VARIATION AND CONVERGENCE IN EDUCATION GRADIENT ON FEMALE IMMIGRANTS' OVERWEIGHT IN THE UNITED STATES: CONCERNS OF PRE-MIGRATION CONTEXTS AND ASSIMILATION

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Haram Jeon

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The dissertation of Haram Jeon was reviewed and approved* by the following:

David P. Baker
Professor of Education and Sociology
Dissertation Advisor
Chair of Committee

Katerina Bodovski
Associate Professor of Educational Theory and Policy

Soo-yong Byun
Assistant Professor of Educational Theory and Policy

Jennifer Van Hook
Professor of Sociology and Demography

Gerald K. LeTendre
Professor of Education and International Affairs
Head of the Department of Education Policy Studies

*Signatures are on file in the Graduate School
ABSTRACT

Education is widely believed to relieve the increasing risk of obesity among Americans by enhancing cognitive decision-making ability for choosing health foods and lifestyles. However, despite the common belief on the effect of education on enhancing health, recent comparative research reported that the association between education and obesity, especially in developing countries, was mixed largely due to different population contexts from developed countries.

The moderating effects of population contexts on the association between education and the likelihood of being overweight were examined for female foreign-born immigrants in the United States. Previous research focused on different national development level of the countries of origin as a key indicator causing the variation of education-overweight gradient among immigrant population. However, preexisting studies lack the detailed information on different contributions to moderating education gradient by specific national indicators.

Distinguished from the previous literature, different moderating effects on education gradient by various measures for pre-migration environment were highlighted, using the national-level indicators: life expectancy, national level of educational expansion, GDP per capita, and national nutrition transition status. As a result, while life expectancy and GDP per capita in pre-migration settings were not statistically significant to predict the likelihood of being overweight among immigrant population and the variation of education gradient, educational expansion level and nutritional status had significant moderating effects on education gradient on overweight.

In addition, it was observed that the patterns of convergence were slightly different by national moderators. After the arrival at the United States, less educated immigrants from the
origin countries with the lower level of nutrition transition became much more vulnerable to the risk of being overweight. In pre-migration settings, they were uniquely protected from weight gains because of less prevalence of energy-dense foods, regardless of educational attainment. However, after their arrival at the United States, they were forced to accept westernized diet styles consisting of high animal fat and sugar/sweeteners and less educated people became more extremely disadvantaged in keeping healthy body shapes. On the contrary, there was no significant pattern of convergence of the moderating effect of national level of education expansion.
# TABLE OF CONTENTS

LIST OF FIGURES ........................................................................................................................................... vii

LIST OF TABLES .................................................................................................................................................. viii

Chapter I. INTRODUCTION ................................................................................................................................. 1

Chapter 2. LITERATURE REVIEW ...................................................................................................................... 5

The Role of Education in the Obesity Epidemic ............................................................................................... 5

Causes of the Obesity/Overweight Epidemic and its Social Impact ................................................................. 5

Education Effect on Health .................................................................................................................................. 6

Education Effect on Reducing Obesity/overweight .......................................................................................... 10

Population Contexts in the Country of Origin and Education Gradient on Obesity ......................................... 12

Education Gradient Differentials by Population Contexts ........................................................................... 12

Nutrition Transition: The Key Determinant of Obesity Epidemic ................................................................. 14

Educational Expansion: Increasing Educational Inequality and the Increased Role of Education in Health ........................................................................................................................................... 17

Immigrant Population: Varying Contexts by the Country of Origin and Health Assimilation .......................... 18

Pre-migration Context in the Country of Origin and the Education-Obesity Gradient .................................... 20


Limitations in preexisting literature .................................................................................................................. 24

Hypotheses ......................................................................................................................................................... 25

Chapter 3. METHOD .......................................................................................................................................... 27

Data ................................................................................................................................................................. 27

Variables ............................................................................................................................................................ 28

Dependent Variable ......................................................................................................................................... 28

Independent Variable...................................................................................................................................... 29
Moderator Variables .................................................................................................................. 29
Control variables ..................................................................................................................... 32
Analytic Strategy ..................................................................................................................... 34
Design effects and multiple imputation of missing data ......................................................... 38
Chapter 4. RESULT .................................................................................................................. 39
Descriptive Statistics .............................................................................................................. 39
Association between Education and Overweight Status ....................................................... 41
Two-way Interactions between Education Gradient and Pre-migration Environment ........... 44
Three-way Interactions: Change in Moderating Effects of Pre-migration Environment over
Time of US residence ............................................................................................................. 49
Chapter 5. DISCUSSION .......................................................................................................... 53
Summary of Main Findings ...................................................................................................... 55
Theory and Policy Implications .............................................................................................. 56
Education as a Social Vaccine among Female Immigrants .................................................... 56
Imported Gradient and Pre-migration Contexts: Different Mechanisms of Interaction .......... 57
Assimilated Gradient and Reduced Effects of Pre-migration Contexts ................................. 59
Limitations and Recommendations for Future Research ..................................................... 60
REFERENCES .......................................................................................................................... 62
LIST OF FIGURES

Figure 2. 1. Moderating Role of Population Contexts in the Effect of Educational Attainment on Reducing Likelihood of Obesity ......................................................... 14

Figure 2. 2. Convergence of Education Gradients by Assimilation ........................................... 23

Figure 3. 1. Cross-national Comparison of NT Status by the Countries of Origin and the United States (1961-2003) .............................................................................................................. 30

Figure 3. 2. Cross-national Comparison of Average Schooling by the Countries of Origin and the United States (1961-2003) .............................................................................................................. 32

Figure 4. 1. Interaction between Education and National NT Status ............................................. 46

Figure 4. 2. Interaction between Education and National Average Schooling ............................... 48

Figure 4. 3. Change of Interaction Effect of NT Status ................................................................. 51
LIST OF TABLES

Table 4. 1. Descriptive Statistics.................................................................................................................. 41

Table 4. 2. Weighted Logistic Regression Estimate on Overweight Status among Female Foreign-born Immigrant aged 25 or more ................................................................. 44

Table 4. 3. Two-way interactions: Educational Attainment and Population Contexts among Foreign-born Immigrants........................................................................................................ 45

Table 4. 4. Three-way interactions: Educational Attainment, Population Contexts and US Residence among Foreign-born Immigrants...................................................................................... 50
Chapter I. INTRODUCTION

The obesity rate among Americans has increased to over thirty per cent and is now a serious concern for health policy in the United States (Singh, Siahpush, Hiatt & Timsina, 2011; Taubes, 1998). In order to relieve the risk of obesity and concomitant diseases, such as type 2 diabetes, researchers have paid attention to the role of formal education due to its significant association with reducing the likelihood of obesity by enhancing an individual's cognitive decision-making ability for choosing healthy foods and understanding the benefits of exercise, as well as the effect of income by more educational attainment (Cutler & Lleras-Muney, 2006; Feinstein, 2002; Krieger, Williams & Moss, 1997; Mirowsky & Ross, 2003; Sassi, Devaux & Church, 2009; Winkleby, Jatulis, Frank & Fortmann, 1992).

Despite the common belief on the effect of education on enhancing health, recent research reported that the association between education and obesity, especially in developing countries, was mixed largely due to different population contexts from developed countries, such as the United States (Jeon, Salinas & Baker, 2014; McLaren, 2007). First of all, education did not necessarily play a protective role in reducing the likelihood of obesity under the early and intermediate stages of nutrition transition status characterized with low consumption of energy-dense foods (e.g., animal fat, sugar/high-caloric sweeteners) (Jeon et al., 2014). Rather, education acts like a risk factor because the obesity-related knowledge and information has not been diffused to the public and the traditional norm of a fat body as a symbol of wealth has added to the confusion in the society with under-nutrition (Kain, Vio, & Albala, 2003; Martorell, Kahn, Hughes & Grummer-Strawn, 1998; Martorell, Kahn, Hughes & Grummer-Strawn, 2000; Monteiro, Conde, Lu & Popkin, 2004). Secondly, the level of educational expansion may have
had an impact on variation in the role of education. In terms of the effect of national expansion of education on population health, countries with better-educated people showed better health indices because they make more informed health choices (Etile & Jones, 2011; Hannum & Buchmann, 2004). Meanwhile, educational expansion showed the significant association with increasing educational inequality among the underprivileged population excluded from the formal schooling (Etile, 2014; Ram, 1990). In other words, the level of education expansion as a significant population context can differentiate the degree of health disparity by educational attainment and of cognitive gains accumulated by schooling.

To show the moderating effect of two population contexts on the education-obesity association, foreign-born immigrants in the United States are selected because their pre-migration environment varies by their countries of origin and the length of their residence in the United States after first migration. In addition, the consideration of population contexts can be a key to understand the so-called “imported gradient” in obesity and other health outcomes (Buttenheim, Goldman, Pebley, Wong & Chung, 2010; Frank & Akresh, 2013). Primarily, this research focuses on finding new moderator directly related to the education-obesity association, after adjusting for the economic development index.

Immigrants experience differing population contexts between their lives in the United States and in their countries of origin (Berry, 1997). Therefore, the contextual differences in the education gradient may disappear over time of residence in the United States because immigrants become increasingly assimilated to the mainstream society in which over-nutrition is rampant but formal education is saturated. The assimilation effect may make the education-obesity association among foreign-born immigrants similar to that of the US-born population. This produces the immigrant assimilation to a steeper education gradient (i.e., a less-educated
population becomes more vulnerable to increased obesity and a more-educated population becomes relatively more protected against over-nutrition) (Frank & Akresh, 2013; Kaplan, Huguet, Newsom & McFarland, 2004). If the assimilation effect is significant, the moderating effect of pre-migration contexts on varying education gradient will become negligible as they live more years in the United States.

Previous research focused on different national development level of the countries of origin as a key indicator causing the variation of education-overweight gradient among immigrant population. However, although they showed the important message about national contexts in the research of the association between education and health, those research lack the detailed information on different contributions to moderating education gradient by specific national indicators. Distinguished from the previous literature, this study will highlight those different moderating effects on education gradient by various measures for pre-migration environment. In addition, it will examine the patterns of convergence of education gradient by national moderators. Using the New Immigrant Survey (NIS) 2003, the following three research questions will be answered by this study.

(1) Among foreign-born adult immigrants, does educational attainment have an effect on reducing the likelihood of being overweight?

(2) Do the different levels of nutrition transition and educational expansion in the country of origin at the time of migration moderate the varying education gradient on the likelihood of being overweight?
(3) Does the length of US residence assimilate immigrants’ varying education gradients by pre-migration contexts into a steeper gradient between education and the likelihood of being overweight?
Chapter 2. LITERATURE REVIEW

The Role of Education in the Obesity Epidemic

_Causes of the Obesity/Overweight Epidemic and its Social Impact_

The increasing prevalence of obesity has been a major concern for health policymakers in the United States not only because of its close correlation with the risk of coronary heart disease, ischemic stroke and type 2 diabetes mellitus, but also because it has been implicated in the development of cancers of the breast, colon, prostate, endometrium, kidney and gall bladder (Feinstein, Sabates, Anderson, Sorhaindo & Hammond, 2006). The World Health Organization (WHO) has already designated obesity/overweight as one of the top seven health risky behaviors in contemporary society along with tobacco use, alcohol use, low fruit and vegetable intake, lack of physical activity, illicit drug use, and engaging in unsafe sex (Feinstein, 2002).

