Distribution Agreement

Reena Oza-Frank Date

Overweight and Diabetes among the U.S. Foreign-Born

By

Reena Oza-Frank

Doctor of Philosophy

Division of Biological and Biomedical Sciences

Nutrition and Health Sciences

K.M. Venkat Narayan
Advisor

Edward Gregg
Committee Member

Usha Ramakrishnan
Committee member

Aryeh D. Stein
Committee member

Rob Stephenson
Committee member

Viola Vaccarino
Committee member

Accepted:

Lisa A. Tedesco, Ph.D.
Dean of the Graduate School

Date

Overweight and Diabetes among the U.S. Foreign-Born

By

Reena Oza-Frank

B.S., The Ohio State University, 1999

M.S.-M.P.H., The University of Tennessee, Knoxville, 2003

Advisor: K.M. Venkat Narayan, M.D., M.Sc., M.B.A.

An Abstract of

a dissertation submitted to the Faculty of the Graduate

School of Emory University in partial fulfillment

of the requirements for the degree of

Doctor of Philosophy

in

Division of Biological and Biomedical Sciences

Nutrition and Health Sciences

2009

ABSTRACT

Overweight and Diabetes among the U.S. Foreign-Born

By

Reena Oza-Frank

In 2007, the U.S. foreign-born population reached a record of 38 million (13% of the population). Previous research has shown that foreign-born individuals are generally in better health compared to native born. However, health outcomes such as overweight and diabetes have been largely understudied among immigrants despite these conditions being at the forefront of public health concern.

Using nationally representative data, we estimated the magnitude of overweight and diabetes among the U.S. foreign-born and examined the relationships between migrant-specific characteristics and these conditions. We found considerable heterogeneity in both prevalence of overweight and diabetes by region of birth. We found that overweight prevalence is consistently associated with length of residence and that immigrants who arrive at younger ages are more likely to be overweight with increasing length of residence than immigrants who arrive at later ages. In addition, depending on region of birth, length of U.S. exposure appears to have a differential impact on overweight prevalence. Diabetes prevalence increases with longer length of residence, independent of age and obesity, and this relationship is consistent across different ages at immigration. Finally, using Asian Americans as a case study, we further show the importance of specific country of birth in highlighting heterogeneity when examining overweight and diabetes.

The U.S. foreign-born population comes from a range of countries, creating a multicultural society with multifaceted needs, not to mention the different genetics and

cultures that interplay with the environment in potentially diverse ways. Our findings contribute to the understanding of migration and health, specifically in the context of overweight and diabetes. Public health prevention efforts will be improved by responding in the following ways: promoting healthy lifestyles soon after migration to prevent excess weight gain; tailoring interventions to target young immigrants; and responding to the needs of diverse immigrants by tailoring interventions to be specific by place of birth.

Overweight and Diabetes among the U.S. Foreign-Born

By

Reena Oza-Frank

B.S., The Ohio State University, 1999

M.S.-M.P.H., The University of Tennessee, Knoxville, 2003

Advisor: K.M. Venkat Narayan, M.D., M.Sc., M.B.A.

A dissertation submitted to the Faculty of the Graduate

School of Emory University in partial fulfillment

of the requirements for the degree of

Doctor of Philosophy

in

Division of Biological and Biomedical Sciences

Nutrition and Health Sciences

2009

ACKNOWLEDGEMENTS

There are many people I would like to thank for their support as I pursued this PhD. I would like to thank the Centers for Disease Control and Prevention and the Emory Global Health Institute for funding this research. Thank you to my committee members, Venkat Narayan, Ed Gregg, Usha Ramakrishnan, Aryeh Stein, Rob Stephenson, and Viola Vaccarino for providing me with expertise and guidance to achieve my best. A very special thank you to my advisor, Venkat Narayan, for providing me with extraordinary training and a tremendously supportive learning environment. He gave me the freedom to direct my research while maximizing my learning potential. For that I am grateful and I am truly honored to be his first PhD student. Thank you to Solveig Argeseanu Cunningham, who I consider an honorary member of my committee and from whom I have learned more than she will ever know. I would like to acknowledge Nana Gletsu for her support and interest in my professional development in her roles as a rotation advisor and as the Director of Graduate Studies for the program. This experience was much more enjoyable and meaningful thanks to my fellow PhD students: Suzanne Judd, Rebecca Lynch, Mary Beth Weber, Kirsten Herrick, Cria Gregory, Camila Corvalán, Beth Imhoff-Kunsch, Phuong Nguyen, Tippawan Pongcharoen, and Jessica Marcinkevage. Finally, thank you to my family and friends for their love, support, and encouragement. To Mom and Dad for being there for me and supporting me throughout each and every one of my life pursuits; to my brother Ritesh for always being there when I need him; and to Matt for joining me on this journey and being the most supportive husband a student and wife could ask for.

Table of Contents

List of Tables

List of Figures

CHAPTER 1: INTRODUCTION

International migration has more than doubled since 1975 with over 191 million individuals migrating worldwide in 2005, an all time high (1). The United States, in particular, has a history of being home to large numbers of migrants and this remains the situation today. Large numbers of international immigrants are migrating to the U.S. (2), and immigrants currently account for nearly half the growth of the U.S. population (3) making this an ideal setting to study immigrant health.

As the immigrant stock in the U.S. has been increasing, so has the diversity among immigrants. At the turn of the century, when migration was at an all time high, the majority of immigrants were arriving from Europe. However, in recent years, immigrants are arriving from more and increasingly diverse regions of the world. Specifically, approximately half of the current foreign-born population in the U.S. comes from Latin America and one-fourth comes from Asia (4).

At the same time, the prevalence of overweight and diabetes[1] are increasing worldwide, and the U.S. is no exception. These chronic conditions are major causes of morbidity and mortality and despite national goals to reduce their incidence and prevalence, more adults in the U.S. were overweight and had diabetes in 2007 than ever before. In 2007, approximately 70% of the U.S. population was overweight or obese and approximately 8% of the U.S. population (24 million people) had diabetes, now the sixth leading cause of death in the nation (5).

Previous research has found that foreign-born individuals have less disease and appear to be healthier than native born individuals. Such findings have led to the

---

[1] For the purposes of this dissertation, diabetes refers to Type 2 diabetes only.

development of theories such as the healthy migrant theory, stating migration is not a random process and is associated with specific characteristics that are also associated with positive health outcomes. Although this has been true for most health outcomes, such as overweight, it is not the case for diabetes, where results have been variable (6), revealing that this theory may not be universal. Moreover, there is concern that prevalence overweight and diabetes among immigrants may converge to native born levels based on more recent work indicating that migrant-specific characteristics, such as age at arrival and length of residence in the host country, are important factors associated with health. Similarly, an immigrant's health profile is influenced by genes and environment, both of which reflect country of birth and are closely linked to overweight and diabetes.

The National Health Interview Survey (NHIS) and the New Immigrant Survey (NIS) are two surveys collecting some information on migration and health. NHIS is an ongoing (since 1957), serial cross-sectional, nationally representative survey designed to monitor the health of the U.S. population (7). NIS is a relatively new survey, collecting data on legal permanent residents based on nationally representative samples of the administrative records, compiled by the U.S. Immigration and Naturalization Service (INS) (8). A cross-sectional component was completed in 2004, and a longitudinal component was completed in 2007-2008 (although not yet publicly available). These datasets allow for cross-sectional examination of migrant-specific characteristics with regard to overweight and diabetes.

The chapters in this document review overweight and diabetes epidemiology in the U.S., (Chapter 2); review U.S. international migration statistics as well as the proposed relationships between migration and health (Chapter 3); and provide an overview of NHIS and NIS design and methods with statistical issues related to the study of migrant health (Chapter 4). The next six chapters report the substantial and methodological findings of this research:

- Chapter 5: Recent work suggests that overweight increases with increasing length of residence. In this chapter, we systematically review the literature to assess the importance of duration of stay on weight among U.S immigrants.
- Chapter 6: The cross-sectional nature of the NHIS allows us to sufficiently estimate the magnitude of overweight and diabetes in the U.S. foreign-born population by region of birth.
- Chapter 7: We take the studies represented in Chapter 6 one step further by examining how age at arrival modifies the association between length of residence and overweight.
- Chapter 8: We examine how the relationship presented in Chapter 7 may differ by region of birth.
- Chapter 9: We expand our focus to diabetes and determine how diabetes prevalence differs by length of residence and age at arrival.
- Chapter 10: We use Asian Americans as a case study to emphasize heterogeneity in overweight and diabetes among individuals that are typically grouped together.

Finally, in Chapter 11, the main findings and public health implications of this body of work are summarized.

As the foreign-born population continues to grow in numbers and diversity, it is important to estimate the magnitude and understand their health with regard to overweight and diabetes, conditions that continually impact the nation's health and economy. Identifying associations with factors specific to migration is important for (a) unraveling new migration-specific factors associated with overweight and diabetes, over and above the role of ethnicity; (b) understanding the health care needs of this population better; and (c) tailoring prevention efforts and health policy specific to this population.

CHAPTER 2: LITERATURE REVIEW - THE GROWING BURDENS OF OVERWEIGHT AND DIABETES

Characterization and epidemiology of overweight and obesity

Overweight and obesity are conditions of excess adiposity and are typically attributed to an imbalance between energy intake and energy expenditure but more completely are a result of the combination of genes, metabolism, behavior, environment, culture, and socioeconomic status (9). Body mass index (BMI) is a tool to assess overweight and obesity and is a measure of an adult's weight in relation to his or her height. Overweight is defined as a body mass index (BMI) of 25 g/m^2 or higher; obesity is defined as a BMI of 30 kg/m^2 or higher (Table 2.1).

Table 2.1 The International Classification of Adult Underweight, Overweight and Obesity according to BMI (10, 11)

Classification	**BMI(kg/m^2)**	
	Principal cut-off points	**Asian-specific cut-off points**
Underweight	<18.50	<18.50
Normal range	18.50 - 24.99	18.50 - 22.99
Overweight	≥25.00	≥23.00
Pre-obese	25.00 - 29.99	23.00 - 27.49
Obese	≥30.00	≥27.50

Worldwide, more than 1.1 billion adults are overweight and 312 million of these people are obese (12). Between 1980 and 2004, obesity prevalence in the U.S. doubled resulting in over 30% of U.S. adults 20 years of age and older (> 70 million people) being obese (13, 14). The inclusion of overweight individuals increases the prevalence to over 65% (14). The increase in overweight prevalence among young people has more than tripled in this same time frame. Among children and adolescents aged 6–19 years, almost

17 percent (over 9 million young people) are considered overweight (15, 16). This is particularly concerning because overweight adolescents have a 70% chance of becoming overweight or obese adults, and this increases to 80% if one or more parent is overweight or obese (17). Both overweight and obesity increase the risk of health problems such as heart disease, diabetes, certain cancers (endometrial, breast, and colon), hypertension, dyslipidemia, stroke, liver and gallbladder disease, sleep apnea and respiratory problems, osteoarthritis (a degeneration of cartilage and its underlying bone within a joint), gynecological problems (abnormal menses, infertility), disability (18) and for the case of obesity, a modestly elevated risk of all-cause mortality (14). Additionally, ~300,000 deaths each year in the U.S. may be attributable to obesity (17).

There are disparities in obesity prevalence by race/ethnicity among U.S. women, but not men. In 2005-2006, among women aged 40-59 years, Non-Hispanic black (53%) and Mexican-American (51%) women were more likely to be obese than non-Hispanic white women (39%). Among women aged 60 years and older, 61% of non-Hispanic black women were obese compared with 32% of non-Hispanic white women and 37% of Mexican-American women (14).

Medical expenses related to overweight and obesity accounted for 9.1 percent of total U.S. medical expenditures in 1998 and may have reached as high as $78.5 billion ($92.6 billion in 2002 dollars) (19). Approximately half of these costs were paid by Medicaid and Medicare.

The increasing proportions of overweight and obesity in the U.S. is a well recognized public health issue. One of the national health objectives for 2010 was to reduce the prevalence of obesity to less than 15%. Although there was no significant change in obesity prevalence between 2003–2004 and 2005–2006, projections indicate that by 2015, the prevalence of overweight will reach 75% and the prevalence of obesity will reach almost 41% among adults (20), suggesting current and future national prevalence estimates are far from meeting this goal.

Although genes and related metabolism are determinants of obesity, non-genetic factors such as behavior, environment, culture, and socioeconomic status also influence body weight (9). For developing nations, the nutrition transition, characterized by changing dietary habits and decreased physical activity, is one of the main reasons cited for these observed trends in weight change (21). In conjunction with globalization, urbanization, economic growth, and advancements in technology (22, 23), diets seem to be shifting worldwide to include more saturated fat, sugar, and refined foods with concomitant reductions in fiber intake and physical activity (22). The World Health Organization estimates that approximately 60% of the world's population does not engage in enough physical activity (24). Currently 30% of the developing population resides in urban areas, which is expected to increase by 50% by 2025, further increasing overweight/obesity prevalence (25).

In the U.S., lower levels of education and income have been linked to obesity, but associations between SES and obesity vary by age, gender, and race/ethnicity, which may be revealing the inability of education or income to reflect SES equally across different subgroups (20). Separating these effects is challenging, yet important to understanding the underlying influences of the recent increases in overweight and obesity prevalence and how different subgroups are differentially impacted.

Characterization and epidemiology of diabetes

Diabetes is “a diverse *group* of metabolic diseases characterized by high blood glucose concentrations” (5). In adults, type 2 diabetes accounts for about 90% to 95% of all diagnosed cases of diabetes and usually begins as insulin resistance (26). As the need for insulin rises, the pancreas gradually loses its ability to produce it, resulting in increased blood glucose (Table 2.2).

Table 2.2 Diagnosis of Diabetes (27)

2-Hour Plasma Glucose Result (mg/dL)	Fasting Plasma Glucose Result (mg/dL)	Diagnosis
139 and below	99 or below	Normal
140 to 199	100 to 125	Pre-diabetes (impaired fasting glucose)
200 and above	126 or above	Diabetes*

*Confirmed by repeating the test on a different day.

Diabetes prevalence is increasing worldwide. Currently, 246 million people are estimated to have the disease (24). Between the years 2000 and 2030, the number of people with diabetes is expected to increase from 171 to 366 million (23). Diabetes has become one of the major causes of premature illness and death in most countries (24) with almost 4 million deaths attributable to diabetes each year (28), making it a huge public health concern. The greatest increases in the number of people with diabetes will be in developing countries, where a 150% rise is expected (24) in this same time period.

Similar to overweight and obesity, one of the national objectives for 2010 is to reduce the rate of diagnosed diabetes. Despite this, the incidence of diagnosed diabetes increased 41% from 1997 to 2003, (29) and currently, the U.S. has the third highest number of individuals with diabetes worldwide (24). The prevalence of diabetes in the U.S. increased by 33% between 1990 and 1998 (30) and has continued to increase through 2007 (5, 31) such that currently, the prevalence of diagnosed and undiagnosed diabetes among people aged 20 years or older is 10.7% (24 million individuals). Among individuals aged 60 and older, diabetes prevalence was 23% (12 million individuals) (5). One in three people born in the United States in 2000 are projected to develop diabetes at some point in their lifetime (32).

In 2006, diabetes was the seventh leading underlying cause of death, however diabetes is likely to be underreported as a cause of death because studies have found that only about 35% to 40% of decedents with diabetes had it listed anywhere on the death certificate and only about 10% to 15% had it listed as the underlying cause of death (5).

Diabetes can lead to serious complications such as such as blindness, kidney damage, cardiovascular disease, and lower-limb amputations and premature death. Specifically, people with diabetes have double the risk for death compared to those without diabetes of similar age. Adults with diabetes have heart disease death rates about 2 to 4 times higher than adults without diabetes, leading to the characterization of diabetes as a risk factor of heart disease (33). The risk for stroke is 2 to 4 times higher among people with diabetes. In 2003-2004, 75% of adults self-reporting diabetes had hypertension or used prescription medications for hypertension. Diabetes is the leading cause of new cases of blindness among adults aged 20–74 years. Diabetes is the leading cause of kidney failure, accounting for 44% of new cases in 2005. Approximately 60-70% of people with diabetes have mild to severe forms of nervous system damage such as impaired sensation or pain in the feet or hands, slowed digestion of food in the stomach, and carpal tunnel syndrome. Severe forms of diabetic nerve disease are a major contributing cause of lower-extremity amputations, more than 60% of which occur in people with diabetes. Other health problems associated with diabetes include periodontal disease, complications related to pregnancy, and increased susceptibility to many other illnesses (5). These burdens will only increase as diabetes prevalence also increases.

In 2007, total direct and indirect costs of diabetes were estimated to be $174 billion (5). After adjusting for population age and sex differences, average medical expenditures among people with diagnosed diabetes were 2.3 times higher than what expenditures would be in the absence of diabetes.

Non-modifiable risk factors for diabetes include increasing age and specific ethnicity. The world's population under 15 years of age is expected to grow only by 22% between 1990-2020, whereas the cohorts of adults between 15-60 years of age is expected to grow by more than 55% (33). This latter statistic is particularly important because those $\geq$ 45 years of age are at the highest risk of developing diabetes (34). By 2030, almost 1 out of 5 Americans, approximately 72 million people, will be 65 years or older. Currently, the age group 85 and older is the fastest growing segment of the U.S. population (35). The aging population will certainly have a significant impact on diabetes incidence and prevalence in the U.S.

Diabetes prevalence is higher in African Americans, Asian Americans and Pacific Islanders, Hispanic Americans, and Native Americans Compared to whites in the United

States (5, 34). Among Hispanics in the U.S., the estimated lifetime risk of developing diabetes is approximately one in two (32). Higher rates of diabetes in African American women compared to white women have been attributed to higher levels of obesity. Asian populations (Filipinos, Japanese, Chinese, and South Asians) with similar body size to whites experience higher diabetes prevalence. This has been attributed to higher levels of visceral adiposity at lower BMI levels. The World Health Organization used this evidence to lower the recommended normal BMI level of Asians to $<23 kg/m^2$ instead of the general standard of <25 kg/m^2 (11) (Table 2.1).

Obesity and diabetes are two of the biggest risk factors for the development of cardiovascular disease (CVD). Worldwide, it is projected that by 2020, heart disease will be the leading cause of death (33). Despite declines in prevalence of other heart disease risk factors in the U.S. resulting from successful medical and lifestyle therapies (36), obesity and diabetes prevalence have increased. These trends are projected to continue, further increasing the burden of all 3 chronic diseases in the U.S. and worldwide. In order to prevent future incidence of such chronic diseases, prevention efforts are necessary.

Diabetes Prevention

Among the modifiable risk factors for diabetes, obesity is the single most compelling (and most predictable) risk factor for diabetes in the general population (12, 37). About 90% of diabetes globally can be attributed to excess weight (12). Large increases in diagnosed diabetes in the U.S. have been observed parallel to increases in overweight/obesity prevalence (38, 39) and accordingly, for every unit BMI increases, diabetes risk increases by 12% (40). The largest increases in diabetes prevalence and incidence are seen among very obese individuals (39, 41). As such, over 80% of people with diabetes are overweight or obese and over half are obese (42). Class III obesity (BMI >40) has increased four-fold over the past 25 years (currently 5%) and accounts for approximately 25% of the secular increase in diabetes prevalence (41, 43).

Thus, targets of diabetes prevention include interventions emphasizing changes in diet and increased physical activity with the intention for successful weight loss. Lifestyle interventions reduce the risk of diabetes by almost 60% in most studies (Appendix A). The results of the prevention studies mentioned show that lifestyle interventions with diet and/or exercise are effective for prevention or delay of type 2 diabetes, especially in high risk populations like those with prediabetes. These lifestyle interventions not only have been shown to prevent or delay diabetes but also have shown benefits related to weight loss, physical activity, an improved diet and beneficial effects on cardiovascular risk profile. In addition, data (44) also indicate that lifestyle interventions to prevent diabetes are highly cost effective and improve quality of life, especially if delivered at the level of primary care. Although practical aspects of delivering and maintaining long term changes in lifestyle are challenging, several strategies and tools to overcome these challenges are available and make primary prevention of diabetes realistic and necessary.

Summary

Obesity and diabetes are intricately related and in order to prevent diabetes, obesity prevention is essential. Although the aging U.S. population and sustainment of ‘obesogenic’ environments explains a portion of the increasing prevalence of overweight, obesity and diabetes, it does not explain all of the observed increases. There may be other factors, such as the changing composition of the U.S. population, specifically with regard to migration, a significant contributor to population growth in the U.S.

CHAPTER 3: LITERATURE REVIEW - MIGRATION AND HEALTH

International migration to the U.S.[2]

In 2005, there were approximately 190 million international migrants worldwide, more than double the number in 1960 and constituting approximately 3% of the world's population (45). Relatively few countries host most of the world's international migrants with 20% coming to the U.S., the largest of any other country (45). Moreover, immigration is expected to be the driving force behind future growth of the U.S. population (46).

According to the U.S. Census Bureau, anyone who is foreign-born is <u>not</u> a U.S. citizen at birth. This includes immigrants, legal nonimmigrants (temporary migrants), humanitarian migrants, and people illegally present in the United States. An immigrant is an alien admitted to the U.S. for lawful permanent residence as defined in the Immigration and Nationality Act (INA).[3] INA, created in 1952, is the basic body of immigration law. The biggest amendments to this law were passed in 1965 and included family reunification and employment preferences (47). The unexpected result from these amendments has been great influxes of legal and unauthorized immigrants, some of the largest in the nation's history.

In 2007, the estimated immigrant population in the U.S. reached a record of 38 million (13% of the population) (48), accounting for every one in eight U.S. residents. This is the largest proportion of foreign-born individuals since the early 1900s (49). This

[2] This dissertation focuses primarily on immigrants who choose to move, and the context reflects this.
[3] For the purposes of this dissertation, the terms foreign-born, immigrant, and migrant will be used interchangeably.

represents a 50% increase from 1990 in the number of immigrants coming to the U.S. (50). Between 1995 and 2000, immigration accounted for 75% of the population growth in the U.S. (50). By 2050, it is projected that one in every five U.S. residents will be an immigrant (51). It is important to note that these figures do not necessarily count the approximately 9-10 million illegal or unauthorized immigrants in the U.S. (52).

In 2006, the top five states with the largest share of foreign born were California (27%), New York (22%), New Jersey (20%), Nevada (19%), and Florida (19%). Between 1990 and 2000, the five states with the largest percent growth of the foreign-born population were North Carolina (288%), Georgia (248%), Nevada (206%), Arkansas (199%), and Nebraska (183%). However, between 2000 and 2006, the five states with the largest percent growth of the foreign-born population were Delaware (53%), South Carolina (52%), Nevada (50%), Georgia (49%), and Tennessee (49%) (53). Such data indicate that immigrants are no longer settling in just a few states in the U.S. and are becoming increasingly numerous throughout the nation.

Currently, the United States accepts more legal immigrants as permanent residents than the rest of the world combined (54) and accordingly, in 2006, the U.S. was one of a few countries in the world that continued to experience large increases in permanent-type legal immigration of foreign nationals (2). Specifically, almost 1.2 million people received lawful permanent residency,[4] representing a 13% increase from 2005, the highest level since 1991 (2). Temporary visas are the typical starting point to

---

[4] A legal permanent resident (LPR) is "a foreign national who has been granted lawful permanent residence in the United States. LPRs, more commonly known as "green card" recipients, are permitted to live and work anywhere in the United States, to own property, to attend public schools, to join certain branches of the armed forces, and may also apply to become U.S. citizens if they meet certain eligibility requirements" (55).

move into LPR status, and demand for such visas remains much higher than availability (2).

Characteristics of the U.S. foreign-born population

Over half of the foreign-born in the U.S. in 2005 were recent arrivals, with about 28% entering after 2000, 29% between 1990 and 1999, and 43% before 1990 (56). Again, as a result of the 1965 amendments to the INA, there was a new, enlarged immigration flow coming from countries in Latin America and Asia (47). Approximately 50% of the foreign-born population in the U.S. comes from Latin America and 25% comes from Asia (4). In addition, approximately 40% of the Latinos and 60% of the Asians in the U.S. are foreign-born (57). The five largest foreign-born populations by specific country of origin are Mexico (11.7 million), China (1.9 million), the Philippines (1.7 million), India (1.5 million), and El Salvador and Vietnam (both at 1.1 million). Over 50% from each group arrived between 1990 and 2005, with the exception of the Philippines (56, 58). Newer arrivals, such as immigrants from Somalia and Kenya (56), contribute to the increasing diversity of the migrant pool.

Approximately 80% of foreign-born are 18-64 years of age, whereas 60% of native born are in this group (59). Furthermore, 45% of foreign-born were 25-44 years of age compared to only 27% of native born. Among those aged 45-64 years, there are approximately equal proportions of foreign- and native born. Regarding children and adolescents <18 years of age, 9% of foreign-born and 28% of native born fall under this category, reflecting the larger number of native born children who have foreign-born parents (59). Over 80% of immigrants arriving to the U.S. are between the working ages of 16-64 years (58). By country of origin, those born in Hungary (64 years) and Italy (63.1) have the oldest median ages, followed by those from Greece, Germany and Ireland. Those born in Somalia have the youngest median age (26.8) (56).

Among adult immigrants, over 30% have not completed high school, compared to only 8% of natives yet the proportions of foreign- and native born with college degrees is approximately equal (28%) (48). With regard to specific countries of origin, 80% of those born in China and >90% of Nigerians, Kenyans, South Africans, and Egyptians are high school graduates. Seventy four percent of people born in India have a bachelor's degree, more than people born in any other foreign country. Proportions of people from Egypt and Nigeria with a bachelor's degree were over 60 percent (56).

Foreign-born from India, Australia, South Africa and the Philippines have the highest median household incomes, while those from Somalia and the Dominican Republic had some of the lowest (56). Median household income among foreign-born remained about $4,300 lower than the native born median household income ($46,881 vs. $51,249). Data on such characteristics highlight the diversity of immigrants in the U.S. and illustrate how they come from a variety of social, economic, cultural backgrounds, each of which shapes health.

Health of the U.S. Foreign-Born

There is a consensus in the literature that migration and health are intertwined (60). Health can be a determinant in the decision to move and migration may affect not only the health of those who move, but also the health of those who remain in the home country, and perhaps even those in the host country (60). Research questions on health in the context of migration offer a better understanding of the complexity of the migration process which is important as migration to the U.S. continues.

Since migration often involves change and adaptation to a new environment, immigrants tend to be selective for personal characteristics, such as health, that foster their ability to handle change and adapt to new environments (60). The health profile of the foreign-born population is generally better than that of the native born counterparts (61, 62). For example, immigrants exhibit longer life expectancies and lower overall mortality rates compared with U.S.-born counterparts. Cause-specific mortality among immigrants is lower on cardiovascular disease, lung and prostate cancer, chronic obstructive pulmonary disease, cirrhosis, pneumonia and influenza, unintentional injuries, and suicide. Migrants also report lower prevalence of conditions such as hypertension, high cholesterol, cardiovascular disease, and asthma compared with U.S.-born counterparts (63-65). In a review of the literature (6), all studies included reported a lower BMI and less overweight/obesity among foreign-born compared to U.S. born. This was true across sex (66) and race/ethnicity (66-69). Among immigrants, there are variations by country of birth (6) with those from the Western Hemisphere being the heaviest and those from Asia the lightest (70). There are also variations by sex such that female migrants are more likely than male migrants to converge to U.S. born levels (66). Finally, there are variations by race/ethnicity. Hispanics converge to or even surpass native counterparts risk levels (71), while blacks may never converge (66).

A theory frequently stated as an explanation for these health differentials is the healthy immigrant theory. This theory specifically states that migration is not a random process and is associated with specific characteristics that are also associated with positive health outcomes. Examples of some of these characteristics were mentioned previously: younger age, better levels of educational attainment, and correspondingly higher socioeconomic status compared to those they leave behind and compared to native born individuals. These characteristics are associated with positive health outcomes and thus result in an apparent health advantage. Additionally, migrants may just be inherently different than nonmigrants in that they are motivated to seek and invest themselves in opportunities (as evidenced by the decision to migrate), and thus may be more likely to protect their health compared to others (70). Other characteristics associated with positive health outcomes that are also characteristics of migrants include (6) a more extensive social support (63), health selection through immigrant screening (70), and the salmon bias, which states that migrants who are ill return to their home countries, resulting in a healthier group of remaining migrants (72).

Another potential explanation for the observed better health is the maintenance of healthy behaviors associated with a traditional lifestyle, reflecting home country environments and norms (62, 73-76). For example, fewer immigrants report smoking compared to native born (77). Additionally, perhaps they eat healthier and engage in physical activity more regularly. Regarding diet, immigrants may change their diets post-migration based on more/less income, access to new foods/lack of access to traditional foods, and stress related to separation anxiety (67, 78), suggesting that traditions, access, and relative wealth are the basis of the differences between foreign-born and native born health.

Genetics may also play a role in explaining better immigrant health. Immigrants may have predispositions to particular health conditions (73). For example, Hispanic whites and Asian Indians are most positively selected for health, but Mexicans are the least selected (70). However, this does not imply that foreign-born is equivalent to race/ethnicity yet race/ethnicity are commonly used to categorize populations on the basis of shared characteristics (79). Race has traditionally and inaccurately been defined by shared biological characteristics such as genes, skin and hair color yet categories based on race account for only 3-7% of total human genetic diversity (79, 80). Ethnicity has been defined by cultural characteristics such as shared language, ancestry, religious traditions, dietary preferences, and history rather than biological characteristics (79, 80). Because race cannot capture biological distinctions, this leads to the conclusion that both race and ethnicity are social, not biological, constructs. Country of birth, rather than race/ethnicity, may better represent the combination of genetic and cultural factors within each ethnic group, but remains an underutilized variable in the current literature. And given the number of sending countries, the diversity of health behaviors that immigrants bring with them can be numerous (70).

Immigrants, however, do not exhibit better health on all health outcomes. For example, compared to native born, immigrants experience higher mortality due to stomach and brain cancer and infectious diseases. Additionally, diabetes is most frequently noted as more common among migrants than U.S. born, and prevalence varies by country of birth. Diabetes prevalence among Arab Americans is similar to native born (81). Filipinas had higher prevalence than white or black women (82), yet no difference from those living in the Philippines (83). Asian Indians had higher prevalence than whites, blacks, Hispanics (84). Immigrant Mexicans had higher diabetes-related death rates and four times greater odds of diabetes than native born counterparts from the same community (85).

