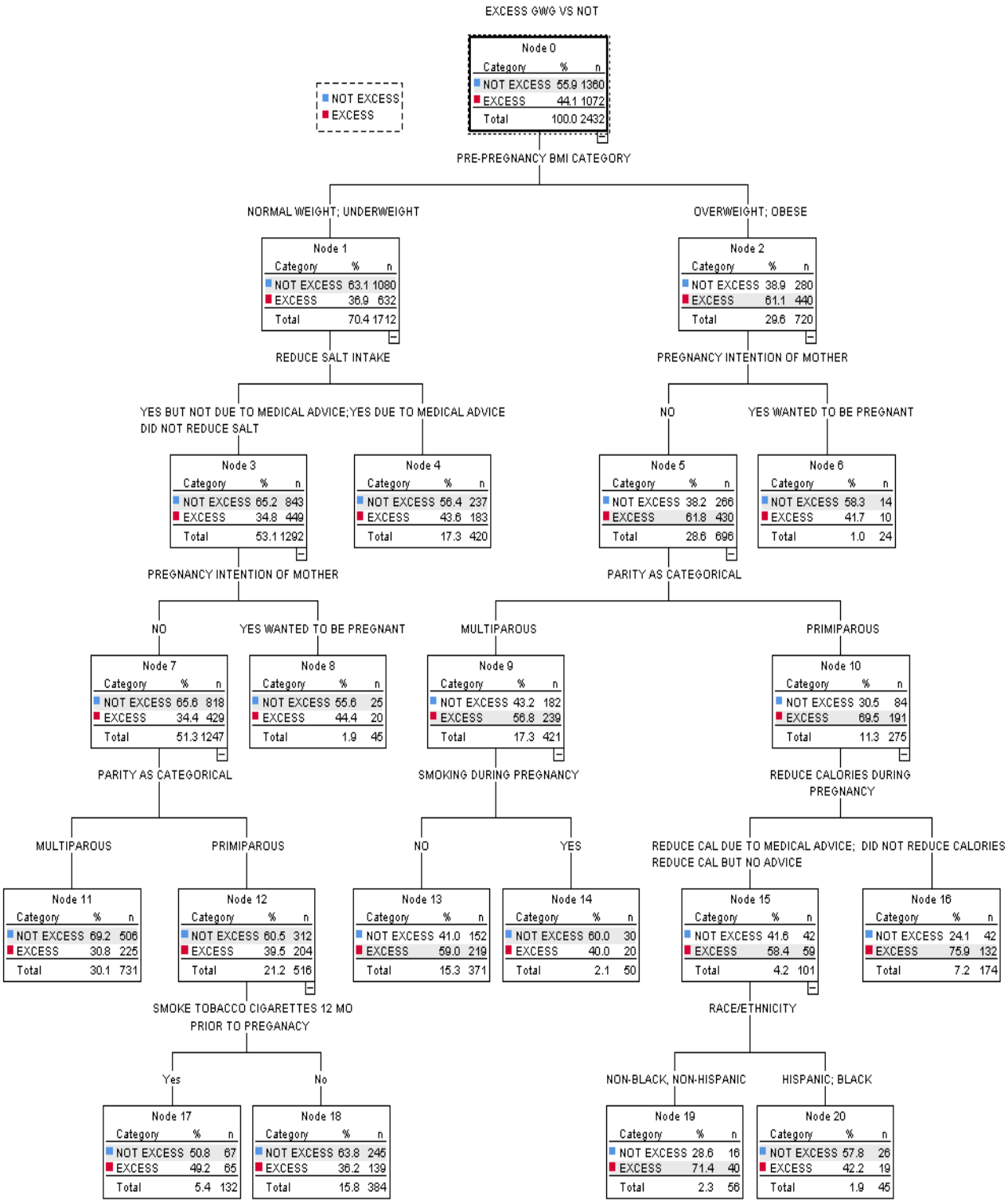

Figure 15. Classification tree for predicting excess GWG among non- immigrants

CHAPTER 5

DISCUSSION

In the U.S. about 51% of the foreign born population are female and among them 80% were between 18-64 years of age. In 2006, there were about 11% second generation immigrants. According to American community survey (ACS) 2013, immigrant women are more likely to have given birth in the last 12 months compared to natives of the same age. Therefore it is important to improve the pregnancy outcomes among immigrant women. About 50% of pregnant women in the U.S. exceed the GWG recommendations based on their pre-pregnancy BMI. Excess GWG contributes to pregnancy complications. The purpose of the current study was to understand the relationship of immigration status (measured as first generation immigrants, second generation immigrants and non-immigrants) and GWG and to develop the socio-demographic and health behavior profile of women who exceeded GWG recommendations. This section will discuss the results of this study in relation to the research questions and current literature. Further, this section will explain the strengths and limitation of the study, the clinical implications and future directions.

Overall, this study showed that there are differences in some of the socio-demographic variables (race/ethnicity, employment, education etc.) and maternal health behaviors (such as alcohol use and smoking) among the three immigration groups; first generation, second generation and non-immigrants. However, there was no evidence of differences in total GWG or risk of excess GWG among these three immigration groups. The profiles of the women who exceeded the GWG recommendations were different for each immigration group. These results will be discussed in this section.

The socio-demographic and maternal health behavior differences among the immigration groups:

According to the results of this study, the three immigration groups were different in the racial/ethnic composition. There were more Hispanics among the first and second generation immigrants compared to the non-immigrants. The Hispanic composition among immigrant women in this sample was slightly higher than the national data. The U.S. census report in 2009 showed that 65.2% of the female population was white, 15% were Hispanic and 12.5% were Black. According to the statistic reports of immigration policy institute, in 2015 45% of the total first generation immigrants and in 2006 45% of second generation immigrants were Hispanic. The total study sample had more Hispanic women and Black women than the general U.S. female population due to the oversampling of these two ethnicities.