With all health concerns associated with an increasing prevalence of obesity in the United States, researchers have tried to shed light on what factors causes obesity and how obesity can be reduced (Singh et al., 2011; Taubes, 1998). Direct factors contributing to the spread of obesity have already been widely investigated; in addition to genetic factors, an unhealthy lifestyle of excessive caloric intake and sedentary inactivity has been reported as the main causes linked to obesity (Rigby, Leach, Lobstein, Huxley & Kumanyika, 2009). Meanwhile, the social impact caused by socioeconomic status (SES) implies an association between social inequality and health disparity, because SES is inversely related to increasing rates of obesity/overweight (Devaux & Sassi, 2011; Jeffrey & French, 1996; McLaren, 2007; Rigby et al., 2009). Likewise,
as one of the significant components in measuring SES, unequal distribution of formal educational attainment is also closely associated with the different likelihood of being obese/overweight (Cutler & Lleras-Muney, 2006; Feinstein et al., 2006; Sassi et al., 2009). In addition, the effect of education gives an implication on how to protect individuals from the risk of obesity and concomitant diseases. This is because more years of formal schooling itself has been demonstrated to significantly reduce the likelihood of obesity even without any further special intervention program (Feinstein, 2002; Feinstein et al., 2006; Rigby et al., 2009; Sassi et al., 2009). The mechanism for the association between higher educational attainment and decreased likelihood of being obese/overweight will now be described more fully along with a detailed explanation on the role of education in population health.

**Education Effect on Health**

Increased educational attainment has been widely believed to promote better health for individuals, such as longer life expectancies and lower morbidity rates (Adams, 2010; Baker et al., 2011; Cutler & Lleras-Muney, 2006; Mirowsky & Ross, 2003). However, it is controversial to interpret this as simply a positive relationship between education and health. Some studies assumed that education is a proxy measure for SES (Desai & Alva, 1998; Elo, 2009; Krieger, Williams & Moss, 1997; Winkleby et al., 1992), whereas others suggested that the net effect of education is substantial to improving health, even after controlling for other components of SES (Baker et al., 2011; Cutler & Lleras-Muney, 2006; Mirowsky & Ross, 2003). While the former argument relies on that the effect of education is mostly mediated by wealth, occupation and social status, the latter focuses more on the development of cognitive skills raised by more
formal schooling (Baker et al., 2011; Card, 2001; Culter & Lleras-Muney, 2006; Krieger et al., 1997; Mirowsky & Ross, 2003).

*Education as a proxy indicator for SES*

Although SES is measured by the combination of income, occupation and education, many health researchers assumed education as a single proxy indicator of SES because of high reliability and validity with cost-time efficiency in collecting information (Winkleby et al., 1992). Indeed, the most widely used indicator of socioeconomic position in US public health research is education (Krieger et al., 1997). Educational attainment is also widely used to measure SES in developing countries because of a lack of information on income, wealth and occupation (Desai & Alva, 1998; Elo, 2009). This is not only due to an ease of measurement for this indicator, but also because of the close relationship between education and future status attainment including occupation and income (Cutler & Lleras-Muney, 2006; Krieger et al., 1997; Winkleby et al., 1992). In addition, higher occupational status and higher income as gains of educational attainment account for some of the relationship between education and health (Mirowsky & Ross, 2003). In terms of an economic explanation in the education-health association, more education results in greater resources including access to better health care due to the labor returns to education (Cutler & Lleras-Muney, 2006; Ross & Wu, 1995). Since highly educated people are likely to receive more income from their occupations, their disposable amount of income provides them with easier access to the health care system. In addition, prestigious occupations for the educated offer better health insurance and a safer work environment (Cutler & Lleras-Muney, 2006). However, despite the causal effect of education on economic earnings and social position (Card, 2001), economic and social explanations only accounted for about 30 percent of
the education-health association (Cutler & Lleras-Muney, 2010). This partial explanation necessitates further exploration on why education improves health, in terms of the net effect of education independent from other SES indicators.

*Net Effect of Education: Improvement of cognitive skills and health knowledge*

In previous research, empirical findings on the relationship between education and health reported significant effect of education, even after controlling for other SES indicators, such as income. The net effect of education has been explained mainly by enhanced knowledge and cognitive skills by which educated people are likely to be more aware of health issues (Cutler & Lleras-Muney, 2006; Mirowsky & Ross, 2003), to have better self-management of diseases (Goldman & Smith, 2002), to better understand the exact nature of a health production function (Altindag, Cannonier & Mocan, 2011; Cohen, 2006; Grossman, 2006), and to have better and faster access to health-related information (Cutler & Lleras-Muney, 2006). The development of cognitive skills by schooling is derived from human capital theory (Becker, 1964; Ross & Mirowsky, 1999). According to human capital theory, schools teach students to improve useful skills for their lives and society, and students can achieve more human capital with more years of schooling (Becker, 1964). The skills acquired from schooling are divided into two categories: job-specific skills and cognitive skills. While job-specific skills are directly limited to getting a job in the future, cognitive skills with its comprehensive, flexible, rational, and complex strategies of thinking can be generalized more broadly to a multitude of diverse issues to which people face in society (Hyman, Wright & Reed, 1976; Spaeth, 1976). Principally, the development of cognitive skills from schooling is closely related to thinking logically with an
increased ability to analyze information related to wide-ranging issues and problem solving (Kohn & Schooler, 1982).

Ross and Mirowsky (1999) connected increased education to improved health based on the effect of cognitive skills required for self-control from the risk against unhealthy lifestyles. More educational attainment is associated with a sense of personal control (Pearlin, Menaghan, Lieberman & Mullan, 1981; Ross & Mirowsky, 1999). The concept of self-control became increasingly linked to improving health during a twentieth century that was characterized by a rapid increase in life expectancy. In this century, the entire human species experienced a shift in disease pattern from infectious and parasitic diseases to chronic diseases such as heart disease and cancer; this shift is referred to as an epidemiologic transition (Omran, 1971). The new prominence of degenerative causes of death created a paradigm shift in our thinking of how to promote health; a healthy life can now be acquired through one's ability for self-regulation from avoiding from risky behaviors and engaging in health-enhancing behaviors (Olshansky & Ault, 1986; Omran, 1971; Ross & Mirowsky, 1999). For example, people learned how to improve their health by quitting smoking, drinking less, eating more fruits and vegetables, and doing more exercise. The selection of health-enhancing behaviors results from the complex and logical strategies associated with the understood information on well-being and health (Ross & Mirowsky, 1999). In other words, educated people can gather more information related to health to summarize, synthesize, and interpret for how to better protect themselves from engaging in risky behaviors. The processing of health-related information is closely related to human capital accumulated by schooling because formal education deals mainly with communication skills such as reading, writing, inquiring, discussing and reasoning (Baker et al., 2011; Peters, Baker, Dieckmann, Leon & Collins, 2010; Ross & Mirowsky, 1999). In this vein, Renkert and Nutbeam
(2001) defined the cognitive skills related to health protection as one's health literacy. They explained that health literacy is the combined cognitive and social skills that allow individuals to gain access to, understand, and use information to promote and maintain their healthy lives. In addition, education can hone health literacy by improving one's capacity to use available health information more effectively.

**Education Effect on Reducing Obesity/overweight**

Like the education-health association, more educational attainment has been reported to be associated with a lower likelihood of obesity (Baum & Ruhm, 2009; Brewis, 2011; Cohen, Rai, Rehkopf & Abrams, 2013; Devaux & Sassi, 2011; Devaux, Sassi, Church, Cecchini & Borgonovi, 2011; Galobardes, Morabia & Bernstein, 2000; Kushi, Lenart, & Willet, 1995; Ogden, Lamb, Carroll & Flegal, 2010; Sobal, 1991; Sobal & Stunkard, 1989; McLaren, 2007). The relationship between higher educational attainment and lower likelihood of obesity/overweight has been also explained by two roles of education: a proxy measure for SES and a role in enhancing health knowledge. The more people attained education, the higher they are likely to earn more incomes and buy more healthful foods. On the contrary, lower educated individuals who with insufficient income are more vulnerable to be exposed to cheap, processed and energy-dense foods (Devaux et al., 2011; Ogden et al., 2010). However, many scholars in obesity research focused on the role of education in improving health knowledge related to individuals' increased ability to control their weight gain by avoiding unhealthy lifestyles including excessive calorie intake, after controlling income and social positions. Specifically, those with more than a college degree more frequently reported that they paid a lot amount of
attention to nutritional information from scientific experts (Pampel, Krueger & Denney, 2010). Similarly, education was reported to reduce obesity prevalence by shaping knowledge about diet, physical activity, and the negative health effects of obesity (Ball & Crawford, 2002). Better self-control from the risk of obesity is a significant characteristic among the educated people. Since educated people are more aware of information related to the health risks of obesity (Kan & Tsai, 2004) and more attentive to the social stigma associated with an obesity/overweight status, particularly among women (Jeffery & French, 1996), they tend to have a more rigorous attitude on weight control practices. Sassi et al. (2009) asserted that there are three main factors determining the positive effect of education on reducing obesity: (a) greater access to health-related information; (b) clearer perception of the risks associated with lifestyle choices; and, (c) improved self-control.

When it comes to gender difference in the education effect on obesity/overweight, the education effect on reducing weight gain was shown to be more significant among women (Jeffery & French, 1996). Yoon et al. (2006) found that income had a greater effect on Body Mass Index (BMI) among men, whereas higher levels of education were closely related to lower BMI among women. The gender difference was interpreted by the tendency that women are generally more sensitive to physical attractiveness by thinness, and education makes them more aware of body dissatisfaction (Jeffrey & French, 1996; McLaren & Kuh, 2003).
Population Contexts in the Country of Origin and Education Gradient on Obesity

Education Gradient Differentials by Population Contexts

Education and health literacy are potentially important factors for controlling obesity/overweight prevalence due to their role as a social vaccine that assist individuals and communities to improve health outcomes (Baker et al., 2011; Peters et al., 2010; Vandemoortele & Delamonica, 2000). Consistent with this role, research in developed countries has reported significant effect of education on reducing individual risk of being overweight, most notably for women (Feinstein, 2002; Feinstein et al., 2006; Gutierrez-Fisac, Regidor, Banegas & Artalejo, 2001; Kan & Tsai, 2004; McLaren, 2007; Sassi et al., 2009; Sobal & Stunkard, 1989). International obesity research, however, reported the cross-national differences in the educational gradient on the likelihood of being overweight (Molarius, Seidell, Sans, Tuomilehto & Kuulasmaa, 2000; Roskam et al., 2010). Furthermore, an inverse relationship was found particularly for low- and middle-income countries, where the more educated are often more likely to be overweight (Hook et al., 2012; Kain, Vio, & Albala, 2003; Martorell et al., 1998; Martorell et al., 2000; Monteiro et al., 2004). Martorell et al. (1998) showed that better educated individuals were more likely to be obese in the poorest countries in Latin America – Haiti, Guatemala and Peru. Martorell et al. (2000) also reported that, in the poorest countries such as in Sub-Saharan Africa, obesity was concentrated in urban areas and more prevalent in highly educated women.