It has been hypothesized that individuals who migrate experience stress, and that this stress may contribute to worsen health. Three related time points of stress among immigrants have been identified: migration stress (related to the process of moving from one country to another), visa stress (related to the process of obtaining legal permanent residence) and stress in the host country (related to acculturation/assimilation into a new lifestyle/environment; loss, separation from family, friends, lifestyles) (70). Within these stresses there are also intermediate types of stresses. For example, illegal immigrants may fear being discovered and subsequent deportation. In addition, immigrants may have pressures to send money to support family members in their country of origin while at the same time support themselves in the host country. Chronic stress increases susceptibility to illness and infection by suppressing the human immune response (70). Prolonged exposure to stress has also been shown to effect cardiovascular health through increased adrenaline and increased blood pressure to raise risk of hypertension (86). Through cortisol production, stress also increases production of glycogen and fat, raising the risk of obesity. This also suppresses insulin production leading to higher levels of blood sugar and a greater risk of diabetes (86). Stress has also been hypothesized to be a risk factor for diabetes through mechanisms linking low socioeconomic status (SES) to weight gain (87). Despite these plausible mechanisms, no direct link between stress and diabetes has been demonstrated (88). Because immigrants are on average younger than the U.S. born population (89), these stresses could lead to earlier onset of chronic diseases.

Other explanations for worse health include (6) harmful work and living environments (90, 91), poorer access to health care (71, 92), lack of health insurance (63, 93, 94), receipt of lower quality health services (95), and lower likelihood of seeking medical assistance and preventive care (92, 96). Specifically, immigrants are twice as likely to be uninsured as the rest of the population (97, 98) and per capita total health care expenditures of immigrants were 55% lower than those of U.S. born persons (99). Access to care varies by immigration status, country of birth, and language/cultural barriers (97). Use of health care is also influenced by cultural barriers in addition to socioeconomic factors (98). For instance, immigrants were less likely than U.S. born individuals to report discussing diet and exercise with clinicians (2). Yet at the same time, new immigrants who had contact with a physician within the past year reported lower rates of chronic diseases compared to native born, indicating the health advantage persists (70).

Finally, differences in socioeconomic status may impact immigrant health. It has been shown that migrants are more educated than their nonmigrant counterparts (100). Yet migrants who arrive to the U.S. from less developed countries are coming from an environment where there is a strong positive relationship between SES and obesity, which is in contrast to observations in developed countries (101). The majority of the immigrant stock in the U.S. is arriving from developing nations, and thus may experience unique patterns and changes in BMI. Recent research has shown little to no change in mean BMI with increasing education or income among foreign-born Asians and Hispanics, whereas among native born, there was somewhat of a negative gradient such that higher education and income corresponded with lower mean BMI (102). The authors of this study concluded that the SES patterning of BMI across the nation is likely to be significantly influenced by immigrants (102).

Acculturation

Recently acculturation[5] has been used to explain health differentials between foreign- and native born. There is evidence that acculturation modifies the health and behavioral risks of immigrants (62, 74, 103, 104). However, acculturation includes a broad set of changes that are difficult to quantify due to the complexity of this construct. Thus, there has been recent recognition of the multidimensional aspects of acculturation (105) and the fact that the health effects of acculturation vary by country of birth (106). Accordingly, acculturation has been measured in many ways: composite scores, scales, changes in SES/diet/physical activity/smoking, language use, social networks, generation, stress, length of residence, and age at immigration. Although such non-scale measures often lack an explicit theoretical model, they offer flexibility in exploring health effects as separate dimensions of acculturation (107).

Health effects of acculturation and the variables used to quantify acculturation vary by the health outcome of interest (106). For example, the association of language preference/usage with BMI has been recently examined among Hispanics. Akresh (108) found that less English usage (interpreted as less acculturation) was associated with higher BMI compared to Hispanic immigrants with more English usage. Barcenas et al. (109) found that high English usage was associated with lower BMI compared to U.S. born. Finally, Himmelgreen et al (110) found no significant association between English

[5] Defined as changes in the behaviors and cultural values of an individual or group as a result of contact with another culture.

language use and BMI among foreign- and native-born Hispanic women, but did find significantly higher BMIs and prevalence of obesity among foreign-born women with higher English fluency. These mixed results using language as a proxy measure for acculturation could potentially be explained by differences in the way the questions about language were asked. They may also be related to differences among Hispanic subgroups. In addition, if language usage is correlated with education, as has been hypothesized (108), then perhaps language is not the best proxy for acculturation.

Similarly, differences in acculturation measures can be seen when diabetes is the outcome. For example, one study (111) calculated an acculturation score based on nativity, length of residence in the U.S., and language spoken at home and found that, among non-Mexican-origin Hispanics, greater acculturation was associated with higher diabetes prevalence compared to lower acculturation. Conversely, a study on Mexican Americans that used three different acculturation scales, increased acculturation was associated with lower diabetes (112). Another study in Hispanics (113) found that individuals with low acculturation, measured by language, were more likely to have diabetes compared to those with higher acculturation. These discrepancies may be highlighting one of two things: differences in measures of acculturation and differences in health beliefs, behaviors, and thus acculturation patterns with regard to diabetes among Hispanic subgroups. This latter point may extend to other race/ethnicity groups (114). Regardless of the various ways to measure/assess acculturation, it is a factor that should be considered when predictors of weight and diabetes in racial/ethnic groups are examined (111).

A general assumption in the use of temporal indices, such as length of residence and age at immigration, is that timing and length of exposure to social contacts and interactions influences health (107). For example, longer duration can lead to improved communication skills and ability to navigate the new society (107). Conversely, it has been shown that the health of foreign-born individuals changes with prolonged stay in developed countries. Specifically, declines in health with increased length of residence have been observed with self-reported/general health (94, 115), cancer (116), and heart disease (76). In addition, increases in obesity and chronic disease are observed as duration in the host country increases (67, 73, 76, 117-119), despite having lower BMI at time of achieving legal permanent residence status (86). [Please see Chapter 5, 7-9 for additional results on associations of temporal indices with weight and diabetes.] Although it has been shown that multidimensional acculturation scales strongly correlate with length of U.S. residence and age at arrival (120), more work is needed to quantify the relationship between temporal indices and other measures of acculturation to better understand what concepts temporal indices are capturing. Possible reasons for these deleterious changes in health include changes in cultural behaviors and attitudes, including diet and physical activity.

Beginning with the Ni-Hon-San study, research has associated increased acculturation to a Western lifestyle with adverse CVD risk factor profiles and increased CVD morbidity and mortality, including increased BMI, waist circumference, hypertension, diabetes, CVD morbidity and mortality (121). Explanations for this include that Japanese in Japan ate the least fat and most carbohydrate, while Japanese living in Hawaii and CA progressively ate more fat and less carbohydrate (121). These historical findings indicate a change in diet post-migration. More recent studies have also indicated such changes. For example, more Korean born immigrants meeting fruit and vegetable recommendations compared to U.S. born Korean (122). Korean Americans who reside in the U.S. longer have decreased intakes of Korean foods (e.g. rice, kimchi) and increased fruit intake (123). Among Hispanics, acculturation/duration positively associated with dietary change and dietary change positively associated with BMI (124). Mexican born adults consumed less fat, more fiber, and met dietary guidelines more frequently compared to U.S. born Mexicans (125). [Please see Chapter 7 for additional results on the association between diet and acculturation.]

It is important to recognize, though, that acculturation is not always associated with poor health outcomes/behavior. Among Hispanics with hypertension, hypercholesterolemia, and/or diabetes, those who spoke Spanish at home and/or spent less than half their lives in the U.S. had higher systolic blood pressure, LDL cholesterol, and fasting blood glucose compared to Hispanics who spoke English and lived more time in the U.S. (111). Potential explanations for such findings include lack of knowledge on how to navigate the U.S. health care system; have poorer patient-physician communication; limited access to care due to financial, temporal, or cultural barriers. Among Arab Americans, lack of acculturation is associated with increased risks of diabetes (114). Regarding physical activity, studies have found an inverse association between acculturation and sedentary activities, which may be an example of ‘positive’ acculturation (109, 126). Despite these potential protective effects of acculturation, adverse effects on risk factor prevalence likely overwhelm any potentially beneficial effects.

Summary

Understanding the dynamics of migration and how it may influence immigrant health might be one approach to learn how to reduce future burden of overweight and diabetes. Considering the role the environment can uncover latent genetic predispositions (127) while at the same time highlight migrant-specific characteristics related to health. Mechanisms by which the environment influences overweight and diabetes in genetically predisposed individuals are unknown (26) as are reasons why all obese individuals do not develop diabetes, (26) but it appears that obesity triggers diabetes only in susceptible individuals (34). Ethnicity differences in overweight and diabetes risk do not account entirely for the disparities in prevalence, indicating there must be other explanations (26). Studying immigrants allows a method of differentiating genetic from environmental causes of geographic variation in disease (128). Three variables in particular emerged from a review of the literature as important factors related to overweight/obesity and diabetes in immigrants, but have limited exposure in the literature: region of birth, length of residence, age at immigration.

As the migrant population continues to increase in size and diversify, we should take advantage of potentially large sample sizes and existing data to study immigrant health. Identifying the importance of place exposures and pre-dispositions in this subgroup will aid in understanding genetic and environmental determinants of disease to health worldwide.

CHAPTER 4: METHODS

Survey designs and sample populations

National Health Interview Survey

The National Health Interview Survey (NHIS) was established as a result of The National Health Survey Act of 1956 to act as the principal source of information on the nation's health. This serial cross-sectional household survey is one of the major data collection programs of the National Center for Health Statistics (NCHS), Centers for Disease Control and Prevention (CDC) (7). NHIS has been ongoing for 50 years and data are collected annually from the civilian, noninstitutionalized, household population of the U.S. Thus excluded persons include patients in long-term care facilities; persons on active duty with the Armed Forces (though their dependents are included); persons incarcerated in the prison system; and U.S. nationals living in foreign countries.

The survey uses a multistage probability design and includes approximately 43,000 households including about 106,000 persons annually (129). The sampling plan is redesigned after every decennial census. The first stage of the current sampling plan consists of a sample of 358 (1995-2005) and 428 (2006 and later) primary sampling units (PSU's: a county, a small group of contiguous counties, or a metropolitan statistical area) drawn from ~1,900 geographically defined PSU's that cover each state and the District of Columbia. The secondary sampling units are clusters of housing units. In 1995, NHIS began oversampling the Hispanic population in addition to the prior oversampling of the black population (67). In 2006, the survey also began oversampling Asian persons. The total NHIS sample is subdivided into four separate panels, each representative of the U.S.

population. The households selected for interview each week in the NHIS are a probability sample representative of the target population. Household Survey participation is voluntary and the confidentiality of responses is assured under Section 308(d) of the Public Health Service Act.

Survey content is updated every 10-15 years and in 1997, a substantially revised NHIS questionnaire was implemented to improve the ability of the NHIS to provide health information (Appendix B). Core questions remain unchanged from year to year and allow for trend analysis and for data pooling increase sample size for analytic purposes. Core components include: Household, Family, Sample Adult, and Sample Child. Data for this dissertation was extracted from (a) The Household component: limited demographic information on all of the individuals living in a particular house and (b) The Sample Adult component (randomly selected adult aged 18 years or older): detailed information on health status and limitations, injuries, healthcare access and utilization, health insurance. Final household and sample adult response rates can be found in Table 4.1.

The U.S. Census Bureau, under a contractual agreement, is the data collection agent for the National Health Interview Survey. NHIS data are collected through a personal household interview by Census interviewers. Data are collected through a self-reported, personal household interview conducted by employees of and trained by the U.S. Bureau of the Census according to procedures specified by the NCHS. Since 1997, the NHIS uses a computer assisted personal interviewing (CAPI) mode, which is administered using a laptop computer. The survey is administered in Spanish or English only and does not allow proxy respondents for Sample Adult questions. Family members

Table 4.1 NHIS Household and Sample Adult Response Rates

NHIS year	1997 (130)	1998 (131)	1999 (132)	2000 (133)	2001 (134)	2002 (135)	2003 (136)	2004 (137)	2005 (138)
Number of households	39832	38209	37573	38633	38932	36161	35921	36579	38509
Total number respondents	103477	98785	97059	100618	100761	93386	92148	94460	98649
Number of randomly selected adults	36116	32440	30801	32374	33326	31044	30852	31326	31428
Final Household Response Rate (%)	91.8	90.0	87.6	88.9	88.9	89.6	89.2	86.9	86.5
Final Adult Sample Response Rate (%)	80.4	73.9	69.6	72.1	73.8	74.3	74.2	72.5	69.0

may translate for a non–English or non–Spanish speaking respondent who is present in the home.

The sample is selected such that each person in the covered population has a known non-zero probability of selection (139). These probabilities of selection are provided by NCHS and account for unequal probabilities of selection resulting from sample design, non-response, and planned oversampling of certain subgroups. The final person-level weights are further adjusted by post-stratification for Census sex, age, and race/ethnicity population controls. Beginning in 2003, NCHS made the transition to weights derived from the 2000-Census-based population estimates (as opposed to the

1990 Census, which was used for 1995-2002). Population weights change each year based on current population. This weighting of data allows estimates to be generalizable to the U.S. civilian, non-institutionalized population.

New Immigrant Survey

The New Immigrant Survey (NIS) is a multiple-cohort, longitudinal survey of a nationally representative sample of adult immigrants with newly acquired legal permanent residence (LPR) and their children. Adults include all immigrants who are 18 years of age or older at admission to LPR and who have visas as principals or as accompanying spouses. The objective of the New Immigrant Survey (NIS) is to provide a public-use data base that will be useful for addressing scientific and policy questions about migration behavior and the impacts of migration through both retrospective and prospective data. Specifically, one of the main research questions of the survey is to determine if over time, migration to the U.S. improves the health of migrants and how does the health and well-being of immigrants compare to that of the native-born (8, 70).

The sample design calls for taking representative cohorts of new legal immigrants and following them over time, with new cohorts selected every four or five years (8). The sample is based on probability samples of administrative records compiled for new immigrants by the U.S. government (via, formerly, the U.S. Immigration and Naturalization Service (INS) and now its successor agencies, the U.S. Citizenship and Immigration Services (USCIS) and the Office of Immigration Statistics (OIS)). The sample represents all those who received their green cards in a certain time period and thus includes both new-arrival immigrants (immigrants arriving in the U.S. with immigrant documents acquired abroad) and adjustee immigrants (immigrants who are already in the United States with a temporary nonimmigrant visa (or, in some cases, illegally) and adjust to lawful permanent residence). For this dissertation, data from the baseline cohort (NIS-2003) were used, the first full cohort of individuals who received their green cards between May and November, 2003.

Interviews for the baseline round are conducted as soon as possible after admission to LPR status. Additionally, interviews are conducted in the language of the immigrant's choice to maximize response rate and data quality. Immigrants are located through the administrative records in the sampling frame, which includes the address to which the immigrant has requested that the green card (the paper evidence of legal permanent residence) be mailed. The sample is stratified by four immigrant visa categories: employment principals, diversity principals, spouses of U.S. citizens, and other immigrants; the first two strata were oversampled. In the adult sample, a response rate of 68.6% was obtained. The geographic sampling design includes all top 85 Metropolitan Statistical Areas (MSAs) and all top 38 counties and to select a random sample of 10 MSAs from among the rest of the MSAs and a random sample of 15 county pairs from among the rest of the counties.

The questionnaire for the baseline round included information on a variety of topics including health, education, marriage and family, skills, language use, labor force participation, earnings, use of government services, networks, travel, and religion (Appendix C). In successive rounds, the instruments will track changes over time. The public-use data set provides researchers with the appropriate sampling weights necessary to account for the complex survey design.

Data Issues

Although NHIS public use microdata files are released on an annual basis, to preserve privacy and confidentiality of survey participants, NCHS does not release all data from the surveys it administers. However, restricted data can be accessed through the Research Data Center (RDC) of NCHS. The RDC was established to meet the Department of Health and Human Services goal of increasing capacity to provide state and local area estimates. The RDC provides a mechanism through which researchers can gain restricted access to detailed data files in a secure environment, without jeopardizing confidentiality. The RDC is located in Hyattsville, MD. Researchers wishing to gain access to the restricted data must submit a proposal with details regarding data specifications (140). For this dissertation, one of the main variables of interest, region of birth, is not available on the public use data files for years 1997- 2001. These years were necessary to include in analyses to increase the foreign-born sample size and answer the research questions of interest. Thus, we requested and were granted access to the country of birth variable, which we categorized to be comparable to the data for years 2002-2005. Analyses found in Chapters 6, 8, 9 were conducted in Hyattsville, MD and reflect the use of the country of birth variable.

Another main variable of interest for this dissertation was age at immigration. This variable is also unavailable in the public use data files. In order to calculate this variable, the continuous data for 'duration of stay in the U.S.' is necessary to subtract from current age. 'Duration of stay' is only available on the public use data files as a categorical variable, and thus we also requested and were granted access to the continuous version of this variable. Analyses found in Chapter 8 and 9 reflect the use of this calculated variable.

Statistical issues

Pooling data from NHIS is a common practice, however, in doing so, statistical procedures are recommended by NCHS. Specifically, sampling weights for pooled data must be adjusted to avoid biased estimates. A valid method for variance estimation is to treat the pooled data like one year of data with a very large sample size, and thus reducing random error. When the years being pooled fall within the same design period (and thus same geographic areas), no changes were made to the design variables within the years being pooled, and (as was the case with the years included in all analyses presented in this dissertation) weight adjustment procedure that NCHS recommends is to divide each sample weight in the pooled dataset by the number of years that are being pooled (e.g., divide by 2 when two years of data are combined, divide by 3 when three years of data are combined, etc) (139). The data years cannot be treated as statistically independent, because the samples for the different years were drawn from the same geographic areas. Doing so would lead to standard error estimates that are too small, and standard error estimates of contrasts between years would tend to be too large if the yearly estimates are positively correlated.

Although there are several beneficial aspects of pooling data, there are also some unavoidable assumptions. Mainly, by pooling data, we are assuming that each cohort of immigrants interviewed from 1997-2005 is the same and there are no variations in characteristics by immigrant cohort. In order to account for potential cohort effects, we included a variable to represent survey year in analyses to adjust for any difference or secular trends in overweight/diabetes prevalence or awareness over the period of interest.

CHAPTER 5: THE WEIGHT OF U.S. RESIDENCE AMONG IMMIGRANTS: A SYSTEMATIC REVIEW

Obesity Reviews. June 15, 2009 doi: 10.1111/j.1467-789X.2009.00610.x

[epub ahead of print].

The Weight of U.S. Residence among Immigrants: A Systematic Review

Running Title: Duration of residence and weight gain

REENA OZA-FRANK, MS-MPH, RD[1]

SOLVEIG ARGESEANU CUNNINGHAM, PhD[2]

[1]Emory University, Nutrition and Health Sciences Program, Graduate Division of Biomedical and Biological Sciences, Atlanta, GA

[2]Emory University, Hubert Department of Global Health, Rollins School of Public Health, Atlanta, GA

Corresponding Author:
Reena Oza-Frank
Emory University
Rollins School of Public Health
1518 Clifton Road, NE
Atlanta, GA 30322
Phone: 614-327-3629
Fax: 404-727-4590
E-mail: roza@emory.edu

Key Words: Overweight/obesity, immigrant, duration of residence, United States

Word Count = 3554

Number of Tables = 1

Abstract

As the number of immigrants in the U.S. continues to rise, it becomes increasingly important to understand how their health differs from native-born individuals. Obesity is a public health concern and a component of health that may differ and change in important ways in immigrants. This research synthesizes the current literature on the relationship between immigrant duration of residence in the USA and body weight. Five databases from the health and social sciences were searched for all pertinent publications. Fifteen articles met inclusion criteria, 14 of which reported a significant, positive relationship between body mass index and duration of residence in the U.S. (all p-values <0.10). Two studies reported a threshold effect of weight gain after 10 years of U.S. residence and another study reported that BMI peaks after 21 years of duration for men and after 15 years for women. The results of this review suggest that weight gain prevention programs would be beneficial for many immigrants within the first decade of residence in the U.S. Prevention efforts may be more successful if nativity and acculturation are considered in addition to race/ethnicity. Future research is needed to identify the specific mechanisms through which living in the U.S. may adversely affect health outcomes.

Introduction

Over the past few decades, the prevalence of obesity (body mass index (BMI) $\geq$ 30 kg/m^2) has been increasing worldwide (1), including in the U.S. (2) Because obesity is a risk factor for chronic diseases such as cardiovascular disease (CVD) (3), diabetes (4), and certain cancers (5-7), obesity prevention is at the forefront of public health research.

Studies of racial and ethnic differences in the prevalence of obesity and obesity-related illnesses have focused on broad categories of race/ethnicity such as African American, Hispanic, and Asian relative to White (8, 9). However, more recently, some studies have shifted focus to immigrants as an additional consideration that parallels racial and ethnic categories. In 2006, immigrants comprised over 12% of the U.S. population (10) and an even larger proportion of many minority groups (11). With the increasing proportion of the population that is foreign-born, the health of the immigrant population will become an important factor in the nation's health.

Evidence suggests that immigrants exhibit better health in general compared to native- born individuals, but this health advantage seems to diminish with length of stay in the U.S. (12-14), even after controlling for age. Several studies have shown that immigrants tend to weigh less upon arriving to the U.S. compared with the native-born (15). However, both weight and obesity have been observed to increase with duration of residence (13, 16-29). This study presents a systematic review of published studies that assesses the relationship between duration of residence in the U.S. and BMI.

Methods

In developing the study, guidelines for systematic reviews were carefully followed (30).

Data sources

We conducted searches in the PubMed, Medline, Econ Lit, Sociological abstracts, and JSTOR databases between March 1 and December 15, 2008 for any peer-reviewed English language studies that fit our search criteria. We used a combination of the following keywords to identify studies (one word from each of the four groups): *immigrant/migrant/foreign-born/birthplace/country of birth/country of origin/region of birth/region of origin* AND *United States/U.S.* AND *BMI/body mass index/overweight/obesity/body weight* AND *duration/length of stay/time of arrival/time/acculturation.* While these terms are not synonyms, they were selected to ensure that all studies on the topic were included. We did not restrict the searches to particular time periods, specific populations or types of migrants, or certain lengths of stay.

Literature Screening

Selection of articles was conducted through two screening phases. In phase one, abstracts were reviewed independently by both authors for the following inclusion criteria: presentation of original research (e.g. no review articles, letters, commentaries); inclusion of foreign-born individuals and specification that the sample or part thereof was foreign-born; based in the United States; measurement of overweight and obesity or BMI as outcome variables; and inclusion of duration of residence as a separate variable (versus as a component in a composite measure of acculturation). We excluded studies that used generation as a measure of duration of stay in the U.S., because this does not capture the effects of exposure to a new environment on migrating individuals, but rather compares different individuals with different characteristics, making strong assumptions about the similarities that may exist between them.

In phase two, full articles were obtained of the abstracts that passed the inclusion criteria and those for which a determination could not be made from the abstract. The same inclusion criteria were applied in phase two and each article was again independently assessed by each author. In a third phase, we searched the references for each of the full articles to find any additional relevant articles that were missed. These were retrieved and subjected to the inclusion criteria. The search was periodically repeated to verify that the results were replicable and located the same articles. A standardized content abstraction form was used to collect key data on each publication included in the review: data source, study type, study population (subgroup(s) represented, sex, age range, etc), sample size, study methods, study result(s), and study weaknesses.

Results

The initial searches identified 1,813 abstracts for screening (this includes abstracts that appeared in more than one database) in PubMed, Medline, and Sociological abstracts. Econ Lit and JSTOR did not yield any additional matches. After exclusion of repeated abstracts, review articles, letters, commentaries, and abstracts that did not meet the inclusion criteria, 60 articles remained. Of these, 47 were rejected after review of full text, resulting in 15 articles (including two that were identified through hand-searching). Details of these articles are presented in Table 5.1 (13, 16-29).

Our main substantive finding is that, despite differences in study methodologies (Table 5.1), all but one article reported a significant, positive relationship between BMI and duration of residence among U.S. immigrants (all p-values <0.10). Two studies (13, 22) specifically concluded an observed threshold effect based on the observation that BMI did not increase substantially after living in the U.S. for at least 10 years. Another study (16) reported that BMI peaks after 21 years after arrival for men and after 15 years for women, and that the importance of U.S. duration for weight weakens after these points.

Four studies (19, 25, 26, 28) showed a significant relationship between BMI and duration of residence among Hispanic immigrants. On the other hand, three studies (25, 26, 28) showed no significant relationship among Asians and mixed results among white and black immigrants. Despite these differences by race/ethnicity, one study (22) found no significant interaction between race/ethnicity and number of years in the U.S. One study found a significant interaction between length of residence and region of birth, however sample size constraints limited further stratified analysis to explain the presence of this interaction (22).

Four studies (24-26, 28) also compared immigrants to native-born individuals. The overall conclusion was consistent with the other studies in the review; however, the results indicate that regardless of duration of residence, U.S. immigrants have lower BMIs compared to native-born individuals.

Two studies (25, 27) analyzed how the relationship between duration and BMI varied based on age at arrival to the U.S. They both found that younger age at arrival (<20 and <22 years) was associated with higher likelihood of being overweight/obese with longer duration compared to those arriving at older ages.

The one study that did not reach the same conclusion had some methodological weaknesses that did not exist in the other studies. Specifically, the survey was conducted using a convenience sample of Korean Americans with a very low response rate (<35%). The authors did not consider how respondents may have been different from those who did not respond. Additionally, this study used different, much larger duration of residence categories (≤15, 16-25, 25+ years) than the others. Because other studies (13, 16, 22) have shown a threshold effect of duration on weight gain after 10 years of residence, the category ≤15 years may actually combine the variability in duration effects, leaving the other categories with insufficient variation. Finally, although the authors conclude that BMI did not increase significantly, the data indicate an upward trend.

All of the articles meeting our inclusion criteria were published in or after 2000 and based on data from cross-sectional surveys. Specifically, eight used data from the National Health Interview Survey (NHIS), a nationally representative survey of the U.S. non-institutionalized population, and two used data from the New Immigrant Survey (NIS), which is nationally representative of newly designated legal permanent residents. Although NIS is designed to be a longitudinal study, as of this review, the second wave of data was not yet available and the articles in this review using NIS data (16, 27) used cross-sectional data. The remaining five articles used data from cross-sectional surveys from specific geographic locations within the U.S.

Immigrant samples within each article included only adults (18+ years), except one article that included all age ranges (27). Sample sizes ranged from 174 to over 60,000, with the largest sample sizes coming from articles using NHIS data. Seven articles represented some variation of all race/ethnic categories (Hispanic; non-Hispanic Black, non-Hispanic White, Asian/Pacific Islander, American Indian); four articles represented only Hispanic immigrants; and two articles represented only Asian immigrants. Two studies used region of birth: one instead of race/ethnicity (27) and another in addition to race/ethnicity (22).

The sample and definition of immigrants differed among the articles. For example, two articles used a survey in which respondents were only newly designated legal permanent residents (16, 27). Other studies either excluded those born in a U.S. territory (19), included them as a comparison group (13, 20, 22, 24, 26, 28), or did not specify the category for those born in a U.S. territory (17, 21, 23, 25, 28).

BMI was defined differently across articles. The majority of articles categorized BMI into overweight (BMI 25-29.9 kg/m^2), obese (BMI $\geq$ 30 kg/m^2), or a combined overweight/obese category (BMI $\geq$ 25 kg/m^2). Six studies (13, 16, 17, 26, 28, 29) used BMI as a linear outcome and one article defined overweight as $\geq$ 27.8 kg/m^2 in men and $\geq$ 27.3 kg/m^2 in women (24). Only one article calculated BMI based on measured height and weight (20), while in the others BMI was calculated based on self-reported measurements. In another article (18), the authors collected self-reported measurements for all subjects and measured height and weight on a random subsample. In comparing then measured and reported anthropometrics, the authors found similar statistical associations and therefore present results from the entire sample (based on self-reported height and weight).

Duration of residence in the U.S. was defined slightly differently between articles. The majority of studies used the following duration categories: <5 y, 5-<10y, 10-<15y, ≥15 y. Some collapsed these into 2 or 3 categories. However, there were some deviations from this. One study used the following categories: <2 y, 2-<10 y, and ≥10 years (20) while another used ≤15 y, 16-25 y, 25+ years (29). Another study (16) used survey questions to develop a cumulative measure of all time spent in the U.S., accounting for time spent elsewhere, and treated it as a continuous variable.

With the exception of one article that included only women (20), all articles included both men and women. Four of the articles (16-18, 28) found that female migrants converge to weight levels similar to native-born more quickly than male migrants. All but one (28) of these results were among female Hispanic immigrants. One article found significant associations between years spent in the U.S. and risk of obesity, but not overweight, in women; whereas the opposite was true for men (23). Another study, which used a combined overweight/obesity measure, found the relationship to be significant only for women (22).

Discussion

In spite of methodological differences, there are significant, positive relationships between body weight and duration of residence among U.S. immigrants. Though our review focused exclusively on international migrants living in the U.S., it is noteworthy that studies of immigrants in other countries report similar results. Studies from Canada found that although migrants overall have lower BMIs than the native born/general population, their BMIs approach the levels observed in the native born/general population over time (31, 32). Arab immigrants in Sweden were more likely to be overweight/obese with increasing duration compared to native-born Swedes (33). Thus, it is evident from research in varied settings that duration of residence is an important consideration in studies of weight change among migrants. This highlights the importance of including duration of residence as an exposure measure in studies of migrant health, health change, and acculturation.

Three of the studies concluded a threshold effect of weight gain among immigrants. Additionally, two studies (25, 27) found that the relationship between duration of residence and overweight/obesity varied by age at arrival. Age at arrival is a variable that has not been utilized much in the literature, yet may have important implications for health. Specifically, younger immigrants have been shown to be more likely to be overweight/obese with increased duration compared to migrants who arrived at older ages.

The effect of duration of residence on weight status has been shown to vary by sex (34, 35). Eight of the articles presented sex-stratified results (16-18, 22, 23, 27-29) and documented sex differences in duration of residence before achieving body weight levels approximating those of the native-born. Several studies report that BMI among Hispanic female immigrants converges to native-born estimates more quickly than among males. Understanding these differences is one of the challenges to future studies of immigrant health.

The impact of duration of residence may differ by race/ethnicity, possibly having different implications for body weight (36). For example, the only study that found no association between duration of residence and BMI was specific to Korean Americans (29). Even though the migrants included in this study (and all studies included in this review) were first generation, these differences may be a result of differences in immigration history or differences in level of acculturation between groups.