This sample was different from the general U.S. population as there were about 20% of the sample in poverty compared to the national level of 15.1% in total population and 16.4% among women in 2012 (Short, 2013). The U.S. census bureau current population surveys from 1985-2012 shows that the national poverty rate had fluctuated between 10-15% over this year range. Oversampling of participants of low SES in the NLSY79 survey could be one of the reasons for this higher poverty rate observed. Results show that the poverty status was not different between the three immigrant groups. In contrast, many studies have reported significant differences in poverty rates between immigrants and natives. According to Zong & Batalova (2015) 20% of first generation immigrant women were in poverty compared to the 8% of native women and according to census data from 1994-2004 immigrants are much more likely to live in poverty than natives, and among recent

immigrants and non-citizens, the poverty rate is more than twice the rate of U.S. natives (Chapman & Bernstein, 2003; Rector, 2006; Gammage, 2002). Dixon (2006) reported that 16% of first generation immigrants were in poverty compared to 9% of second generation immigrants and 10% of non-immigrants.

The current region of residence of the groups was also different showing that majority of first and second generation immigrants are from the West, Northeast or the South and urban residences. According to the Migration policy institute, California, New York, Texas and Florida are the states that have the highest number of immigrants in the U.S. Majority of the immigrants concentrated in the major cities and more than half lives in the West or South of the country (Willcox, 1906; Gonzalez-Barrera & Lopez, 2013; Portes & Rumbaut, 2001; Dey & Lucas, 2006).

In line with U.S. statistic reports and research among immigrant populations, employment status, marital status, and education levels were also different among the three immigration groups. The percentage of employed women and women with college level education was highest in the second generation immigrants. Their employment rate and rate of college level education was higher than the total sample levels. National census data show a higher rate of college education among 2nd generation immigrants. In 2006, about 31% of second generation immigrants had college level or higher education compared to 27% of first generation and 28% of non-immigrants (Dixon, 2006). Gambino (2017) also reported similar results of higher educational attainment among second generation immigrants compared to 1st generation and 3rd or later generations of immigrants. Studies have reported that even though the immigrants arrived with a lower level of education, the 2nd generation meets or exceeds the educational level attained by children of natives. However, these national rates

are lower than this study's sample indicating that the participants in this study were more educated than the expected level for their immigration group. According to Zong & Batalova (2015) the rates of college level education, below high school education and high school graduates among 1st generation immigrant women were 28%, 30%, and 42% of respectively compared to 30%, 9% and 61% among native born women. These educational data of native women are comparable to the results of the non-immigrants category of the current study. Studies have also shown that the education attainment of immigrants depends on their country of origin and gender.

Most of the first generation mothers were out of the labor force and the employment rate was lower among first generation immigrants compared to the other two groups. Alkerwi et al. (2012) reported that the employment rate among foreign born women in U.S. was between 38.2% - 62.5% during 1980-1990 depending on their ethnic group (Waldinger & Reichl, 2006). The employment rate among first generation immigrants in the current study fall between this reported range. However, the general labor force participation is only slightly higher among natives women compared U.S. immigrant women because work is a crucial dimension of post-migration life of immigrants (American immigration council, 2014). In general immigrant women are more likely to work in the U.S. than when they were in their country of origin due to increased household requirements and low wages offered to immigrants in the U.S. The large gap in employment between foreign borne and natives observed in current sample might be due to the higher number of women with below high school education among the first generation immigrants in this sample. According to the 2014 current population survey among the general U.S. population 57% of all women are employed (Ro & Goldberg, 2017) which is similar to the employment rates among total

sample and non-immigrants in the current study. Second generation immigrants had the highest employment rate in the current sample similar to the results reported by Alkerwi et al (2012). According to Waldinger & Reichl, (2006) during 1980-1990 the employment rate among 2nd generation immigrants in U.S. was between 51.5%- 68.4% which is higher than the first generation and similar to the 3rd generation. The employment rate of the 2nd generation in current sample was within this reported range. The higher employment rate in this group might be due to the higher percentage of women with college level or higher education in the 2nd generation compered to non-immigrants.

Compared to the non-immigrants, the second generation immigrants were significantly older, had a higher percentage of pregnancies after 1990, and were most likely to be first time mothers compared to other two groups. The mean family size was highest among the first generation immigrants, which was about 4 members in each family and they were more likely to be married than the natives. ACS 2013 data shows that immigrant women are more likely to have given birth in the last 12 months compared to the natives of the same age group and 52% of immigrants women have more than one children living with them which might explains the observed larger family size among immigrants compared to natives. Similar to the current sample, Zong & Batalova (2015) states that 77% of the immigrant women giving birth were married and Guendelman & Abrams (1995) reported that first generation immigrant women are more likely to be married when they give birth compared to natives or second generation immigrants. Percentage of second generation women who were married was not different from the other two groups even though some studies have reported that more pregnant second generation immigrants are unmarried compared to first generation (Guendelman & Abrams, 1995).

In the total sample 18% were overweight and 10% were obese. According to NHANES III (1988-1994), the age adjusted prevalence of overweight among women was 24.7%, among 20-29 and 30-39 age groups this was 18.5% and 21.2% respectively. The age adjusted obesity prevalence was 14.2%, among 20-29 and 30-39 age groups this was 8.6% and 14.1% respectively (Flegal, Carroll, Kuczmarski, & Johnson, 1998). As the mean age of the current sample was 28 years, the current study sample was similar to the general U.S. population during late eighties and early nineties with respect to overweight/obesity prevalence. The obesity rates were similar among all three immigrant groups in the current study even though many literature on immigration and health shows the rates of obesity are lower among recent immigrants, and increase with time in U.S. or generational status (Chrisman et al., 2017; Ryan-Ibarra et al., 2017). Consistent with our results, Wingo et al. (2009) have reported no difference in obesity rates between 1st and 2nd generation immigrants. This result contradicts to the immigrant paradox theory which explains that first generation immigrants outperform higher generations of immigrants and non-immigrants on number of health behaviors (North, 2009). However, immigrant paradox theory also explains that with increasing time in U.S. and acculturation to the American culture the health benefits degrade (Cho, Frisbie, Hummer, & Rogers, 2004). Therefore, the inconsistencies in obesity patterns by immigration generation might be due to the variations in length of exposure to the U.S. culture among 1st generation immigrants (Oza-Frank & Cunningham, 2010). In this study sample, majority of the first generation immigrants immigrated to U.S. before the age of 14 years and had been in U.S. for more than 10 years. Longer time in U.S. place them at higher risk for overweight and obesity (Creighton, Goldman, Pebley, & Chung, 2012), which

was indicated by the current results. The study findings might be different if the first generation immigrant group consists of more adults immigrants with less time in U.S.