On the basis of comparative and international perspectives, the effect of education on health varies by population contexts even among the countries with similar levels of economic development (Baker et al., 2011; Beckfield & Olafsdottir, 2008). In terms of the varying education gradient on obesity, researchers are increasing attending to the moderating effect of population contexts especially in the developing countries. Despite the importance of national
economic index in health studies (i.e., GDP per capita), the economic difference did not fully address education gradient differentials in the obesity epidemic. This is because life styles and nutritional status directly related to obesity, such as ideal body image, diet style, and physical activity are also determined by non-economic and cultural contexts (Brewis, 2011; McLaren & Kuh, 2004; Popkin, Horton & Kim, 2001). In addition, the education gradient on obesity may be influenced by the national quality of formal education. This is not only because national educational expansion enhances a population's health by providing the potential for more informed health choices (Hannum & Buchmann, 2004), but because less schooled populations are more disadvantaged by lack of schooling in the countries in which formal schooling is highly saturated (Etile, 2014; Ram, 1990).

To understand the moderating role of population contexts shown in Figure 2.1., the two population contexts related to education-obesity association will be more addressed in order to support the theoretical framework on the varying education gradient by pre-migration environment. Nutrition transition status will first be introduced as a key determining factor in establishing the obesity epidemic and national concerns about the risk of obesity. Secondly, national educational expansion is introduced to explain increasing educational inequality among the lowest strata and the reinforced role of education under national environments with widespread formal schooling and increased quality of education.
**Nutrition Transition: The Key Determinant of Obesity Epidemic**

According to the theory of epidemiological transition, health-risk behaviors or chronic diseases are not familiar to the population facing earlier stages in the transition than they are at the final stage where degenerative causes of death become more widespread (Omran, 1971; McLaren, 2007; Smith, Anderson, Horvatek, Salinas & Baker, 2014). In addition, the health-risk behaviors in the advanced society matter beyond absolute conditions for survival; these behaviors were believed to the matters of preference and also symbols of wealth, such as sex with multiple partners, alcohol consumption, cigarette use, or overeating (Baker et al., 2011; Cogan, Bhalla, Sefa-dedeh & Rothblum, 1996; De Walque, 2004; McLaren, 2007). In earlier stages in the epidemiological transition, education has a modest effect on enhancing health due to two reasons; (1) education increases material and economic gains for greater access to preferences and over-nutrition as images of high status (McLaren, 2007; Pampel & Denney, 2011); and (2)
cognitive skills for self-regulation does not help to enhance an individual's health because of the lack of information provided on why individuals have to control their health-risk behaviors (Baker et al., 2011; Peters et al., 2010). For example, when it comes to the avoiding behaviors that lead to disease or other health risks, such as those behaviors associated with contracting HIV/AIDS or smoking, higher educational attainment in developing countries has been observed as a risk factor for poor health (Baker, Leon & Collins, 2010; Pampel & Denney, 2011). However, the effect of education became positive to improve health after the information related to the behaviors was widespread enough with increasing prevalence of the health risks (Cutler & Lleras-Muney, 2006; de Walque 2004; Fortson, 2008; Pampel & Denney, 2011).

Similarly to epidemiological transition and contextual explanations on the education-health association, nutrition transition (i.e., how many calories individuals take in and which foods they select for consumption) has been considered an important population context for explaining the relationship between educational attainment and obesity epidemic (Jeon et al., 2014; Popkin, 1993). In fact, nutrition transition and related to nutritional knowledge in a society are directly related to increases in obesity prevalence across national contexts. In addition, national nutrition transition status reflects economic development, cultural values in diet, globalization in food market and urbanization (Brewis, 2011; McKay, 2004; Popkin, 2001; Swinburn et al., 2011). Thus, nutritional status gives more detailed and specific contextual information related to obesity epidemic in a country.

Indeed, the emerging obesity epidemic in Latin America, Asia and other developing and middle-income countries, is the result of the intensive changes in their food environments and diet styles associated with nutrition transition (Mendez, Monteiro & Popkin, 2005). Popkin (1999) defined the transition from traditional to contemporary nutritional patterns as a process
with several stages. In the early stages, people had diet styles low in fats and high in cereals and often suffered from nutritional deficiency (i.e., famine) due to the low development of their food supply technologies (i.e., hunting, gathering food, low level agricultural skills in self-sufficient economy). In intermediate stages, nutritional status consisted of more fat, especially from animal products, sugar and processed foods, which caused degenerative diseases such as obesity. Lastly, in the more advanced and final stages, people in the developed countries try to change their diet style to reduce body fat levels through taking in less fat and processed food, while eating more fruits and vegetables. Large shifts towards the intermediate and advanced stages occurred in the last several decades of the 20th century as more societies experienced the ‘Western diet’ (i.e., consumption of animal fats, sugar, and refined foods that were low in fiber) which led to changes in average stature, body composition, and morbidity (Popkin & Gordon-Larsen, 2004).

The nutrition transition to a westernized diet style not only increases the prevalence of obesity in the whole population (Popkin & Gordon-Larsen, 2004), but it also changes the education-obesity relationship (Jeon et al., 2014). Jeon et al. (2014) empirically analyzed the moderating effect of nutrition transition at the population level on the relationship between educational attainment and mothers’ likelihood of being overweight in Latin American and Caribbean countries, using the Demographic and Health Survey (DHS) data. As a result, as national nutrition transition status developed with a greater access to a westernized diet consisting of animal fat and sugar/sweeteners, the education effect on reducing the likelihood of being overweight became much greater even among the least educated women. The empirical study showed that the rapid changes brought about by the nutrition transition in a country, and the extent to which education eventually plays a preventive factor on being overweight are highly contextualized by population level dynamics.
Educational Expansion: Increasing Educational Inequality and the Increased Role of Education in Health

Educational expansion in a society is another population context in the relationship between education and obesity. It is believed to a result in improving economic welfare, social well-being and the health of individuals in those societies (Becker & Hadjar, 2009; Hannum & Buchmann, 2004). In terms of the effect of national expansion of education on population health, countries with better-educated people showed longer life expectancy, lower infant mortality, and lower morbidity, because their populace had an increased capacity to make more informed health choices (Hannum & Buchmann, 2004; Etile & Jones, 2011; Jurges, Reinhold & Salm, 2011). Thus, the national average of educational attainment can indicate the average level of population health with lower BMI and lower prevalence of obesity/overweight.

The national level of educational expansion is also related to education gradient in health, as well as the aggregate level of population health. First of all, educational expansion is moderately associated with increasing educational inequalities (Etile, 2014; Ram, 1990). Ram (1990) found that educational inequalities first increases as the average level of schooling increases, based on data from approximately 100 countries. Regarding educational inequalities in obesity, Etile (2004) conducted an empirical analysis on the changing inequalities in BMI by education among French population from 1981 to 2003. Considering historical increase of educational expansion during last two decades in France, the analysis showed that, while educational expansion reduced the overall inequalities in BMI by the increasing proportion of
better-educated people, education gradient in BMI became steeper because of the increase of relative loss among disadvantaged population who cannot benefit fully from higher education.

Secondly, national average in educational attainment has used as an indicator of the overall quality of formal schooling (Barro & Lee, 1996; Baker et al., 2011). Since the quality of formal schooling results in the increasing effect of education on social outcomes, the average years of schooling can serve as a significant population context affecting the education gradient in health including the likelihood of being obese/overweight (Baker et al., 2011).

**Immigrant Population: Varying Contexts by the Country of Origin and Health Assimilation**

Immigrants represent an interesting population in health research because they experienced very different contexts between their countries of origin and the United States (Berry, 1997). Indeed, immigrants often hold on to their cultural values as they adjust to the different cultural environment that they encounter in the United States. In population health, immigrants preserving the cultural values of their homeland are sometimes at an advantage for being healthier than those individuals who were born in the United States, in spite of better contextual conditions for health, such as better medical care systems. This is referred to as the immigrant paradox (Jasso, Massey, Rosenzweig & Smith, 2004; Kaplan et al., 2004). For example, Hispanic immigrants' health levels were reported to be much better than those of US-born Hispanics and even those of non-Hispanic whites, although they share similar socioeconomic status (Jasso et al., 2004). When it comes to obesity, body mass index (BMI) and obesity vary by the country of origin, but BMI among first-generation immigrants is lower than for later generations born in the United States (Bates, Acevedo-Garcia, Alegria & Krieger, 2008). The
paradoxical phenomenon is interpreted by the cultural buffering effect of immigrant families (i.e., lower rates of risky health behaviors, such as smoking and being overweight, in the country of origin). It is closely related to better health conditions among immigrants from these countries, compared to US-born population (Antecol & Bedard, 2006; Brewis, 2001; Cunningham, Ruben & Narayan, 2008; Jasso et al., 2004). In other words, the pre-migration environment has an impact on determining immigrants’ health status including weight gain.

Despite the apparent protective factors of the immigrant paradox for new arrivals, assimilation to the new environment in the United States has been reported to make the paradoxical phenomenon diminish over time. Jasso et al. (2004) argues that the protective cultural buffering began to fade away with increased assimilation to the US norm. They also reported this deterioration became more severe among second- and third-generation immigrants. Kaplan et al. (2004) also showed that newly arrived Hispanic immigrants are generally healthier than the U.S. born population, but this advantage tends to diminish over time with assimilation to the new sociocultural environment. The deterioration of health outcomes caused by assimilation is consistent with the critique against the assumption that it is simply desirable to assimilate into mainstream population of the country of destination (Rumbaut, 1997). In other words, the assimilation does not necessarily benefit immigrants because they become similar to both positive and negative aspects of dominant group in the place of destination. The harm effect of assimilation is especially well documented with the increase of obesity prevalence among immigrants converging to the level of the US-born population (Antecol & Bedard, 2006). Antecol and Bedard (2006) found that so-called “healthy immigrant effect” eroded over time after arrival in the United States for immigrants who assimilated to unhealthy American BMI levels. Other research also reported that the more years foreign-born immigrants live in the
United States, the higher their BMI became (Akresh, 2007; Kaplan et al., 2004; Goel et al, 2004). They pointed out their adoption of the unhealthy dietary practices and sedentary lifestyles found in the United States (Akresh, 2007; Antecol & Bedard, 2006; Kaplan et al., 2004).