Changing diet and physical activity behaviors are often cited as potential explanations for changes in immigrant weight post-migration because they directly influence body weight. Increased length of exposure to the U.S. environment has been shown to lead to greater dietary change (16, 27) and adoption of American dietary and physical activity patterns (29, 37, 38). This translates into decreasing intake of traditional foods (29) and increasing fat, sugar, and caloric intake (37, 39). With respect to physical activity, among the studies included in our review, two studies found positive effects of increased duration of residence (18, 22): migrants with longer residence (and characterized as more acculturated) were less likely to engage in sedentary activities. Three studies (16, 18, 28) controlled for physical activity and only one study (28) also included a measure of nutrition, specifically fruit and vegetable consumption, in their analysis. Even after the inclusion of these controls, duration of residence remained a significant predictor of weight increase.

An additional set of conditions that may be associated with weight change in immigrants include neighborhood, community and environmental factors. Specifically, urban form, norms, expectations, and resources may impact physical activity and diet (40, 41) in ways that promote unhealthy weight gain. For example, eating outside the home and consuming fast food (42) and soft drink (42-44), habits that may be adopted after migration to the U.S., generally positively correlate with overweight (45). In addition, access to low cost healthy foods may be more difficult in poorer neighborhoods, and immigrants tend to live in such neighborhoods initially (46). These low income areas are also less likely to have facilities that enable physical activity (47). Despite the potential role of neighborhood and environmental conditions as risk factors for obesity among residents of the U.S., few studies consider them. One study (26 found no change in the relationship between duration and weight after inclusion of neighborhood-level characteristics (immigrant density and linguistic isolation). Another study of immigrants aged 50+ years found that men living in high immigrant areas were more likely to be obese than those living in low immigrant areas (48). Yet another study (49) specific to immigrant women living in the Boston area found that higher neighborhood proportions of foreign-born individuals was associated with higher individual daily fruit and vegetable consumption. This latter result suggests that immigrant neighborhoods may have better availability of produce or that healthier diets from countries of origin are preserved in areas with higher immigrant density, but these hypotheses have yet to be tested. Studies that include neighborhood characteristics can provide additional insight into targets for behavior change, both on an individual and community level.

Although duration of residence has often been used in health research as an indicator of acculturation, or adoption of local lifestyles, the extent to which this assumption is valid has not been demonstrated in the literature. Acculturation is a process that involves a broad set of changes and to test hypotheses on acculturation, more direct and proximate measures need to be utilized (24). Examples of such measures might be the extent to which one identifies with one's native culture, including using the native language, celebrating holidays and cultural events, eating ethnic foods, participating in ethnic-cultural network, and interaction with members (friends, relatives, or coworkers) of that group (50). Future studies could attempt to quantify the relationship between duration of residence and other such measures to better determine if and how these variables may represent acculturation.

We would like to highlight that one hypothesis this review was unable to consider was how weight change after exposure to the U.S. environment may differ by migrant background and characteristics. Social, economic, and cultural aspects of the place of origin, together with race and ethnicity (36), may change the ways in which migrant integrate into the host community and the ways in which their weight patterns are affected. In addition, migration history may also have an effect, and labor migrants, refugees, and trailing family members may each adapt differently to life in the U.S. For example, refugees who experienced extraordinary hunger and deprivation would have different patterns of weight change from other immigrants (51). None of the studies of duration of residence and weight distinguished between different circumstances of migration. It is interesting to note that in spite of differences in circumstances of migration and place of origin, the studies we identified consistently found similar patterns of weight change among migrants.

We would also like to highlight some of the methodological strengths and weaknesses of the studies of duration of residence and weight change. The use of BMI as a measure of healthy body weight is debated in the literature (52, 53). Because BMI can easily be calculated using self-reported height and weight, it is a common measure found in large-scale studies. Patterns of miss-reporting have been observed, and these appear to differ between native and foreign born: on average, immigrant women in the U.S. underreport weight less than native-born woman, while native and immigrant men underreport their weight equally (17). Furthermore, BMI categories are not as meaningful indicators of disease risks as adiposity (54, 55) or abdominal obesity (56), especially with respect to the most important health risks of obesity, cardiovascular disease and diabetes. In addition, studies have found that even though they have lower or similar BMIs to native-born Americans, Asians immigrants have higher levels of adiposity (55, 57). Finally, a complication that limits the potential of comparisons across studies is that researchers are not consistent in defining BMI categories, as is apparent from our results.

The majority of the studies we reviewed used data from the National Health Interview Survey (NHIS). The NHIS is a nationally representative sample of the U.S. adult population, and thus results are generalizable to the U.S. population. The extent to which they can be generalized to U.S. immigrants is limited by the reach of the survey among immigrant groups. For example, this survey is conducted only in English and Spanish, thus limiting participation to only those individuals who are able to communicate in these languages. Additionally, we may expect that undocumented immigrants and those engaged in circular or seasonal migration may be under-represented in the NHIS, and therefore in studies that use this data source. Other studies in the review used surveys that focused more specific immigrant groups, and thus face the disadvantage of limited generalizability.

A major limitation of all the studies is that they were cross sectional, preventing any inference about causal relationships. Using cross sectional data may result in duration of residence variables being confounded with cohort effects; that is, individuals who arrived during the same period may be more similar to each other, and cross-sectional data cannot be used to distinguish between this and the acculturation effects of years of residence (23). Longitudinal studies are necessary to examine this relationship. An ideal longitudinal study design might identify migrants prior to migration (58), allowing baseline assessment of demographics, weight, and lifestyle behaviors (i.e. diet and physical activity) and follow them into destination countries up to 5-10 years post migration, with annual data collection on weight and lifestyle, including indicators of acculturation. This would allow assessment of *when* individual changes in these factors occur and *how* these changes may explain weight changes. If changes in immigrant behavior can be predicted, interventions can be designed and implemented before detrimental behavior changes are adopted.

Conclusions

Despite heterogeneity in pre-migration exposure, circumstances of migration, and countries of origin, this review revealed consistently significant evidence across studies that body weight is positively associated with duration of residence among U.S. immigrants, indicating that these observed trends are generally pertinent to migrants to the U.S. under varying circumstances. Some migrants arrive underweight and will benefit from some, though not excessive, weight gain (59). However, the findings from this review indicate that immigrants with the longest durations of residence have a similar prevalence of overweight/obesity compared to the native born population, indicating the weight in the majority of U.S. immigrants is excessive and thus associated with negative health consequences (3-7). Our finding that weight gain is widespread highlights the importance of prevention programs aimed at reducing excessive weight gain among immigrants within the first decade after arrival in the U.S. Efforts to promote healthy weight and lifestyles may be more successful if nativity (including country of birth) and duration of residence are considered, and such efforts should be tailored to the needs, expectations, and migration circumstances of immigrant communities. To further assist such prevention efforts, research is needed to identify the specific mechanisms through which living in the U.S. may adversely impact health outcomes.

Author Contributions:

Study concept and design: R. Oza-Frank, S. Argeseanu Cunningham.

Acquisition of data: R. Oza-Frank.

Analysis and interpretation of data: R. Oza-Frank, S. Argeseanu Cunningham.

Drafting of the manuscript: R. Oza-Frank.

Critical revision of the manuscript for important intellectual content: R. Oza-Frank, S. Argeseanu Cunningham.

Statistical expertise: R. Oza-Frank, S. Argeseanu Cunningham.

Study supervision: S. Argeseanu Cunningham.

Acknowledgements: Reena Oza-Frank was partly supported by a grant from the Emory University Global Health Institute and by Grant/Cooperative Agreement Number 1R36SH000008-01 from the Centers for Disease Control and Prevention (CDC). Solveig Argeseanu Cunningham was partly supported by an educational grant from Eli Lilly and Company and a grant from the Emory University Global Health Institute. The contents of this work are solely the responsibility of the authors and do not necessarily represent the views of the CDC, the Emory University Global Health Institute, or Eli Lilly and Company.

Role of Sponsor**:** None.

Potential Conflicts of Interest: None.

References

1. Caballero B. The global epidemic of obesity: an overview. *Epidemiol Rev* 2007;29:1-5.
2. Flegal KM, Carroll MD, Ogden CL, Johnson CL. Prevalence and trends in obesity among US adults, 1999-2000. *JAMA* 2002;288:1723-7.
3. Manson JE, Colditz GA, Stampfer MJ, et al. A prospective study of obesity and risk of coronary heart disease in women. *N Engl J Med* 1990;322:882-9.
4. Colditz GA, Willett WC, Stampfer MJ, et al. Weight as a risk factor for clinical diabetes in women. *Am J Epidemiol* 1990;132:501-13.
5. Huang Z, Hankinson SE, Colditz GA, et al. Dual effects of weight and weight gain on breast cancer risk. *JAMA* 1997;278:1407-11.
6. Shoff SM, Newcomb PA. Diabetes, body size, and risk of endometrial cancer. *Am J Epidemiol* 1998;148:234-40.
7. Tornberg SA, Carstensen JM. Relationship between Quetelet's index and cancer of breast and female genital tract in 47,000 women followed for 25 years. *Br J Cancer* 1994;69:358-61.
8. Mokdad AH, Ford ES, Bowman BA, et al. Prevalence of obesity, diabetes, and obesity-related health risk factors, 2001. *JAMA* 2003;289:76-9.
9. World Health Organization. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. *Lancet* 2004;363:157-63.
10. Migration Policy Institute. Size of the Foreign-Born Population and Foreign Born as a Percentage of the Total Population, for the United States: 1850 to 2006.

[WWW document]. 2007. URL http://www.migrationinformation.org/DataHub/charts/final.fb.shtml (Accessed August 28, 2008).

11. Schmidley D. The foreign-born population in the United States: March 2002. In: U.S. Bureau of the Census, ed. U.S. Bureau of the Census, Current Population Reports: Current Population Reports, U.S. Government Printing Office, 2003:P20-539.
12. Frisbie WP, Cho Y, Hummer RA. Immigration and the health of Asian and Pacific Islander adults in the United States. *Am J Epidemiol* 2001;153:372-80.
13. Goel MS, McCarthy EP, Phillips RS, Wee CC. Obesity among US immigrant subgroups by duration of residence. *JAMA* 2004;292:2860-7.
14. Stephen EH, Foote K, Hendershot GE, Schoenborn CA. Health of the foreign-born population: United States, 1989-90. *Adv Data* 1994:1-12.
15. Argeseanu Cunningham S, Ruben JD, Venkat Narayan KM. Health of foreign-born people in the United States: a review. *Health Place* 2008;14:623-35.
16. Akresh IR. Dietary assimilation and health among hispanic immigrants to the United States. *J Health Soc Behav* 2007;48:404-17.
17. Antecol H, Bedard K. Unhealthy assimilation: why do immigrants converge to American health status levels? *Demography* 2006;43:337-60.
18. Barcenas CH, Wilkinson AV, Strom SS, et al. Birthplace, years of residence in the United States, and obesity among Mexican-American adults. *Obesity* (Silver Spring) 2007;15:1043-52.

19. Dey AN, Lucas JW. Physical and mental health characteristics of U.S.- and foreign-born adults: United States, 1998-2003. *Adv Data* 2006:1-19.

20. Himmelgreen DA, Perez-Escamilla R, Martinez D, et al. The longer you stay, the bigger you get: length of time and language use in the U.S. are associated with obesity in Puerto Rican women. *Am J Phys Anthropol* 2004;125:90-6.

21. Kaplan MS, Huguet N, Newsom JT, McFarland BH. The association between length of residence and obesity among Hispanic immigrants. *Am J Prev Med* 2004;27:323-6.

22. Koya DL, Egede LE. Association between length of residence and cardiovascular disease risk factors among an ethnically diverse group of United States immigrants. *J Gen Intern Med* 2007;22:841-6.

23. Lauderdale DS, Rathouz PJ. Body mass index in a US national sample of Asian Americans: effects of nativity, years since immigration and socioeconomic status. *Int J Obes Relat Metab Disord* 2000;24:1188-94.

24. Singh GK, Siahpush M. Ethnic-immigrant differentials in health behaviors, morbidity, and cause-specific mortality in the United States: an analysis of two national data bases. *Hum Biol* 2002;74:83-109.

25. Kaushal N. Adversities of acculturation? Prevalence of obesity among immigrants. *Health Econ* 2008.

26. Park Y, Neckerman KM, Quinn J, Weiss C, Rundle A. Place of birth, duration of residence, neighborhood immigrant composition and body mass index in New York City. *Int J Behav Nutr Phys Act* 2008;5:19.

27. Roshania R, Venkat Narayan KM, Oza-Frank R. Age at Arrival and Risk of Obesity Among US Immigrants. *Obesity* (Silver Spring) 2008.

28. Sanchez-Vaznaugh EV, Kawachi I, Subramanian SV, Sanchez BN, Acevedo-Garcia D. Differential effect of birthplace and length of residence on body mass index (BMI) by education, gender and race/ethnicity. *Soc Sci Med* 2008;67:1300-10.

29. Yang EJ, Chung HK, Kim WY, Bianchi L, Song WO. Chronic diseases and dietary changes in relation to Korean Americans' length of residence in the United States. *J Am Diet Assoc 2007*;107:942-50.

30. Higgins J, Green S. Cochrane Handbook for Systematic Reviews of Interventions Version 5.0.1 The Cochrane Collaboration, 2008.

31. Cairney J, Ostbye T. Time since immigration and excess body weight. *Canadian Journal of Public Health* 1999;90:120-4.

32. McDonald JT, Kennedy S. Is migration to Canada associated with unhealthy weight gain? Overweight and obesity among Canada's immigrants. *Soc Sci Med* 2005;61:2469-81.

33. Lindstrom M, Sundquist K. The impact of country of birth and time in Sweden on overweight and obesity: a population-based study. *Scand J Public Health* 2005;33:276-84.

34. Cerrutti M, Massey DS. On the auspices of female migration from Mexico to the United States. *Demography* 2001;38:187-200.

35. Kanaiaupuni S. Reframining the Migration Question: An Analysis of Men, Women, and Gender in Mexico. *Social Forces* 2000;78:1311-1347.

36. Huh J, Prause JA, Dooley CD. The impact of nativity on chronic diseases, self-rated health and comorbidity status of Asian and Hispanic immigrants. *J Immigr Minor Health* 2008;10:103-18.

37. Lv N, Cason KL. Dietary pattern change and acculturation of Chinese Americans in Pennsylvania. *J Am Diet Assoc* 2004;104:771-8.

38. Raj S, Ganganna P, Bowering J. Dietary habits of Asian Indians in relation to length of residence in the United States. *J Am Diet Assoc* 1999;99:1106-8.

39. Pan YL, Dixon Z, Himburg S, Huffman F. Asian students change their eating patterns after living in the United States. *J Am Diet Assoc* 1999;99:54-7.

40. Garn SM. Obesity in black and white mothers and daughters. Am J Public Health 1994;84:1727-8.

41. Golan M, Crow S. Parents are key players in the prevention and treatment of weight-related problems. *Nutr Rev* 2004;62:39-50.

42. Johnson-Taylor WL, Everhart JE. Modifiable environmental and behavioral determinants of overweight among children and adolescents: report of a workshop. *Obesity* (Silver Spring) 2006;14:929-66.

43. Novotny R, Daida YG, Acharya S, Grove JS, Vogt TM. Dairy intake is associated with lower body fat and soda intake with greater weight in adolescent girls. *J Nutr* 2004;134:1905-9.

44. Newby PK. Are dietary intakes and eating behaviors related to childhood obesity? A comprehensive review of the evidence. *J Law Med Ethics* 2007;35:35-60.

45. French SA, Story M, Jeffery RW. Environmental influences on eating and physical activity. *Annu Rev Public Health* 2001;22:309-35.

46. Powell LM, Slater S, Mirtcheva D, Bao Y, Chaloupka FJ. Food store availability and neighborhood characteristics in the United States. Prev Med 2007;44:189-95.

47. Powell LM, Slater S, Chaloupka FJ, Harper D. Availability of physical activity-related facilities and neighborhood demographic and socioeconomic characteristics: a national study. *Am J Public Health* 2006;96:1676-80.

48. Grafova IB, Freedman VA, Kumar R, Rogowski J. Neighborhoods and obesity in later life. *Am J Public Health* 2008;98:2065-71.

49. Dubowitz T, Subramanian SV, Acevedo-Garcia D, Osypuk TL, Peterson KE. Individual and neighborhood differences in diet among low-income foreign and U.S.-born women. *Womens Health Issues* 2008;18:181-90.

50. Arcia E, Skinner M, Bailey D, Correa V. Models of acculturation and health behaviors among Latino immigrants to the US. *Soc Sci Med* 2001;53:41-53.

51. Renzaho AM. Fat, rich and beautiful: changing socio-cultural paradigms associated with obesity risk, nutritional status and refugee children from sub-Saharan Africa. *Health and Place* 2004;10:105-113.

52. Jackson AS, Stanforth PR, Gagnon J, et al. The effect of sex, age and race on estimating percentage body fat from body mass index: The Heritage Family Study. *Int J Obes Relat Metab Disord* 2002;26:789-96.

53. Romero-Corral A, Somers VK, Sierra-Johnson J, et al. Diagnostic performance of body mass index to detect obesity in patients with coronary artery disease. *Eur Heart J* 2007;28:2087-93.

54. Boyko EJ, Fujimoto WY, Leonetti DL, Newell-Morris L. Visceral adiposity and risk of type 2 diabetes: a prospective study among Japanese Americans. *Diabetes Care* 2000;23:465-71.

55. Chandalia M, Lin P, Seenivasan T, et al. Insulin resistance and body fat distribution in South Asian men compared to Caucasian men. *PLoS ONE* 2007;2:e812.

56. Ho SC, Chen YM, Woo JL, Leung SS, Lam TH, Janus ED. Association between simple anthropometric indices and cardiovascular risk factors. *Int J Obes Relat Metab Disord* 2001;25:1689-97.

57. Araneta MR, Barrett-Connor E. Ethnic differences in visceral adipose tissue and type 2 diabetes: Filipino, African-American, and white women. *Obes Res* 2005;13:1458-65.

58. Rubalcava LN, Teruel GM, Thomas D, Goldman N. The healthy migrant effect: new findings from the Mexican Family Life Survey. *Am J Public Health* 2008;98:78-84.

59. Smith PK, Bogin B, Varela–Silva MI, Orden B, Loucky J. Does immigration help or harm children’s health? The Mayan case. *Social Science Quarterly* 2002;83:994-1002.

Table 5.1 Study Characteristics of Articles on the Association between Immigrant Duration of U.S. Residence and Body Mass Index (BMI)

Reference	Data	Immigrant Population	Age Range	Sample Size*	Outcome	Duration Variable	Variables adjusted for	Study Limitations
Akresh, 2007 (16)	New Immigrant Survey, 2003 (nationally representative of newly designated LPR)	Central American, Cuban, Dominican Republican, Mexican, and South American	18+ years	2,132	BMI [continuous]	Cumulative measure of all time spent in the US	Age, sex, marital st, household income, edu, smk, physically active, diabetes or high blood pressure before coming to US	Cross-sectional, LPR only (may be different from those who have not obtained this status)
Antecol, 2006 (17)	NHIS 1989-1996 (nationally representative)	Hispanic, non-Hispanic white, non-Hispanic black	20-64 years	61,234	1. Natural log of BMI 2. Overweight: $\geq$25 kg/m^2 3. Obese: $\geq$30 kg/m^2	0-4, 5-9, 10-14, 15+ years	Age, sex, edu, marital st, employed, urban residence, region of U.S.residence, survey year	Cross-sectional, Self-reported, Did not consider region of birth
Barcenas, 2007 (18)	Mano y Mano Cohort (randomly recruited from 7/01 to 9/05)	Mexican [living in Harris County, TX]	20+ years	5,226	1.Underweight: <18.50 kg/m^2 2.Normal weight: 18.50-24.99 kg/m^2 3. Overweight: 25.00-29.99 kg/m^2 4. Obese I: 30.00-34.99 kg/m^2 5. Obese II: 35.00-39.99 kg/m^2 6. Obese III: >40.00 kg/m^2	<5, 5-9, 10-14, 15+ years	Age, sex, education, smoking, alcohol use, physical activity, acculturation (Bi-dimensional Acculturation Scale for Hispanics)	Cross-sectional, Self-reported, Limited generalizability

Dey, 2006 (19)	NHIS 1998-2003 (nationally representative)	Asian, Hispanic, non-Hispanic white, non-Hispanic black	18+ years	25,628	Obese: $\geq$30 kg/m^2	<5, $\geq$5 years	Age	Cross-sectional, Self-reported, Dichotomization of duration variable, Sample size constraints, Did not consider region of birth
Goel, 2004 (13)	NHIS 2000 (nationally representative)	Asian, Black, Latino, White	18+ years	5,318	1.BMI [continuous] 2.Normal weight: 18.50-24.99 kg/m^2 3. Overweight: 25.00-29.99 kg/m^2 4. Obese I: 30.00-34.99 kg/m^2 5. Obese II: 35.00-39.99 kg/m^2 6. Obese III: >40.00 kg/m2	<5, 5-<10, 10-<15, 15+ years	Age, sex, education, income, race/ethnicity	Cross-sectional, Self-reported, Did not consider region of birth, Power limitations
Himmelgreen, 2004 (20)	Acculturation and Nutritional Needs Assessment (ANNA) (convenience sample - data collected between 5/1998-9/1999)	Puerto Rican [living in Hartford, CT]	18+ years (only women)	174	1.Underweight: <18.50 kg/m^2 2.Normal weight: 18.50-24.99 kg/m^2 3. Overweight: 25.00-29.99 kg/m^2 4. Obese: $\geq$30 kg/m^2	$\leq$2, >2-9.99, 10+ years	None	Cross-sectional, Convenience sample, Limited generalizability

Kaplan, 2004 (21)	NHIS 1998 (nationally representative)	Caribbean, Central and South American, Mexican	18+ years	2,420	1.Normal weight: 20.0-24.9 kg/m^2 2. Obese: $\geq$30 kg/m^2	0-4, 5-9, 10-14, 15+ years	Age, sex, edu, household income, smk, self-assessed health, chronic conditions, functional limitations, psychological distress, access to healthcare	Cross-sectional, Self-reported, Sample size constraints
Kaushal, 2008 (25)	NHIS 1990-2004 (nationally representative	Asian, Black, Hispanic, White	18-59 years	75,834	1. Overweight: 25.00-29.99 kg/m^2 2. Obese: $\geq$30 kg/m^2	<1, 1-<5, 5-<10, 10-<15, 15-<59 years	Age, gender, race/eth, edu, marital st, age of U.S. arrival, cohort effects	Cross-sectional, Self-reported
Koya, 2007 (22)	NHIS 2002 (nationally representative)	African, Asian, Central and South American, European, Middle Eastern, Russian	18+ years	5,230	1.Normal weight: <25 kg/m^2 2.Overweight/obese: $\geq$25 kg/m^2	<10, 10-<15,15+ years	Age, sex, education, income, race/ethnicity, insurance, marital status, employment, source of care, health status, region of birth, citizenship	Cross-sectional, Self-reported, Region of birth categories limited, Sample size constraints
Lauderdale, 2000 (23)	NHIS 1992-1995 (nationally representative)	Asian Indian, Chinese, Filipino, Japanese, Korean, Vietnamese	18-59 years	6,053	1.Overweight:$\geq$25 kg/m^2 2. Obese: $\geq$30 kg/m^2	<5, 5-15, >15 years	Age, sex, ethnicity	Cross-sectional, Self-reported, Sample size constraints

Park, 2008 (26)	Health survey of volunteers in all 5 New York City boroughs (data collected between 1/2000-12/2002)	Asian American, Black-Caribbean American, Caucasian, Hispanic, Other	Mean age=47.0 years	4,306	BMI [continuous]	<5, 5-9, 10-14, 15-24, 25+ years	Age, gender, education, race/ethnicity, neighborhood characteristics (immigrant density, linguistic isolation)	Cross-sectional, Volunteer sample, US born used as comparison group
Roshania, 2008 (27)	New Immigrant Survey, 2003 (nationally representative of newly designated legal permanent residents)	Sub-Sahara African, Caribbean/Latin American, European/Central Asian, Middle Eastern/North African, South/East/Southeast Asian	All	6,421	1.Underweight: <18.50 kg/m^2 2.Normal weight: 18.50-24.99 kg/m^2 3. Overweight/obese: $\geq$ 30 kg/m^2	<1, 1-<5, 5-<10, 10-<15, 15+ years	Age, sex, education, region of birth	Cross-sectional, Legal permanent residents only (may be different from those who haven't obtained this status)
Sanchez-Vaznaugh, 2008 (28)	California Health Interview Survey (CHIS) 2001	Asian/API, Blacks, Hispanic, White	25-64 years	9,378	BMI [continuous]	<5, 5-9, 10-14, 15+ years	Age, sex, education, income, race/ethnicity, marital status, fruit and vegetable consumption, smoking status, alcohol use, and exercise	Cross-sectional, Self-reported, US born used as comparison group

Singh, 2002 (24)	NHIS 1993-1994 (nationally representative)	American Indian, Asian/Pacific Islander, Hispanic, non Hispanic white, non Hispanic black	25+ years	23,547	Overweight/obese: $\geq$27.8 kg/m^2 men; $\geq$27.3 kg/m^2 women	<1, 1-5, 5-10, 10-15, 15+ years	Age, sex, edu, employment status, family income, race/ethnicity, nativity, marital st, family size, region of residence	Cross-sectional, Self-reported, US born used as comparison group
Yang, 2007 (29)	Mailed survey (data collected between 3/2000-8/2000)	Korean American [living in Michigan]	30-87 years	497	BMI [continuous]	$\leq$15, 16-25, 25+ years	Age, sex	Cross-sectional, Self-reported, Convenience sample, Low response rate, Limited generalizability

*Sample size includes foreign-born only

Summary

The consistency of results across studies in this systematic review reinforces the importance of length of residence in assessing overweight risk among immigrants. Therefore, in the next analysis we estimated the magnitude of overweight and diabetes among immigrants, adjusted for length of residence.

CHAPTER 6: OVERWEIGHT AND DIABETES PREVALENCE AMONG U.S. IMMIGRANTS

AJPH (in press)

Overweight and Diabetes Prevalence among US Immigrants

REENA OZA-FRANK, MS-MPH, RD[1]

K.M. VENKAT NARAYAN, MD[1,2,3]

[1]Emory University, Nutrition and Health Sciences Program, Graduate Division of Biomedical and Biological Sciences, Atlanta, GA

[2]Emory University, Hubert Department of Global Health, Rollins School of Public Health, Atlanta, GA

[3]Emory University, School of Medicine, Atlanta, GA.

Corresponding Author:
Reena Oza-Frank
Emory University
Rollins School of Public Health
1518 Clifton Road, NE
Atlanta, GA 30322
Phone: 614-327-3629
Fax: 404-727-4590
E-mail: roza@emory.edu

Word Count (text only): 3439

Tables: 3

Figures: 2

Abstract

Objectives: We estimated the prevalence of overweight and diabetes among US immigrants by region of birth.

Methods: We analyzed data on 34,456 US immigrant adults from the National Health Interview Survey, pooling years 1997-2005. We estimated age- and sex-adjusted and multivariable adjusted overweight and diabetes prevalence by region of birth using logistic regression.

Results: Both men (OR 3.3, 95% CI: 1.9, 5.8) and women (OR 4.2, 95% CI: 2.3, 7.7) from the Indian subcontinent were more likely than European migrants to have diabetes without corresponding increased risk of being overweight. Men and women from Mexico, Central America, or the Caribbean were more likely to be overweight (men: OR 1.5, 95% CI: 1.3, 1.7; women: OR 2.0, 95% CI: 1.7, 2.2) and to have diabetes (men: OR 2.0, 95% CI: 1.4, 2.9; women OR 2.0, 95% CI: 1.4, 2.8) compared to European migrants.

Conclusions: Considerable heterogeneity in both prevalence of overweight and diabetes by region of birth highlights the importance of making this distinction among US immigrants to better identify subgroups with higher risks of these conditions.

Introduction

Coincidental with the increases in prevalence of overweight/obesity (body mass index (BMI) $\geq$ 25 kg/m^2) and associated diseases such as diabetes,[1-3] the US population has grown and diversified, especially with regard to the immigrant population. In 2006, the US immigrant population accounted for over 12% of the total population,[4] the largest proportion in the US since the early 1900s,[5] reflecting the large waves of immigration to the US over the past two decades.[6] By 2050, it is projected that nearly 1 in 5 US residents will be an immigrant compared with 1 in 8 in 2005.[7] At the same time, the numbers of people with diabetes in the US are projected to rise to 48 million by 2050,[8] with changing US demography cited as a major reason for this increase.[9] These projections, however, do not specifically estimate the contribution of immigrants to current or future prevalence estimates, largely reflecting a dearth of national estimates of overweight and diabetes for this growing and diverse sub-population.

Generally, immigrants have better health profiles compared to US born.[10-12] However, it has been shown that immigrants who arrive to the US at younger ages are more likely to be overweight or obese with increasing length of residence than immigrants who arrive to the US at later ages.[13] Grouping immigrants together into one or a few large categories may mask important heterogeneity with regard to specific health conditions, especially overweight and diabetes, which are driven by contemporary urban lifestyles in addition to genetic susceptibility.[14]

We used nationally representative data to estimate and compare overweight and diabetes prevalence across nine regions of birth, covering 100 countries, and representing 16 million US immigrants.

Methods

Data Source

Data on 34,456 immigrants (defined as people living in the US who are not US citizens at birth[15]) adult respondents were analyzed from the nationally representative National Health Interview Survey (NHIS), pooling years 1997-2005. The NHIS is a continuous, in-person health survey of the civilian, non-institutionalized adults 18 years and older, administered by the US Bureau of the Census for the National Center for Health Statistics (NCHS).[16] The survey uses a multistage probability design, with oversampling of Hispanics and Blacks, and includes approximately 43,000 households and about 106,000 persons annually.[16] Respondents provide self-reported information about basic measures of health status, utilization of health services, and social and demographic characteristics. In addition, one randomly selected adult per household is asked to complete the Sample Adult Module which elicits more detailed information on health care services, behavior, and health status including height, weight, and diabetes.

Data were pooled to improve reliability of statistical estimates.[17] To pool data, we first merged the sample adult file with the person-level file for each year included. Then, using NCHS guidelines for combining NHIS data with the same sample design, years 1997-2005 were concatenated into one data set.[17] For this analysis, 2001 was the midpoint of the time interval included in the pooled data, and thus the estimates represent this point in time.[17]

Sample weights provided by NCHS account for the complex sampling design of NHIS and for unequal probabilities of selection resulting from sample design, non-response, and planned over-sampling of certain subgroups. The survey is administered in

Spanish or English languages and does not allow proxy respondents for Sample Adult questions. Family members may translate for a non-English or non-Spanish speaking respondent who is present in the home.