In NLSY 79 survey majority of interviews were done in English among all three immigration groups. Compared to the other two immigrant groups the first generation women had more interviews conducted in other languages and fewer done in English. Compared to natives, fewer 1st generation women had a good understanding of the interview questions and this could be due to the lower educational level among the first generation immigrants compared to the other groups. Even though, the majority of first generation immigrant women preferred to conduct the interview in English, 90% of them used a foreign language at home. The reason could be that, more than 85% of these women have lived in U.S. for more than 10 years. The number of years in U.S. is associated with the use of English and English speaking ability. According to 2012 American community survey, about 85% of foreign born population uses a foreign language at home even though almost 50% spoke English very well (Gambino et al., 2014). It is not likely language barriers affected participants' ability to complete the survey interview accurately; however, this could have been a slight issue for some of the 1st generation women.

Even though others have reported immigrants underutilize healthcare and seek prenatal care later in pregnancy, there was no difference in the use of prenatal care or month starting prenatal care in our sample. Majority of women in the current sample had reported their first prenatal care visit within the first three months of pregnancy and almost all women had attended prenatal care. This rate was higher than what was reported in National vital statistics reports using 2007 data. According to this report only 70.8% women started prenatal care in first 3 months of pregnancy and 7.1% had late or no cares (Martin et al.,

2010). The use of prenatal care was even lower during the 1900s and had risen through 2003 (Martin et al., 2005). Zong & Batalova, (2015) showed that immigrant women are more likely to be insured than immigrant men and more likely to be covered by public health insurance which might explain the similar use of prenatal care among 1st generation immigrants compared to other two groups. Also, attitudes and practices toward prenatal care among immigrants may be different than attitudes and practices toward general healthcare among immigrants making them seek care during pregnancy than for any other health problem. However, there was no measure of the quality, frequency or content of antenatal care in this survey. Therefore, even though, all groups of women reported early use of pre-natal care, the adequacy of care might be different among the groups. Almeida et al. (2013) have reported less optimal care among immigrants due to inappropriate strategies, inadequate medical treatment and miscommunication.

Compared to the other two immigrant groups first generation immigrants had lower alcohol consumption and smoking prior to pregnancy. This is in line with most of the literature reporting lower levels of alcohol use and smoking habits among first generation immigrants (Chrisman et al., 2017; Svensson & Hagquist, 2010; Hamilton, van der Maas, Boak, & Mann, 2014). Among first generation immigrants the more acculturated and those who are experiencing more stressful situations show smoking and alcohol abuse. These behaviors also depend on the alcohol consumption and smoking rates of the country of origin (Barsties et al., 2017). As Svensson & Hagquist (2010) & Walsh et al. (2014) reported, the 2nd generation immigrants of the study sample had alcohol use similar to natives. The non-immigrant group had the highest number of smokers prior to pregnancy. The differences in substance use could be explained by the differences in socio-economic conditions, religious

attitudes and norms regarding substance use among immigrants and natives (Svensson & Hagquist, 2010). Lower socio-economic status is associated with higher substance use due to greater experiences of negative life events and stress/depression symptoms (Hamilton et al., 2014). The lower rates of alcohol use among immigrants could be attributed to the influence of cultural values and norms discouraging alcohol use (Barsties et al., 2017).

Even though, the adverse effects of consuming alcohol and smoking during pregnancy are common knowledge, our results indicate that about 10% of total sample and 20% of first generation immigrants continue to smoke during pregnancy. The alcohol use and smoking during pregnancy was highest among the first generation immigrants. This is in contrast to the literature stating immigrant women have better or similar health promoting behaviors during pregnancy compared to natives such as lower substance use (Acevedo-Garcia, Soobader, & Berkman, 2005; Fuentes-afflick, Hessol, Pe, & Deangelis, 1999; Gagnon, Zimbeck, Zeitlin, & The ROAM Collaboration, 2009). However, there are differences in research findings depending on the geographical origin of the immigrants. A study done in Greece showed that smoking cessation rates were lower among immigrants compared to natives (Tsakiridis et al., 2018). Smoking during pregnancy could be attributed to lower education, higher stress, depression, less social support and unintended pregnancy (Härkönen, Lindberg, Karlsson, Karlsson, & Scheinin, 2018; Miyazaki, Hayashi, & Imazeki, 2015; US Department of Health and Human Services, 2014; Smedberg, et al. 2015) and the willingness to quit smoking during pregnancy also depends on SES (Ebert & Fahy, 2007). Phinney et al. (2000) reported that among foreign borne women experiencing conflicts created by demands of two cultures (heritage and host culture) and stress associated with adaptation to new situation are at a higher risk of health deteriorating behaviors. If the reason

for the first generation immigrants to smoke is related to stressful life events, pregnancy might increase the level of stress and distress. Also, most of the 1st generation women were not expecting the pregnancy (>85%), and this might explain the higher smoking among immigrant women in this sample compared to general population of immigrants in U.S.

The current study provides evidence of differences in socio-demographic variables, alcohol consumption and smoking habits among the two generations of immigrants and natives. The socio-ecological model of health explains that the health of a person is determined by the environment they live in and the interactions they have with the environment as well as their individual behaviors. The maternal behavioral differences observed among the three groups could be explained by the differences in environments they live in. Most of the differences were observed between the first generation immigrants and non-immigrants. Second generation immigrants fall between the other two groups and have characteristics and behaviors representing both their parents and the natives.

The level of acculturation among immigrants and their SES determine how much they resemble the natives. In general, first generation recent immigrants tend to preserve their cultural values with little exposure to American culture. First generation women socialize within the ethnic neighborhood and replicate, within their small social circles and the neighborhood, many aspects of their lives in country of origin (Viruell-Fuentes, 2007). Those who immigrate for financial opportunities may be more acculturated than those who enter U.S. as refugees/asylee or for family reunion (Gibson, 2001). This could be due to higher socio-economic status, fluency in/ preference for and use of English language, more social networks with host society and/or acquiring citizenship (Repke & Benet-Martínez, 2017; Rumbaut, 1994).