**Pre-migration Context in the Country of Origin and the Education-Obesity Gradient**

Prior to assimilation, immigrants not only have a difference in the prevalence of obesity, their pre-migration environments may also exhibit a difference in the extent of education effect on obesity. First of all, preexisting studies have pointed out the differential effects of the education gradient between immigrants and US population on several health outcomes. Kimbro et al. (2008) analyzed the differential effects of education on six health outcomes between a foreign-born population and their native-born counterparts in the United States: current smoking, heavy drinking, work limitations, obesity, self-reported health, and low physical activity. As the result of those analyses, the education gradient tended to be generally flatter in the foreign-born population than in the native-born population. They also maintained that the smaller differences among heterogeneous groupings of educational attainment may be due to the better health outcomes among lower educated immigrants. Additionally, Buttenheim et al. (2010) also reported that adults of Mexican-origin in the United States had a weaker or flatter education gradient in health, compared to the steep gradient noted for non-Hispanic whites.

In order to explain the flatter gradient of education in health among immigrant populations, comparative perspectives addressed the idea that the national contexts of the country of origin may limit the role of education for improving health (Baker et al., 2010; Buttenheim et al., 2010; Kimbro et al., 2008; McLaren, 2007). Different sociocultural
environments may differently organize the relationship between education and health. For example, smoking and obesity has been more prevalent among more educated people in Mexico and other Latin American countries than among less educated people affecting their immigrants' education gradient (Buttenheim et al., 2010; Kimbro et al., 2008). A so-called "imported gradient" shows the moderating effect of population context on the education gradient (Buttenheim et al., 2010). McLaren (2007) showed that the education gradient on obesity, varied by a country's national development index. In these studies, developed countries with more educational attainment by its citizens reduced the likelihood of obesity, but the gradient became flat or even inverse in developing countries. Frank and Akresh (2013) applied the moderating effect of national development to explain the varying gradients among immigrants. Their analysis showed that the education gradient was much steeper among immigrants from highly developed countries than from developing ones.

Considering the theoretical basis of the relationship between national development and education gradient, this study separates the moderating effects of national development into the effects of two population contexts related to obesity and the role of education. First of all, nutrition transition status will be considered because of the close relationship between diet style and obesity prevalence. As nutritional status in a country of origin is further from the westernized diet style, immigrants from that country will be less sensitive to the obesity epidemic regardless of educational level. This is because low nutrition transition status did not foster the obesity epidemic and the diffusion of the related information on the risk of obesity in the pre-migration environment. Secondly, the degree of educational expansion in the pre-migration environment will also moderate the variation in the education-obesity gradient among
immigrants, because widespread formal schooling bolsters the role of education resulting in better social outcomes including higher social status and better health (Baker, 2014).

**Assimilation Process in the United States: Its Influence on the Education-Obesity Gradient**

Even though pre-migration contexts make a difference in the education gradient among immigrants, the assimilation process may make this contextual variation negligible (See Figure 2.2.). Frank and Akresh (2013) analyzed the change of SES gradient in weight gain; they found that the initial protection from increasing BMI among all foreign-born immigrants, regardless of their SES, disappeared over time after their arrival to the United States. This is because lower-SES individuals became vulnerable to cheaper energy-dense foods, whereas higher-SES individuals controlled themselves from the newly introduced diet styles. In terms of nutrition transition as a pre-migration context related to obesity, immigrants from the lower level of nutrition transition may be protected from the risk of obesity because of their diet style being endemic in their culture. However, as immigrants lived longer in the United States, their prevalent style from the country of origin may have a weaker impact on moderating the variation in education-obesity association due to dietary assimilation. In other words, while educated people will be more likely to make healthy decisions in food selection even after migration, less-educated immigrants will be more vulnerable to the exposure of cheap and energy-dense foods. This phenomenon will lead to the convergence of education gradients among immigrants to much steeper gradient of the US-born population.
In addition to dietary assimilation, the assimilation to the US society with widespread formal schooling may be another key to understanding the convergence of education gradients after migration. As aforementioned, the level of educational expansion and education gradient is correlated because of increasing educational inequality (Etile, 2014; Ram, 1990) and greater returns to formal schooling (Baker et al., 2011; Montez et al., 2011). Migration to the United States, where the average years of schooling typically exceeds those found in immigrants' countries origin, indicates unprecedented contextual change in education environments. Therefore, assimilation to a society with more years of formal schooling may create a steeper education gradient in health because education is much highly valued and thus the returns to higher education increases with an increased magnitude of educational expansion (Baker, 2014; Etile, 2014; Montez et al., 2011).
Limitations in preexisting literature

Although this single measure for the development level of the origin country showed the important message about national contexts in the research of the association between education and health, this indicator cannot capture different contributions to moderating education gradient by specific national indicators. For example, Frank and Akresh (2013) used a Human Development Index (HDI) for the national development level and examined whether different levels of HDI in the countries of origin was associated with the magnitude of how much immigrants' socioeconomic status explained the likelihood of being overweight. In addition, they also observed that the pattern of convergence in SES-BMI gradients depended on the development level of their origin countries. Nevertheless, the preexisting studies including Frank and Akresh (2013) and McLaren (2007) did not have a consideration on which national contexts, or national moderators, better accounted for varying education gradient on the likelihood of being overweight. Indeed, HDI used in the preexisting literature is a composite score consisting of life expectancy, educational attainment and income at national level. Distinguished from the previous literature, I tried to highlight those different moderating effects on education gradient by various measures for pre-migration environment. For this research purpose, I examined the statistical significance of the following national moderators, using interaction terms: national nutrition transition status, national level of educational expansion, life expectancy, and GDP per capita. First two pre-migration contexts were mainly examined in this study, controlling for last two variables as indicators for measuring HDI.
Hypotheses

The preceding review of the literature demonstrating the complicated associations among educational attainment, pre-migration population contexts and assimilation enables the formulation of the following hypotheses.

**H1: Effect of education on reducing the likelihood of being overweight**
Educational attainment will be negatively associated with the likelihood of being overweight among foreign-born adult immigrants.

**H2: Moderating effect of nutrition transition on education gradient**
The education gradient on the likelihood of being overweight will differ by nutrition transition status in the country of origin at the year they first migrated to the United States.

**H3: Moderating effect of educational expansion on education gradient**
The education gradient on the likelihood of being overweight will differ by the level of educational expansion in the country of origin at the year they first migrated to the United States. More average years of formal schooling in the country of origin will produce a steeper education gradient.

**H4: Convergence of education gradient varying by nutrition transition**
Variation of the education gradient by different nutrition transition in the pre-migration setting will vanish over time during US residence after migration. The moderating effect of nutrition transition will become non-significant, especially among earlier migrations.
**H5: Convergence of education gradient varying by level of educational expansion**

Variation of the education gradient by different level of education expansion in the pre-migration setting will vanish over time during US residence after migration. Experiencing a more highly schooled society in the United States will strengthen the effect of education regardless of pre-migration context related to educational expansion.
Chapter 3. METHOD

Data

To test five hypotheses related to variation and convergence of the education-overweight gradient among foreign-born adult immigrants in the United States, the New Immigrant Survey (NIS) 2003 was used as the main data source. The NIS is a nationally representative study for legal permanent immigrants and their children, and it includes data obtained from the responses to many important questions about immigration and their aspects of human development (Jasso, Massey, Rosenzweig & Smith, 2000). The first full cohorts of the NIS sampled 8,573 legal immigrants aged 18 or older during the period from May to November 2003 (Jasso et al., 2000). Since the NIS provides health status, demographic characteristics, socioeconomic status and especially migration histories including where immigrants came from, when they migrated to the United States and where they settled down for immigrants from more than 21 countries (Frank & Akresh, 2013), the data can show the complicated relationship between education and being overweight with a full consideration of immigrants' experiences in the different contexts between the country of origin and the United States.

For the information regarding nutrition transition (hereafter NT) status and average educational attainment for the level of educational expansion in the country of origin at the time of migration, two additional data sources were used in this research. For NT status, the Food and Agriculture Organization of the United Nations (hereafter FAO) provides information of food balance by country and by time since 1961. The Food Balance Sheet (hereafter FBS) by FAO includes the information on the total energy expenditure per day per capita (kcal/day/capita), the energy derived from each dietary source per day per capita (kcal/day/capita), and the consumed
weight of each dietary source per day per capita (g/day/capita) for each population in a year. The NT status of each administration was calculated from the dietary intake information at population level from the FBS. For the average educational attainment, the international data set of educational attainment from 1950 to 2010 by Barro and Lee (2010) was used. They provided data for the national average years of schooling in 146 countries, using the census data for mortality rates and school completion rates by age and education level (Barro & Lee, 2010).

Finally, female foreign-born immigrants aged 25 or older who migrated from 19 countries of origin to the United States from 1961 to 2003 were selected as the target population based on the data availability. In this research, adult immigrants over 25-year-old because individuals aged more than 25 are most likely to complete their formal education (Cutler & Lleras-Muney, 2006). The total number of cases is 2,288 female foreign-born adult immigrants in the United States in 2003.

Variables

Dependent Variable

The dependent variable in this research is overweight status measured as a dichotomous variable constructed from a Body Mass Index (BMI = weight(kg)/height^2(m^2)). If a person's BMI is over 25.0 kg/m^2 in 2003, he or she is coded as 1 as being overweight, and normal weighing individuals whose BMI is lower than 25.0 kg/m^2 is the reference category coded as 0 (World

---

1 Because the information on NT status has been provided by Food and Agriculture Organization since 1961, immigrants who migrated to the United States before 1961 were omitted in this research. The proportion of the omitted cases is less than 0.7% (n=59).
Health Organization [WHO], 2000; Sassi et al., 2009). The weight and height were based on the self-reported measures in the NIS data.

**Independent Variable**

*Education* is measured as the years of schooling completed by individual immigrants in 2003. Therefore, the effect of education describes the additional increase in the likelihood of being overweight by adding one more year of formal education.

**Moderator Variables**

To examine the interaction effect by which the general effect of formal education on being overweight differs depending on population contexts and assimilation, three moderator variables are considered in the analysis. The first-order moderator variables for two-way interaction by population contexts in pre-migration are *NT status* and *Average schooling*, and the second-order moderator variable for three-way interaction by assimilation is *US residence*.

*NT Status* indicates the national nutritional status in the country of origin at the year when an immigrant first migrated to the United States. It is measured by the proportion of animal fat and sugar/sweeteners over the total food supply quantity (kcal/capita/day) from FBS by FAO, because nutritional status develops to the westernization in dietary intake with energy-dense foods including animal fat and sugar/sweeteners (Jeon et al., 2014; Popkin, 1993; Popkin, 2001). As shown in Figure 3.1., the NT status varies by countries and by time within a country. In figure
3.1. The bar indicates the average NT status in each country of origin from 1961 to 2003, and the distance between highest and lowest points show the variation between maximum/minimum NT status in that country during the same period. For example, in South Korea as a country showing the biggest historical change in NT status, the average NT status was 10.76% of energy-dense foods over total dietary intake, the minimum NT in Korea was 2.23% and the maximum NT was 20.80%. Compared to the nutritional environment in the country of destination, the consumption of animal fat and sugar/sweeteners in the United States was top ranked averaging (35.82%) in the NIS 2003.

![Graph showing cross-national comparison of NT status by countries of origin and the United States (1961-2003)](image)

Figure 3.1. Cross-national Comparison of NT Status by the Countries of Origin and the United States (1961-2003)

Note: The countries of origin in the table were sorted in ascending order based on average NT status.