Definition of Immigrant and Region of Birth

Foreign birth was considered a proxy for immigrant status. All naturalized citizens, legal permanent residents, undocumented immigrants, and persons on long-term temporary visas (such as students or guest workers) also fall into this category. Region of birth data is provided by NHIS from 2002-2005 based on the question “Where were you born?”. Prior to 2002, this information is not publicly available and, thus, use of this variable was requested through the NCHS Research Data Center.[18] The nine mutually exclusive regions of birth categories provided by NCHS were: Mexico, Central America, Caribbean Islands (hereinto referred to as Mexico in the text); South America; Europe; Russia (and former USSR areas); Africa; Middle East; Indian Subcontinent; Central Asia; and Southeast (SE) Asia. Details on specific countries included in each of the regions has been published elsewhere.[19] Europe was considered the referent category for comparative analyses.

Outcomes of Interest

We focused on two outcomes: overweight and diabetes. Overweight and obesity were combined into one category and referred to as overweight, and defined as body mass index (BMI) ≥ 25 (measured as weight in kilograms divided by the square of height in meters) among adults.[20] The NHIS calculates BMI from self-reported information on height (“How tall are you without shoes?”) and weight (“How much do you weigh without shoes?"), measures previously established as largely valid when used in combination with adjustments for age.[21] To estimate prevalence of diabetes by BMI, we used categories based on the National Institutes of Health cut-offs:[20] normal weight (18.5-24.9), overweight (25-29.9), and obese ($\geq$30). We combined overweight and obese categories into a single category for use as a dichotomous outcome in all logistic regression analyses examining the relationship with region of birth.

Since 1997, all sampled adults have been asked "[Other than during pregnancy], have you EVER been told by a doctor or health professional that you have diabetes or sugar diabetes?". Responses to this question were coded as a dichotomous outcome (yes vs no).

Covariates of Interest

Socio-demographic characteristics included age (18-24, 25-44, 45-64, 65-74), sex, and poverty income ratio (PIR) (< 1.00 (below federal poverty line), 1.00-1.99, 2.00-2.99, 3.00-4.99, and >5.00)). PIR was calculated and recoded for public data use so there is no direct question relating to this variable. We did not include education level because the effects of number of years of school may not be equivalent across the regions represented. Lifestyle characteristics included smoking status (current, former, never), alcohol drinking status (lifetime abstainer, former, current), and physical activity level[22] (high, moderate, sedentary). Because acculturation to US norms over time may lead to an increasing prevalence of obesity and obesity-related morbidity among immigrants,[14] duration of residence in the US (respondents were asked "About how long have you been in the U.S. (years)?") was also included in the analysis (<5 years, 5-<10 years, 10-<15 years, >15 years). Other variables considered but not included in the analyses due to lack of association were marital status, region of residence in the US, metropolitan statistical area size, and insurance status. Persons with data missing on immigrant status, region of birth, age, sex, body mass index were excluded (5% of the sample).

Statistical Analysis

Sampling weights were adjusted to account for the pooled data.[17] To assess differences in sample characteristics by region of birth, we used chi-square tests for categorical variables and ANOVA for continuous variables. Two-tailed P-values of $\leq$0.05 were considered significant for all analyses.

We estimated age- and sex-adjusted overweight prevalence by region of birth and BMI categories.[23] We then performed multivariable logistic regression analyses, and computed predictive marginals (with standard errors (SE)) to estimate the multivariable adjusted prevalence of overweight and diabetes by region of birth. Predictive marginals are a type of direct standardization in which the predicted values from the logistic regression models are averaged over the covariate distribution of the population.[8, 24] Models had either overweight or diabetes as the outcome and region of birth as the primary exposure of interest. Significance of the interaction term of region of birth with sex was assessed for both outcomes to determine if the associations between region of birth and the outcomes of interest varied by sex. Standard errors were calculated with SAS-callable SUDAAN software (version 9.0 Research Triangle Institute, Research Triangle Park, NC).

Results

The majority of migrants were born in Mexico (48%), followed by migrants from all regions in Asia (~20%), Europe, South America, Africa, Middle East, and Russia, respectively (Table 6.1). The mean age ranged from 38.0$\pm$0.5 (Africa) to 45.8$\pm$0.3 (Europe). Proportion with PIR below the federal poverty line ranged from 5.4%$\pm$0.4 (Europe) to 18.8%$\pm$0.5 (Mexico). The majority of migrants, regardless of region, had resided in the US for at least 15 years at the time of interview.

Overweight and diabetes prevalence by region of birth

The number of overweight migrants represents over 8 million individuals. Age- and sex-adjusted overweight prevalence varied by region of birth and ranged from 24.4%$\pm$1.3 in Central Asian migrants to 64.4%$\pm$0.4 in Mexican migrants (Figure 6.1, Top Panel), which was significantly higher than the other regions ($P<0.05$). Overweight prevalence among respondents from each of the three Asian regions was lower than all other regions ($P<0.05$); within this subgroup, migrants from the Indian subcontinent had the highest prevalence (40.1%$\pm$1.9), followed by SE Asia (31.9%$\pm$1.2) and then Central Asia (24.4%$\pm$1.3) ($P<0.05$).

The 1749 immigrant respondents who self-reported having diabetes represent approximately one million individuals. Age- and sex-adjusted diabetes prevalence ranged from 3.1%$\pm$0.3 in European migrants to 10.0%$\pm$1.2 in migrants from the Indian subcontinent. Migrants from the Indian subcontinent had the highest diabetes prevalence, significantly higher than migrants from any other region ($P<0.05$), except Mexico and Africa (Figure 6.1, bottom panel).

Diabetes prevalence by BMI and region of birth

Among normal weight immigrants, age- and sex-adjusted diabetes prevalence ranged from 1.2%±0.7 (Russia) to 7.9%±1.8 (Indian subcontinent); among overweight from 3.0%±1.2 (Middle East) to 9.7%±1.9 (Indian subcontinent); and among obese from 5.2%±1.2 (South America) to 28.7%±5.2 (Indian subcontinent) (Figure 6.2). Diabetes prevalence in normal weight immigrants from Africa and the Indian subcontinent were higher than prevalence in obese Europeans and South Americans ($P<0.05$). Obese Africans and Indians had statistically similar diabetes prevalence, which were also the highest among all BMI categories and regions.

Differences in diabetes prevalence among Asian and Hispanic migrants varied by BMI category. The prevalence of diabetes among overweight migrants from the Indian subcontinent was 9.7%±1.9. This was significantly higher than the prevalence of diabetes compared to overweight migrants from Central Asia (3.4%±0.9) ($P<0.05$). Obese migrants from the Indian subcontinent had a significantly higher diabetes prevalence than obese migrants from SE Asia (9.1%±3.1) ($P<0.05$). Migrants from Mexico, however, had a significantly higher diabetes prevalence than migrants from South America in each BMI category ($P<0.05$).

Multivariable adjusted overweight prevalence by region of birth

Adjusted for age, PIR, and duration of residence, overweight prevalence among both immigrant men and women was the lowest in Central Asians and highest in Mexicans (Table 6.2). In all regions, men had significantly ($P<0.05$) higher overweight prevalence than women except among migrants from Africa or the Indian subcontinent, where there were no differences by sex. Compared to European migrant men, male migrants from Mexico and South America were more likely to be overweight, while migrants from Africa and anywhere in Asia were less likely to be overweight (Table 6.2). Among women, Mexican and African migrant women were more likely to be overweight compared to European migrant women. Women from SE and Central Asia were less likely to be overweight compared to European migrant women (Table 6.2).

Multivariable adjusted diabetes prevalence by region of birth

Adjusted for age, PIR, and duration of residence, diabetes prevalence among immigrant men ranged from 1.7%±0.9 in Middle Eastern migrants to 8.2%±1.6 in Indian migrants (Table 6.3). Diabetes prevalence among immigrant women ranged from 2.3%±0.5 in migrants from Central Asia to 11.6%±2.3 in migrants from the Indian subcontinent.

Among men, migrants from Mexico were twice as likely to have diabetes compared to European migrant men, while migrants from Africa and the Indian subcontinent were over 3 times as likely to have diabetes (Table 6.3). Migrants from SE Asia were also more likely to have diabetes. Among women, both migrants from Mexico and the Indian subcontinent were more likely to have diabetes compared to European migrant women.

Lower odds of overweight and higher odds of diabetes, compared to European migrants, was the general pattern observed among migrant Asian men and women, regardless of region, as exemplified in migrants from the Indian subcontinent. In multivariable models, the inclusion of BMI resulted in little change in prevalence or predicted probability, except for the Asian regions. The inclusion of BMI increased prevalence estimates around 1% for each Asian region for both men and women and increased odds ratios by over 20% among men, and between 12-40% among women (Table 6.3).

Discussion

Using data from NHIS 1997-2005, we report considerable heterogeneity among US immigrants in both the prevalence of overweight and diabetes by region of birth; with overweight prevalence ranging from 24.4% (Central Asia) to 64.4% (Mexico, Central America, Caribbean) and affecting over half the represented sample; and diabetes prevalence from 3.1% (Europe) to 10.0% (Indian subcontinent), affecting over 6% of the represented sample. Interestingly, differences in overweight prevalence by region did not necessarily correspond with differences in diabetes prevalence. Specifically, overweight prevalence was highest in both men and women from Mexico and lowest in migrants from Central Asia. Diabetes prevalence, though, was highest in both men and women from the Indian subcontinent but lowest in men from the Middle East and in women from Central Asia.

Our results indicate that overweight prevalence is lower among all migrants from Asia compared to those from Europe. Of note, adjusting for BMI inflated diabetes prevalence among Asian migrants but deflated it among migrants from all other regions. This suggests that the effect of BMI on diabetes varies by migrant sub-population, and may have an effect at lower thresholds in Asian population compared to other regions.[25]

Our results indicate a higher diabetes prevalence and a lower overweight prevalence in migrants from the Indian subcontinent compared to European migrants. Other US studies have shown that Asians (without a separate distinction for immigrant status) have lower prevalence of overweight compared to other racial/ethnic groups,[26-28] and either higher diabetes prevalence[29] or variable diabetes prevalence specifically when comparing immigrant Asians to native born.[10] Similar results for overweight[30] and diabetes have been found in studies among migrants from the Indian subcontinent (also referred to as South Asians) in the UK.[31] It is not clear why migrants from the Indian subcontinent had the highest diabetes prevalence among all immigrants, but neither age nor BMI, two of the most influential factors on diabetes, explain the high diabetes prevalence observed in this population. Diabetes prevalence within urban India, for example, has been reported to be as high as 15%,[29] indicating diabetes is an issue for South Asians in general, not only migrants. Reasons hypothesized for this higher prevalence of diabetes among South Asians include a genetic predisposition[32] that coincides with weight gain, insulin resistance,[33] along with a lower BMI threshold, a greater prevalence of high visceral adiposity,[25, 34] and lower levels of adiponectin.[35]

Immigrants from Mexico were the only subgroup more likely to have both higher diabetes and overweight prevalence compared to European migrants. Previous research has shown that Hispanic individuals have higher diabetes and overweight prevalence when compared to non-Hispanic blacks, whites[36, 37], or Asian Americans.[28] However, our results indicate that migrants from South America, a subgroup that would typically be classified as Hispanic, have lower diabetes and overweight prevalence than migrants from Mexico, Central America, and the Caribbean. Not only does this further support the notion that grouping together individuals by region of birth can mask differences in disease prevalence, but also from a clinical perspective, classifying a patient as Hispanic may not be as informative as obtaining nativity information.

African Americans (without a separate distinction for immigrant status) are commonly noted as having higher rates of diabetes compared with Caucasians.[38] Our results provide evidence of this among African migrant men, but not women. The literature also indicates that the higher diabetes prevalence in African Americans can be explained by increased insulin resistance at adiposity levels similar to Caucasians.[39] Our data are in agreement with previous research showing African American women have twice the obesity prevalence of European American women.[3]

Differences by sex indicated that immigrant men had a consistently higher overweight prevalence compared to women from the same region; however, these differences did not translate into differences in diabetes prevalence between sexes. When comparing across regions, associations were variable. Potential gender differences could be explained by weight-gain retention or gestational diabetes among women of child bearing age. Differences by gender in physical activity[40] or dietary intake could also play a part in the differences between genders.

Focusing on region of birth as the exposure variable, rather than on race/ethnicity is a unique aspect of our analysis. Race/ethnicity was not included in the analyses as we felt this would inappropriately dilute the associations between region of birth and the outcomes of interest. Race/ethnicity as reported in NHIS is primarily used as a socio-cultural construct rather than as a biological variable, whereas using region of birth may be more specific to genetics.[12] In one study,[41] the association between birthplace and obesity remained even after adjustment for measures of acculturation, suggesting that region of birth represents other phenomena related to the etiology of obesity beyond environmental processes.

The main limitation of our study is the use of self-reported data. The accuracy of self-reporting for diabetes is reasonably high in population surveys.[42] Undiagnosed diabetes cannot be assessed using NHIS and the percentage of undiagnosed diabetes in the migrant population is unknown. As a result, our study may underestimate the total diabetes prevalence in this population. Regarding self-reported height and weight, a previous study analyzed data from adults in NHANES III and found that the average immigrant woman underreported her weight less than the average native woman. On the other hand, the average native and immigrant man both underreported their actual weight equally.[43] Although it is a good epidemiological tool in large surveys, BMI is most likely not the best measure of adiposity and does not provide information on the location of adiposity (visceral vs. subcutaneous fat), which has implications for diabetes risk[44] and could explain the discordance between overweight and diabetes in our study. Adiposity measures are not available in the NHIS.

NHIS does not differentiate between Type 1 and Type 2 diabetes, however, we can assume that 90-95% of individuals who self-reported having diabetes had Type 2 diabetes.[38] NHIS data also does not differentiate between types of migrants and thus naturalized citizens, legal permanent residents, illegal immigrants, and nonimmigrants (students, visitors, guest workers, etc) are all included in the same category. Although it would be interesting to examine differences between types of migrants and characteristics that distinguish these groups and consequently their health, this was not the focus of our study. Finally, we did not have information on dietary habits, activity, or family history. However, NHIS is the only current and continuous US nationally representative survey that includes information on both nativity and health in the level of detail presented here.

Future studies should explore potential lifestyle and genetic contributors to morbidity in immigrants.

Our study had three major strengths: the use of nationally representative data; large sample size; and consistency of measures across all years. Other studies using NHIS data[29, 45, 46] were limited by sample size and unable to disaggregate data by the nine categories of region of birth represented in this study. It is important to note, however, that pooling almost a decade of NHIS data resulted in less than 2000 immigrants self-reporting diabetes and we were still unable to disaggregate the countries represented in region of birth any further than the nine categories in the analysis. Nevertheless, pooling NHIS data is a common practice[43, 47] and estimates are considered reliable when proper adjustments to sampling weights are made.[17] Another strength of this study is the comparison of migrants to each other. Comparisons among migrants potentially highlight differences related to the migration process, a common experience among migrants that may influence their health.[48]

There are an estimated 8 million overweight and 1 million people with diabetes within the diverse immigrant population in the US. The US accepts more legal immigrants per year than any other nation in the world.[49] The considerable heterogeneity by region of birth in overweight and diabetes risk among US immigrants, and the lack of correspondence between overweight and diabetes risks across immigrants point to the complex epidemiology of these conditions. Further investigations aimed at disentangling this complexity may provide greater clues to the roles of genes and environment on overweight and diabetes etiology. Given the growing numbers and diversity of immigrants in the US, greater attention to prevention research in this sub-population is urgently needed. National data systems should consider oversampling immigrants to get more accurate prevalence estimates for chronic diseases that will aid in informing prevention efforts specific to this subgroup.[50] Monitoring the health of this growing segment of the US population is important because the health of immigrants impacts national health outcomes.[43] Inclusion of immigrants as a subgroup in national documents, such as Healthy People 2020,[51] would aid monitoring efforts.

About the Authors

Reena Oza-Frank is a PhD candidate in the Nutrition and Health Sciences Program, Graduate Division of Biomedical and Biological Sciences, Emory University, Atlanta, GA and K.M. Venkat Narayan is a professor in the Hubert Department of Global Health, Rollins School of Public Health, Emory University, Atlanta, GA.

Contributors

R. Oza-Frank completed the analyses and led the writing of the article. K.M. V. Narayan supervised analyses and assisted in drafting of the article. Both authors helped to originate ideas, interpret findings, and review drafts of the article.

Acknowledgments

Conflicts of Interest/Financial Disclosures: None.

This manuscript was supported by Grant/Cooperative Agreement Number 1R36SH000008-01 from CDC. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of CDC.

These results were presented in part at the 68th Annual Scientific Sessions of the American Diabetes Association, June 6-10, 2008, San Francisco, CA.

Human Participant Protection

This study received exempt approval from the Emory University Institutional Review Board.

References

1. Field AE, Coakley EH, Must A, Spadano JL, Laird N, Dietz WH, et al. Impact of overweight on the risk of developing common chronic diseases during a 10-year period. *Arch Intern Med.* 2001;161(13):1581-1586.

2. Gregg EW, Cheng YJ, Narayan KM, Thompson TJ, Williamson DF. The relative contributions of different levels of overweight and obesity to the increased prevalence of diabetes in the United States: 1976-2004. *Prev Med.*2007;45(5):348-352.

3. Flegal KM, Carroll MD, Ogden CL, Johnson CL. Prevalence and trends in obesity among US adults, 1999-2000. *JAMA.* 2002;288(14):1723-1727.

4. Migration Policy Institute. Size of the Foreign-Born Population and Foreign Born as a Percentage of the Total Population, for the United States: 1850 to 2006. http://www.migrationinformation.org/DataHub/charts/final.fb.shtml. Accessed December 10, 2008.

5. Jasso G, Rosenzweig M. *The new chosen people: Immigrants in the United States*. New York: Russell Sage Foundation; 1990.

6. Kandula NR, Kersey M, Lurie N. Assuring the health of immigrants: what the leading health indicators tell us. *Annu Rev Public Health.* 2004;25:357-376.

7. Passel JS, Cohn D. *U.S. Population Projections: 2005-2050*: Pew Research Center; 2008.

8. Saaddine JB, Cadwell B, Gregg EW, Engelgau MM, Vinicor F, Imperatore G, et al. Improvements in diabetes processes of care and intermediate outcomes: United States, 1988-2002. *Ann Intern Med.* 2006;144(7):465-474.

9. Boyle JP, Honeycutt AA, Narayan KM, Hoerger TJ, Geiss LS, Chen H, et al. Projection of diabetes burden through 2050: impact of changing demography and disease prevalence in the U.S. *Diabetes Care.* 2001;24(11):1936-1940.

10. Cunningham SA, Ruben JD, Narayan KM. Health of foreign-born people in the United States: A review. *Health Place.* 2008 [Epub ahead of print]. doi:10.1016/j.healthplace.2007.12.002

11. Singh GK, Siahpush M. All-cause and cause-specific mortality of immigrants and native born in the United States. *Am J Public Health.*2001;91(3):392-399.

12. Singh GK, Siahpush M. Ethnic-immigrant differentials in health behaviors, morbidity, and cause-specific mortality in the United States: an analysis of two national data bases. *Hum Biol.* 2002;74(1):83-109.

13. Roshania R, Venkat Narayan KM, Oza-Frank R. Age at Arrival and Risk of Obesity Among US Immigrants. *Obesity (Silver Spring).* 2008;16(12): 2669–2675.

14. World Health Organization. Obesity and overweight [Fact Sheet]; 2003. http://www.who.int/hpr/NPH/docs/gs_obesity.pdf. Accessed June 20, 2008.

15. Schmidley D. The foreign-born population in the United States: March 2002. In: US Bureau of the Census, ed. *Current Population Reports.* Washington, DC: US Government Printing Office; 2003:20-539.

16. National Center for Health Statistics. National Health Interview Survey. http://www.cdc.gov/nchs/about/major/nhis/hisdesc.htm. Accessed May 15, 2008.

17. National Center for Health Statistics. Variance Estimation and Other Analytic Issues in the 1997-2005 NHIS (Adapted from Appendices III and VII of the 2005

NHIS Survey Description Document, and Appendix III of the 2006 NHIS Survey Description Document). http://www.cdc.gov/nchs/data/nhis/9705var.pdf. Accessed June 20, 2008.

18. National Center for Health Statistics. Research Data Center. http://www.cdc.gov/nchs/r&d/rdc.htm. Accessed June 20, 2008.

19. National Center for Health Statistics. National Health Interview Survey (NHIS) Public Use Data Release: NHIS Survey Description 2005. ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NHIS/2005/srvydesc.pdf Accessed December 10, 2008.

20. Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults--The Evidence Report. National Institutes of Health. *Obes Res.* 1998;6 Suppl 2:51S-209S.

21. Kuczmarski MF, Kuczmarski RJ, Najjar M. Effects of age on validity of self-reported height, weight, and body mass index: findings from the Third National Health and Nutrition Examination Survey, 1988-1994. *J Am Diet Assoc.*2001;101(1):28-34.

22. Haskell WL, Lee IM, Pate RR, Powell KE, Blair SN, Franklin BA, et al. Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. *Circulation.* 2007;116(9):1081-1093.

23. Research Triangle Institute (2001). *SUDAAN User's Manual, Release 8.0* Research Triangle Park, NC: Research Triangle Institute.

24. Graubard BI, Korn EL. Predictive margins with survey data. *Biometrics.* 1999;55(2):652-659.

25. Ramachandran A, Snehalatha C, Vijay V. Low risk threshold for acquired diabetogenic factors in Asian Indians. *Diabetes Res Clin Pract.* 2004;65(3):189-195.

26. Lauderdale DS, Rathouz PJ. Body mass index in a US national sample of Asian Americans: effects of nativity, years since immigration and socioeconomic status. *Int J Obes Relat Metab Disord.* 2000;24(9):1188-1194.

27. McNeely MJ, Boyko EJ. Type 2 diabetes prevalence in Asian Americans: results of a national health survey. *Diabetes Care.* 2004;27(1):66-69.

28. Bates LM, Acevedo-Garcia D, Alegria M, Krieger N. Immigration and Generational Trends in Body Mass Index and Obesity in the United States: Results of the National Latino and Asian American Survey, 2002-2003. *Am J Public Health.* 2008;98(1):70-77.

29. Mohanty SA, Woolhandler S, Himmelstein DU, Bor DH. Diabetes and cardiovascular disease among Asian Indians in the United States. *J Gen Intern Med.* 2005;20(5):474-478.

30. Patel S, Unwin N, Bhopal R, et al. A comparison of proxy measures of abdominal obesity in Chinese, European and South Asian adults. *Diabet Med.* 1999;16(10):853-860.

31. McKeigue PM, Marmot MG. Mortality from coronary heart disease in Asian communities in London. *BMJ.* 1988;297(6653):903.

32. Chambers JC, Elliott P, Zabaneh D, et al. Common genetic variation near MC4R is associated with waist circumference and insulin resistance. *Nat Genet.* 2008;40(6): 716-718.

33. Chandalia M, Abate N, Garg A, Stray-Gundersen J, Grundy SM. Relationship between generalized and upper body obesity to insulin resistance in Asian Indian men. *J Clin Endocrinol Metab.* 1999;84(7):2329-2335.

34. Sniderman AD, Bhopal R, Prabhakaran D, Sarrafzadegan N, Tchernof A. Why might South Asians be so susceptible to central obesity and its atherogenic consequences? The adipose tissue overflow hypothesis. *Int J Epidemiol.* 2007;36(1):220-225.

35. Mohan V, Deepa R, Pradeepa R, et al. Association of low adiponectin levels with the metabolic syndrome—the Chennai Urban Rural Epidemiology Study (CURES-4). *Metabolism.* 2003;54(4):476-481.

36. Harris MI. Diabetes in America: epidemiology and scope of the problem.[see comment]. *Diabetes Care.* Dec 1998;21 Suppl 3:C11-14.

37. Mokdad AH, Ford ES, Bowman BA, et al. Diabetes trends in the U.S.: 1990-1998.[see comment]. *Diabetes Care.* 2000;23(9):1278-1283.

38. CDC. National diabetes fact sheet: General information and national estimates on diabetes in the United States, 2005. http://www.cdc.gov/diabetes/pubs/factsheet05.htm. Accessed February 17, 2007.

39. Okosun IS, Liao Y, Rotimi CN, Prewitt TE, Cooper RS. Abdominal adiposity and clustering of multiple metabolic syndrome in White, Black and Hispanic americans. *Ann Epidemiol.* 2000;10(5):263-270.

40. Caspersen CJ, Pereira MA, Curran KM. Changes in physical activity patterns in the United States, by sex and cross-sectional age. *Med Sci Sports Exerc.* 2000;32(9):1601-1609.

41. Barcenas CH, Wilkinson AV, Strom SS, Cao Y, Saunders KC, Mahabir S, et al. Birthplace, years of residence in the United States, and obesity among Mexican-American adults. *Obesity (Silver Spring).* 2007;15(4):1043-1052.

42. Saydah SH, Geiss LS, Tierney E, Benjamin SM, Engelgau M, Brancati F. Review of the performance of methods to identify diabetes cases among vital statistics, administrative, and survey data. *Ann Epidemiol.* 2004;14(7):507-516.

43. Antecol H, Bedard K. Unhealthy assimilation: Why do immigrants converge to American health status levels? *Demography.* 2006;43(2):337-360.

44. Tran TT, Yamamoto Y, Gesta S, Kahn CR. Beneficial effects of subcutaneous fat transplantation on metabolism. *Cell Metab.* 2008;7(5):410-420.

45. Goel MS, McCarthy EP, Phillips RS, Wee CC. Obesity among US immigrant subgroups by duration of residence. *JAMA.* 2004;292(23):2860-2867.

46. Koya D, Egede L. Assocation between length of residence and cardiovascular disease risk factors among an ethnically diverse group of United States immigrants. *Society of General Internal Medicine.* 2007;22:841-846.

47. Dey AN, Lucas JW. Physical and mental health characteristics of U.S.- and foreign-born adults: United States, 1998-2003. *Adv Data.* 2006(369):1-19.

48. Jasso G MD, Rosenzweig M, Smith J. Immigration, health, and New York City: Early results based on the US New Immigrant Cohort of 2003. Economic Policy Review - Federal Reserve Bank of New York. 2005;11(2):127.

49. Department of Economic and Social Affairs, Population Division. United Nations. Trends in total migrant stock: The 2005 revision. 2006. http://www.un.org/esa/population/publications/migration/UN_Migrant_Stock_Documentation_2005.pdf. Accessed June 20, 2008.

50. Burrows NR, Lojo J, Engelgau MM, Geiss LS. Using survey data for diabetes surveillance among minority populations: a report of the Centers for Disease Control and Prevention's expert panel meeting. *Prev Chronic Dis.*2004;1(2):A02.

51. Department of Health and Human Services. Developing Healthy People 2020. Available at: http://www.healthypeople.gov/HP2020/. Accessed February 22, 2009.

Table 6.1 Characteristics of NHIS Sample by Region of Birth, 1997-2005[*, †]

	Mexico, Cent Am, Carribbean (n = 20172) % (SE)	South America (n = 2405) % (SE)	Europe (n = 3771) % (SE)	Russia (n = 511) % (SE)	Africa (n = 925) % (SE)	Middle East (n = 712) % (SE)	Indian Subcontinent (n = 1013) % (SE)	Central Asia (n = 1651) % (SE)	SE Asia (n = 2139) % (SE)
% Migrant Population	47.8 (0.7)	6.7 (0.2)	13.7 (0.3)	2.0 (0.2)	3.0 (0.2)	2.8 (0.2)	4.5 (0.2)	6.4 (0.3)	9.3 (0.3)
Age, mean, SE	38.5 (0.2)	41.2 (0.4)	45.8 (0.3)	42.5 (0.9)	38.0 (0.5)	39.9 (0.8)	39.0 (0.4)	41.9 (0.5)	40.0 (0.4)
Female, %, SE	46.9 (0.5)	48.4 (1.3)	51.4 (1.0)	52.8 (2.8)	38.9 (2.0)	42.7 (2.0)	40.6 (1.8)	52.7 (1.5)	50.1 (1.2)
Below Federal Poverty Level, %	18.8 (0.5)	8.5 (0.8)	5.4 (0.4)	11.5 (1.6)	9.8 (1.1)	14.6 (1.8)	7.3 (1.0)	10.7 (1.2)	10.9 (0.9)
BMI, mean, SE	27.0 (0.05)	25.8 (0.1)	25.8 (0.1)	25.5 (0.3)	25.9 (0.2)	25.5 (0.2)	24.2 (0.2)	23.0 (0.1)	23.6 (0.1)
Body Mass Index, %									
Normal weight	25.6 (0.4)	44.9 (1.2)	45.3 (1.0)	45.3 (2.8)	46.2 (2.0)	45.4 (2.2)	56.7 (1.9)	70.0 (1.4)	62.5 (1.2)
Overweight	42.1 (0.4)	37.3 (1.2)	36.3 (0.9)	36.0 (2.5)	36.7 (1.9)	39.7 (2.2)	32.3 (1.8)	20.9 (1.2)	24.8 (1.1)
Obese	21.2 (0.4)	15.5 (0.9)	15.9 (0.7)	15.0 (1.9)	15.5 (1.4)	12.5 (1.5)	6.6 (0.9)	3.2 (0.5)	6.5 (0.8)
Duration of Residence in the US, %									
<5 years	14.7 (0.5)	18.3 (1.3)	10.2 (0.7)	24.2 (2.1)	22.2 (1.6)	18.9 (1.9)	24.1 (1.7)	18.4 (1.4)	11.4 (0.9)
5-<10 years	18.4 (0.4)	17.4 (0.9)	9.1 (0.7)	32.9 (2.2)	25.0 (1.9)	13.5 (1.5)	21.0 (1.4)	17.6 (1.2)	14.1 (0.9)
10-<15 years	17.7 (0.4)	14.7 (0.8)	8.4 (0.5)	21.5 (2.2)	12.5 (1.2)	19.3 (2.1)	19.0 (1.5)	13.6 (0.9)	16.6 (1.0)
15+ years	49.2 (0.7)	49.6 (1.7)	72.3 (1.0)	21.8 (1.8)	40.3 (2.2)	48.3 (2.7)	35.8 (1.7)	50.5 (1.7)	57.9 (1.3)

[*] Percentages based on weighted, unadjusted data.