The amount of interactions with the host society and the relationships with conational people (people with same nationality or country of origin) both living in the host country and in country of origin, combined with SES determine the characteristics and behaviors of second generation immigrants. The acculturation among second generation immigrants depends on presence/absence of discrimination, neighborhood they live in and presence/absence of a strong receiving country (Rumbaut, 1994). Living in communities primarily consisting of people from similar ethnic origin/nationality can reduce the impacts of the host culture (Portes & Rumbaut, 2001). According to Pew research center (2013) data second generation immigrants are more likely to think of themselves as typical Americans, and have higher socio-economic status (SES) compared to their parents which resembles the U.S. population. However, they more resemble to their 1st generation than natives with respect to their attitudes, behavior and life priorities

This data set does not have a reliable measure of acculturation of immigrants; therefore, we cannot conclude that observed differences are mainly due to acculturation. Differences in SES could explain some of the observed differences between the groups. This study provides evidence that changes in environment could change the individual behaviors as explained in the socio-ecological model and therefore, we can expect these groups to have different health outcomes or varying levels of risk of health consequences.

The associations between immigration generation status and GWG:

There are reported differences in environmental variables, general health behaviors and maternal health behaviors among immigrant groups. Therefore, the GWG patterns and risk of excessive GWG among different generations of immigrants and non-immigrants was

expected to be different. Typically, first generation immigrants have better maternal health behaviors and a strong social support from the immigration culture, which can lead to healthy GWG. Second generation immigrants tend to be more acculturated to the U.S. cultural and dietary practices, while retaining some of their original cultural values. Acculturation can drive many of the later generations of immigrants to become overweight or obese and to have a higher risk of excess GWG. Therefore, later generations of immigrants have lower or similar health outcomes to natives. The second aim of this study was to determine whether there are differences in total GWG among immigrant groups and whether the risk of excess GWG is different among these groups after controlling for potential covariates.

In opposition to the hypothesis there was no significant difference in total GWG or in likelihood of excess GWG among the three immigration groups after controlling for the potential covariates, even though there were differences among the three immigration groups in some of the maternal health behaviors related to GWG mentioned in the previous section (smoking, and alcohol use). This result is in contrast to Larouche et al. (2010), who reported that non-immigrants gained significantly more GWG compared to the 1st generation immigrants who had been in Canada for more than 10 years. The possible reasons for the current study results might be 1) due to the limited number of 1st and 2nd generation immigrants in the current sample, 2) all immigrants of different origins and varying levels of acculturation were combined, 3) majority of the first generation immigrants have been in U.S. for > 10 years (longer time in U.S. is associated with reduced protective effects of heritage culture) and 4) most of these data were collected in 1990s, and most of the differences we observe between the current immigrants and natives might not be true for this time period. It is also possible that the health behaviors that were different between the three

groups have no or negligible effect on GWG. Lof et al. (2008) reported that smoking, parity, education, age and PA in combination explain only 4% variance in total GWG. Therefore, larger sample sizes of all immigrant groups might be required to identify the effect of immigration generation status on GWG. This might explain that the GWG is a result of multiple factors affecting in combination. All three immigrant groups have both health promoting as well as health deteriorating behaviors/ characteristics. Therefore, all the groups are at risk of exceeding GWG recommendation if control measures are not provided.

BMI and parity were the only variables significantly associated with total GWG and greater risk of excess GWG. Many studies have shown that pre-pregnancy BMI or pre-pregnancy obesity and, parity are associated with total GWG (Bergmann, Flagg, Miracle-McMahill, & Boeing, 1997; Olafsdottir, Skuladottir, Thorsdottir, Hauksson, & Steingrimsdottir, 2006; Olson & Strawderman, 2008; Pawlak, Alvarez, Jones, & Lezotte, 2015; Rosal et al., 2016; Wells, Schwalberg, Noonan, & Gabor, 2006). Even though there are inconsistencies in results as shown in majority of previous studies (Chu, Callaghan, Bish, & D'Angelo, 2009; Hill et al., 2017; Lan-Pidhainy, Nohr, & Rasmussen, 2013), primiparous women in this study were more likely to gain excess GWG compared to multiparous women. The role of parity on GWG is unclear (Hill et al., 2017). The possible explanations for this might be related to both physiological and psychological experiences among primiparous women such as, 1) the unique fat storage characteristics observed in first pregnancy (Lan-Pidhainy et al., 2013), 2) feeling dissatisfied with the body during pregnancy (Hartley, McPhie, Fuller-Tyszkiewicz, Briony Hill, & Helen Skouteris, 2016), or 3) first time mothers have more time for themselves (compared to pregnant mothers with other children) which could lead to overeating or sedentary behaviors. This is important because more than 40% of

births in western countries typically occur in primiparous women. Also, excess GWG is predictive of postpartum weight retention, if these women continue to gain excess GWG in each successive pregnancies there is an increased risk of future obesity. Underweight and normal weight women have a lower likelihood of gaining excess GWG compared to obese women. Overweight women were more likely to gain excess GWG compared to obese women. Pre-pregnant overweight and obese women gain less weight compared to normal weight and underweight women as suggested by the IOM. However, due to the lower threshold for meeting the GWG guidelines (lower and narrower ranges recommended for high BMI status) overweight and obese women are at risk of excess GWG compared to other weight status groups. Pre-pregnancy BMI is a reflection of maternal nutrition status prior to pregnancy (Soltani, Lipoeto, Fair, Kilner, & Yusrawati, 2017) and women with higher BMI might have dietary and physical activity behaviors that promote weight gain. Overweight/obese women generally under estimate their weight (Boudet-Berquier, Salanave, Desenclos, & Castetbon, 2017) and show relaxation of body concerns during pregnancy compared to normal weight women which could lead to more GWG.