*Average schooling* is a continuous variable showing the level of national educational expansion. This index indicates the national average years of formal schooling among adult population in
the country of origin during the year when an immigrant first migrated to the United States. It is measured using Barro-Lee's international data on educational attainment from 1950 to 2010 (Barro & Lee, 2010). They estimated national average years of educational attainment among adult population aged 25 or older for 146 countries in 5-year intervals from 1950 to 2010. To determine the average years of schooling in each year between 5-year intervals, forward and backward linear extrapolation was used assuming an equal increase/decrease of educational attainment between 5-year intervals.\(^2\) Figure 3.2. shows the historical growth of national average years of schooling in the countries of origin and the United States since 1960. The bar indicates the average years of formal schooling in each country of origin from 1961 to 2003 and the highest/lowest points show the maximum/minimum years of formal schooling in individual countries during the same period. The United States demonstrated the highest level of educational expansion compared with immigrant countries, with national average years of formal schooling, 11.61 years.

\(^2\) For example, educational attainment in Mexico in 2003 was estimated by the following extrapolation:

Figure 3.2. Cross-national Comparison of Average Schooling by the Countries of Origin and the United States (1961-2003)

Note: The countries of origin in the table were sorted in ascending order based on average schooling years.

*US residence* is measured by a respondent's 2003 reporting of the amount years that he or she lived in the United States.

**Control variables**

In order to eliminate any omitted variables bias, eight control variables are considered in the analysis: household earning, education in USA, age, marital status, SES in childhood, migration in childhood, and two confounding population-level variables. As indicators for measuring HDI
life expectancy and GDP per capita in the country of origin at the time of migration.

*Household earning* is a measure of the natural logged value of the total yearly household earnings combining an individual immigrant's earnings with his or her spouse. Annual earning indicates the total amount of money obtained from self-employment, wage and salary, and other income sources during the year.

*Employment* is a dichotomous variable measured as employment status in the United States in 2003. If a respondent was a full-time employed worker in the United States in 2003, he or she is coded as 1 and others are coded as 0.

*Education in USA* is a dichotomous variable related to the experience of formal education in the United States. If a respondent had at least one year of schooling in the United States, he or she is coded as 1 and others are coded as 0.

*Age* indicates individual adult immigrant's age ranging from 25 to 94. Age is the most important demographic indicator for estimating health outcomes (House et al., 1994; Rodin, 1986) as weight gain naturally occurs during aging (Newman et al., 2005). However, most people who are 65 years or older experience unintentional weight loss (Alibhai et al., 2005; Wallace et al., 1995). The squared term of age (*Age^2*) is also considered in the analysis in order to control decelerating effect of age on the likelihood of being overweight.

*Marital status* as a variable of social support (Mirowsky & Ross, 2003) is measured by a respondent's reporting of their marital status in 2003. If he or she is currently married in 2003, it is coded as 1 and others are coded as 0.

*SES in childhood* indicates the relative status of family income in a respondent's childhood, compared with families in their country of origin. In the NIS survey, this status is measured by a
respondent's 5-point Likert scaled responses to the question, "Thinking about the time when you were 16 years old, compared with families in the country where you grew up, would you say your family income during that time was (1) far below average, (2) below average, (3) average, (4) above average, or (5) far above average?"

*Migration in childhood* indicates whether a respondent migrated to the United States before they were 20 years old. If he or she migrated before the age of 20, it is coded as 1 and others are coded as 0.

*Life expectancy* is a measure of the expected years of how long a person may live in the country of origin.

*GDP per capita* is a measure of the natural logged value of the GDP per capita in the country of origin during the year when an immigrant first migrated to the United States. GDP per capita for each country from 1960 to 2003 was retrieved from the World Bank statistics.

**Analytic Strategy**

Logistic regression is an appropriate method to examine the effect of formal education and the interaction effects of population contexts and the length of US residence on determining the likelihood of being overweight as a dichotomous variable. Separate logistic regressions by gender will be conducted because of the differing nature of the experiences for males and females in the obesity epidemic (Greenblatt et al., 1984; Lafortuna et al, 2005).

In models 1, 2 and 3, the logistic regression analysis examines the general effect of formal education for the first hypothesis. In model 1, the gross effect of education on being overweight is examined without any moderator variables and control variables. In model 2, three
moderator variables are examined in addition to educational attainment. Model 3 examines the net effect of educational attainment and the net effect of population contexts from the country of origin at the time of migration, considering control variables. The following equation describes the analytical framework for model 3.

**H1: Education - Overweight**

\[
\ln[P_i/(1-P_i)] = \beta_0 + \beta_1(\text{Education}) + \beta_2(\text{NT status}) + \beta_3(\text{Average schooling}) + \beta_4(\text{US residence}) + \beta_k(\text{Controls}) + e_i
\]

In the equation, \(P_i\) indicates the likelihood of being overweight for individual immigrant \(i\) (1= overweight; 0 = normal). The outcome is the log odds of the likelihood of being overweight (\(P_i\)) over the likelihood of being normal (1-\(P_i\)). \(\beta_0\) denotes the average likelihood of obesity for all immigrants in the analysis. The coefficient of \(\beta_1\) is the effect of an additional year of formal education and the direction will be negative if formal education is significant on reducing the likelihood of being overweight. \(\beta_2, \beta_3\) and \(\beta_4\) represent the increase of the log odds by assuming a 1% additional increase of animal fat and sugar/sweeteners over total energy-intake, one additional year of national average educational attainment, and one additional year increase of residence in the United States, respectively. \(\beta_k\) indicates the effect of control variables on the log odds and \(e_i\) is the error term.

Model 4 for hypothesis 2 representing the interaction term between education and NT status will be added to model 3.
H2: Education - NT status - Overweight

\[
\ln\left(\frac{P_i}{1-P_i}\right) = \beta_0 + \beta_1(\text{Education}) + \beta_2(\text{NT status}) + \beta_3(\text{Average schooling}) + \beta_4(\text{US residence}) + \\
\beta_{5a}(\text{Education*NT status}) + \beta_k(\text{Controls}) + \epsilon_i
\]

Model 4 adds an interaction term (\(\beta_{5a}\)) between educational attainment and NT status in the country of origin at the time of migration. In other words, the coefficient of \(\beta_{5a}\) indicates the logistic coefficient showing the increase/decrease of log odds of educational attainment given a 1-unit increase in NT status in pre-migration. A negative and significant interaction term would support the second hypothesis that the education-overweight gradient becomes negatively steeper among immigrants who already experienced westernized dietary intake even while in their pre-migration environment.

H3: Education - Average schooling - Overweight

\[
\ln\left(\frac{P_i}{1-P_i}\right) = \beta_0 + \beta_1(\text{Education}) + \beta_2(\text{NT status}) + \beta_3(\text{Average schooling}) + \beta_4(\text{US residence}) + \\
\beta_{5b}(\text{Education*Average schooling}) + \beta_k(\text{Controls}) + \epsilon_i
\]

In the similar vein, model 5 examines the third hypothesis that the education-overweight gradient will be negatively steeper among immigrants whose countries of origin showed higher average years of formal schooling at the time of their migration. Accordingly, \(\beta_{5b}\) indicates the interaction term between individual educational attainment and national average schooling years in the country of origin at the time of migration. If \(\beta_{5b}\) is negative and statistically significant, the result would support hypothesis 3.
H4: Education - NT status - US residence - Overweight

\[
\ln\left(\frac{P_i}{1-P_i}\right) = \beta_0 + \beta_1(\text{Education}) + \beta_2(\text{NT status}) + \beta_3(\text{Average schooling}) + \beta_4(\text{US residence}) + \beta_5(\text{Education} \times \text{NT status}) + \beta_6(\text{Education} \times \text{US residence}) + \beta_7(\text{NT status} \times \text{US residence}) + \beta_8(\text{Education} \times \text{NT status} \times \text{US residence}) + \beta_k(\text{Controls}) + e_i
\]

Hypothesis 4 and 5 assumed three-way interactions among individual educational attainment, population context in the country of origin at the time of migration, and the length of residence in the United States after the first migration. To assume a three-way interaction term among those three variables, two underlying interaction terms (\(\beta_{6a}\) and \(\beta_{7a}\)) are technically added to the model (Jaccard, 2001; Kleinbaum, 2010). Consequently, model 6 focuses on the significance of \(\beta_{8a}\) as a three-way interaction term among educational attainment, NT status and the length of US residence. The three-way interaction term shows whether the variation in education gradient by NT status in the country of origin remains, disappears, or increases according to the length of residence in the United States.

H5: Education - Average schooling - US residence - Overweight

\[
\ln\left(\frac{P_i}{1-P_i}\right) = \beta_0 + \beta_1(\text{Education}) + \beta_2(\text{NT status}) + \beta_3(\text{Average schooling}) + \beta_4(\text{US residence}) + \beta_5(\text{Education} \times \text{Average schooling}) + \beta_6(\text{Education} \times \text{US residence}) + \beta_7(\text{Average schooling} \times \text{US residence}) + \beta_8(\text{Education} \times \text{Average schooling} \times \text{US residence}) + \beta_k(\text{Controls}) + e_i
\]

Finally, the fifth hypothesis will be examined by a three-way interaction term considering the
assimilation effect of the increasing years of US residence on the relationship between education-obesity gradient and the average years of schooling in the country of origin at the time of migration. Accordingly, the model 7 uses a three-way interaction term of $\beta_{sb}$ to indicate whether the variation in education gradient by national average schooling years in the country of origin remains, disappears, or increases according to the length of residence in the United States.

**Design effects and multiple imputation of missing data**

To consider the design effects of the data set, the analysis used a sample weight of NIS and country codes with a cluster option for robust standard errors. For the missing variables, a multiple imputation technique (Schafer & Graham, 2002) was employed with the `ice` option in the STAT 12.0 software. On the basis of the recommendation by Rubin (1987) and von Hippel (2005), five data sets were generated with five different sets of imputed values for the pooled sample and then averaged the coefficients, standard errors and R squared from analyses across the five data sets using the Rubin’s (1987) rule.
Chapter 4. RESULT

This chapter will first report the descriptive statistics obtained from the analysis of the data. Next, the main effect of educational attainment on the likelihood of being overweight among immigrants aged 25 or older is first addressed, considering moderator variables and control variables. Then, the two-way interaction terms between educational attainment and pre-migration contexts in the country of origin are tested. Finally, the three-way interaction terms are examined to see whether the variation in the education gradient by pre-migration contexts disappears over time after migration in terms of assimilation with the US-born population.

Descriptive Statistics

Table 4.1. represents descriptive statistics for the prevalence of overweight immigrant respondents and mean differences of variables between overweight and non-overweight status for female foreign-born immigrants aged 25 or older in the United States in 2003. On average, about 42.8% of the adult foreign-born women in the sample were overweight (48.7%).

When it comes to the mean differences in independent and moderator variables, overweight immigrants attained less years of formal schooling, experienced higher NT status and lower average years of schooling in their pre-migration environment, and lived longer in the United States since migration compared with non-overweight immigrants. All the mean differences in independent and moderator variables are statistically significant at p < 0.05.