[†] All p-values<0.01 when comparing each row of data across migrant subgroup

Table 6.2 Multivariable* Adjusted Prevalence and Odds Ratios of Overweight among Immigrant Men and Women

	MEN		**WOMEN**	
Region of Birth	**Prevalence (95% CI)**	**OR (95% CI)**	**Prevalence (95% CI)**	**OR (95% CI)**
Europe	60.58 (57.60-63.56)	*reference*	43.15 (40.25-46.05)	*reference*
Mexico, Central Am, Caribbean	68.82 (67.53-70.11)	1.46 (1.26-1.69)	58.68 (57.31-60.05)	1.95 (1.71-2.24)
South America	65.47 (62.26-68.68)	1.25 (1.03-1.51)	42.49 (38.86-46.12)	0.97 (0.80-1.18)
Russia	65.09 (56.29-73.89)	1.22 (0.79-1.88)	47.79 (40.26-55.32)	1.22 (0.88-1.70)
Africa	52.14 (46.50-57.79)	0.70 (0.54-0.91)	55.07 (48.72-61.42)	1.67 (1.24-2.24)
Middle East	61.34 (54.87-67.81)	1.03 (0.76-1.41)	38.43 (31.82-45.04)	0.81 (0.58-1.13)
Indian Subcontinent	44.63 (38.32-50.94)	0.51 (0.38-0.68)	42.77 (36.38-49.16)	0.98 (0.72-1.34)
Central Asia	35.21 (30.47-40.00)	0.34 (0.26-0.44)	17.45 (13.88-21.02)	0.26 (0.19-0.35)
SE Asia	39.14 (35.28-43.00)	0.40 (0.33-0.49)	28.39 (24.61-32.17)	0.50 (0.40-0.63)

* Adjusted for age, poverty income ratio, and duration of residence

Table 6.3 Multivariable Adjusted Prevalence and Odds Ratios of Diabetes Without and With Adjustment for BMI among Immigrant Men and Women

	MEN			
	Diabetes*		Diabetes†	
Region of Birth	**Prevalence (95% CI)**	**OR (95% CI)**	**Prevalence (95% CI)**	**OR (95% CI)**
Europe	2.85 (1.94-3.75)	*reference*	2.79 (1.91-3.67)	*reference*
Mexico, Central Am, Caribbean	5.29 (4.64-5.94)	1.98 (1.37-2.87)	5.07 (4.44-5.70)	1.95 (1.34-2.84)
South America	3.19 (2.00-4.42)	1.13 (0.66-1.93)	3.09 (1.89-4.29)	1.12 (0.65-1.92)
Russia	5.06 (0.67-9.45)‡	1.89 (0.67-5.28)	4.78 (0.54-9.01)‡	1.82 (0.63-5.30)
Africa	7.76 (4.39-11.13)	3.11 (1.65-5.89)	7.62 (4.37-10.87)	3.16 (1.67-6.00)
Middle East	1.68 (0.08-3.44)‡	0.57 (0.20-1.65)	1.69 (0.01-3.40)‡	0.59 (0.21-1.66)
Indian Subcontinent	8.19 (5.15-11.23)	3.32 (1.90-5.82)	9.32 (6.00-12.65)	4.07 (2.31-7.18)
Central Asia	3.50 (1.70-5.30)	1.25 (0.67-2.34)	4.13 (2.01-6.25)	1.54 (0.82-2.91)
SE Asia	5.06 (3.22-6.90)	1.89 (1.12-3.17)	5.84 (3.76-7.92)	2.30 (1.36-3.89)

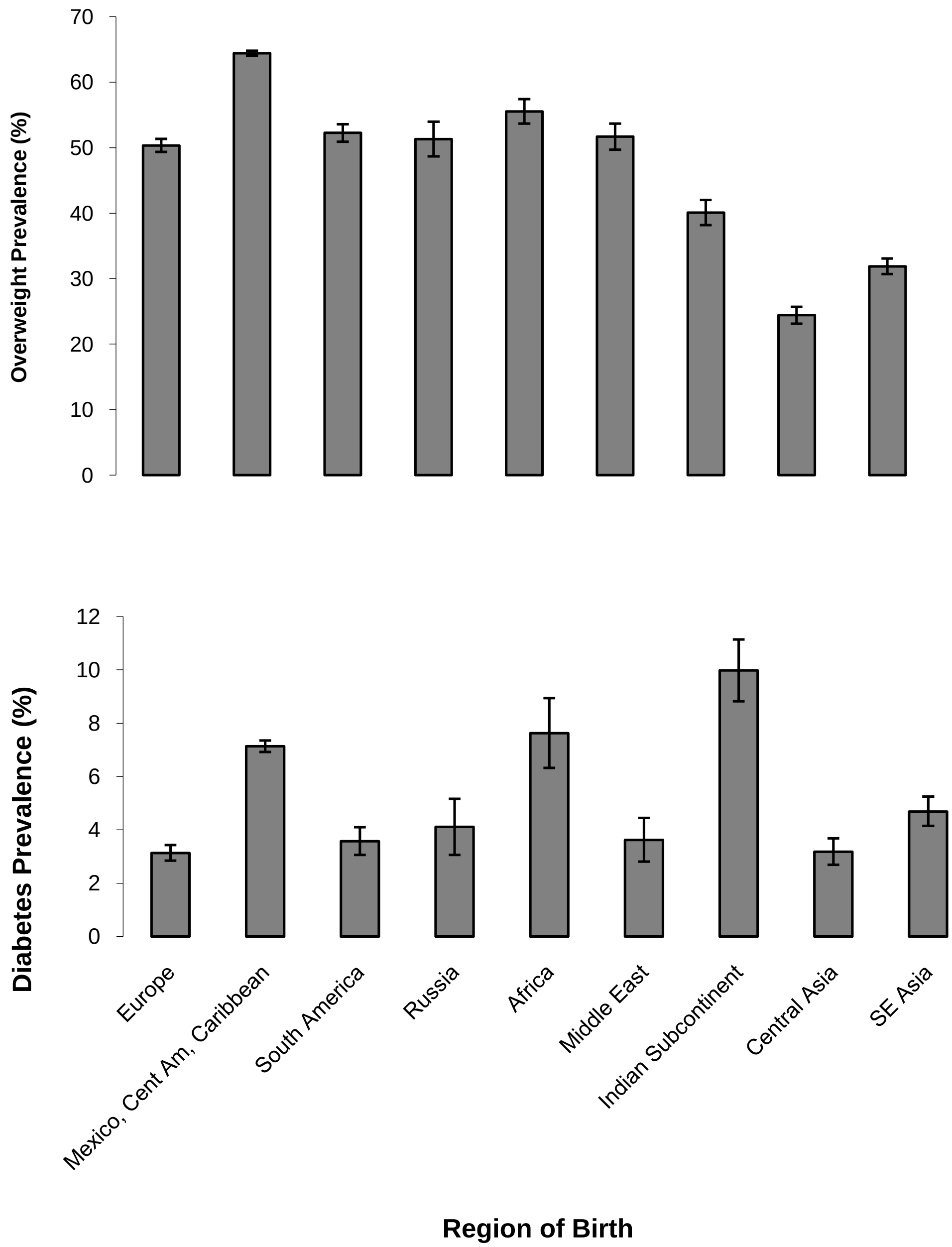
	WOMEN			
	Diabetes*		Diabetes†	
Region of Birth	**Prevalence (95% CI)**	**OR (95% CI)**	**Prevalence (95% CI)**	**OR (95% CI)**
Europe	3.42 (2.40-4.44)	*reference*	3.51 (2.49-4.53)	*reference*
Mexico, Central Am, Caribbean	6.20 (5.48-6.93)	1.94 (1.36-2.76)	5.64 (4.97-6.31)	1.72 (1.21-2.45)
South America	3.04 (1.92-4.16)	0.88 (0.53-1.46)	3.11 (1.97-4.25)	0.88 (0.53-1.45)
Russia	4.25 (1.07-7.43)‡	1.27 (0.51-3.15)	4.40 (1.13-7.67)‡	1.29 (0.50-3.32)
Africa	4.57 (2.36-6.78)	1.37 (0.73-2.57)	4.38 (2.17-6.59)	1.29 (0.67-2.47)
Middle East	2.54 (0.20-5.28)‡	0.73 (0.22-2.36)	2.61 (0.17-5.39)‡	0.72 (0.22-2.34)
Indian Subcontinent	11.57 (7.06-16.08)	4.16 (2.26-7.67)	12.51 (7.88-17.14)	4.70 (2.55-8.68)
Central Asia	2.26 (1.30-3.22)	0.64 (0.37-1.11)	3.20 (1.87-4.53)	0.90 (0.52-1.56)
SE Asia	4.00 (2.39-5.61)	1.19 (0.68-2.06)	4.96 (2.94-6.98)	1.48 (0.58-2.03)

* Adjusted for age, poverty income ratio, and duration of residence

† Adjusted for age, poverty income ratio, duration of residence, and BMI

‡ Estimates have a relative standard error of greater than 30% and should be used with caution as they do not meet the standard of reliability or precision.

Figure 6.1 Overweight and Diabetes Prevalence by Region of Birth



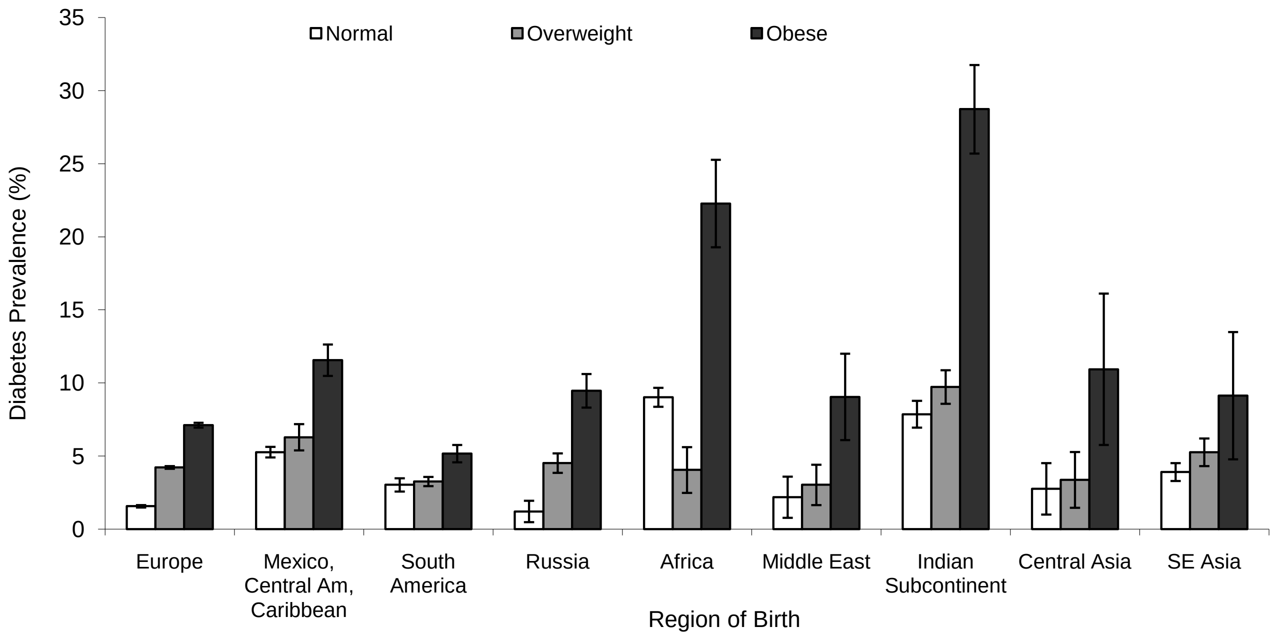
Overweight/obesity defined as body mass index ≥25 and was calculated as weight in kilograms divided by height in meters squared.

Self-reported diabetes was assessed from the question: “[Other than during pregnancy], have you EVER been told by a doctor or health professional that you have diabetes or sugar diabetes?”

Estimates are age- and sex-adjusted.

Error bars represent standard errors.

Figure 6.2 Diabetes Prevalence by Region of Birth and Body Mass Index Category



Body mass index was calculated as weight in kilograms divided by height in meters squared.

Estimates are age- and sex-adjusted.

Error bars represent standard errors.

The following data in the figure have a relative standard error of greater than 30% and should be used with caution as they do not meet the standard of reliability or precision: Each Russian and Middle Eastern BMI category, African overweight, Central Asian obese, SE Asian obese

Summary

In this chapter, we showed that overweight and diabetes prevalence varies by region of birth. However, the age at which an immigrant arrives may modify this association. For example, an immigrant arriving during childhood or adolescence may adopt U.S. lifestyle behaviors more quickly and thus have a different health profile and/or risk of overweight than immigrants who arrive as adults. Age at arrival is a variable that is not routinely collected directly, but can be calculated by subtracting length of residence (which is routinely collected) from current age. This was the case with the publicly available data from the New Immigrant Survey. Therefore, the objective of the next chapter was to determine how age at arrival modifies the association between length of residence and overweight.

CHAPTER 7: AGE AT ARRIVAL AND RISK OF OBESITY AMONG US IMMIGRANTS

Obesity. 2008;16(12): 2669–2675

Age at Arrival and Risk of Obesity among US Immigrants

RESHMA ROSHANIA, MPH[1]

K.M. VENKAT NARAYAN, MD[1,2,3]

REENA OZA-FRANK, MS-MPH, RD[3]

[1] Emory University, Hubert Department of Global Health, Rollins School of Public Health, Atlanta, GA

[2] Emory University, School of Medicine, Atlanta, GA

[3] Emory University, Nutrition and Health Sciences Program, Graduate Division of Biomedical and Biological Sciences, Atlanta, GA

Corresponding Author:
Reena Oza-Frank
Emory University
Rollins School of Public Health
1518 Clifton Road, NE
Atlanta, GA 30322
Phone: 614-327-3629
Fax: 404-727-4590
E-mail: roza@emory.edu

Word Count (text only): 3148

Tables: 3

Figures: 2

Abstract

Although immigrants are a rapidly growing sub-group, little is known about overweight/obesity among the foreign-born in the US, especially regarding the effect of age at arrival. This study determined whether overweight/obesity prevalence is associated with age at arrival of immigrants to the US. We analyzed data on 6421 adult immigrants from the New Immigrant Survey, a study that is nationally representative of adult immigrants with newly acquired legal permanent residence (LPR). Multiple regression analyses tested the effects of duration of residence and age at arrival on overweight/obesity, defined by body mass index of $\geq$25 kg/m ^{2}, and self-reported dietary change score. We found the relationship between duration of residence and overweight/obesity prevalence varied by age at arrival ($P<.001$). Immigrants $\leq$20 years old at arrival who had resided in the US $\geq$15 years were 11 times (95% CI: 5.33, 22.56) more likely to be overweight/obese than immigrants $\leq$20 years old at arrival who had resided in the US $\leq$1 year. By comparison, there was no difference in overweight/obesity prevalence by duration among immigrants who arrived at >50 years of age. Higher self-reported dietary change is also associated with overweight/obesity. In conclusion, immigrants younger than 20 at arrival in the US may be at higher risk of overweight/obesity with increasing duration of residence than those who arrive at later ages. Obesity prevention among young US immigrants should be a priority.

Introduction

The foreign-born population is a rapidly growing sub-group in the United States, currently representing almost 12% (or 37 million) of the national population (1); approximately 20% of all children under the age of 18 in the United States are either first- or second-generation immigrants (2). Overweight and obesity prevalence in the US has increased dramatically over the past decades (3, 4), with minorities disproportionately affected (5, 6).

Although at arrival, immigrants are less likely than native-born individuals to be overweight and obese, increasing length of residence in the destination/receiving country is associated with higher risk of overweight and obesity (7-10). Increasing duration of residence leads to the adoption of the host country's dietary patterns (11-13), and may be especially important in the context of overweight and obesity. Past studies suggest that age at arrival of migrants is a critical variable, reflective of adaptive capability, education level and motive for migration, and may be important to consider in acculturation to western lifestyle, specifically smoking (14), physical activity levels (15), self-assessed overall health (16), and socioeconomic status (17). For example, a study of Mexicans in Houston found that younger age at migration predicts history of smoking (14). Another study of Hispanic women in North Carolina found that participants who arrived to the US at younger ages were more likely to report being physically active (15). Similar to these studies, much of the current literature highlights only specific regions of the US and specific immigrant subgroups, decreasing their generalizability. There is little information on overweight and obesity among the US foreign-born, especially regarding the effect of age at arrival on overweight and obesity.

Using the New Immigrant Survey (NIS), we examined whether the relationship between overweight and obesity prevalence and duration of residence differs by age at arrival. Secondly, we explored level of self-reported dietary change after migration as a possible explanatory factor in overweight and obesity prevalence.

Methods and Procedures

Data source

Data from the New Immigrant Survey (NIS), which is nationally representative of adult immigrants with newly acquired legal permanent residence (LPR) and their children, were used for this study (18). Specifically, we used data from the baseline cohort (NIS-2003) of sampled adult immigrants (n=8573). Details of NIS have been published elsewhere (19). Briefly, the sampling frame of NIS-2003 was based on electronic administrative records compiled by the United States Citizenship and Immigration Services and consists of adult immigrants admitted to LPR between May and November 2003, and was stratified by four immigrant visa categories: employment principals, diversity principals, spouses of US citizens, and other immigrants; the first two strata were over-sampled.

To avoid potential bias in our analyses, only subjects who reported migrating directly from their country of birth to the US were included (n=7247), and those respondents who were overseas at the time of interview were excluded (n=216). Of the remaining 7031 subjects, those who did not provide data necessary to calculate duration of residence or age at arrival were excluded (n=185). Finally, subjects providing missing height or weight data (n=357) and unreliable BMI (≤12.5 or ≥42.5 kg/m^2, n=68) were excluded, resulting in a final sample size of 6421.

Variables of interest

Body mass index (BMI) was calculated from self-reported height and weight data, and was categorized as underweight (<18.5 kg/m^2), normal weight (18.5 to <25 kg/m^2), and overweight/obese (≥25 kg/m^2). Duration of residence was calculated by subtracting year of migration from year of interview, and was categorized as follows: <1, 1 to <5, 5 to <10, 10 to <15, and ≥15 years. Year of migration was determined based on the respondent's answer to 'In what month and year did you first leave [country of birth] to live in another country for at least 60 days?' Similarly, age at arrival was determined by subtracting years of duration from current age, and was categorized into the following groups: ≤20, 21 to 30, 31 to 40, 41 to 50, and >50.

Level of dietary change after migration was assessed by asking the following question: 'Using a scale from one to ten, where 10 indicates exactly the same and 1 means completely different, how would you compare the similarity in diet in the food you now normally eat in the United States with the food you normally ate in your home country?' Based on the distribution of responses, we collapsed the scale into three levels of dietary change: low, moderate, and high.

Other variables of interest included current age (≤24, 25 to 34, 35 to 44, 45 to 54, 55 to 64, ≥65 years), sex, years of education (<12, ≥12), marital status (married, not married) and region of origin. Education was dichotomized due to the varying interpretation of years of education across countries. We considered

12 years of education as the cutoff point based on the mean and median of the sample distribution.

To determine region of origin, subjects were asked to respond to ‘In what country were you born?’ by choosing their country of birth from a list. Responses were then categorized into the following regions: Asia (including South, East and Southeast Asia), Latin America and the Caribbean, Sub-Saharan Africa, Europe and Central Asia (including Russia, Eastern Europe and Western Europe), and Middle East and North Africa.

Education level was considered a more appropriate indicator of socioeconomic status than income due to the loss of status that immigrants may experience; that is, income in the host country may not adequately reflect profession and/or education in the home country (20). The following variables were assessed but were not significant in regression analyses: health insurance, physical activity, smoking, alcohol use.

Statistical analysis

To explore baseline differences in overweight/obesity prevalence among immigrants who have resided in the US for less than one year by sex, education, region of origin and marital status, χ^2 tests were done. For the entire sample, multiple logistic regression analyses with overweight/obesity as the outcome variable were done with age at arrival and duration of residence as the exposures of interest. Although age at arrival and duration of residence were correlated *(r=-.404, P<.001)*, there was low multi-collinearity, determined by a variance inflation factor (VIF) of 1.22, allowing simultaneous assessment of both variables in models. However, adding current age with these variables resulted in high levels of multi-collinearity (VIF=6.58), which was expected since current age is the sum of duration of residence and age at arrival. Therefore, we conducted separate analyses including duration of residence and current age in the first model, age at arrival and current age in the second model, and age at arrival and duration of residence in the third model. Because previous studies have shown sex differences in the associations between health behaviors and acculturation (9), the significance of sex interacting with age at arrival and duration of residence was assessed. We also tested the interaction between age at arrival and duration of residence to answer our main question of interest.

Bivariate associations of dietary change with duration of residence and age at arrival, were done using χ^2 tests. Ordinal logistic regression analyses with dietary change as the outcome were done to assess multivariable associations after verifying the proportional odds assumption was met. Categorical dietary change was the outcome variable, and age at arrival (continuous) and duration of residence (continuous) were the exposures of interest. Final models were determined by the backwards elimination method.

Analyses were performed in SAS-callable SUDAAN (version 9.0, Research Triangle Institute, Research Triangle Park, NC) to account for the complex sampling design of NIS-2003. For all analyses, sample weights were applied and statistical significance was considered at $P \leq .05$.

Results

The majority of immigrants in this sample resided in the US for 5 years or less, and over half of all migrants arrived at younger than 30 years of age (Table 7.1).

Overweight and Obesity

Among immigrants who have resided in the US for less than one year, males were significantly more likely to be overweight/obese (40.96%) than females (31.91%) *($P<.001$)*, and married immigrants are significantly less likely to be overweight/obese (33.86%) than unmarried immigrants (38.64%) *($P<.001$)* after age-standardizing directly to the distribution of the population. Overweight/obesity prevalence at arrival differed across regions of origin *($P<.001$)*; 23.74% of people from Asia were overweight/obese at arrival versus 51.25% of immigrants from Latin America and the Caribbean. There was no significant association between overweight/obesity prevalence and education *($P=.07$)*. (Data not shown.)

Figure 7.1 shows that prevalence of overweight/obesity among all age at arrival cohorts increases with greater duration of residence in the US. Although immigrants 20 years old or younger are significantly less likely to be overweight/obese than immigrants greater than 50 years of age at arrival (13.54% vs. 42.29% in males, *$P<.001$;* 9.76% vs. 56.01% in females, *$P<.001$)*, the difference in overweight/obesity prevalence by age at arrival groups narrows and is no longer significant for males at 5 years of residence *($P=.15$)*, and for females at 10 years of residence *($P=.20$)*

There was a significant interaction between sex and duration of residence *($P<.01$)* and between sex and age at arrival *($P<.001$)*. Model 1 (Table 7.2) confirms our bivariate results, showing higher overweight/obesity prevalence with increasing duration of residence adjusted for current age, education and region of origin. Model 2 (Table 7.2) shows that for both males and females, immigrants who were $\leq$ 20 years old at arrival are more likely to report being overweight/obese compared to all other age at arrival cohorts, controlled for current age, education and region of origin. Results from both models also suggest sex differences in overweight/obesity prevalence by region of origin and education. With regard to education, female immigrants with more than 12 years of education were less likely to be overweight/obese than those with less than 12 years of education (Table 7.2); there was no association between education and overweight/obesity for males. A sensitivity analysis using education as a continuous variable indicates the associations between weight and education for both females and males remain the same.

Adjusted for sex, education level and region of origin, there was a significant interaction between duration of residence and age at arrival *($P<.001$)* in predicting overweight/obesity, indicating that age at arrival modifies the relationship between duration of residence and overweight/obesity prevalence among immigrants in the US.

Further analyses, stratified by age at arrival group (Table 7.3), show the largest difference in overweight/obesity prevalence by duration of residence was observed in the youngest age at arrival group. Trends were similar between males and females; therefore the overall results adjusted for sex are presented. Immigrants $\leq$20 years old at arrival who had resided in the US $\geq$15 years were 11 times more likely to be overweight/obese than immigrants $\leq$20 years old at arrival who had resided in the US $\leq$1 year (OR=10.96, 95% CI: 5.33, 22.56; *$P<.001$)*. By comparison, among immigrants older than 40 years of age at arrival, those having resided in the US for 10 years or longer are no more likely to self-report being overweight/obese than those who have recently arrived *(P=.42)*.

Dietary Change

Self-reported high dietary change after migration was found to be significantly and independently associated with overweight/obesity, controlling for age at arrival, duration of residence, sex and education. Specifically, immigrants reporting high dietary change are 1.32 times more likely to self-report being overweight/obese compared to immigrants reporting low dietary change (95% CI: 1.13, 1.53; $P<.001$). (Data not shown.)

Immigrants who have been in the US longer are significantly more likely to report high dietary change from pre-migration diets than recently arrived immigrants $(P<.001)$ (Table 7.1). Overall, those immigrants who are youngest at arrival are significantly more likely to report high dietary change, whereas immigrants oldest upon arrival are more likely to report low dietary change $(P<.001)$ (Figure 7.2).

Adjusted for sex, education and region of origin, there is a significant interaction found between age at arrival and duration of residence in predicting dietary change *(P=.03)*, indicating that age at arrival of immigrants also modifies the relationship between duration of residence in the US and dietary change.

Discussion

We found that immigrants who arrive to the US before the age of 20 are more likely to be overweight or obese with increasing duration of residence than immigrants who arrive to the US at later ages. Increasing duration of residence in the US is significantly associated with greater odds of overweight/obesity, and age at arrival significantly modifies this relationship. We also found that the relationship between self-reported dietary change and duration of residence is modified by age at arrival; immigrants who arrive to the US at younger ages are more likely to report high levels of dietary change than immigrants who arrive at older ages. Lastly, dietary change was associated with overweight and obesity; immigrants reporting high dietary change are more likely to be overweight and obese than immigrants reporting low dietary change.

The differences in overweight/obesity development and dietary change by age at arrival can potentially be explained by several factors: increased exposure and adaptability of younger immigrants to US lifestyles, differences in motives for migration by age group, and health selection for migration later in life. Compared to immigrants who arrive to the US at later ages, immigrants who migrate during childhood and adolescence are more exposed to the lifestyles of their native-born counterparts since they are more likely to receive schooling in the US, and are more likely to marry native-born Americans (21). Older immigrants are less likely to acculturate or build new social networks since they usually migrate to rejoin family members already in the US (22), and the presence of a network of people of the same ethnicity is likely to delay or inhibit acculturation (10); young immigrants migrate either accompanying their families or for educational and/or economic opportunities and as a result, may be more willing to acculturate (23). Lastly, health selection may operate in one of two ways on immigrants arriving to the US at older ages. Consistent with the healthy immigrant effect, only those elderly individuals who are positively selected for health will migrate (24, 25) and furthermore, only those who remain healthy will stay in the US, while unhealthy individuals may return to their home countries (26). Conversely, there is the possibility of negative selection (24), whereby elderly individuals migrate to seek care, and by accessing health services are less likely to develop overweight/obesity after arrival in the US.

This study's finding that level of dietary change after migration is significantly associated with overweight/obesity is consistent with previous studies that have documented increased fat and sugar intake and decreased fruit and vegetable intake post-migration (11, 27, 28), implying that immigrants may be shifting towards more unhealthy dietary patterns after arrival to the US.

Region of origin emerged as an important factor in overweight/obesity and dietary patterns in this study. Immigrants from Asia are the least likely to be overweight/obese and are the least likely to report high dietary change, while immigrants from Latin America and the Caribbean are the most likely to be overweight/obese and after Sub-Saharan Africans, are the most likely to report high dietary change. These findings are consistent with the literature on increasing obesity among Latin American immigrants in the US (29, 30).

Diversity between traditional and US diets, as well as increasing availability of western foods in certain regions could be explanations for the differences in dietary change by region of origin. For example, European and North American diets are relatively similar and therefore, high dietary change may not be perceived among European immigrants after migration to the United States. However, we found that immigrants from Asia, whose traditional diets differ considerably from the North

American diet (11, 31, 32), were no more likely to report high dietary change than European immigrants. For recently arrived immigrants, this can be explained by the increased availability and consumption of western foods by Asians prior to migration (12). Conversely, a study of Sub-Saharan African immigrants, the most likely to report high dietary change in our sample, noted increased consumption of western foods that were not available in Africa (27).

There were some limitations to our study. Although the NIS study is designed to be longitudinal, only the NIS-2003 baseline data were available for this study; the cross-sectional nature of this study cannot allow us to make any inferences regarding causality. The sampling method of selecting new immigrants for the NIS study resulted in a disproportionate number of immigrants who have resided in the US for 5 years or less; furthermore, NIS samples only immigrants with newly acquired legal permanent residence (LPR) status, who may be different from immigrants without LPR. Pre-categorized countries of birth did not allow the examination of differences within regions (e.g. South Asian versus other Asian). Our sample also includes immigrants who migrated directly from their country of birth to the United States and may have migrated elsewhere afterwards, eventually returning to the US. In these cases, duration of residence is overestimated, and thus observed increases in weight may have actually occurred within a shorter period than calculated in this study. Although our analysis could not account for cohort effects related to year at migration, previous research implies that overall, patterns of health assimilation including BMI are similar across cohorts of immigrants (33). Lastly, height and weight data are self-reported, thereby leading to potential recall and misreporting biases (34, 35). Although the dietary change score has not been validated, inclusion of a dietary change component in exploring overweight/obesity among immigrants and data that is nationally representative of adult immigrants with newly acquired LPR allowed us to analyze a unique research question with relevant public health implications.

While previous studies have observed increasing trends in overweight and obesity among second- and third-generation adolescent immigrants (36), our results have clearly indicated that young first-generation immigrants are also experiencing rises in overweight and obesity and in fact, to a greater degree than the national population. At arrival, immigrants 20 years of age or younger are much less overweight and obese (12%) than the US population in the same age group (35%) (37), and at 15 years of duration in the US, the overweight/obesity prevalence of the same age at arrival cohort (61%) has almost converged to the national overall prevalence (66%) (38). Although the age group under 20 includes both children and adolescents, our analysis showed no difference between younger age sub-groups by overweight/obesity prevalence, suggesting that it is important to intervene among all immigrants who arrive at 20 years of age or younger, regardless of specific age of migration..

In summary, immigrants who arrived to the US at younger ages may be at higher risk of overweight/obesity with duration of residence than immigrants who arrive at later ages. Immigrants who are younger at arrival are also more likely to report a high level of dietary change post-migration, which is associated with overweight and obesity. Our findings emphasize the need for aggressive overweight and obesity prevention programs tailored to immigrant youth in the US.

Author Contributions

R. Roshania and R. Oza-Frank led the writing of the article. R. Roshania completed the analyses with supervision from R. Oza-Frank. All authors helped to originate ideas, interpret findings, and review drafts of the article.

Acknowledgements

We thank Solveig Argeseanu Cunningham, PhD, for her thoughtful review of the manuscript prior to submission.

Disclosure

The authors declare no conflict of interest.

References

1. Martin P, Midgley E. Immigration: shaping and reshaping America. *Popul Bull.* 2006;61(4):3-28.

2. Fix M, Passel JS. US immigration: trends and implications for schools [Online]. 2003 [cited 2007 Dec 15]; Available from: URL:http://www.urban.org/url.cfm?ID=410654

3. Flegal KM, Carroll MD, Ogden CL, Johnson CL. Prevalence and trends in obesity among US adults, 1999-2000. *JAMA.* 2002;288(14):1723-7.