As both pre-pregnancy BMI and parity are non-modifiable after pregnancy began, more sustained approaches to improve women's health and education across the lifespan could be more beneficial to control excess GWG compared to interventions provided during pregnancy. As explained by Barnes, Heaton, Goates, & Packer (2016) human lives are linked through shared relationships and interdependent across generations. Pre-conception obesity could lead to excess GWG during pregnancy, which could result in LGA babies. These babies are more at risk for childhood obesity and adulthood obesity (Mitanchez & Chavatte-Palmer, 2018). If the child is a girl, she is also more likely to be obese before pregnancy and

continue the cycle of obesity (Derraik, Ahlsson, Diderholm, & Lundgren, 2015). Therefore, it is necessary to consider both critical and sensitive periods throughout the life cycle where exposures are more powerful in predisposing to risk of diseases (Herman et al., 2014). Pregnancy is such a period of life, and as women have frequent contacts with the health care providers, it is easier to intervene. Pregnancy is also considered a "teachable moment" for women as they are motivated to spontaneously adopt risk-reducing health behaviors (Phelan, 2010). Teachable moments are characterized as natural life transition that increase perceptions of personal risk and outcome expectancies, prompt strong affective or emotional responses, and redefine self-concept or social roles. Pregnancy could be an opputunity to motivating women to make lifestyle changes to control weight gain. This might have benefits beyond better pregnancy outcomes, which could lead to reduce obesity among the future generations.

Chu et al. (2009) also reported that race/ethnicity and level of education were associated with total GWG in multivariate analysis. In this study these variables were not significant predictors of GWG. Larouche et al. (2010) also reported that certain ethnic groups of first generation immigrants were at greater risk of excess GWG compared to others. They found that Latin American immigrants gained more weight during pregnancy compared to South Asian immigrants. This needs to be further studied with a larger sample of first generation immigrant women.

Current results do not supports the immigrant paradox theory, which states that first generation immigrants have better health and pregnancy outcomes compared to natives and later generations. The first generation immigrants are not at a lower risk for exceeding GWG recommendations compared to other two groups. However, the behavior/characteristics

profile of women most likely to exceed GWG recommendations and those who are more likely to adhere to GWG recommendations could be different for each immigration group. The results of the final aim of this study shows how these profiles vary among the three immigration groups.

The classification tree for exceeding GWG recommendations:

In the process of controlling excess GWG earlier identification of at risk groups is advantageous for both development of interventions and pre-natal counseling. Even though there were no differences in the risk of excess GWG among the immigrations groups in this study, some of the socio-demographic characteristics and maternal health behaviors that have been related to GWG in previous research differed across the groups. As the final aim of the study, subgroups at greatest risk of excess GWG and their characteristics for each immigration group were determined.

The classification tree results for the total sample identified two main profiles for women who are most likely to exceed GWG recommendations; Overweight and obese primiparous women who did not control caloric intake during pregnancy and Non-Hispanic white overweight and obese, primiparous women who reduced caloric intake during pregnancy.

As explained previously, being overweight or obese and first time mother are risk factors of excess GWG. This is consistent with past research; higher pre-pregnancy BMI and first birth were most significant predictors of excess GWG (Chu et al., 2009; Fuller-Tyszkiewicz, Skouteris, Hill, Teede, & McPhie, 2016; Lan-Pidhainy, Nohr, & Rasmussen, 2013; Rodrigues, Costa de Oliveira, Santos Brito, & Kac, 2010). Risk of excess GWG is

further increased among overweight/obese women who did not control their caloric intake during pregnancy. There is evidence that overweight/obese women who had restrictive eating behaviors prior to pregnancy are more likely to exceed GWG recommendations as there is less pressure to restrict food during pregnancy (Conway, Reddy, & Davies, 1999; Mumford, Siega-Riz, Herring, & Evenson, 2008). Therefore, not controlling the caloric intake during pregnancy could results in exceeding GWG recommendations. The study by Olafsdottir et al. (2006) supports this result. They reported that higher energy intake in late pregnancy is associated with excess GWG.

According to the second profile, in addition to the effects of higher BMI and being a first time mother, non-Hispanic white women who reported reductions in caloric intake during pregnancy are also at risk of excess GWG. This is contradictory to the first profile on the effect of caloric intake control. Dietary restrictions among some women make them more vulnerable to stress induced eating, especially in obese women (Greeno & Wing, 1994). Being a mother for the first time could also be a stressor, if no support is received from the family, which leads to stress overeating (Greeno & Wing, 1994). Disinhibited eating among women attempting to restrict their dietary intake may explain the excess GWG among non-Hispanic white obese first time mothers. The majority of participants in studies showing pre-pregnancy dietary restraint is associated with excess GWG was non-Hispanic white women (Conway, Reddy, & Davies, 1999; Heery, Wall, Kelleher, & Mcauliffe, 2016; Mumford, Siega-Riz, Herring, & Evenson, 2008), and Mumford et al. (2008) also reported that majority of the dieters in their sample were white women. Therefore, the race might modify the effect of dietary restrictions on GWG which need to be further studied.

Two profiles were identified for women who are more likely to adhere to GWG recommendations, for the total sample. Normal weight, multiparous women and normal weight, primiparous women above 33.5 years of age who have college or higher education are most likely to gain weight within the IOM recommendations. Normal weight and underweight women are required to gain higher amount of weight compared to overweight or obese women. This gives them more room to gain weight without exceeding the GWG recommendations. Having healthier weight status prior to pregnancy is an indication of better dietary and PA habits and these women are more likely to continue these behaviors through pregnancy. Normal weight women also show less stress induced overeating compared to obese women, which might protect them from excess GWG (Greeno & Wing, 1994). Having other children could make women more active compared to women who do not have any other children at home. Being more experienced with pregnancy could reduce the level of stress associated with being pregnant and knowledge gained from previous pregnancy could help multiparous women to better plan their diets and PA behaviors. Since these multiparous women were normal weight pre-pregnancy indicates that they have successfully reduced the postpartum weights from previous pregnancies, which could be a result of their positive health behaviors. The second profile explains that even though, women are in their first pregnancy, older age and higher level of education with normal pre-pregnancy BMI could make women gain weight according to the recommendations. Higher level of education could indicate better nutritional knowledge and healthier behaviors (Boudet-Berquier et al., 2017) and better SES. Women above 30 years are more concerned about their health and shows better health behaviors, regular health checks compared to younger women (Deeks,

Lombard, Michelmore, & Teede, 2009). These two factors could minimize the risks associated with first pregnancy and excess GWG.

The characteristic profiles of women who are more likely to exceed GWG recommendations and adhere to GWG recommendations identified by CRT for each immigration group are given in Table 12 and 13.