Control variables included household earning, employment, education in the United States, age, marital status, SES in childhood, migration in childhood, life expectancy and GDP per capita. Household earning and employment status were identified as confounders related to
measuring socioeconomic status. These variables showed significant mean difference between those who were overweight and their counterparts, except for household earning and education in the United States. Household earning was not different by overweight status among women. In the mean difference in employment by overweight status, employment status was negatively associated with overweight. That is, being overweight was less widespread among employed female immigrants than other female immigrants. Overweight people tend to be older than non-overweight people among female immigrants, and there was significant mean difference in marital status among female immigrants. In other words, married women reported being overweight less than unmarried women. In addition, overweight immigrants tended to report lower family SES during their childhood and they more frequently reported that they migrated to the United States as a child than non-overweight immigrants. Finally, GDP per capita in the country of origin was significantly higher among overweight immigrants than non-overweight immigrants.
### Table 4.1. Descriptive Statistics

<table>
<thead>
<tr>
<th>Variables</th>
<th>Total Mean</th>
<th>Total SD</th>
<th>Overweight Mean</th>
<th>Overweight SD</th>
<th>Non-overweight Mean</th>
<th>Non-overweight SD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dependent variable</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overweight</td>
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<tr>
<td><strong>Independent variables</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NT status</td>
<td>22.032</td>
<td>5.777</td>
<td>23.047</td>
<td>5.417*</td>
<td>21.273</td>
<td>5.914</td>
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<tr>
<td>Average schooling</td>
<td>6.319</td>
<td>2.314</td>
<td>5.910</td>
<td>2.229*</td>
<td>6.626</td>
<td>2.330</td>
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<tr>
<td><strong>Control variables</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Employment</td>
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<td>0.499</td>
<td>0.426</td>
<td>0.495*</td>
<td>0.503</td>
<td>0.500</td>
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<td>Education in USA</td>
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<td>0.333</td>
<td>0.126</td>
<td>0.332</td>
<td>0.128</td>
<td>0.335</td>
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<tr>
<td>Age</td>
<td>41.649</td>
<td>12.939</td>
<td>43.899</td>
<td>13.226*</td>
<td>39.967</td>
<td>12.462</td>
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<td>0.457</td>
<td>0.677</td>
<td>0.468*</td>
<td>0.721</td>
<td>0.449</td>
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<td>SES in childhood</td>
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<td>0.942</td>
<td>2.569</td>
<td>1.016*</td>
<td>2.887</td>
<td>0.857</td>
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<tr>
<td>Migration in childhood</td>
<td>0.250</td>
<td>0.433</td>
<td>0.286</td>
<td>0.452*</td>
<td>0.222</td>
<td>0.416</td>
</tr>
<tr>
<td>Life expectancy</td>
<td>68.794</td>
<td>5.265</td>
<td>68.285</td>
<td>5.510</td>
<td>69.175</td>
<td>5.043</td>
</tr>
<tr>
<td>GDP per capita</td>
<td>8.178</td>
<td>0.636</td>
<td>8.211</td>
<td>0.625*</td>
<td>8.154</td>
<td>0.643</td>
</tr>
</tbody>
</table>

Note: * indicates the significant mean difference in each variable between the overweight group and non-overweight group at p<.05.

### Association between Education and Overweight Status

Next, the logistic regression analysis examined the impact of educational attainment on reducing the likelihood of being overweight among adult foreign-born immigrants. The analysis focuses on examining the first hypothesis that better-educated immigrants will be less likely to be overweight after adjusting for individual and population characteristics. In addition, NT status and national average schooling years in the country of origin at the time of migration, and the length of US residence were also observed to assume the interactions with educational attainment on predicting the likelihood of being overweight among foreign-born immigrant population.
As shown in table 4.2, below, the coefficients of the educational attainment, moderator variables and control variables are separately addressed for male and female adult immigrants. All the coefficients present the log odds of being overweight for males and females. In addition, standard errors (SE) and odds ratio (OR) are reported for the relationships between the likelihood of being overweight and each variable.

Model 1 examined the gross effect of educational attainment on overweight status without adding other variables. More education significantly reduced the likelihood of being overweight \((B=-0.107; \ OR=0.898; \ p<0.001)\). In other words, each additional year of formal schooling contributed to reduce the odds of being overweight by 10.2% among female immigrants.

In model 2, population contexts in the country of origin at the time of migration and the length of US residence were added to model 1 predictors in order to examine the effect of the pre-migration environment and assimilation on overweight prevalence. First, the likelihood of being overweight among women were still significantly affected by educational attainment even in model 2 \((B=-0.084; \ OR=0.920; \ p<0.001)\). Secondly, three moderator variables had significant effects on determining the likelihood of being overweight among women. NT status increased the odds of being overweight among adult immigrants. A 1% point increase of high calorie nutrition over total energy intake was associated with the increase of the odds of being overweight by 9.5% \((B=0.091; \ OR=1.095; \ p<0.001)\) for women. On the contrary, national average schooling years decreased the likelihood of being overweight by 17.3% \((B=-0.190; \ OR=0.827; \ p<0.001)\) for women. Finally, longer residence in the United States significantly increased the likelihood of being overweight for all individuals in the adult immigrant population.
In other words, an additional year of US residence increased the odds of being overweight by 2.1% (B=0.021; OR=1.021; p<0.05) for women.

Model 3 added control variables and examined the significance of the associations between the likelihood of being overweight and educational attainment. For female immigrants, educational attainment and three moderator variables still had significant effect on overweight prevalence. While a 1 unit increase of NT status and US residence increased the odds of being overweight by 11.4% (B=0.108; OR=1.114; p<0.001) and 2.6% (B=0.026; OR=1.026; p<0.05), a 1 unit increase for educational attainment and national average schooling decreased the odds by 5.8% (B=0.060; OR=0.942; p<0.001) and 17.9% (B=-0.198; OR=0.821; p<0.001). Among control variables, household earning significantly increased the odds of being overweight but full-time employment status, SES in childhood, life expectancy and GDP per capita in the country of origin at migration decreased the odds significantly.

To summarize the first analysis for testing the hypothesis 1, educational attainment was significantly associated with a decrease in the odds of being overweight for female adult immigrants, even after adjustment for three moderator variables and nine control variables. In other words, hypothesis 1 is accepted in support of an additional year increase of formal schooling had a significant effect on reducing the likelihood of being overweight for women.
Table 4.2. Weighted Logistic Regression Estimate on Overweight Status among Female Foreign-born Immigrant aged 25 or more

<table>
<thead>
<tr>
<th>DV: Overweight</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Model1</td>
</tr>
<tr>
<td>Log Odds</td>
<td>S.E. a</td>
</tr>
<tr>
<td>Education</td>
<td>-0.107 ***</td>
</tr>
<tr>
<td>NT status c</td>
<td>0.091 ***</td>
</tr>
<tr>
<td>Average schooling c</td>
<td>-0.190 ***</td>
</tr>
<tr>
<td>US residence</td>
<td>0.021 *</td>
</tr>
<tr>
<td>Control variables</td>
<td></td>
</tr>
<tr>
<td>Household earning</td>
<td></td>
</tr>
<tr>
<td>Employment</td>
<td>-0.251 **</td>
</tr>
<tr>
<td>Education in USA</td>
<td>-0.050</td>
</tr>
<tr>
<td>Age</td>
<td>0.050</td>
</tr>
<tr>
<td>Age²</td>
<td>0.000</td>
</tr>
<tr>
<td>Marital status</td>
<td>-0.041</td>
</tr>
<tr>
<td>SES in childhood</td>
<td>-0.111 †</td>
</tr>
<tr>
<td>Migration in childhood</td>
<td>-0.169</td>
</tr>
<tr>
<td>Life Expectancy</td>
<td>-0.058 †</td>
</tr>
<tr>
<td>GDP per capita</td>
<td>-0.192 †</td>
</tr>
<tr>
<td>Intercept</td>
<td>0.939 *</td>
</tr>
<tr>
<td>Log pseudo-likelihood</td>
<td>-1648.926</td>
</tr>
</tbody>
</table>

*** p<0.001 ** p<0.01 * p<0.05 † p<0.1

a. S.E. indicates a robust standard error considering the data structure clustered by country.
b. OR indicates odds ratio as the exponent of the log odds of each independent variable.
c. NT status and average schooling were transformed to mean centered to make the intercept more meaningful as the likelihood of overweight status among immigrants at the average level of population contexts in their pre-migration setting.

Two-way Interactions between Education Gradient and Pre-migration Environment

The second analysis examined the moderating effect of the pre-migration environment on the association between educational attainment and the likelihood of being overweight among female foreign-born adult immigrants. The analysis for male immigrants was omitted because of
the non-significant effect of educational attainment on being overweight for this gender after adjustment for moderator variables and control variables. The moderating role of the pre-migration environment in determining the education-overweight gradient was considered by testing two moderator variables: NT status and national average schooling years as proxy indicators for the level of educational expansion. These two moderator variables were regarded as important factors for determining the role of education as a social vaccine in reducing the prevalence of being overweight. Additionally, these moderator variables represent the population context regarding the obesity phenomenon in the country of origin at the time of migration to the United States.

Table 4. 3. Two-way interactions: Educational Attainment and Population Contexts among Foreign-born Immigrants

<table>
<thead>
<tr>
<th>DV: Overweight</th>
<th>Female</th>
<th>Model4</th>
<th>Model5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Log Odds</td>
<td>S.E.</td>
<td>OR</td>
</tr>
<tr>
<td>Education</td>
<td>-0.06</td>
<td>0.12</td>
<td>0.94</td>
</tr>
<tr>
<td>Education*NT status</td>
<td>-0.006 ***</td>
<td>0.002</td>
<td>0.994</td>
</tr>
<tr>
<td>Education*Average schooling</td>
<td>-0.011 †</td>
<td>0.006</td>
<td>0.989</td>
</tr>
<tr>
<td>NT status</td>
<td>0.178 ***</td>
<td>0.043</td>
<td>1.195</td>
</tr>
<tr>
<td>Average schooling</td>
<td>-0.188 ***</td>
<td>0.054</td>
<td>0.829</td>
</tr>
<tr>
<td>US residence</td>
<td>0.026 *</td>
<td>0.011</td>
<td>1.026</td>
</tr>
<tr>
<td>Intercept</td>
<td>0.988</td>
<td>2.185</td>
<td>2.686</td>
</tr>
<tr>
<td>Log pseudolikelihood</td>
<td>-1535.354</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*** p<0.001 ** p<0.01 * p<0.05 † p<0.1
a. S.E. indicates a robust standard error considering the data structure clustered by country.
b. OR indicates odds ratio as the exponent of the log odds of each independent variable.
c. NT status and average schooling were transformed to mean centered to make the intercept more meaningful as the likelihood of being overweight among immigrants at the average level of population contexts in pre-migration setting.