4. Kuczmarski RJ, Flegal KM, Campbell SM, Johnson CL. Increasing prevalence of overweight among US adults: the National Health and Nutrition Examination Surveys, 1960 to 1991. *JAMA.* 1994;272(3):205-11.

5. Hedley AA, Ogden CL, Johnson CL, Carroll MD, Curtin LR, Flegal KM. Prevalence of overweight and obesity among US children, adolescents, and adults, 1999-2002. *JAMA.* 2004;291(23):2847-50.

6. Ogden CL, Flegal KM, Carroll MD, Johnson CL. Prevalence and trends in overweight among US children and adolescents, 1999-2000. *JAMA.* 2002;288(14):1728-32.

7. Cairney J, Ostbye T. Time since immigration and excess body weight. *Can J Public Health.* 1999;90(2):120-4.

8. Goel MS, McCarthy EP, Phillips RS, Wee CC. Obesity among US immigrant subgroups by duration of residence. *JAMA.* 2004;292(23):2860-7.

9. Koya DL, Egede LE. Association between length of residence and cardiovascular disease risk factors among an ethnically diverse group of United States immigrants. *J Gen Intern Med.* 2007;22(6):841-6.

10. McDonald JT, Kennedy S. Is migration to Canada associated with unhealthy weight gain? Overweight and obesity among Canada's immigrants. *Soc Sci Med.* 2005;61(12):2469-81.

11. Lv N, Cason KL. Dietary pattern change and acculturation of Chinese Americans in Pennsylvania. *J Am Diet Assoc.* 2004;104(5):771-8.

12. Raj S, Ganganna P, Bowering J. Dietary habits of Asian Indians in relation to length of residence in the United States. *J Am Diet Assoc.* 1999;99(9):1106-8.

13. Yang EJ, Chung HK, Kim WY, Bianchi L, Song WO. Chronic diseases and dietary changes in relation to Korean Americans' length of residence in the United States. *J Am Diet Assoc.* 2007;107(6):942-50.

14. Wilkinson AV, Spitz MR, Strom SS, et al. Effects of nativity, age at migration, and acculturation on smoking among adult Houston residents of Mexican descent. *Am J Public Health.* 2005;95(6):1043-9.

15. Evenson KR, Sarmiento OL, Ayala GX. Acculturation and physical activity among North Carolina Latina immigrants. *Soc Sci Med.* 2004;59(12):2509-22.

16. Angel JL, Angel RJ. Age at migration, social connections, and well-being among elderly Hispanics. *J Aging Health.* 1992;4(4):480-99.

17. Schaafsma J, Sweetman A. Immigrant earnings: age at immigration matters. *Can J Econ.* 2001;34(4):1066-99.

18. Jasso G, Massey DS, Rosenzweig MR, Smith JP. The New Immigrant Survey 2003 Round 1 (NIS-2003-1) public release data. [Online]. March 2006. Available from: http://nis.princeton.edu/data.html [cited 2006 Nov 15].

19. Jasso G, Massey DS, Rosenzweig MR, Smith JP. Immigration, health, and New York City: early results based on the U.S. new immigrant cohort of 2003. *FRBNY Economic Policy Review.* 2005;11:127-51.

20. Barringer HR, Takeuchi DT, Xenos P. Education, occupational prestige, and income of Asian Americans. *Sociol Educ.* 1990;63:27-43.

21. Stevens G. Age at immigration and second language proficiency among foreign-born adults. *Language in Society.* 1999;28(4):555-78.

22. Angel RJ, Angel JL, Lee GY, Markides KS. Age at migration and family dependency among older Mexican immigrants: recent evidence from the Mexican American EPESE. *Gerontologist.* 1999;39(1):59-65.

23. Gibson MA. Immigrant adaptation and patterns of acculturation. *Hum Dev.* 2001;44:19-23.

24. Jasso G, Massey DS, Rosenzweig MR, Smith JP. Immigrant health: selectivity and acculturation. In: Bulatao RA, Cohen B, editors. *Critical Perspectives on Racial and Ethnic Differences in Health in Late Life*. Washington DC: National Academy Press; 2004. p. 227-66.

25. McDonald JT, Kennedy S. Insights into the 'healthy immigrant effect': health status and health service use of immigrants to Canada. *Soc Sci Med.* 2004;59(8):1613-27.

26. Palloni A, Arias E. Paradox lost: explaining the Hispanic adult mortality advantage. *Demography.* 2004;41(3):385-415.

27. Kruseman M, Barandereka NA, Hudelson P, Stalder H. Post-migration dietary changes among African refugees in Geneva: a rapid assessment study to inform nutritional interventions. *Soz Praventivmed.* 2005;50(3):161-5.

28. Pan YL, Dixon Z, Himburg S, Huffman F. Asian students change their eating patterns after living in the United States. *J Am Diet Assoc.* 1999;99(1):54-7.

29. Barcenas CH, Wilkinson AV, Strom SS, et al. Birthplace, years of residence in the United States, and obesity among Mexican-American adults. *Obesity (Silver Spring, Md)* 2007;15(4):1043-52.

30. Kaplan MS, Huguet N, Newsom JT, McFarland BH. The Association between length of residence and obesity among Hispanic immigrants. *Am J Prev Med.* 2004;27(4):323-6.

31. Lee SK, Sobal J, Frongillo EA. Acculturation, food consumption and diet-related factors among Korean Americans. *J Nutr Educ.* 1999;31(6):321-30.

32. Varghese S, Moore-Orr R. Dietary acculturation and health-related issues of Indian immigrant families in Newfoundland. *Can J Diet Pract Res.* 2002;63(2):72-9.

33. Antecol H, Bedard K. Unhealthy assimilation: why do immigrants converge to American health status levels? *Demography.* 2006;43(2):337-60.

34. Palta M, Prineas RJ, Berman R, Hannan P. Comparison of self-reported and measured height and weight. *Am J Epidemiol.* 1982;115(2):223-230.

35. Rowland ML. Self-reported weight and height. *Am J Clin Nutr.* 1990;52(6):1125-33.

36. Popkin BM, Udry JR. Adolescent obesity increases significantly in second and third generation U.S. immigrants: the National Longitudinal Study of Adolescent Health. *The Journal of nutrition* 1998;128:701-6.

37. National Health Interview Survey 2003 [Online]. 2004. Available from: National Center for Health Statistics, Centers for Disease Control and Prevention. Hyattsville (MD). [cited 2007 Nov 15].

38. Ogden CL, Carroll MD, Curtin LR, McDowell MA, Tabak CJ, Flegal KM. Prevalence of overweight and obesity in the United States, 1999-2004. *JAMA*. 2006;295(13):1549-5.

Table 7.1 Characteristics of Respondents by Duration of Residence in the United States, 2003[a, b]

		Duration of Residence in the U.S.			
	All (n=6421)	**<1 year (n=1790)**	**1 to <5 years (n=1815)**	**5 to <10 years (n=1192)**	**10 to <15 years (n=863)**
Current Age, mean (SE), y	38.28 (0.17)	40.28 (0.39)	37.49 (0.35)	36.17 (0.38)	37.05 (0.42)
Age at Arrival, % (SE)					
≤ 20 years	19.48 (0.60)	5.17 (0.60)	8.48 (0.77)	19.90 (1.51)	40.48 (1.95)
21 to 30	36.59 (0.69)	24.46 (1.20)	39.47 (1.34)	46.37 (1.75)	37.53 (1.86)
31 to 40	19.83 (0.57)	26.28 (1.20)	22.71 (1.15)	18.68 (1.35)	13.63 (1.27)
41 to 50	11.23 (0.44)	20.56 (1.09)	12.71 (0.88)	7.69 (0.88)	4.75 (0.79)
> 50 years	12.87 (0.42)	23.53 (1.12)	16.63 (0.88)	7.36 (0.83)	3.71 (0.66)
Female, % (SE)	55.74 (0.71)	55.28 (1.34)	62.90 (1.29)	55.55 (1.73)	46.72 (1.95)
Married, % (SE)	73.98 (0.52)	67.85 (1.19)	77.74 (0.95)	82.55 (1.16)	72.11 (1.60)
Education ≥ 12 yrs, % (SE)	64.49 (0.67)	59.98 (1.33)	71.42 (1.21)	76.27 (1.52)	56.40 (1.93)
Region of Origin[c], % (SE)					
Asia	30.52 (0.65)	46.40 (1.36)	33.45 (1.29)	31.67 (1.51)	16.25 (1.34)
Latin America & the Caribbean	45.83 (0.72)	29.41 (1.27)	34.52 (1.32)	43.22 (1.77)	70.21 (1.74)
Sub Saharan Africa	5.69 (0.31)	7.74 (0.62)	6.94 (0.61)	6.33 (0.89)	1.98 (0.52)
Europe & Central Asia	12.73 (0.47)	12.64 (0.86)	17.29 (0.99)	13.05 (1.15)	8.83 (1.08)
Middle East & North Africa	3.46 (0.26)	3.54 (0.44)	4.98 (0.58)	3.37 (0.69)	1.47 (0.47)
BMI[d], mean (SE)	24.94 (0.06)	24.02 (0.12)	24.13 (0.11)	24.97 (0.15)	26.42 (0.16)
BMI[d], % (SE)					
< 18.5	4.07 (0.29)	6.19 (0.70)	5.26 (0.62)	3.51 (0.63)	1.73 (0.47)
18.5 to < 25	50.50 (0.73)	57.46 (1.35)	57.48 (1.35)	50.45 (1.76)	37.79 (1.89)
25 to < 30	33.16 (0.69)	27.83 (1.22)	29.40 (1.25)	34.76 (1.68)	39.60 (1.91)
≥ 30	12.26 (0.48)	8.52 (0.76)	7.86 (0.70)	11.28 (1.15)	20.88 (1.63)
High Dietary Change, % (SE)	28.81 (0.67)	22.18 (1.14)	25.21 (1.21)	30.90 (1.68)	37.22 (1.89)

[a] Percentages based on weighted, unadjusted data.

[b] Columns totals may not equal 100 due to rounding.

[c] *Other* category (n=106) not presented.

[d] Body Mass Index (BMI; calculated as weight in kilograms divided by the square of height in meters).

Table 7.2 Adjusted Prevalence and Odds Ratios of Overweight/Obesity Stratified by Sex

	% (SE)		OR (95% CI)	
	Male	**Female**	**Male**	**Female**
Model 1[a]				
Duration				
<1 year	46.18 (0.02)	35.75 (0.02)	Reference	Reference
1 - <5 years	50.31 (0.02)	34.81 (0.02)	1.20 (0.94, 1.53)	0.95 (0.75, 1.20)
5 - <10 years	60.25 (0.02)	37.69 (0.02)	1.87 (1.43, 2.45)	1.10 (0.84, 1.44)
10 - <15 years	59.88 (0.03)	47.18 (0.03)	1.84 (1.37, 2.48)	1.74 (1.29, 2.35)
≥15 years	62.57 (0.03)	43.77 (0.03)	2.08 (1.51, 2.87)	1.48 (1.09, 2.02)
Current Age				
≤ 24 years	35.00 (0.03)	18.19 (0.02)	Reference	Reference
25 - 34 years	51.16 (0.12)	34.23 (0.02)	2.09 (1.51, 2.88)	2.58 (1.82, 3.64)
35 - 44 years	62.06 (0.02)	39.79 (0.02)	3.43 (2.46, 4.79)	3.38 (2.37, 4.82)
45 - 54 years	66.41 (0.03)	50.52 (0.02)	4.24 (2.90, 6.20)	5.59 (3.82, 8.19)
55 - 64 years	60.87 (0.04)	55.63 (0.03)	3.25 (2.09, 5.03)	7.10 (4.64, 10.84)
≥ 65 years	45.08 (0.04)	48.64 (0.04)	1.59 (1.01, 2.50)	5.13 (3.26, 8.06)
Education				
< 12 years	53.26 (0.02)	44.42 (0.02)	Reference	Reference
≥ 12 years	55.06 (0.01)	34.63 (0.01)	1.09 (0.88, 1.34)	0.62 (0.51, 0.75)
Region of Origin[b]				
Europe & Central Asia	53.40 (0.03)	33.24 (0.03)	Reference	Reference
Asia	36.46 (0.02)	21.66 (0.01)	0.48 (0.36, 0.64)	0.53 (0.40, 0.71)
Latin America & the Caribbean	65.92 (0.02)	49.79 (0.02)	1.75 (1.29, 2.37)	2.13 (1.61, 2.83)
Sub Saharan Africa	46.67 (0.04)	51.82 (0.04)	0.78 (0.54, 1.13)	2.33 (1.53, 3.57)
Middle East & North Africa	56.14 (0.05)	53.30 (0.06)	1.13 (0.71, 1.77)	2.49 (1.39, 4.48)
Model 2[c]				
Age at Arrival				
≤ 20 years	63.19 (0.03)	45.85 (0.03)	Reference	Reference
21 to 30 years	57.28 (0.02)	39.55 (0.02)	0.76 (0.56, 1.03)	0.73 (0.55, 0.98)
31 to 40 years	50.44 (0.02)	33.15 (0.02)	0.55 (0.38, 0.80)	0.53 (0.37, 0.75)
41 to 50 years	44.83 (0.04)	33.65 (0.03)	0.43 (0.27, 0.68)	0.54 (0.35, 0.84)
> 50 years	44.89 (0.05)	37.79 (0.04)	0.43 (0.24, 0.77)	0.67 (0.39, 1.15)
Current Age				
≤ 24 years	27.38 (0.03)	14.44 (0.02)	Reference	Reference

25 - 34 years	47.90 (0.02)	32.25 (0.02)	2.69 (1.90, 3.80)	3.12 (2.18, 4.48)
35 - 44 years	63.92 (0.02)	43.42 (0.02)	5.62 (3.76, 8.41)	5.40 (3.59, 8.10)
45 - 54 years	71.45 (0.03)	54.83 (0.03)	8.28 (5.05, 13.58)	9.19 (5.70, 14.79)
55 - 64 years	66.97 (0.04)	56.18 (0.04)	6.54 (3.53, 12.14)	9.79 (5.40, 17.75)
≥ 65 years	51.77 (0.06)	49.03 (0.05)	3.20 (1.61, 6.35)	7.01 (3.66, 13.45)
Education				
< 12 years	52.58 (0.02)	44.39 (0.02)	Reference	Reference
≥ 12 years	55.41 (0.01)	34.63 (0.01)	1.14 (0.92, 1.41)	0.62 (0.51, 0.75)
Region of Origin[b]				
Europe & Central Asia	53.12 (0.03)	32.90 (0.02)	Reference	Reference
Asia	35.76 (0.02)	21.11 (0.01)	0.47 (0.36, 0.63)	0.52 (0.39, 0.70)
Latin America & the Caribbean	66.66 (0.02)	50.34 (0.02)	1.83 (1.36, 2.46)	2.22 (1.68, 2.93)
Sub Saharan Africa	46.28 (0.04)	51.70 (0.04)	0.75 (0.51, 1.09)	2.35 (1.55, 3.58)
Middle East & North Africa	55.46 (0.05)	52.82 (0.06)	1.11 (0.70, 1.74)	2.47 (1.40, 4.38)

[a] Adjusted for duration of residence, current age, education and region of origin.
[b] Other category (n=106) not presented.
[c] Adjusted for age at arrival, current age, education, and region of origin.

Table 7.3 Adjusted Odds Ratios of Overweight/Obesity Stratified by Age at Arrival

	OR (95% CI)[a]				
	≤ 20 years	**21 - 30**	**31 - 40**	**41 - 50**	**> 50 years**
Duration					
<1 year	Reference	Reference	Reference	Reference	Reference
1 to <5 years	3.76 (1.71-8.30)	1.42 (1.01-2.01)	1.19 (0.85-1.66)	0.76 (0.51-1.12)	0.82 (0.59-1.14)
5 to <10 years	4.25 (1.99-9.08)	2.44 (1.71-3.48)	1.74 (1.17-2.58)	2.53 (1.37-4.66)	0.89 (0.52-1.50)
10 to <15 years	9.40 (4.51-19.57)	3.99 (2.72-5.84)	2.35 (1.47-3.77)	1.41 (0.61-3.30)	0.60 (0.28-1.27)
≥15 years	10.96 (5.33-22.56)	3.93 (2.63-5.86)	2.31 (1.23-4.36)	1.52 (0.54-4.24)	1.02 (0.34-3.04)

[a] Adjusted for sex, education and region of origin

Figure 7.1 Overweight/Obesity Prevalence by Duration of Residence and Age at Arrival in the U.S.

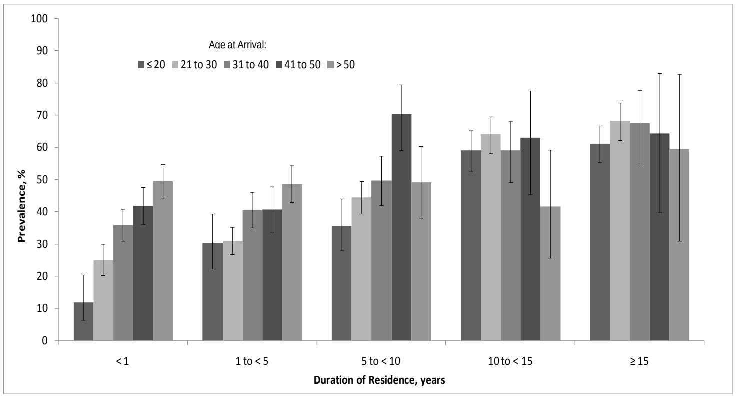
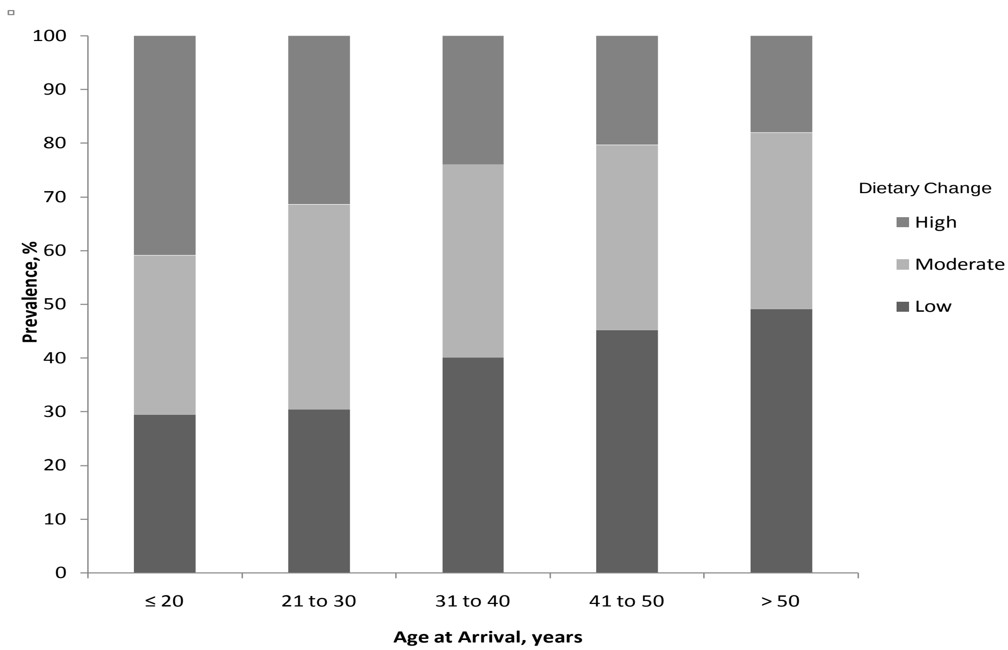


Figure 7.2 Dietary Change Level by Age at Arrival to the U.S.



Summary

This chapter showed that younger immigrants were more likely to be overweight or obese with increasing length of residence than immigrants who arrive at later ages. The objective of the next chapter was to determine if and how these associations differ by region of birth.

CHAPTER 8: EFFECT OF LENGTH OF RESIDENCE ON OVERWEIGHT BY REGION OF BIRTH AND AGE AT ARRIVAL

Effect of Length of Residence on Overweight by Region of Birth and Age at Arrival among U.S. Immigrants

Running Title: Differences in overweight among U.S. immigrants

REENA OZA-FRANK, MS-MPH, RD[1]

K.M. VENKAT NARAYAN, MD[1,2,3]

[1]Emory University, Nutrition and Health Sciences Program, Graduate Division of Biomedical and Biological Sciences, Atlanta, GA

[2]Emory University, Hubert Department of Global Health, Rollins School of Public Health, Atlanta, GA

[3]Emory University, School of Medicine, Atlanta, GA.

Corresponding Author:
Reena Oza-Frank
Emory University
Rollins School of Public Health
1518 Clifton Road, NE
Atlanta, GA 30322
Phone: 614-327-3629
Fax: 404-727-4590
E-mail: roza@emory.edu

Word Count (text only): 2648

Tables: 3

Figures: 1

Key Words: Immigrant, overweight, length of residence, region of birth, age at arrival, NHIS

Abstract

Objective: Currently, one in eight U.S. residents is an immigrant, yet there is little information on the factors associated with overweight prevalence among immigrants. Therefore, we estimated associations between length of residence and overweight among U.S. immigrants by region of birth and age at arrival.

Design: Cross-sectional, survey study.

Methods: Data on 33 299 immigrant adults aged 18-74 years from the National Health Interview Survey 1997-2005 were pooled. Multivariate-adjusted prevalence and odds ratios were computed to test associations of length of residence and overweight (body mass index $\geq$25 kg/m^2) using SUDAAN software.

Results: Migrants from Mexico, South America, Europe, Russia, Africa, and the Middle East residing in the U.S. for 15+y were each approximately 3 times more likely to self report being overweight compared to their counterparts residing in the U.S. for <5y; migrants from Central Asia were approximately twice as likely to report being overweight. In contrast, migrants from the Indian subcontinent and SE Asia had no association between length of residence and overweight prevalence. Among both men and women, weight differences emerged as early as 5y after arrival among those arriving at 18-24y of age (OR range=1.5-1.8). Hispanic men arriving <18y were more likely to report being overweight compared to European migrants (Mexico OR=1.7,95%CI: 1.3-2.2; South America OR=1.5,95%CI: 1.0-2.3), while those from Africa and SE Asia were less likely to be overweight (OR=0.5,95%CI:0.3-0.9 and OR=0.5,95%CI:0.4-0.8, respectively). Among women who arrived at 25-44y, those from Africa and Indian

subcontinent were more likely to be overweight (OR=2.9,95% CI:1.7-5.0 and OR=1.8,95%CI:1.8-2.8, respectively).

Conclusions: We found the associations between length of residence and overweight to vary by region of birth and age at arrival, highlighting the importance of these characteristics in assessing overweight risk among U.S. immigrants.

Introduction

Although several studies have shown that, at arrival, U.S. immigrants weigh less and have a lower prevalence of overweight compared to native born individuals,[1] this apparent health advantage declines with increased length of residence. Specifically, a significant, positive relationship has been observed between length of residence and body mass index (BMI).[2,3,4] Similarly, age at arrival has been hypothesized to be an important determinant of weight change among immigrants.[5] For example, it has been shown that immigrants who arrive to the U.S. at younger ages are at higher risk of overweight or obesity with increasing length of residence than immigrants who arrive at older ages.[6] Consequently, length of residence and age at arrival are often used in health research as indicators of acculturation to host country lifestyles. We previously reported that overweight prevalence among U.S. immigrants varies by region of birth,[7] however, there is little information on differences in overweight by region of birth and age at arrival with regard to length of residence.

The number of immigrants in the U.S. has increased in recent decades, resulting in over 38.1 million living in the U.S. (over 12% of the population).[8] These individuals arrive from all over the world, with approximately 50% coming from Latin America and 25% coming from Asia.[9] Grouping immigrants together into one large category may mask important heterogeneity with regard to specific health conditions, especially weight, which is driven by contemporary urban lifestyles in addition to genetic susceptibility.[10] Therefore, the objective of this study was to use nationally representative data to estimate associations between length of residence and overweight by region of birth and age at arrival among immigrants living in the U.S.

Methods

Data Source

Data on immigrant (defined as people living in the U.S. who were not U.S. citizens at birth[11]) adult respondents aged 18-74 years were analyzed from the nationally representative National Health Interview Survey (NHIS), pooling years 1997-2005 (n=33 299). The NHIS is a continuous, in-person health survey of civilian, non-institutionalized adults 18 years and older, administered by the U.S. Bureau of the Census for the National Center for Health Statistics (NCHS).[12] The survey uses a multistage probability design, with oversampling of Hispanics and Blacks, and includes approximately 43,000 households and about 106,000 persons annually.[12] Respondents provide self-reported information about basic measures of health status, utilization of health services, and social and demographic characteristics. In addition, one randomly selected adult per household is asked to complete the Sample Adult Module which elicits more detailed information on health care services, behavior, and health status including height and weight.

Data were pooled to improve reliability of statistical estimates.[13] To pool data, we first merged the sample adult file with the person-level file for each year included. Then, using NCHS guidelines for combining NHIS data with the same sample design, years 1997-2005 were concatenated into one data set.[13] For this analysis, 2001 was the midpoint of the time interval included in the pooled data, and thus the estimates are representative of this point in time.[13]

Sample weights provided by NCHS account for the complex sampling design of NHIS and for unequal probabilities of selection resulting from sample design, non-response, and planned over-sampling of certain subgroups. The survey is administered in Spanish or English languages and does not allow proxy respondents for Sample Adult questions. Family members may translate for a non-English or non-Spanish speaking respondent who is present in the home.

Definition of Immigrant and Region of Birth

The terms ‘immigrant’ and ‘migrant’ are used interchangeably in the text and refer to persons who were not U.S. citizens at birth.[14] All naturalized citizens, legal permanent residents, undocumented immigrants, and persons on long-term temporary visas (such as students or guest workers) also fall into this category. Region of birth data is provided by NHIS from 2002-2005 based on the question “Where were you born?”. Prior to 2002, this information is not publicly available and, thus use of this variable was requested through the NCHS Research Data Center.[15] The nine mutually exclusive regions of birth categories used in this analysis, as provided by NCHS, were: Mexico, Central America, Caribbean Islands (hereinto referred to as Mexico in the text); South America; Europe; Russia (and former USSR areas); Africa; Middle East; Indian Subcontinent; Central Asia; and Southeast (SE) Asia.

Outcome of Interest

Overweight and obesity were combined into one category and referred to as overweight, and defined as body mass index (BMI) $\geq$ 25 (measured as weight in kilograms divided by the square of height in meters) among adults.[16] The NHIS calculates BMI from self-reported information on height (“How tall are you without shoes?") and weight ("How much do you weigh without shoes?"), measures previously established as largely valid when used in combination with adjustments for age.[17]

Length of Residence and Age at Arrival

Length of residence in the U.S. was determined based on the answer to the question "About how long have you been in the United States?". This variable was then categorized by NCHS into one of the five following categories: <1 year, 1-<5 years, 5-<10 years, 10-<15 years, 15+ years. Based on the distribution of responses, the first two categories were collapsed, resulting in four residence categories used in these analyses. Age at arrival was calculated by subtracting length of residence from current age, and subsequently creating four age at arrival categories based on frequency distributions (<18y, 18-24y, 25-44y, 45-74y). The length of residence information is not publicly available as a continuous variable and thus the continuous variable was accessed through the NCHS Research Data Center.[13]

Covariates of Interest

Socio-demographic characteristics included sex, poverty income ratio (PIR) (< 1.00 (below federal poverty line), 1.00-1.99, 2.00-2.99, 3.00-4.99, and ≥5.00)), education (< high school, high school graduate, some college, college graduate). Lifestyle characteristics included marital status, smoking status, and physical activity level. Other variables considered but not included in the analyses due to lack of association were alcohol drinking status, region of residence in the U.S., metropolitan statistical area size, and insurance status.

Statistical Analysis

Sampling weights were adjusted to account for the pooled data.[13] To assess differences in sample characteristics by region of birth, we used chi-square tests for categorical variables and ANOVA for continuous variables. Two-tailed P-values of ≤ 0.05 were considered significant for all analyses.

We performed multivariable logistic regression analyses stratified by region of birth (interaction term length of residence*region of birth p=0.01), and computed predictive marginals (with standard errors (SE)) to estimate the multivariable adjusted prevalence of overweight by region of birth. Predictive marginals are a type of direct standardization in which the predicted values from the logistic regression models are averaged over the covariate distribution of the population.[18,19] We then performed multivariable logistic regressions analyses stratified by age at arrival and sex (interaction terms length of residence*age at arrival and age at arrival*sex p<0.01). Because of the mathematical relationship: age at arrival = age – length of residence, these three variables could not all be entered in the same models.[16] Standard errors were calculated with SAS-callable SUDAAN software (version 9.0 Research Triangle Institute, Research Triangle Park, NC).

Results

The majority of migrants were born in Mexico (48%), followed by migrants from all regions in Asia (~20%) (Table 8.1). The mean age ranged from 38.0 ± 0.5 (Africa) to 45.8 ± 0.3 (Europe). Migrants from the Indian subcontinent had the highest proportion with a college degree ($65.7\% \pm 2.0$). Migrants from Mexico had the highest proportion living below the federal poverty line (25.0%±0.6) and the highest mean BMI (27.0±0.1 kg/m^2). Migrants from Russia, Africa, and the Indian subcontinent had higher proportions of individuals residing in the U.S. <15y, while the majority of migrants from the other regions had resided in the U.S. for at least 15y at the time of interview. Migrants from Europe had the highest proportion of individuals who arrived <18y of age.

Multivariate adjusted analyses indicate that overweight prevalence increased by length of residence for all regions (P for trends <0.01) except for the Indian subcontinent and SE Asia, where no significant trend was observed (Figure 8.1). For these latter two regions, the percentage point difference in overweight prevalence between <5y residence and 15+y residence was less than 10%, whereas for all other regions, the difference ranged from 13% (Central Asia) to 29% (Africa).

Furthermore, migrants from Mexico, South America, Europe, Russia, Africa, and the Middle East residing in the U.S. for 15+y were each approximately three times more likely to self report being overweight compared to their counterparts residing in the U.S. for <5y; migrants from Central Asia were approximately twice as likely to report being overweight (Table 8.2). Again, migrants from the Indian subcontinent and SE Asia had no associations between length of residence and overweight prevalence.