Table 12: Predictors of excess GWG for each immigration group

		Pre-preg. weight		Parity		Diet change			
	Non-His. White	Normal	Ob/Ow	Primiparous	Multiparous	No diet change	Diet change	Unplanned pregnancy	Visa/residency status
1st generation			X						X
2nd generation			X						
Non-Immigrant	B		A,B	A,B		A	B	A,B	

Note: Letters indicate the profiles (profile A = overweight/obese, primiparous, no diet change, unplanned pregnancy and profile B = Non-Hispanic white, overweight/obese, primiparous, unplanned pregnancy, with diet change)

Table 13: Predictors of adequate GWG among the three immigration groups

	Education		Pre-preg. weight		Parity		Age (years)		
	Lo	Hi	Normal	Unplanned pregnancy	Primiparous	Multiparous	<33	>33	Visa/residency status
1st generation									X
2nd generation	B	A,	A, B					A	
Non-Immigrant			X	X		X			

Note: Letters indicate the profiles (profile A = high education, normal weight, and >33 years of age, profile B = lower education, normal weight)

According to the classification tree of the first generation women, immigrants who most likely came to the US with certain visa/residency status indicating non-emergency immigration situations (such as family reunion, diversity and legalization, temporary visits) and were overweight or obese are the ones mostly at risk of excess GWG. This profile is similar to the profiles of 2nd generation and non-immigrants as it includes pre-pregnancy overweight/obesity. However, the effect of visa/residency status was unique to this group profile, which is not a relevant to other two groups as all those women are U.S. citizens from birth. There is evidence of immigrants with certain visa status are at risk of adverse health outcomes and at risk of obesity (Finch & Vega, 2003; Yeh, Parikh, Megliola, & Kelvin, 2016). According to the acculturation literature immigrants who came to the U.S. for financial opportunities or education generally have better SES and more interactions with the host society. This leads to higher levels of acculturation among this group of immigrants. Acculturation results in increased health deteriorating behaviors such as high caloric/junk food intake, alcohol use, smoking and reduction in protective effects of the original culture. These reasons could explain the high risk of excess GWG among this group. As explained previously, being overweight or obese could further increase this risk. This group of immigrants is the most likely to have health insurance and seek health care, therefore it is more convenient to design more targeted interventions to control excess GWG among this subgroup.

Women who immigrated to U.S. due emergency situations (such as fear of persecution in their native country, need protection due to an internal or external armed conflict or environmental disaster in their native country e.g. refugees or asylee), illegal border crossers and those came for permanent residency sponsored by the employer were

more likely to adhere to GWG recommendations. Immigrants who came to U.S. under emergency conditions are more likely to be much more impoverished than those who came for education, family members or financial gain. They tend to live in ethnic enclaves with minimal contact with the host society and are least likely to acculturate. Therefore, they retain most of the health protecting behaviors of the culture making them less susceptible to excess GWG. As explained by socio-ecological model, these two groups of first generation immigrants have different micro systems and interactions with their systems which could explain the difference in GWG.

Among second generation immigrants pre-pregnancy BMI was the most significant variable predicting excess GWG. The women who were most likely to exceed GWG recommendation were overweight or obese prior to pregnancy. As the health advantages observed among first generation immigrants explained by healthy migrant effect are reduced or lost by second generation, this group is already at risk of health complications. Due to acculturation, they may have lost some of the healthier behaviors common in their culture making them more susceptible to weight gain/obesity. So, compared to first generation, pre-pregnancy BMI is more important among second generation immigrants and should be advised to try to reduce weight prior to becoming pregnant.

As shown in Table 13, two profiles were identified for second generation immigrants who are more likely to adhere to GWG recommendations. Normal weight women with only high school education and normal weight women with college level education and above 33.5 years of age are the two groups who gain weight within the guidelines. The later profile is similar to what was identified with the total sample. Higher age and education could improve the advantage of being normal weight and lower risk of excess GWG. The better

GWG outcome among normal weight women with only high school education was interesting. In general women with higher education are more likely to have better SES and live in more favorable environments compared to women with lower SES who live in disadvantaged areas with obesogenic environment.

Among non-immigrant women, two main profiles were identified for women who were more likely to gain excess GWG. Overweight/obese women, having their first child, who did not plan the pregnancy, and did not reduce caloric intake during pregnancy and Non-Hispanic white overweight/obese women, having their first child, who did not plan the pregnancy, and reduced caloric intake during pregnancy are the two profiles. As majority of the current sample is non-immigrants, the profiles of women exceeding GWG recommendations in this group were similar to the total sample. Only difference was pregnancy intention of mother was included in the profile of women with excess GWG in non-immigrant group. Both profiles of non–immigrants included unplanned pregnancy as a characteristic predicting excess GWG. This is contradictory to Hickey et al. (1997) which showed that unplanned or mistimed pregnancy is associated with inadequate GWG. However, the effects of pregnancy intention on GWG are not much studied. Planning status of a pregnancy is associated with women's age, marital status, parity, education and poverty status (Kost, Landry & Darroch, 1998) and may affect maternal behaviors during pregnancy. Unplanned pregnancies may be more common among those with eating disorders; at least in part because irregular periods may interfere with the realization one is pregnant (Connan & Bhattacharya, 2012). Eating disorders such as binge eating, bulimia nervosa are common among overweight/obese women. These are shown to be associated with excess GWG and higher rates of weight gain during pregnancy (Zerwas et al., 2014; Park et al., 2015; Micali et

al., 2012). Pregnancy intention of mother could be linked to many factors associated with GWG, and there is a possibility that women with unplanned pregnancies need more counseling during pregnancy.

Among non-immigrant group, women who were more likely to adhere to GWG recommendations were normal/underweight women, did not plan the pregnancy, reduce salt intake and multiparous. As explained earlier, having lower BMI and being multiparous reduces the risk of excess GWG leading to more adherences to GWG recommendations. In contrast to the profile of excess GWG (among overweight/obese, primiparous women unplanned pregnancies predict excess GWG), unplanned pregnancies among underweight/normal weight multiparous women predict more adherences to GWG recommendations. The individual differences model of stress induced eating predicts that identifiable groups will differ in their eating when they are stressed. The individual differences in learning history, attitudes, or biology determine the effects of stress on eating (Greeno & Wing, 1994). Therefore, some women experiencing stress during pregnancy could eat less and have lower GWG, while another group of women with stress, experiencing stress induced overeating and gaining excess GWG.