Note: The analysis controlled household earning, employment, education in USA, age, age², marital status, SES in childhood, migration in childhood, life expectancy and GDP per capita.
In model 4, the interaction term of NT status on the education-overweight gradient was examined to test hypothesis 2 that the effect of education on reducing the likelihood of being overweight will be stronger among the immigrant population from the country of origin where NT status is higher, compared to the counterpart from the country with lower NT status. After considering control variables and other moderator variables, the interaction term was statistically significant at p<0.001. Because of the identical direction between the education gradient and the interaction term, the interaction effect indicates that as the NT status of pre-migration environment increased, the protective role of education had a larger effect on reducing the likelihood of being overweight among female adult immigrants. For example, while the log odds of being overweight among female immigrants from the country whose NT status is 21.896 as the grand mean of the sample is -0.060 (OR=0.942), the log odds of overweight becomes more negative as -0.066 (OR=0.936) as NT status increases by one unit from the grand mean.

![Figure 4.1 Interaction between Education and National NT Status](image.png)

**Figure 4.1 Interaction between Education and National NT Status**

Note: They are categorized with three groups by the following criteria; if immigrants migrated from origin countries showed -0.5SD below average of NT status, they are low group of NT status; if immigrants migrated from countries between -0.5SD above average and 0.5SD below average of NT status, they are medium group; and immigrants from countries with the level of NT status 0.5SD above average are high group. Lines indicate the predicted association between the likelihood of being overweight and educational attainment. Dots indicate the actual likelihood of being overweight among female immigrants.
Figure 4.1. is the graph showing the predictive margins for the likelihood of being overweight by the increase of educational attainment among three different NT statuses of the country of origin. First, the line of the medium group illustrates the education-overweight gradient among female immigrants from the pre-migration environment with a medium NT status (21.896). Among females in this population, the likelihood of being overweight had a predictive range from 58.4% for the non-educated to 31.9% for the most-educated who completed 20 years of formal education. The decrease in the likelihood for being overweight was 1.33% for each additional year of formal schooling for this group. Second, the line of the low group shows the education-overweight gradient from the low NT status (15.724) defined as 1 SD below the medium NT status. Under the pre-migration context of low NT status, the initial likelihood of being overweight is relatively low at 35.4% but the gradient is much flatter in its decreasing pattern by educational attainment. The flatter gradient had just a 0.51% point decrease for an additional year increase of formal schooling. This shallow slope only produced an approximately 10% difference between the non-educated and the most-educated (25.2%). Finally, the group having high NT status (28.068), defined as 1 SD higher than the medium NT status, showed a more steeply decreasing gradient as illustrated in the high group. The likelihood of being overweight ranged from 78.4% for the non-educated to 39.4% for the most-educated, resulted from a much steeper education gradient of 2.95% point decrease by each additional year of formal schooling. Therefore, the higher NT status in the pre-migration environment contributed to moderating steeper education gradient, as well as increasing the overall prevalence of overweight status among female immigrants.

In model 5, hypothesis 3 was tested by examining the interaction term between educational attainment and national average schooling years in the country of origin. Hypothesis
assumes that the education gradient will be likely to be negatively steeper among immigrants from the country of origin in which formal education is more widespread, compared to the counterparts from the countries with lower average levels of education. Since the interaction term was negative but modestly significant at p<0.1, the result partially supported the hypothesis that the decreasing slope would become more pronounced in the countries of origin having higher average schooling years. For example, the log odds of being overweight by educational attainment is -0.076 (=-0.065-0.011*1yr; OR=0.927) among the female population from a country of origin in which the national average schooling years is one year longer than another country that had a grand mean schooling years of 6.162 years. Compared to that population, the log odds is -0.065 (OR=0.937) among the female population at the mean level of national average schooling years.

Figure 4. 2. Interaction between Education and National Average Schooling

note: They are categorized with three groups by the following criteria; if immigrants migrated from origin countries showed -0.5SD below average of educational expansion, they are low group of educational expansion; if immigrants migrated from countries between -0.5SD above average and 0.5SD below average of educational expansion, they are medium group; and immigrants from countries with the level of educational expansion 0.5SD above average are high group. Lines indicate the predicted association between the likelihood of being overweight and educational attainment. Dots indicate the actual likelihood of being overweight among female immigrants.
Figure 4.2 describes the predictive margins for the likelihood of being overweight by educational attainment among three groups categorized by different levels of national educational expansion. From the graph, the initial probabilities were clustered at 60% (62.9% for low average group; 60.1% for medium average group; and 57.2% for high average group), but the likelihood gap among the three groups became largest as educational attainment increased at the 20 years of schooling (45.7% for low average group; 31.8% for medium average group; and 20.3% for high average group). The larger gap resulted from the different education gradients among three groups. While there was a 0.86% point decrease of the likelihood of being overweight for each year increase of schooling for the group with low national average schooling years, there was a likelihood decreased of 1.85% point for each year increase of schooling for the group with high national average schooling years.

**Three-way Interactions: Change in Moderating Effects of Pre-migration Environment over Time of US residence**

The final analysis examined the three-way interaction effect among educational attainment, pre-migration environment and assimilation over time of US residence. As shown in Table 4.3., Figure 4.1 and Figure 4.2 above, the education gradient on overweight status among female immigrants varied according to their pre-migration contexts related to the level of NT status and educational expansion in their countries of origin. In addition, the assimilation effect from the length of US residence was considered in the final analysis to better understand the complicated picture in the changing role of education for determining the likelihood of being overweight.
The fourth and fifth hypotheses assume that the moderating effect of pre-migration contexts will be weakened over time after migration due to the assimilation to the context of living in the United States. The native-born population in the United States has already experienced high levels of NT status and educational expansion during the last several decades. Therefore, the varying education gradients by pre-migration contexts will converge to that among female immigrants from the countries with higher levels of NT status and educational expansion, if the assimilation effect is significant as the time of US residence gets longer.

Table 4.4. Three-way interactions: Educational Attainment, Population Contexts and US Residence among Foreign-born Immigrants

<table>
<thead>
<tr>
<th>DV: Overweight</th>
<th>Female</th>
<th>Model 6</th>
<th>Model 7</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Log Odds</td>
<td>S.E.*</td>
</tr>
<tr>
<td>Education</td>
<td>-0.054</td>
<td>***</td>
<td>0.947</td>
</tr>
<tr>
<td>Education*NT status</td>
<td>-0.007</td>
<td>***</td>
<td>0.993</td>
</tr>
<tr>
<td>Education<em>NT status</em>US residence</td>
<td>0.0004</td>
<td>†</td>
<td>0.0002</td>
</tr>
<tr>
<td>Education*Average schooling</td>
<td>-0.016</td>
<td>*</td>
<td>0.985</td>
</tr>
<tr>
<td>Education<em>Average schooling</em>US residence</td>
<td>0.0005</td>
<td>0.001</td>
<td>1.0005</td>
</tr>
<tr>
<td>Intercept</td>
<td>0.386</td>
<td></td>
<td>1.471</td>
</tr>
<tr>
<td>Log pseudolikelihood</td>
<td>-1521.392</td>
<td></td>
<td>-1530.275</td>
</tr>
</tbody>
</table>

*** p<0.001 ** p<0.01 * p<0.05 † p<0.1  
a. S.E. indicates a robust standard error considering the data structure clustered by country.  
b. OR indicates odds ratio as the exponent of the log odds of each independent variable.  
c. NT status and average schooling were transformed to mean centered to make the intercept more meaningful as the likelihood of being overweight among immigrants at the average level of population contexts in pre-migration setting.  
Note: The analysis controlled household earning, employment, education in USA, age, age^2, marital status, SES in childhood, migration in childhood, life expectancy and GDP per capita. The log odds, S.E., and OR of control variables and three interactions (education*US residence, NT status*US residence, and average schooling*US residence) were omitted.

Model 6 tested the hypothesis 4 that the interaction effect between education and NT status will diminish over the time of US residence. If the hypothesis is supported, the three-way interaction term will be significant in the inverse direction against the two-way interaction effect of NT
status. This is because the assimilation effect will decrease variation caused by pre-migration contexts. Results of the final analysis indicated that the log odds of the three-way interaction among educational attainment, NT status and US residence was modestly significant and inverse against the interaction effect of NT status ($B=0.0004; \text{OR}=1.0002; p<0.1$). In other words, the variation in education gradient by NT status experienced in the country of origin was reduced the longer immigrants lived in the United States after their migration.

![Figure 4.3. Change of Interaction Effect of NT Status on Education Gradient over Time of US Residence](image)

To understand the reduced variation in the education gradient over time, figure 4.3 describes the predictive margins for the likelihood of being overweight by different NT status in each quartile of length of US residence. Quartile 1 includes female immigrants who migrated to the United
States most recently, whereas quartile 4 includes female immigrants migrated during the earliest period. For the first quartile, the variation in education by different NT status is largest among recent female migrants. The nutritional environment in the country of origin had a significant impact on determining the role of education in the likelihood of being overweight. However, for the immigrants in the fourth quartile, the education gradient slopes were identical regardless of the level of NT status in the country of origin. That is, education gradients by different nutritional environment in pre-migration had converged during the length of US residence after migration. In addition, while the association between education and the likelihood of being overweight in for the high NT status group did not change over the time of their US residence, education gradients in the medium and low NT status groups became steeper reducing their likelihood of being overweight over time. Therefore, these results support the reinforced and clearer role of education as social vaccine reducing the obesity epidemic in societies with a highly westernized diet style, as well as the fourth hypothesis related to the assimilation effect reducing the imported gradient from the pre-migration environment.

Model 7 results contrasts with model 6 in that the three-way interactions among educational attainment, national average schooling years, and US residence was not statistically significant in spite of the inverse effect against the two-way interaction term between educational attainment and national average schooling. Thus, the fifth hypothesis was rejected in the analysis using the sample of NIS 2003 data.
Chapter 5. DISCUSSION

The fact that education has a positive impact on better health sounds self-evident with a great deal of support from the literature (Mirowsky & Ross, 2003). However, exceptions have been reported especially in the associations between education and newly introduced health risk behaviors in developing countries. One illustration of this effect can be seen in the case of education having a non-significant or negative impact for decreasing the prevalence of HIV/AIDS (Baker et al., 2011; Fortson, 2008), tobacco use (de Walque, 2004; Pampel & Denney, 2011), or obesity/overweight status rate (Jeon et al., 2014; McLaren, 2007) in those regions. In order to address the mixed effect of education on health, previous research focused on distinct contexts in developing countries where the risk of those behaviors were already diffused into the population (Baker et al., 2011; Pampel & Denney, 2011; Jeon et al., 2014). Since information on the health risk behaviors was lacking and those behaviors had been valued as symbols of high status, education was believed to be a risk factor to harm the health of those populations. However, previous studies also pointed out that education recuperated its protective role in health as population contexts became more similar to the contexts in developed regions. In other words, the mixed effect of education on some health risk behaviors has been reported as a passing phenomenon under the unique context found in developing countries.

In this study, variation in the education gradient and the role of education to function as social vaccine were examined for their ability to affect the likelihood of being overweight among foreign-born adult immigrants in the United States. Immigrants are an optimal population to test the theoretical hypotheses because they not only have diverse backgrounds from their countries of origin (for variation in education gradient) but also experience a very different population context after migration to the United States during their lifetimes (for convergence in education
Furthermore, the obesity epidemic is an increasing concern for public health in the United States, including for immigrants who tend to be more vulnerable to excessive weight gain after migration.