Stratified by age at arrival (Table 8.3), men and women aged <45y at arrival with >5y residence were generally more likely to be overweight compared to those residing in the U.S. <5y. A dose-response relationship is strongly evident among men and women arriving at 18-24y, such that effects of duration began as early as 5y duration. Additionally, Hispanic men arriving <18y were more likely to report being overweight compared to European migrants, while those from Africa and SE Asia were less likely to be overweight. Women from Mexico who arrived <age 45 were more likely to be overweight compared to Europeans (OR range=1.3-1.9), and those from Central and SE Asia were consistently less likely to be overweight across all age at arrival categories (OR range=0.1-0.5). Among women who arrived at 25-44y, those from Africa and Indian subcontinent were more likely to be overweight.

Discussion

We found the association between length of residence and overweight to be consistently positive across different regions of birth, except among Asian migrants, where minimal or no association was observed. In men and women, effects of duration began as early as 5y after arrival among those arriving at 18-24y of age. Younger ages at arrival and longer length of residence appear to be most important for Hispanics. Additionally, arriving during child-bearing years increases the odds of being overweight among African and Indian immigrant women.

Consistent with previous studies, length of residence is positively associated with weight among immigrants.[2,3,20,21] Also consistent with previous studies, region of birth is associated with overweight/obesity. For example, one study showed a significant, positive association between being born in Mexico and obesity.[21] Other studies have assessed this relationship by race/ethnicity and found significant weight increases among Hispanics, but mixed results among white, black, and Asian immigrants.[2,5,22] The inconsistency of results by race/ethnicity might reflect the use of this variable as a socio-cultural construct rather than as a biological variable, whereas using region of birth may be a better indicator of genetic endowments.[23]

Two previous studies found that the relationship between overweight/obesity and length of residence varied by age at arrival. Specifically, arrival at younger ages was associated with higher prevalence of overweight with increased length of residence compared to arrival at older ages.[6] Not only did our study have better precision than this one, but our study also showed that this relationship was consistent among men and women. Another study[5] assessing this relationship by race/ethnicity observed no association between age at arrival and obesity among Asians. Because we stratified by region of birth, we were able to differentiate Asian migrants and found that although men and women from Asian regions generally had lower odds of overweight regardless of age at arrival, women from the Indian subcontinent arriving at 25-44y of age showed increased odds.

There are several potential explanations for our findings. First, as suggested earlier, region of birth may be specific to genetics,[23] which entails that our study may be revealing genetics as a stronger influence on weight than exposure to the U.S. environment.[7,21] Another explanation is that there is an interaction effect, with the effect of U.S. exposure differing by country of birth.[24,25] For example, countries that have started sending emigrants to the U.S. recently may be increasingly similar to the U.S. in terms of dietary and physical activity norms, and thus effects of U.S. exposure may be lesser for more recent waves of migrants.[22] On the other hand, recent migrants (e.g. migrants from the Indian subcontinent, Central Asia) may not have been exposed to the U.S. environment sufficiently to experience the effect of U.S. exposure on weight.[25]

Some of the differences across regions of birth may also be due to differences in education. The association of length of residence with overweight has been shown to be particularly large for immigrants with lower education levels.[5,26] This could be a reason for the significant results we observed between length of residence and overweight among Mexican migrants, as more than half of migrants from Mexico in our sample have less than a high school education. Finally, changes in diet may explain the observed results. Higher levels of self-reported dietary change post migration have been shown to be significantly and independently associated with overweight after adjusting for age at arrival, length of residence, sex and education.[6] Additionally, immigrants who have resided the longest in the U.S. or arrived at younger ages were significantly more likely to report high dietary change from pre-migration diets than recently arrived immigrants.[6] Dietary data were not available in the dataset used in these analyses.

The main limitation of our study is the use of cross-sectional data, making it difficult to disentangle age/period/cohort effects. For example, the use of cross sectional data may result in length of residence and age at arrival variables being confounded with cohort effects; that is, individuals who arrived during the same period may be more similar to each other, and cross-sectional data cannot be used to distinguish between this and the effects of years of residence and age at arrival.[27] The complex relationships between length of residence, age at arrival, and overweight would be best examined with longitudinal data, which would allow examination of the relationships between change in BMI since arrival and the contribution of changing lifestyle factors, such as diet and physical activity.

Another limitation is the use of self-reported height and weight. A previous study analyzing data from adults in NHANES III found that the average immigrant woman underreported her weight less than the average native woman. On the other hand, average native and immigrant men both underreported their actual weight equally.[20] Finally, NHIS data do not differentiate between types of migrants and thus naturalized citizens, legal permanent residents, unauthorized immigrants, and temporary immigrants (students, visitors, guest workers, etc) are all grouped in the same category. Despite these limitations, NHIS is the only nationally representative survey that provides information on both health and migration in this level of detail. The availability of such data have allowed researchers to move beyond comparing migrants to native born, and allowed us to examine characteristics specific to migrants that make them a distinct subgroup of the U.S. population.

The main strength of this study was the use of a nationally representative, annual survey with standardized variables. Pooling data across years resulted in relatively large sample of nationally representative immigrant adults. This allowed us to stratify results by region of birth and age at arrival, variables that remain under-studied in the current body of migrant literature. Finally, although length of residence and age at arrival are proxy measures of acculturation, these variables place minimal burden on respondents and are relatively easily translated.[28]

Increases in overweight prevalence among immigrants with longer duration or residence in the U.S., possibly as a result of adoption of U.S. lifestyles, is concerning given the adverse health consequences associated with excess weight.[29] Our study highlights the importance of migrant-specific characteristics such as length of residence, age at arrival, and region of birth in assessing overweight risk and in identifying post-migration time points to target overweight prevention efforts. Further investigations aimed at disentangling the reasons for this may provide clues to the roles of genes and environment on the etiology of overweight and to potential mechanisms for prevention.

Author Contributions:

R. Oza-Frank completed the analyses and led the writing of the article. K.M. V. Narayan supervised analyses. Both authors helped to originate ideas, interpret findings, and review drafts of the article.

Acknowledgements:

Reena Oza-Frank was supported by Grant/Cooperative Agreement Number 1R36SH000008-01 from the Centers for Disease Control and Prevention. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of CDC.

These results were presented in part at the 69th Annual Scientific Sessions of the American Diabetes Association, June 5-9, 2009, New Orleans, LA.

The authors would like to acknowledge Solveig A. Cunningham for her thoughtful review of the manuscript.

Conflict of interest: The authors declare no conflict of interest.

References

1. Singh GK, Siahpush M. All-cause and cause-specific mortality of immigrants and native born in the United States. *Am J Pub Health* 2001; **91:** 392-399.

2. Goel MS, McCarthy EP, Phillips RS, Wee CC. Obesity among US immigrant subgroups by duration of residence. *JAMA* 2004; **292:** 2860-2867.

3. Koya DL, Egede LE. Association between length of residence and cardiovascular disease risk factors among an ethnically diverse group of United States immigrants. *J Gen Intern Med* 2007; **22:** 841-846.

4. Oza-Frank R, Argeseanu-Cunningham S. The Weight of U.S. Residence among Immigrants: A Systematic Review. *Obes Rev* (in press).

5. Kaushal N. Adversities of acculturation? Prevalence of obesity among immigrants. *Health Econ* 2009; **18:** 291-303.

6. Roshania R, Venkat Narayan KM, Oza-Frank R. Age at Arrival and Risk of Obesity Among US Immigrants. *Obesity* 2008; **16:** 2669-2675.

7. Oza-Frank R, Narayan KMV. Overweight and Diabetes Prevalence among US Immigrants. *Am J Pub Health* (in press).

8. U.S. Census Bureau. Census Bureau Data Show Characteristics of the U.S. Foreign-Born Population, available at URL http://www.census.gov/Press-Release/www/releases/archives/american_community_survey_acs/013308.html. (Accessed April 11, 2009).

9. U.S. Census Bureau. Foreign-Born Population Tops 34 Million, Census Bureau Estimates, available at URL http://www.census.gov/Press-

Release/www/releases/archives/foreignborn_population/003969.html. (Accessed April 11, 2009).

10. World Health Organization. Obesity and overweight [Fact Sheet], available at URL http://www.who.int/hpr/NPH/docs/gs_obesity.pdf. (Accessed April 11, 2009).

11. Schmidley D. The foreign-born population in the United States: March 2002. In: US Bureau of the Census, ed. *U.S. Bureau of the Census, Current Population Reports*: Current Population Reports, U.S. Government Printing Office; 2003:P20-539.

12. National Center for Health Statistics. National Health Interview Survey, available at URL http://www.cdc.gov/nchs/about/major/nhis/hisdesc.htm. (Accessed April 11, 2009).

13. National Center for Health Statistics. Variance Estimation and Other Analytic Issues in the 1997-2005 NHIS (Adapted from Appendices III and VII of the 2005 NHIS Survey Description Document, and Appendix III of the 2006 NHIS Survey Description Document), available at URL http://www.cdc.gov/nchs/data/nhis/9705var.pdf. (Accessed April 11, 2009).

14. U.S. Census Bureau. The Foreign-Born Population in the United States: March 1999 Current Population Reports; 1999: Series P20-519.

15. National Center for Health Statistics. Research Data Center, available at URL http://www.cdc.gov/nchs/r&d/rdc.htm. (Accessed April 11, 2009).

16. Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults--The Evidence Report. National Institutes of Health. *Obes Res* 1998; **6 Suppl 2:** 51S-209S.

17. Kuczmarski MF, Kuczmarski RJ, Najjar M. Effects of age on validity of self-reported height, weight, and body mass index: findings from the Third National Health and Nutrition Examination Survey, 1988-1994. *J Am Diet Assoc* 2001; **101:** 28-34.

18. Graubard BI, Korn EL. Predictive margins with survey data. *Biometrics* 1999; **55:** 652-659.

19. Saaddine JB, Cadwell B, Gregg EW, Engelgau MM, Vinicor F, Imperatore G, *et al.* Improvements in diabetes processes of care and intermediate outcomes: United States, 1988-2002. *Ann Intern Med* 2006; **144:** 465-474.

20. Antecol H, Bedard K. Unhealthy assimilation: why do immigrants converge to American health status levels? *Demography* 2006; **43:** 337-360.

21. Barcenas CH, Wilkinson AV, Strom SS, Cao Y, Saunders KC, Mahabir S, *et al.* Birthplace, years of residence in the United States, and obesity among Mexican-American adults. *Obesity* 2007; **15:** 1043-1052.

22. Park Y, Neckerman KM, Quinn J, Weiss C, Rundle A. Place of birth, duration of residence, neighborhood immigrant composition and body mass index in New York City. *Int J Behav Nutr Phys Act* 2008; **5:** 19.

23. Singh G, Siahpush M. Ethnic-immigrant differentials in health behaviors, morbidity, and cause-specific mortality in the United States: An analysis of two national data bases. *Human Biology* 2002; **74:** 83-109.

24. Gordon-Larsen P, Harris KM, Ward DS, Popkin BM, National Longitudinal Study of Adolescent H. Acculturation and overweight-related behaviors among Hispanic immigrants to the US: the National Longitudinal Study of Adolescent Health. *Soc Sci Med* 2003; **57:** 2023-2034.

25. Huh J, Prause JA, Dooley CD. The impact of nativity on chronic diseases, self-rated health and comorbidity status of Asian and Hispanic immigrants. *J Immigr Minor Health* 2008; **10:** 103-118.

26. Sanchez-Vaznaugh EV, Kawachi I, Subramanian SV, Sanchez BN, Acevedo-Garcia D. Differential effect of birthplace and length of residence on body mass index (BMI) by education, gender and race/ethnicity. *Soc Sci Med* 2008; **67:** 1300-1310.

27. Lauderdale DS, Rathouz PJ. Body mass index in a US national sample of Asian Americans: effects of nativity, years since immigration and socioeconomic status. *Int J Obes Relat Metab Disord* 2000; **24:** 1188-1194.

28. Salant T, Lauderdale DS. Measuring culture: a critical review of acculturation and health in Asian immigrant populations. *Soc Sci Med* 2003; **57:** 71-90.

29. Mokdad AH, Marks JS, Stroup DF, Gerberding JL. Actual causes of death in the United States, 2000. *JAMA* 2004; **291:** 1238-1245.

Table 8.1 Sample Characteristics by Region of Birth[1, 2]

	Mexico, Cent Am, Carribbean (n = 20172)	South America (n = 2405)	Europe (n = 3771)	Russia (n = 511)	Africa (n = 925)	Middle East (n = 712)	Indian Subcontinent (n = 1013)	Central Asia (n = 1651)	SE Asia (n = 2139)
	% (SE)	% (SE)	% (SE)	% (SE)	% (SE)	% (SE)	% (SE)	% (SE)	% (SE)
% Migrant Population	47.8 (0.7)	6.7 (0.2)	13.7 (0.3)	2.0 (0.2)	3.0 (0.2)	2.8 (0.2)	4.5 (0.2)	6.4 (0.3)	9.3 (0.3)
Age, mean, SE	38.5 (0.2)	41.2 (0.4)	45.8 (0.3)	42.5 (0.9)	38.0 (0.5)	39.9 (0.8)	39.0 (0.4)	41.9 (0.5)	40.0 (0.4)
Female, %, SE	46.9 (0.5)	48.4 (1.3)	51.4 (1.0)	52.8 (2.8)	38.9 (2.0)	42.7 (2.0)	40.6 (1.8)	52.7 (1.5)	50.1 (1.2)
Education Level									
< High school	55.9 (0.7)	16.6 (0.9)	12.9 (0.6)	8.0 (1.4)	8.5 (1.2)	16.2 (2.3)	9.2 (1.2)	10.0 (1.0)	16.1 (1.1)
High school graduate	21.0 (0.4)	28.0 (1.1)	27.3 (0.8)	20.4 (2.2)	15.5 (1.6)	21.9 (1.8)	11.4 (1.2)	19.5 (1.2)	19.3 (1.1)
Some college	15.3 (0.4)	28.8 (1.0)	27.9 (0.9)	19.8 (2.2)	32.7 (2.1)	20.8 (1.5)	13.7 (1.5)	20.4 (1.1)	27.1 (1.4)
College graduate	7.9 (0.3)	26.6 (1.2)	31.9 (0.9)	51.8 (3.1)	43.3 (2.1)	41.1 (3.0)	65.7 (2.0)	50.2 (1.6)	37.5 (1.3)
Below Federal Poverty Level, %	25.0 (0.6)	11.3 (1.2)	7.0 (0.5)	15.0 (2.1)	12.9 (1.5)	19.9 (2.4)	9.6 (1.3)	13.1 (1.5)	13.9 (1.1)
BMI, mean, SE	27.0 (0.05)	25.8 (0.1)	25.8 (0.1)	25.5 (0.3)	25.9 (0.2)	25.5 (0.2)	24.2 (0.2)	23.0 (0.1)	23.6 (0.1)
Duration of Residence in the US, %									
<5 years	14.7 (0.5)	18.3 (1.3)	10.2 (0.7)	24.2 (2.1)	22.2 (1.6)	18.9 (1.9)	24.1 (1.7)	18.4 (1.4)	11.4 (0.9)
5-<10 years	18.4 (0.4)	17.4 (0.9)	9.1 (0.7)	32.9 (2.2)	25.0 (1.9)	13.5 (1.5)	21.0 (1.4)	17.6 (1.2)	14.1 (0.9)
10-<15 years	17.7 (0.4)	14.7 (0.8)	8.4 (0.5)	21.5 (2.2)	12.5 (1.2)	19.3 (2.1)	19.0 (1.5)	13.6 (0.9)	16.6 (1.0)
15+ years	49.2 (0.7)	49.6 (1.7)	72.3 (1.0)	21.8 (1.8)	40.3 (2.2)	48.3 (2.7)	35.8 (1.7)	50.5 (1.7)	57.9 (1.3)
Age at Immigration, %									
<18 years	33.1 (0.5)	24.9 (1.1)	41.7 (1.0)	19.6 (2.5)	20.6 (1.7)	27.3 (1.8)	16.4 (1.6)	27.0 (1.3)	34.2 (1.2)
18-25 years	32.1 (0.5)	26.4 (1.1)	24.2 (0.8)	14.5 (1.6)	32.3 (1.8)	32.5 (2.3)	31.7 (1.8)	21.2 (1.1)	23.4 (1.1)
25-44 years	31.1 (0.5)	43.1 (1.2)	31.2 (1.0)	48.7 (2.6)	43.6 (1.9)	32.0 (2.2)	45.1 (1.8)	43.6 (1.4)	34.9 (1.3)
45-74 years	3.7 (0.2)	5.7 (0.5)	2.9 (0.3)	17.3 (1.9)	3.6 (0.6)	8.2 (1.6)	6.8 (1.0)	8.2 (1.0)	1.5 (0.6)

[1]Percentages based on weighted, unadjusted data

[2]All p-values<0.01 when comparing each row of data across migrant subgroup

Table 8.2 Adjusted Odds Ratios of Overweight Stratified by Region of Birth[1]

		Mexico, Central America, Caribbean	South America	Europe	Russia	Africa	Middle East	Indian Subcontinent	Central Asia	SE Asia
Length of Residence, y	<5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	5-<10	**1.25 (1.06-1.47)**	1.29 (0.85-1.96)	1.45 (0.92-2.27)	1.66 (0.82-3.36)	1.47 (0.89-2.42)	2.36 (1.04-5.35)	0.47 (0.26-0.83)	1.45 (0.83-2.55)	0.97 (0.55-1.74)
	10-<15	**2.03 (1.73-2.38)**	**2.06 (1.36-3.13)**	**2.27 (1.46-3.54)**	**2.37 (1.10-5.11)**	**2.08 (1.07-4.07)**	**2.77 (1.37-5.60)**	1.60 (0.93-2.75)	1.67 (0.95-2.94)	1.17 (0.75-1.84)
	15+	**2.63 (2.25-3.08)**	**2.53 (1.67-3.81)**	**3.22 (2.20-4.71)**	**2.55 (1.36-4.78)**	**3.67 (2.13-6.31)**	**2.61 (1.43-4.79)**	1.14 (0.70-1.86)	**2.15 (1.30-3.53)**	1.46 (0.91-2.34)
Sex	Men	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Women	**0.69 (0.63-0.75)**	**0.34 (0.27-0.43)**	**0.41 (0.34-0.50)**	**0.41 (0.25-0.65)**	1.09 (0.74-1.61)	**0.26 (0.17-0.40)**	0.71 (0.47-1.07)	**0.33 (0.24-0.47)**	**0.52 (0.41-0.67)**
Education Level	< High school	1	1	1	1	1	1	1	1	1
	High school graduate	**0.78 (0.70-0.87)**	**0.54 (0.36-0.80)**	0.75 (0.54-1.05)	0.83 (0.22-3.10)	1.03 (0.42-2.53)	1.42 (0.65-3.08)	0.92 (0.36-2.32)	0.80 (0.40-1.58)	0.92 (0.58-1.45)
	Some college	**0.77 (0.69-0.97)**	**0.49 (0.33-0.71)**	**0.67 (0.49-0.92)**	0.52 (0.15-1.78)	0.97 (0.46-2.05)	0.87 (0.44-1.72)	1.02 (0.41-2.53)	0.89 (0.47-1.67)	0.80 (0.54-1.19)
	College graduate	**0.68 (0.57-0.81)**	**0.51 (0.33-0.79)**	**0.56 (0.39-0.80)**	0.33 (0.09-1.18)	0.92 (0.44-1.94)	0.90 (0.43-1.88)	0.72 (0.30-1.72)	0.87 (0.47-1.58)	0.85 (0.55-1.31)
Poverty Income Ratio	<1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	1-1.99	0.94 (0.85-1.05)	1.04 (0.71-1.53)	0.72 (0.45-1.16)	1.70 (0.67-4.33)	1.12 (0.59-2.11)	1.58 (0.83-3.00)	1.38 (0.64-2.96)	**0.54 (0.30-0.96)**	0.67 (0.44-1.02)
	2-2.99	0.91 (0.79-1.06)	1.24 (0.88-1.76)	0.69 (0.44-1.06)	1.07 (0.43-2.63)	1.34 (0.77-2.34)	1.13 (0.54-2.35)	1.30 (0.65-2.60)	**0.42 (0.21-0.82)**	0.65 (0.42-1.02)
	3-4.99	0.97 (0.83-1.14)	1.24 (0.80-1.90)	0.76 (0.50-1.17)	1.08 (0.46-2.56)	1.36 (0.70-2.63)	0.96 (0.52-1.75)	0.94 (0.48-1.82)	0.81 (0.46-1.44)	0.75 (0.50-1.12)
	≥5.00	**0.80 (0.67-0.96)**	0.94 (0.59-1.48)	**0.60 (0.39-0.93)**	1.40 (0.51-3.82)	0.79 (0.41-1.52)	0.61 (0.29-1.28)	1.26 (0.63-2.53)	0.87 (0.46-1.64)	0.79 (0.53-1.17)

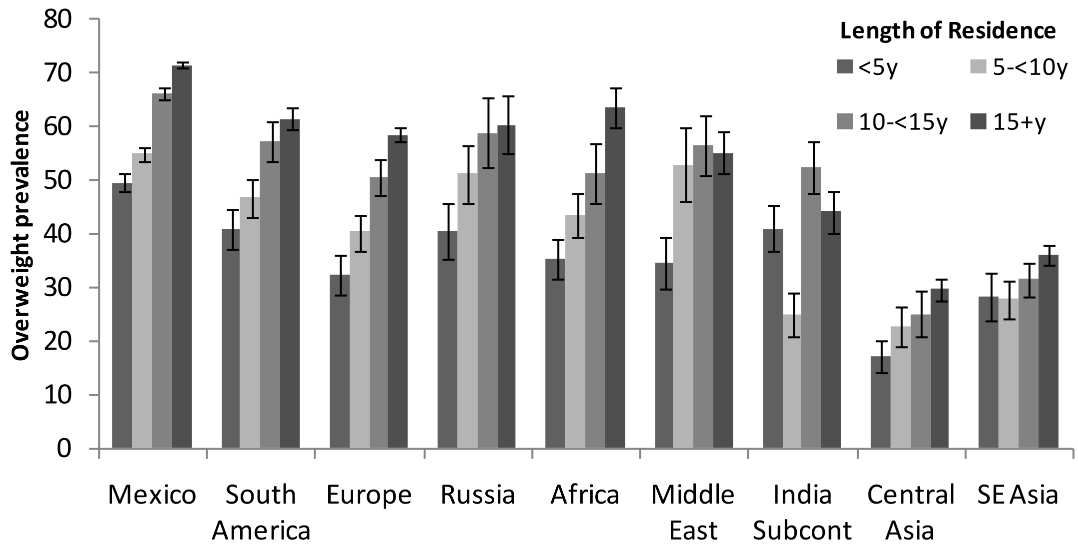
[1]Models are additionally adjusted for age at arrival, marital status, smoking status, and physical activity level

Table 8.3 Adjusted Odds Ratios of Overweight Stratified Sex and Age at Arrival[1]

	MEN OR (95% CI)				WOMEN OR (95% CI)			
Length of residence	<18 years	18-24 years	25-44 years	45-74 years	<18 years	18-24 years	25-44 years	45-74 years
<5y	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
5-<10y	1.5 (0.8-2.8)	**1.5 (1.2-2.1)**	**1.3 (1.0-1.7)**	0.7 (0.4-1.4)	0.8 (0.5-1.5)	**1.8 (1.3-2.5)**	1.2 (0.9-1.5)	0.9 (0.5-1.7)
10-<15y	**2.5 (1.4-4.3)**	**2.8 (2.0-3.9)**	**1.8 (1.4-2.3)**	0.3 (0.2-0.6)	1.5 (0.8-2.7)	**3.0 (2.1-4.1)**	**2.3 (1.8-3.0)**	1.2 (0.7-2.1)
15+	**3.8 (2.2-6.4)**	**2.8 (2.1-3.7)**	**1.6 (1.3-2.0)**	0.6 (0.3-1.2)	**2.3 (1.3-3.8)**	**4.3 (3.2-5.6)**	**2.3 (1.9-2.8)**	1.2 (0.6-2.2)
Region of birth								
Europe	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Mexico, Central America, Caribbean	**1.1 (1.3-2.2)**	1.5 (1.0-2.1)	1.3 (1.0-1.6)	0.6 (0.2-1.5)	**1.3 (1.0-1.6)**	**1.8 (1.3-2.3**)	**1.9 (1.5-2.6)**	1.2 (0.5-2.7)
South America	**1.5 (1.0-2.3)**	1.1 (0.7-1.8)	1.3 (0.9-1.8)	0.4 (0.1-1.4)	0.8 (0.6-1.2)	0.8 (0.5-1.1)	1.2 (0.8-1.7)	0.7 (0.3-2.1)
Russia	1.0 (0.4-3.0)	0.7 (0.2-2.1)	1.3 (0.7-2.3)	0.7 (0.2-2.5)	0.5 (0.2-1.4)	1.6 (0.5-4.9)	1.5 (0.9-2.6)	0.9 (0.3-2.8)
Africa	**0.5 (0.3-0.9)**	**0.5 (0.3-0.9)**	1.2 (0.8-1.8)	0.3 (0.1-1.5)	1.1 (0.6-1.9)	1.2 (0.7-2.1)	**2.9 (1.7-5.0)**	1.9 (0.4-9.5)
Middle East	0.8 (0.5-1.5)	1.5 (0.8-2.8)	1.3 (0.7-2.2)	0.4 (0.1-1.4)	0.7 (0.4-1.3)	0.8 (0.4-1.5)	1.1 (0.6-2.0)	0.5 (0.1-2.0)
Indian subcontinent	1.9 (0.8-4.1)	**0.4 (0.2-0.7)**	**0.5 (0.3-0.7)**	**0.1 (0.0-0.4)**	0.6 (0.2-1.3)	0.9 (0.5-1.6)	**1.8 (1.1-2.8)**	0.4 (0.1-1.5)
Central Asia	0.6 (0.4-1.0)	**0.2 (0.1-0.4)**	**0.3 (0.2-0.5)**	**0.0 (0.0-0.1)**	**0.4 (0.2-0.6)**	**0.3 (0.2-0.5)**	**0.2 (0.1-0.4)**	**0.1 (0.1-0.4)**
SE Asia	**0.5 (0.4-0.8)**	**0.4 (0.3-0.7)**	**0.3 (0.2-0.5)**	**0.1 (0.1-0.4)**	**0.4 (0.3-0.6)**	**0.5 (0.4-0.9)**	**0.9 (0.3-0.7)**	**0.2 (0.1-0.5)**

[1]Models are additionally adjusted for education, poverty income ratio, marital status, smoking status, and physical activity level (data not shown)

Figure 8.1 Overweight Prevalence by Length of Residence and Region of Birth



Overweight defined as body mass index > 25 kg/m^2.

Estimates are adjusted for sex, age at arrival, education, poverty income ratio, marital status, smoking status, and physical activity level.

P for trend <0.01 for all regions except Indian Subcontinent and SE Asia, where P=0.06 for both regions.

Error bars represent standard errors.

Summary

The previous four chapters emphasized the importance of three migrant-specific characteristics (region of birth, length of residence, and age at arrival) on overweight. We showed that all three variables are associated with overweight, and that further exploration into these variables could pinpoint mechanisms through which interventions can be tailored for maximum impact on preventing excess weight gain. Although the number of immigrant cases of diabetes in NHIS was too small to conduct comparable analyses to Chapters 7 and 8 with diabetes as the outcome, in Chapter 9 we were able to examine the associations between diabetes and length of residence and age at arrival.

CHAPTER 9: DIABETES PREVALENCE AMONG U.S. IMMIGRANTS BY LENGTH OF RESIDENCE

Diabetes prevalence by length of residence among U.S. immigrants

Running Title: Diabetes by length of stay among U.S. migrants

REENA OZA-FRANK, MS-MPH, RD[1]

ROB STEPHENSON, PhD[1,2]

K.M. VENKAT NARAYAN, MD[1,2,3]

[1]Emory University, Nutrition and Health Sciences Program, Graduate Division of Biomedical and Biological Sciences, Atlanta, GA

[2]Emory University, Hubert Department of Global Health, Rollins School of Public Health, Atlanta, GA

[3]Emory University, School of Medicine, Atlanta, GA.

Corresponding Author:
Reena Oza-Frank
Emory University
Rollins School of Public Health
1518 Clifton Road, NE
Atlanta, GA 30322
Phone: 614-327-3629
Fax: 404-727-4590
E-mail: roza@emory.edu

Word Count (text only): 3000

Number of Tables = 2

Number of Figures = 2

Abstract

Objective Among U.S. immigrants, investigate the association between length of residence and diabetes prevalence and assess how this is modified by age at immigration.

Research Design and Methods Nationally representative data on U.S. immigrant adults aged 18+ years from the National Health Interview Survey, pooled for 1997-2005 (n=33,499). We performed multivariable logistic regression analyses and computed predictive marginals to estimate the adjusted diabetes prevalence by length of residence.

Results Self-reported diabetes prevalence was higher with increased length of residence in the U.S, independent of age and body mass index (<5 years residence: 3.3%; 5-<10y: 3.4%; 10-<15y: 4.5%; 15+y: 5.3%; *P* for trend < 0.001). Length of residence had the largest effect on diabetes prevalence among immigrants who arrived at 25-44 years of age (prevalence: 1.4% for <5y vs. 11.1% for 15+y; odds ratio=9.7 (95% CI: 5.2-18.1)). However, those who arrived at 45-74 years of age are also at increased risk of diabetes with longer residence (prevalence: 9.5% for <5y vs. 17.4% for 15+y; odds ratio=2.1 (95% CI: 1.2-3.9)). In each age at immigration strata, there was no difference in diabetes prevalence for residence longer than 10 years.

Conclusions Among U.S. immigrants, diabetes prevalence increases with longer length of residence, independent of age and obesity, and this relationship was modified by age at immigration. Diabetes prevalence appears to reach a plateau at 10+ years of residence in all age at immigration strata. Prevention efforts may need to start soon after migration.

Although several studies have shown that at arrival, U.S. immigrants weigh less and have a lower prevalence of overweight compared to native born individuals (1), this apparent health advantage reduces with increased length of residence. Specifically, a significant, positive relationship has been observed between body mass index (BMI) and length of residence, regardless of race/ethnicity (2, 3). What is unknown, though, is whether length of residence similarly affects diabetes risk.

Diabetes has been found to be more frequent among immigrants compared to native born individuals (4), but the reasons for this have not been fully explored. Genetics, selectivity, and acculturation have been suggested as potential explanations. The majority of migrants who come to the U.S. arrive from developing nations, where historically, a consistent positive relationship between SES and obesity has been observed (5). Thus, migrants may simultaneously be selected on higher SES and a trajectory towards developing obesity/diabetes.