An important finding from the CRT is that even though the normal weight women are at lower risk of excess GWG, some characteristics such as being a Hispanic or below 33.5 years of age or college level or more education slightly increased the risk of excess GWG. This result is important in prenatal counseling as generally normal weight women are not the target of GWG interventions. Concentrating on only one factor associated with GWG (e.g. BMI) in deciding who needs special counseling or interventions during pregnancy could eliminate certain groups of women who needs such care. The profile identified in the CRT

could be useful in targeting different groups of women at risk of excess GWG, which could lead to more success in reducing prevalence of excess GWG in U.S.

Strengths and limitations:

The data for the current study was taken from a nationally representative longitudinal data set that has been used for decades (McDonald et al., 2009; Smith, Bogin & Bishai, 2005; Wise et al., 2017; Ranchod et al., 2016). This sample had an adequate number of first generation and second generation immigrants with complete information to decide their immigration category. The sample also had an adequate number of women with pregnancy data to conduct this study. However, one limitation of this data set is that there was not enough sample size to further subdivide the first generation immigrants based on their length of residency, age at arrival or country of origin. There is evidence of country of origin, length of residency and age of arrival to U.S. is associated health outcomes among first generation immigrants (Alegria, Sribney, Woo, Torres, & Guarnaccia, 2007; Larouche, Ponette, Correa, & Krishnamurthy, 2010; Tsujimoto, Kajio, & Sugiyama, 2016), combining all foreign borne into single category might affect the accuracy of the results. Thus, the results of associations between country of origin, length of residency and age of arrival to U.S. with total GWG and risk of excess GWG added clarity to current results. Only Mexican origin was associated with total GWG among the first generation immigrants. Therefore, more studies are needed to understand the association between Mexican origin and GWG among pregnant women.

Another limitation is majority of the pregnancies were reported before 1990, but I used the most recent GWG recommendations from 2009 to determine excess GWG. Knowledge of GWG recommendations is a predictor of GWG (Ledoux, Berg, Leung, &

Berens, 2015) but the effect is very small. Also, the upper limits of GWG were established because it was discovered that pregnancy risks increase above that threshold regardless of when pregnancies occurred. Use of 2009 GWG recommendations improves the validity of the results as it gives a upper limit for GWG among obese women and use the WHO, BMI cutoffs.

The mode of data collection of the NLSY79 was an interview guided by a questionnaire. The interview format may reduce the number of missing values because the interviewer can probe and prompt and clarify items for the respondent. Providing the opportunity to conduct the interview in a language they are comfortable with improves the validity of the responses. Majority of the women were interested in the interview and cooperative, and except for about 7%, all other women had a good understanding of the questions asked in the survey which added to the accuracy of the data collected in the survey.

There is no published data to show that the survey questions used in the NLSY79 have been validated. All the height/weight measurements were self-reported. To improve the validity of collected data consistency edits were performed since 1982 on the fertility data. The responses to the questions from previous interviews were included in the subsequent interviews, so the interviewer could verify past information and update current information. This improved the consistency of responses across survey years. Ranchod et al., (2016) assessed the reliability of self- reported weights by comparing the pre-pregnancy weight data with the weight reported in the survey 1-2 years prior to the pregnancy and reported reasonable agreement. However, the GWG data could not be validated as there are no measured weight data available in this data set.

Another limitation in this study is that physical activity data were excluded from the analysis as those were available only for some of the survey years with a high percentage of missing values. The measure of dietary intake was poor as it was only 2 questions asking whether women reduced caloric intake during pregnancy and if reduced whether it was because of medical advice. There was no information on actual caloric intake. These maternal behaviors are important determinants of GWG and also might indicate differences among the three immigration groups. However, this is the first time studying GWG among different generations of immigrants and compare with natives using U.S. data. Future studies could use more recent data and include physical activity and dietary data.

Clinical implications:

It is important for clinicians to understand the differences between various generations of immigrants and non-immigrants. These differences are not limited to racial ethnic and cultural differences. There are SES differences including income, education and employment. These groups are also different in their health behaviors during pregnancy such as alcohol and smoking habits. The differences must be accounted for when providing prenatal counseling to future mothers of different immigration generations. The results also shows that immigrant mothers are more likely to smoke and drink during pregnancy than other two groups of mothers. These behaviors could create health complications to both the mother and the new born. Clinicians should provide more help for immigrant women to quit these behaviors and control weight during pregnancy. As explained earlier, pregnancy is a "teachable moment" for most women (Phelan, 2010) and they are more willing to make positive behavioral changes. Pregnancy is an oppurtunity to motivate women to quit smoking and harmful alcohol addictions. This could be recognized by the number of women who quit

drinking and smoking during pregnancy in this study. Majority of alcohol users and about 50% of smokers quit these behaviors during pregnancy. Therefore, specifically designed interventions or counseling programs for immigrant pregnant women to help quit substance use during pregnancy might be more effective than at any other period of life.

The current study found no evidence of differences in risk of excess GWG or total GWG among first generation, second generation immigrants and non-immigrants. The majority of all groups exceeded GWG recommendations. Therefore, all generations of immigrants should be provided with counseling regarding excess GWG, and should be given the opportunity to participate in interventions and prevention programs. Even though, normal weight and underweight women are at lower risk of excess GWG there are subgroups with lower BMI, who might be at risk of exceeding GWG recommendations. Normal weight women are generally considered a low risk group for excess GWG, so health care providers might not discuss weight gain or controlling behaviors leading to excess GWG with them. According to the CRT results certain groups of normal weight/underweight women are at a risk of exceeding GWG. These groups also should be targeted by healthy GWG interventions. In minimum, all pregnant women should be educated about the required GWG based on their pre-pregnancy BMI, nutritional requirement, engaging in regular physical activity, and risks associated with excess GWG.