This study considered two specific contextual indicators to estimate the variation and convergence in the education gradient on the likelihood of being overweight: nutrition transition and educational expansion. Preexisting studies categorized populations mostly by one indicator, such as the economic development index (Frank & Akresh, 2013) or the human development index (HDI) (McLaren, 2007). However, this research decomposed the impact of context on the obesity epidemic and the education gradient in order to examine what specific contexts moderate the association between education and obesity epidemic. Nutrition transition status is assumed to be a key indicator for understanding the spread of the obesity epidemic from the West to the other regions in the world. Educational expansion is also assumed to be a critical variable explaining the varying education gradient in social outcomes from the different quality and inequality of formal schooling.

Finally, assimilation effect over time of residence in the United States since first migration was examined to test the hypothesis regarding the convergence of different education gradient by pre-migration context. The hypothesis of converging gradient was based on the argument on the health immigrant effect and unhealthy assimilation (Antecol & Bedard, 2006; Bates et al., 2008; Frank & Akresh, 2013; Goel et al., 2004; Jasso et al., 2004). Especially, the argument on the unhealthy assimilation discussed the increasing health disparity by SES due to the exacerbated status among the lower SES group of immigrants after their migration. In this study, the unhealthy assimilation was tested by assuming the better capability to selectively adjust to a new environment among higher educated immigrants. Better-educated immigrants
were assumed to utilize their cognitive skills to keep their cultural buffering against the "obesity-friendly" environment in the United States.

For the purposes, this empirical study tested five hypotheses related to the general effect of education on the likelihood of being overweight, the moderating effect of two pre-migration contexts on the education gradient, and the assimilation effect of US residence using NIS 2003 data. To address the moderating effects of population contexts and assimilation, their interaction effects were examined.

**Summary of Main Findings**

The empirical analysis was separated into two logistic regressions by gender. The results among female immigrants supported all hypotheses except for the fifth. For the first hypothesis concerning the effect of educational attainment on reducing the likelihood of being overweight, the effect was significant among women, even controlling for three moderator variables and the control variables. More educational attainment significantly reduced the likelihood of being overweight for individual female immigrants. For the second and third hypotheses, the education gradients differed by pre-migration contexts; higher NT status and higher level of educational expansion significantly moderated the slope of the education effect making it more steeply negative. However, the assimilation effect demonstrated by the converging education gradients among immigrants was partially supported by the three-way interaction among educational attainment, NT status and length of US residence. When it comes to variation in the education gradient moderated by different NT status in the pre-migration environment, varying education gradients converged into a steeper gradient showing a more protective role of for education in
reducing the prevalence of being overweight. However, the three-way interaction among educational attainment, educational expansion and US residence was not statistically significant.

**Theory and Policy Implications**

*Education as a Social Vaccine among Female Immigrants*

Educational attainment led to reducing the likelihood of being overweight for females in the immigrant population in the United States. By and large, education played a protective role as a social vaccine in reducing excessive weight gain for female immigrants, even after consideration of other SES indicators and control variables. Therefore, the empirical finding supported the theoretical framework that education has a net impact on enhancing population health (Baker et al., 2011; Mirowsky & Ross, 2003).

Nevertheless, it is questionable that this research only found the social vaccine effect for education reducing the prevalence of being overweight on average among immigrants, even though previous studies reported non-significant, curvilinear or inverse effects for education on the likelihood of being overweight among the populations from developing countries. There may be two reasons to explain the general effect of education for reducing the prevalence of being overweight in the immigrant population. First of all, the overall effect of education as a social vaccine may result from the data structure which includes immigrants from the developed countries, such as Canada and United Kingdom where the nutritional and educational contexts are similar to those in the United States. The proportion of immigrants from developed countries may affect the estimate of the general effect of education on being overweight. Secondly,
immigrant selectivity may generally affect education acting as a social vaccine in reducing the likelihood of being overweight. Immigrant selectivity denotes that immigrants tend to have superior characteristics related to economic wealth, social status, and educational attainment, compared to people who remain in the sending society (Feliciano, 2005; Gans, 2000). Even though the degree of immigrant selectivity varies by the country of origin and the time of migration, their selective characteristics explains the phenomenon of the average education gradient distinction from the gradient of the population remaining in their home countries (Feliciano, 2005). In addition, the fact that NIS 2003 sampled only legal immigrants supported the implications of immigrant selectivity on the role of education in being overweight.

**Imported Gradient and Pre-migration Contexts: Different Mechanisms of Interaction**

Despite the overall social vaccine effect of education on reducing the prevalence overweight for immigrant females, the pre-migration environment moderated the variation of the education gradient, as well as the likelihood of being overweight itself. The analysis does not only show that the imported gradient of immigrants with a weaker association between educational attainment and the likelihood of being overweight, but it also suggests different mechanisms for a contextual interaction in nutritional status and educational expansion in the country of origin at the time of migration. The education gradient significantly varied by pre-migration contexts, depending upon the level of NT status and education expansion.

There was a significant interaction for the first contextual factor, NT status, on the education gradient for female immigrants. This finding is consistent with previous empirical findings in Jeon et al. (2014) which focused on Latin American/Caribbean mothers. As the level
of NT status increases, the education gradient becomes more negatively steeper, indicating the stronger effect of education on reducing the likelihood of being overweight. Particularly, while the whole population showed the low likelihood of being overweight regardless of their educational attainment in the low NT group, the likelihood of being overweight for the less-educated population sharply increases in the high NT group. In other words, in societies where over-nutrition and energy-dense foods are widely available, the health disparity will increase by level of education attainment because the education will become more important for individual's choosing health foods and protecting themselves from the risk of obesity. Meanwhile, it is also important to observe the overall increase of the likelihood of being overweight as NT status increases.

The level of educational expansion provides another implication for the varying education gradient by population context. Educational expansion is an indicator for schooled societies where formal schooling is a social norm for achieving social outcomes beyond an individual's social status and wealth (Baker, 2014). In schooled societies, the role of education in enhancing health becomes strengthened because of better cognitive knowledge provided by quality schooling system (Baker, 2014), as well as increasing educational inequality (Etile, 2014; Ram, 1990). In terms of educational inequality, if an individual does not receive formal schooling in the society where all students complete secondary and even tertiary education, less-educated individuals are more relatively excluded from the mainstream society. The changed norm in educational attainment by educational expansion reflects the variation in the education-overweight gradient. Unlike the varying gradient by NT status, the level of educational expansion changed the likelihood of being overweight among the most-educated populations. In the low level of educational expansion, even the most-education individuals showed more than a
40% likelihood of being overweight. Conversely, in the high level of educational expansion, the effect of education increased, reducing the likelihood of being overweight among the most-educated individuals to almost 20%. While NT status increased obesity prevalence and then established the information and knowledge on health risk caused by obesity, educational expansion strengthened the protective role of education from the risk of obesity.

**Assimilated Gradient and Reduced Effects of Pre-migration Contexts**

Immigrant assimilation of the education gradient was partially supported only in the three-way interaction among educational attainment, NT status and US residence. As shown in previous studies, an imported gradient among immigrants indicates cultural buffering from the risk of obesity but the buffering effect diminished over the time after migration. This is because immigrants are forced to assimilate themselves into the westernized diet style and food markets with energy-dense foods that are mainstream conditions in the United States (Akresh, 2007). The empirical analysis using female immigrants in 2003 also supported the moderating effects of pre-migration contexts was reduced by the length of US residence. Graphing the changing trend of the education gradient varying by NT status, figure 4.3 showed that varying gradients became parallel with the line of the high NT group. Simply put, the effect of a unique nutrition context became null and the education gradients among immigrants changed into the pattern similar to that of the US-born population in the high NT status. Therefore, this finding gives implies that educational inequality in health status becomes a matter among the immigrant population over the time of their residence in the United States. More importantly, this finding also indicates the increasing importance of intervention on weight gain among the less-educated immigrant
population. By contrast, the moderating effect of the level of educational expansion did not change even among earlier migrants. This may be because most foreign-born adult immigrants already completed their formal schooling in their counties of origin and thus the length of US residence did not change the value of education (i.e., cognitive skills).

**Limitations and Recommendations for Future Research**

Although the empirical analysis showed the variation and convergence in education-overweight gradient, as well as the overall effect of education on being overweight, there are three methodological limitations to be considered for future research. First of all, this study is based mostly on cross-sectional data; in order to fully address the historical change in the education gradient over time, it may be more suitable to use the same individuals in longitudinal data or to conduct an analysis for generational differences in education gradient. Nevertheless, this research used the NIS 2003 as a cross-sectional data set because they collected detailed information on pre-migration contexts and experiences (Jasso et al., 2000) and allowing for a more descriptive illustration for the association between educational attainment and the likelihood of being overweight, considering many covariates, such as family SES in childhood and migration in childhood. Secondly, the NIS survey only sampled the immigrants who were legally permitted to live permanently in the United States (Jasso et al., 2000). Despite the detailed information on current immigrants in the United States, the empirical findings were unable to determine any difference related to obesity epidemic among legally permitted immigrants, temporary immigrants and illegal immigrants. Since temporary immigrants and illegal immigrants tend to have very different backgrounds from legally permitted immigrants.
(Kandula, Kersey & Lurie, 2004), the findings in the research should be interpreted with a caveat related to this data limitation. Finally, the omitted variable bias should be considered because the impact of ethnic enclaves in the United States and race/ethnicity could not be examined despite the significance in predicting the likelihood of overweight (Frank & Akresh, 2013).
REFERENCES


EDUCATION

2015  Ph. D., Pennsylvania State University
      Dual-degree: Educational Theory and Policy & Comparative and International Education

2006  M.A., Korea University
      Concentration: Sociology of Education

2004  B.A., Korea University
      Major: Education

SELECT PUBLICATION


RESEARCH EXPERIENCE

2010-2015  Research assistant
            Dr. David P. Baker, Pennsylvania State University
            Collaborated on NIH Research Grant Proposal: Shifting Education Effect on Mother Overweight over the Population Nutritional Transition (Application Number: 1 R21 HD081321-01)

2012-2013  Research assistant
            Population Research Institute (PRI), Pennsylvania State University
            Collaborated on data cleaning of Demographic and Health Survey (DHS) data

TEACHING EXPERIENCE

2015 (spring)  Teaching assistant
                Dr. Soo-yong Byun, Pennsylvania State University
                Course Title: Research in Comparative Education (EDTHP 597)

2014-2015  Lecturer
            Kyungmin College
            Sociology of education (short-term winter course)

GRANTS, AWARDS AND HONORS

2015  AERA Grant on Statistical Analysis: Causal Analysis Using International Data

2014  Accepted Dissertation Proposal, CIES New Scholars Dissertation Mentoring Workshop

2010-present  Dean’s graduate assistantship, College of Education, Pennsylvania State University

2005-2006  Academic fellowship, Department of Education, Korea University

2004  Summa cum laude, Korea University