Similar to most previous studies, pre-pregnancy BMI was related to excess GWG. Pre-pregnant overweight/obese women are consistently shown to be at risk of excess GWG even after controlling for SES, parity and race/ethnicity. The complication associated with excess GWG could be compounded with risks of high BMI (Stephansson, Dickman, Johansson, & Cnattingius, 2001). Dietary and PA interventions during pregnancy targeting

overweight/obese women during pregnancy have shown to be effective in reducing GWG but, still the majority of women exceed the GWG recommendations. One possible explanation might be that these interventions start late in first trimester or early second trimester and most women have already gained much weight by the time they start (Flynn et al., 2016). It is impractical to start these interventions much earlier as women are recruited for the interventions through pre-natal care, and most women starts maternity care late in their first trimester (Goldstein, Hons, Teede, Thangaratinam, & Boyle, 2016). Designing more pre-conception lifestyle interventions to motivate overweight/obese women to lose weight prior to pregnancy, through dietary and PA changes might limit the first trimester weight gain (Goldstein et al., 2016). Counseling women about adaptive eating behaviors such as intuitive eating at this stage in place of dietary restraints might also limit excess GWG as strict dietary control pre-pregnancy is associated with excess GWG. Women should be advised to continue the pre-pregnancy weight control efforts during pregnancy to prevent excessive GWG (Phelan, 2010).

Future Directions:

According to current study results there was no difference in the pre-pregnancy BMI among the three immigration groups. The healthy migrant effect states that first generation immigrants have better health status compared to the later generations of immigrants. More studies are required to investigate whether healthy migrant effect is true with respect to BMI and rates of obesity. As literature also states that healthy migrant effect seem to decrease with time in U.S., future studies should investigate whether the observed similarity between the different immigration groups are due to the length of residency in U.S. If this is true it will be important to identify how long the beneficial effects of immigration paradox retains among

first generation immigrants, when it starts to decline and what are the risk factors associated with health decline.

Another interesting result of this study was that, smoking and alcohol use during pregnancy was highest among first generation immigrant women. This is against the common belief that immigrants have better health behaviors during pregnancy. Smoking and alcohol use during pregnancy could cause major health consequences in the baby. Therefore, it is necessary to do more research on substance use during pregnancy with immigrant women of different origins and SES. It may be necessary to identify the leading causes for this behavior in these groups and then develop better programs to help immigrant women to quit smoking/alcohol use during pregnancy.

Similar to this study many studies have identified that pre-pregnancy BMI is a major risk factor for excess GWG. As explained in previous sections it is hard to reduce excess GWG among overweight and obese women just through interventions and counseling provided during the pregnancy period. Pre-conception interventions could be a missed opportunity in the efforts to reduce unhealthy weight gains during pregnancy. Future studies should look at whether pre-conception lifestyle interventions promoting healthy dietary and PA behavior among overweight and obese women are effective in reduce excess GWG among this group of women.

This study was conducted using the data from NLSY79 and most of the data are from survey years 1986-1990 and the first generation immigrants had come to U.S. by 1979. The characteristics of more recent immigrants in U.S. could be different than this sample. The pre-natal counseling and pregnancy related information these women received could be

different than the current situation. This might be a reason for not finding any difference in the GWG among the three immigration groups. Therefore future studies can evaluate this association among different generations of immigrants using more recent data.

There was no good measure of dietary intake and PA among pregnancy women, which are two major contributors to weight gain during pregnancy. If more comprehensive measure of diet (24 hr. dietary recall or food records etc.) and PA (accelerometer or physical activity questionnaire etc.) was used, we will be able to understand more about the behavioral differences among the three immigrations groups. Future studies should also include more specific PA data such as minutes of light PA, minutes of moderate to vigorous PA and dietary data such as total caloric intake, macro nutrient intake and diet quality data in CRT get a better profile of women at risk of exceeding GWG recommendations. This data will also be beneficial to understand what behaviors need to be changed through interventions targeting specific immigration groups in order control excess GWG.

This is the first time the association between immigration generation status and GWG is studied with a U.S. sample of women. Current study found no evidence of a difference in the GWG or risk of excess GWG among the three immigration groups. One limitation of this study was that first generation immigrants of different ethnic origins, levels of acculturation and length of residency were combined in to a single group. This could be a potential reason for not being able to detect any significant differences. Future studies need to look at this relationship for Hispanic immigrants, Asian immigrants and African immigrants separately comparing them with their 2^{nd} generation and U.S. natives. In these studies, recent immigrants and immigrants being in U.S. for more than 10 years should also be considered

as two different groups of immigrants and the level of acculturation should be controlled for in the analysis.

The characteristic profiles identified by the CRT showed that among non-immigrants, women who are more likely to exceed GWG recommendations have a profile that may reflect higher levels of stress. The effects of parity, pregnancy intention and stress on GWG have not studied much. More studies are needed to understand how these individual variables and variable in combination are related to GWG. Interestingly among both 1st and 2nd generation immigrants, characteristics that may be associated with stress were not identified in their profiles as related to excess GWG. Different cultures and ethnic groups might have different stress management and coping mechanisms which needs to be studied more.

Conclusions:

Findings from this study shows that immigration groups in the current study were different on their racial/ethnic composition, employment status, and marital status and education levels. The groups also were different in their smoking and alcohol consumption prior to and during pregnancy. However, after controlling for the effects of BMI, parity, race/ethnicity, income and interview language there were no differences in the total GWG among the three immigration groups. Also, there was no difference in the risk of exceeding GWG recommendation between the three immigration groups. The CRT analysis showed that among the total sample those who were most likely to gain excess GWG were white, had not reduced calorie intake during pregnancy, pregnant with first child, and were overweight or obese before pregnancy. Among the first generation immigrants, those who are overweight and obese and immigrated to U.S. with certain visa or residency status that may indicate they

immigrated to the US under non-emergency conditions are more likely to exceed GWG recommendations. Among second generation immigrants those who are overweight and obese are the most likely to have excess GWG. Finally among non-immigrants, those who were most likely to exceed GWG were overweight/obese, primiparous, and have an unplanned pregnancy. In addition, for non-Hispanic, white women, attempts to reduce calorie intake during pregnancy added to excess GWG risk. For all other racial/ethnic non-immigrant groups, a failure to reduce calorie intake during pregnancy was a risk for excess GWG. Perhaps disinhibited eating or loss of control tendencies explains these differences.

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