Acculturation [adoption of behaviors and cultural values of an individual or group as a result of contact with another culture]has been shown to modify the health and behavioral risks of immigrants (6). For example, changes in diet associated with acculturation have been hypothesized as reasons for increases in weight and subsequent increases in diabetes in immigrants (7). Both length of residence and age at immigration are often used as proxy measures of acculturation. It has been shown that immigrants who arrive to the U.S. at younger ages are at higher risk of overweight or obesity with increasing length of residence than immigrants who arrive at later ages (8). These variables, though, have been minimally studied with regard to diabetes. Examining the effect of length of residence and age at immigration together can provide additional insight about the role of migrant-specific characteristics in the risk of diabetes. The objective of this study was to use nationally representative data to investigate the association between length of residence and diabetes and to assess whether this association is modified by age at immigration.

Research Design and Methods

Sample

Data on 33,499 immigrant adult respondents (defined as people living in the U.S. who are not U.S. citizens at birth (9)) were analyzed from the nationally representative National Health Interview Survey (NHIS), pooling years 1997-2005. The NHIS is a continuous, in-person health survey of the civilian, non-institutionalized adults 18 years and older, administered by the U.S. Bureau of the Census for the National Center for Health Statistics (NCHS) (10). The survey uses a multistage probability design, with oversampling of Hispanics and Blacks, and includes approximately 43,000 households and 106,000 persons annually (10). Respondents provide self-reported information about basic measures of health status, utilization of health services, and social and demographic characteristics. In addition, one randomly selected adult per household is asked to complete the Sample Adult Module which elicits more detailed information on health care services, behavior, and health status including height, weight, and diabetes.

Data were pooled to improve reliability of statistical estimates. To pool data, the sample adult file was merged with the person-level file for each year included. Then, using NCHS guidelines for combining NHIS data with the same sample design, years 1997-2005 were concatenated into one data set (11). For this analysis, 2001 was the midpoint of the time interval included in the pooled data, and thus the estimates represent this point in time.

Sample weights provided by NCHS account for the complex sampling design of NHIS and for unequal probabilities of selection resulting from sample design, non-response, and planned over-sampling of certain subgroups. The survey is administered in Spanish or English languages and does not allow proxy respondents for Sample Adult questions.

Foreign birth was considered a proxy for immigrant status. There is no distinction among immigrants and thus all naturalized citizens, legal permanent residents, undocumented immigrants, and persons on long-term temporary visas (such as students or guest workers) also fall into this category. The main outcome of interest was diabetes. Since 1997, all sampled adults have been asked "[Other than during pregnancy], have you EVER been told by a doctor or health professional that you have diabetes or sugar diabetes?". The main exposure of interest was length of residence in the U.S., which was determined based on the answer to the question "About how long have you been in the United States?". This variable was then categorized by NCHS into one of the five following categories: <1 year, 1-<5 years, 5-<10 years, 10-<15 years, 15+ years. Based on the distribution of responses, the first two categories were collapsed, resulting in four residence categories used in these analyses. Age at immigration was calculated from subtracting length of residence from current age, and subsequently creating four age at immigration categories based on frequency distributions (<18y, 18-24y, 25-44y, 45-74y). The length of residence information is not publicly available as a continuous variable and thus the continuous variable was accessed through the NCHS Research Data Center (12).

Covariates of Interest

The NHIS calculates body mass index (BMI) as weight in kilograms divided by the square of height in meters from self-reported information on height (“How tall are you without shoes?”) and weight (“How much do you weigh without shoes?”), measures previously established as largely valid when used in combination with adjustments for age (13). BMI was grouped into the following categories: normal weight (18.5-24.9 kg/m^2), overweight (25.0-29.9 kg/m^2), and obese ($\geq$30.0 kg/m^2). Socio-demographic characteristics included age (18-24, 25-44, 45-64, 65-74), sex, and poverty income ratio (PIR) (< 1.00 (below federal poverty line), 1.00-1.99, 2.00-2.99, 3.00-4.99, and $\geq$5.00)). We did not include education level for 2 reasons: because the effects of number of years of school may not be equivalent across the regions of birth represented and because education was not significant in bivariate analyses. We included region of birth as this variable provides more specific information with regard to genetics and culture compared to race/ethnicity. Lifestyle characteristics included smoking status, alcohol drinking status, and marital status. Other variables considered but not included in the analyses due to lack of association were physical activity, region of residence in the U.S., metropolitan statistical area size, and insurance status.

Statistical Analysis

Sampling weights were adjusted to account for the pooled data (11). To assess differences in sample characteristics by length of residence, we used chi-square tests. Two-tailed *P* values of $\leq$0.05 were considered significant for all analyses.

We performed multivariable logistic regression analyses and computed predictive marginals (with standard errors (SE)) to estimate the multivariable adjusted prevalence of diabetes by length of residence. Predictive marginals are a type of direct standardization in which the predicted values from the logistic regression models are averaged over the covariate distribution of the population (14). We assessed significance of interaction of length of residence with age at immigration, sex, BMI, and region of birth separately to determine if the association between length of residence and diabetes varied by these variables. Because of the mathematical relationship: age at immigration = age – length of residence, these three variables could not all be entered in the same models (15). Additionally, a variable representing survey year was included in the analysis to adjust for any difference or secular trends in diabetes prevalence or awareness over the 9-year period. All statistical analyses were conducted using SAS-callable SUDAAN software (version 9.0 Research Triangle Institute, Research Triangle Park, NC).

Results

The characteristics of the study participants are shown in Table 9.1. Approximately half of the sample reported residing in the U.S. for 15+ years. Approximately half of the sample came from Mexico, Central America, or the Caribbean and approximately 25% came from one of the three Asian regions (data not shown). The proportion of immigrants below the federal poverty level decreased with increasing length of residence. Immigrants with longer residence in the U.S. were more likely to be obese, married, and current consumers of alcohol.

Multivariable adjusted results indicated that reported diabetes prevalence increased with increasing length of residence (Figure 9.1; P for trend <0.001). The prevalence for both 10-<15 years (4.5%) and 15+ years (5.3%) length of residence were statistically higher than the shortest residence category (3.3%; *P* for trend<0.01), however, there was no statistically difference between the upper two residence categories.

In multivariable analyses, immigrants residing in the U.S. for 15+ years were 1.7 times more likely to self-report diabetes compared to those residing in the U.S. for <5 years, independent of age and BMI (Table 9.2). Overweight and obese immigrants were 1.3 and 2.9 times more likely, respectively, to report diabetes compared to normal weight immigrants. Compared to immigrants reporting poverty income ratios (PIR) below the federal poverty level, all other PIR categories were less likely to report diabetes. The analysis was repeated without BMI to see if it confounded the relationship between length of residence and diabetes and results were similar (data not shown).

The only significant interaction term was length of residence*age at immigration (*P*<0.001). Therefore, we conducted additional analyses stratified by age at immigration. There was a significant increasing trend of diabetes prevalence by length of residence among all age at immigration strata (*P* for trend <0.01 in all strata) (Figure 9.2). Migrants who arrived at 25-44 years of age and resided in the U.S. for 15+ years were 9 times more likely to report diabetes. The two younger age at immigration categories showed significant associations only in the 15+ year residence category, whereas the two older age at immigration categories showed significant associations beginning at the 10-<15 year residence category. In each age at immigration strata, prevalence at 15+ years residence was statistically similar to prevalence at 10-<15 years residence.

Conclusions

Among U.S. immigrants, diabetes prevalence increased with increasing length of residence in the U.S. This association remained after multivariable adjustment, including adjustment for age and BMI. The association was also consistent across all age at immigration categories, although length of residence appeared to have the greatest effect on immigrants who arrive at 25-44 years of age. Finally, diabetes prevalence appeared to reach a plateau beginning after 10 years residence, regardless of age at immigration.

Other studies have assessed the relationship between diabetes and length of residence in U.S. immigrants (3, 7). One study (16) found that diabetes was significantly related to length of residence in an Asian Indian population. Singh and Siahpush (6) found an increasing risk of chronic diseases (which included diabetes) with increasing residence, but this study did not assess the relationship specifically between diabetes and length of residence. Another study (17) found a higher diabetes prevalence among Hispanic immigrants who had lived in the U.S. for 5+ years compared with immigrants who had lived in the U.S. for <5 years. However, this relationship was not found among other race/ethnicity groups. Other studies (3, 7, 18) found no association between length of U.S. residence and diabetes. However, two of these studies used fewer categories of length of residence, possibly decreasing the ability of statistical tests to detect differences between them; additionally, two of these studies were done in specific minority subgroups.

Length of residence and age at immigration are only two of many measures of acculturation used in the literature. Several studies done in Hispanics (but not specific to migrants) have had mixed results depending on the measure used: one study (19) calculated an acculturation score based on nativity, length of residence in the U.S., and language spoken at home and found that, among non-Mexican-origin Hispanics, greater acculturation was associated with higher diabetes prevalence compared to lower acculturation. Conversely, a study on Mexican Americans that used three different acculturation scales, increased acculturation was associated with lower diabetes (20). Another study in Hispanics (21) found that individuals with low acculturation, measured by language, were more likely to have diabetes compared to those with higher acculturation. These discrepancies may be highlighting one of two things: differences in measures of acculturation and differences in health beliefs, behaviors, and thus acculturation patterns with regard to diabetes among Hispanic subgroups. This latter point may extend to other race/ethnicity groups (22). Regardless of the various ways to measure/assess acculturation, it is a factor that should be considered when predictors of diabetes in racial/ethnic groups are examined (19). Additionally, future studies should assess the reliability and validity of different measures of acculturation.

Another potential explanation for the observed results are the social, cultural, and administrative barriers that lead to lower access and under-utilization of health care among U.S. immigrants. For example, per capita total health care expenditures of immigrants were 55% lower than those of U.S. born persons (23) and immigrants were less likely than U.S. born individuals to report discussing diet and exercise with clinicians (2). Over 90% of immigrants in our sample had some form of insurance, limiting our ability to assess differences by this variable.

Finally, changes in diet may explain the observed results. Roshania et al found that higher levels of self-reported dietary change post migration were found to be significantly and independently associated with overweight/obesity after adjusting for age at arrival, length of residence, sex and education (8). Additionally, immigrants who have resided the longest in the U.S. longer or arrived at younger ages were significantly more likely to report high dietary change from pre-migration diets than recently arrived immigrants. With the exception of alcohol intake, which was included in the analyses, dietary data was not available in the dataset used in these analyses.

One main limitation of our study is the use of cross-sectional data, making it difficult to disentangle age/period/cohort effects or causality. The complex relationship between length of residence in the U.S. and diabetes may best be examined with longitudinal data, which would allow examination of the relationships between *change* in BMI between arrival and diabetes onset and the contribution of changing lifestyle factors, such as diet and physical activity. At the same time, though, the lack of longitudinal data to study this relationship limits researchers to utilize available, cross-sectional data sources.

A second limitation is the use of self-reported data. The accuracy of self-reporting for diabetes is reasonably high in population surveys (24). There is no lab component of NHIS and thus percentage of undiagnosed cases of diabetes cannot be assessed; therefore, our study may underestimate the total diabetes prevalence in this population. However, a previous study (25) found minimal differences in diagnosed diabetes between foreign-born and U.S. born individuals. A third limitation is that NHIS does not differentiate between types of migrants (i.e. unauthorized immigrants, temporary residents, refugees, etc.) and health outcomes may vary depending on migrant type.

Even after pooling almost a decade of NHIS data, this still resulted in less than 2000 cases of diabetes among immigrants. Additionally, the majority of migrants arrived at <44 years of age and have lived in the U.S. for 15+ years, resulting in some imprecise estimates as indicated by the wide confidence intervals in Table 2 and unreliable estimates in Figure 2. This also prevented us from stratifying analyses further by region of birth to assess differences in results by genetic/cultural factors shared by migrant groups. We did, however, adjust for region of origin in our analyses in an attempt to address the potential differences that may exist beyond race/ethnicity. Nevertheless, pooling NHIS data is common in the literature (17) and estimates are considered reliable when proper adjustments to sampling weights are made (11).

The main strength of this study was the use of a nationally representative, annual survey with standardized variables. Pooling data across years resulted in relatively large sample of nationally representative immigrant adults. This allowed us to stratify results by age at immigration, a variable that remains under-studied in the current body of migrant literature. In addition, the NHIS is the only nationally representative survey that provides information on both health and migration in this level of detail. The availability of such data have allowed researchers to move beyond comparing migrants to native born, and allowed us to examine characteristics specific to migrants that make them a distinct subgroup of the U.S. population.

In conclusion, we found that among U.S. immigrants, diabetes prevalence increases with increasing length of residence in the U.S., and this relationship is modified by age at immigration. Diabetes prevalence appears to reach a plateau at 10+ years of residence in all age at immigration strata and diabetes prevention efforts may need to start soon after migration. Longitudinal studies with large sample sizes, using validated measures of acculturation and clinical measurements are needed to gain a more comprehensive understanding of the association between length of residence and diabetes. As immigration to the U.S. continues to increase past all-time high in100 years, understanding and promoting the health of immigrants becomes increasingly important to the nation.

Author Contributions: R. Oza-Frank completed the analyses and led the writing of the article. R. Oza-Frank and K.M.V. Narayan originated ideas. K.M. V. Narayan supervised analyses All authors helped to interpret findings and review drafts of the article.

Acknowledgements: This manuscript was supported by Grant/Cooperative Agreement Number 1R36SH000008-01 from CDC. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of CDC.

Disclosure: Authors have no relevant conflicts of interest to disclose.

References

1. Singh GK, Siahpush M: All-cause and cause-specific mortality of immigrants and native born in the United States. *Am J Public Health* 91:392-9, 2001

2. Goel MS, McCarthy EP, Phillips RS, Wee CC: Obesity among US immigrant subgroups by duration of residence. *JAMA* 292:2860-7, 2004

3. Koya DL, Egede LE: Association between length of residence and cardiovascular disease risk factors among an ethnically diverse group of United States immigrants. *J Gen Intern Med* 22:841-6, 2007

4. Argeseanu Cunningham S, Ruben JD, Venkat Narayan KM: Health of foreign-born people in the United States: A review. *Health and Place* 14:623-35, 2008

5. Sobal J, Stunkard AJ: Socioeconomic status and obesity: a review of the literature. *Psychol Bull* 105:260-75, 1989

6. Singh GK, Siahpush M: Ethnic-immigrant differentials in health behaviors, morbidity, and cause-specific mortality in the United States: an analysis of two national data bases. *Hum Biol* 74:83-109, 2002

7. Yang EJ, Chung HK, Kim WY, Bianchi L, Song WO: Chronic diseases and dietary changes in relation to Korean Americans' length of residence in the United States. *J Am Diet Assoc* 107:942-50, 2007

8. Roshania R, Venkat Narayan KM, Oza-Frank R: Age at Arrival and Risk of Obesity Among US Immigrants. *Obesity* 16: 2669-2675, 2008

9. Schmidley D: The foreign-born population in the United States: March 2002. In: US Bureau of the Census, ed. *U.S. Bureau of the Census, Current Population*

Reports: Current Population Reports, U.S. Government Printing Office; 2003:P20-539

10. National Center for Health Statistics: National Health Interview Survey. Available from: http://www.cdc.gov/nchs/about/major/nhis/hisdesc.htm. Accessed January 14, 2009

11. National Center for Health Statistics: Variance Estimation and Other Analytic Issues in the 1997-2005 NHIS (Adapted from Appendices III and VII of the 2005 NHIS Survey Description Document, and Appendix III of the 2006 NHIS Survey Description Document). Available from: http://www.cdc.gov/nchs/data/nhis/9705var.pdf. Accessed January 14, 2009

12. National Center for Health Statistics: Research Data Center. Available from: http://www.cdc.gov/nchs/r&d/rdc.htm. Accessed January 14, 2009

13. Kuczmarski MF, Kuczmarski RJ, Najjar M: Effects of age on validity of self-reported height, weight, and body mass index: findings from the Third National Health and Nutrition Examination Survey, 1988-1994. *J Am Diet Assoc* 101:28-34, 2001

14. Graubard BI, Korn EL: Predictive margins with survey data. *Biometrics* 55:652-9, 1999

15. Harris MI: Diabetes in America: Epidemiology and scope of the problem. *Diabetes Care* 21 Suppl 3:C11-4, 1998

16. Mooteri SN, Petersen F, Dagubati R, Pai RG: Duration of residence in the United States as a new risk factor for coronary artery disease (The Konkani Heart Study). *Am J Cardiol* 93:359-61, 2004

17. Dey AN, Lucas JW: Physical and mental health characteristics of U.S.- and foreign-born adults: United States, 1998-2003. *Adv Data* 1-19, 2006.

18. Araneta MR, Wingard DL, Barrett-Connor E: Type 2 diabetes and metabolic syndrome in Filipina-American women: a high-risk nonobese population. *Diabetes Care* 25:494-9, 2002

19. Kandula NR, Diez-Roux AV, Chan C, Daviglus ML, Jackson SA, Ni H, Schreiner PJ: Association of acculturation levels and prevalence of diabetes in the multi-ethnic study of atherosclerosis (MESA). *Diabetes Care* 31:1621-8, 2008

20. Hazuda HP, Haffner SM, Stern MP, Eifler CW: Effects of acculturation and socioeconomic status on obesity and diabetes in Mexican Americans. The San Antonio Heart Study. *Am J Epidemiol* 128:1289-301, 1998

21. Mainous AG, Majeed A, Koopman RJ, Baker R, Everett CJ, Tilley BC, Diaz VA: Acculturation and diabetes among Hispanics: evidence from the 1999-2002 National Health and Nutrition Examination Survey. *Public Health Rep* 121:60-6, 2006

22. Jaber LA, Brown MB, Hammad A, Zhu Q, Herman WH: Lack of acculturation is a risk factor for diabetes in Arab immigrants in the US. *Diabetes Care* 6:2010-4, 2003

23. Robert SA: Community-level socioeconomic status effects on adult health. *J Health Soc Behav* 39:18-37, 1998

24. Saydah SH, Geiss LS, Tierney E, Benjamin SM, Engelgau M, Brancati F: Review of the performance of methods to identify diabetes cases among vital statistics, administrative, and survey data. *Ann Epidemiol* 14:507-16, 2004

25. Thorpe LE, Upadhyay UD, Chamany S, Garg R, Mandel-Ricci J, Kellerman S, Berger DK, Frieden TR, Gwynn C: Prevalence and control of diabetes and impaired fasting glucose in New York City. *Diabetes Care* 32:57-62, 2009

Table 9.1 Characteristics of Immigrant Population by Length of Residence in the United States

	Duration of Residence, years			
	<5	5-<10	10-<15	15+
n	4907	5546	5223	17823
% of all subjects	14.7	16.6	15.6	53.2
Age, y				
18-24	30.6 ± 0.9	20.3 ± 0.8	13.8 ± 0.7	5.6 ± 0.2
25-44	56.0 ± 0.9	63.0 ± 0.9	65.1 ± 0.9	42.1 ± 0.5
45-64	11.7 ± 0.7	14.7 ± 0.7	18.6 ± 0.8	40.9 ± 0.5
65-74	1.8 ± 0.2	2.0 ± 0.2	2.6 ± 0.3	11.4 ± 0.3
Age at arrival, y				
<18	8.5 ± 0.5	20.2 ± 0.8	27.2 ± 0.9	44.2 ± 0.5
18-24	32.8 ± 0.9	30.1 ± 0.7	28.9 ± 0.8	26.7 ± 0.4
25-44	49.6 ± 0.9	41.7 ± 0.8	36.6 ± 0.8	27.1 ± 0.5
45-74	10.2 ± 0.6	8.0 ± 0.5	6.2 ± 0.4	2.0 ± 0.1
Sex, female	46.2 ± 1.0	48.6 ± 0.8	47.0 ± 0.8	48.6 ± 0.5
Below Federal Poverty Level	29.4 ± 0.9	20.6 ± 0.9	18.7 ± 0.8	12.9 ± 0.4
Body Mass Index, kg/m^2				
Normal Weight (18.5-24.9)	54.5 ± 0.9	50.1 ± 0.8	42.5 0.8	40.1 ± 0.5
Overweight (25.0-29.9)	31.5 ± 0.9	34.1 ± 0.7	39.8 0.8	38.7 ± 0.5
Obese (≥30.0)	9.2 ± 0.5	12.5 ± 0.5	15.1 0.6	19.7 ± 0.4
Region of Birth*				
Mexico, Central America, Caribbean	43.8 ± 1.3	49.8 ± 1.1	51.3 ± 1.2	41.0 ± 0.7

South America	7.7 ± 0.6	6.6 ± 0.4	6.0 ± 0.4	5.8 ± 0.2
Europe	8.9 ± 0.6	7.2 ± 0.5	7.0 ± 0.4	17.5 ±0.4
Russia	3.0 ± 0.4	3.7 ± 0.4	2.6 ± 0.4	0.7 ±0.1
Africa	4.2 ± 0.4	4.3 ± 0.4	2.3 ±0.3	2.1 ±0.1
Middle East	3.3 ± 0.4	2.2 ± 0.3	3.3 ± 0.5	2.4 ±0.2
Indian Subcontinent	6.9 ± 0.6	5.4 ± 0.4	5.3 ± 0.5	2.9 ± 0.2
Central Asia	7.4 ± 0.7	6.4 ± 0.5	5.3 ± 0.4	5.7 ±0.3
SE Asia	6.7 ± 0.6	7.5 ± 0.5	9.5 ± 0.6	9.5 ±0.3
Married	59.0 ± 1.1	65.2 ± 0.8	68.6 ± 0.8	71.8 ± 0.4
Current Smoker	16.0 ± 0.7	15.3 ± 0.6	14.2 ± 0.6	15.8 ± 0.3
Drank at least one alcoholic beverage in the past year	45.2 ± 1.0	47.5 ± 0.9	49.2 ± 1.0	56.8 ± 0.5

*Columns do not add to 100 percent because ‘Elsewhere’ category not presented.

All estimates are percentages weighted to be representative of the U.S. noninstitutionalized population aged 20 to 74 years and are ± standard error (SE).

All chi-square tests across each variable were significant ($p<0.05$).

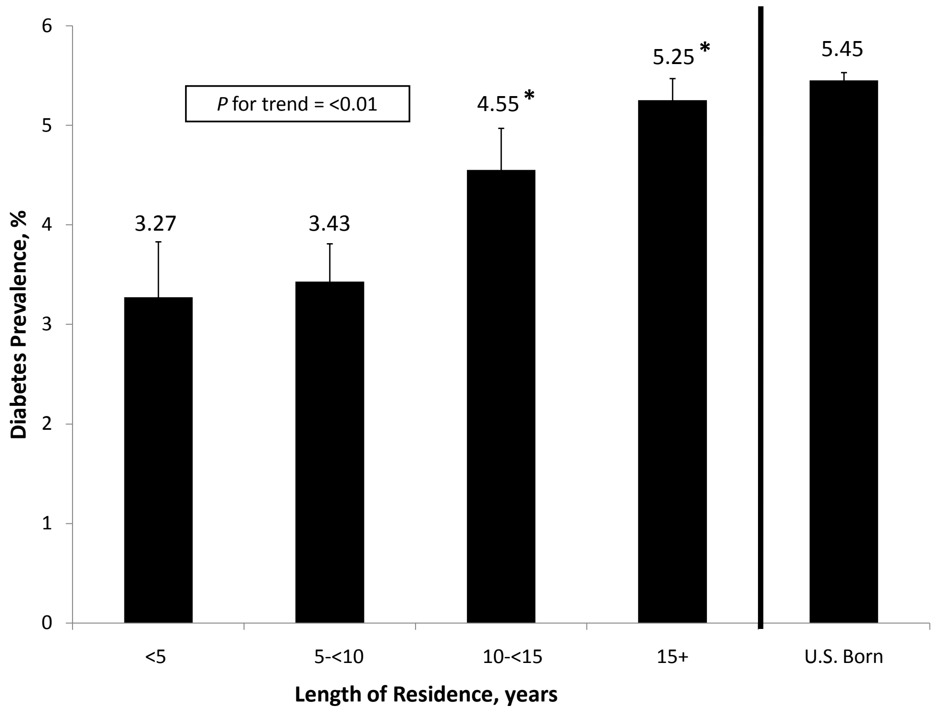
Columns may not add up to 100 percent due to rounding.

Table 9.2 Adjusted Odds Ratios of Diabetes Overall and Stratified by Age at Arrival

	Overall	Age at Immigration, years			
Duration, years		<18	18-24	25-44	45-74
<5	1.0	1.0	1.0	1.0	1.0
5-<10	1.1 (0.7-1.6)	1.9 (0.2-17.5)	1.4 (0.4-4.4)	1.5 (0.7-3.1)	1.5 (0.8-3.0)
10-<15	1.5 (1.0-2.2)	1.0 (0.1-10.3)	2.1 (0.7-6.1)	4.0 (2.1-7.9)	2.3 (1.2-4.5)
15+	1.7 (1.2-2.6)	18.2 (2.4-138.0)	9.1 (3.3-25.4)	9.7 (5.2-18.1)	2.1 (1.2-3.9)
Body Mass Index, kg/m^2					
Normal Weight (18.5-24.9)	1.0	1.0	1.0	1.0	1.0
Overweight (25.0-29.9)	1.3 (1.1-1.6)	1.6 (0.9-2.6)	1.8 (1.2-2.7)	1.2 (0.9-1.6)	1.2 (0.7-2.1)
Obese (≥30.0)	2.8 (2.3-3.5)	4.3 (2.6-7.2)	2.8 (1.8-4.4)	3.0 (2.3-4.1)	1.4 (0.7-2.6)
Poverty Income Ratio					
<1	1.0	1.0	1.0	1.0	1.0
1-1.99	0.8 (0.6-0.9)	0.9 (0.6-1.5)	0.8 (0.6-1.1)	0.7 (0.5-0.9)	1.1 (0.7-1.8)
2-2.99	0.6 (0.5-0.8)	0.6 (0.3-1.1)	0.8 (0.5-1.2)	0.5 (0.3-0.7)	1.2 (0.6-2.5)
3-4.99	0.5 (0.4-0.7)	0.5 (0.3-0.9)	0.6 (0.4-1.0)	0.6 (0.4-0.8)	0.9 (0.5-1.7)
5+	0.5 (0.4-0.7)	0.8 (0.4-1.4)	0.9 (0.6-1.5)	0.5 (0.4-0.8)	0.6 (0.2-1.6)

OR is the odds ratio for diabetes (95% CI). The overall model is additionally adjusted for age, sex, region of birth, smoking status, alcohol drinking status, and marital status. The stratified model is additionally adjusted for sex, region of birth, smoking status, alcohol drinking status, marital status, and survey year.

Figure 9.1 Multivariable Adjusted Diabetes Prevalence by Length of Residence



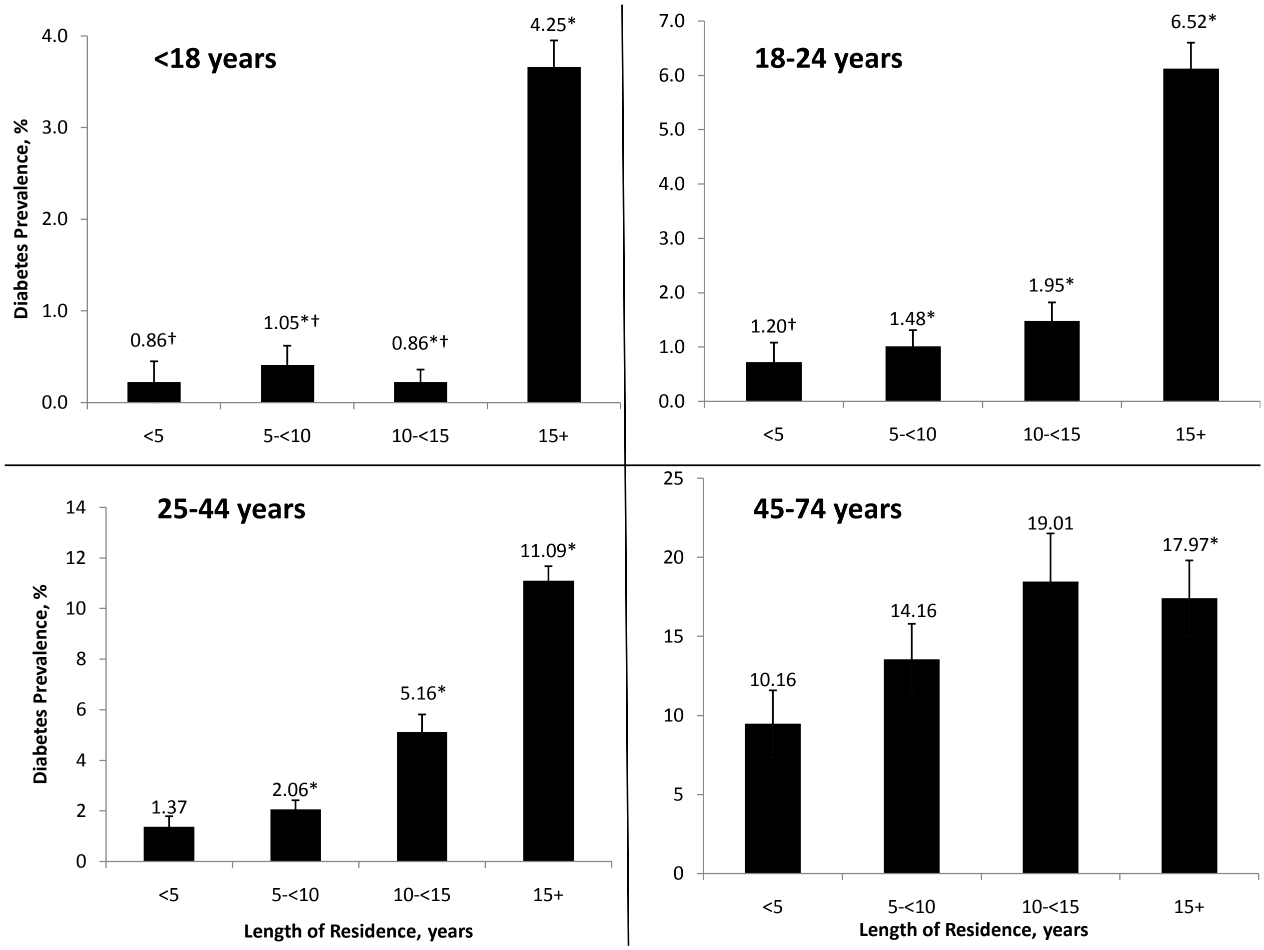
*significantly different from <5 year category at $P<0.001$.

Estimates were weighted to reflect national population estimates.

Immigrant estimates were adjusted for age, sex, poverty income ratio, region of birth, BMI, smoking status, alcohol drinking status, marital status, survey year. U.S. born prevalence was estimated using the same dataset and adjusted for age, sex, poverty income ratio, BMI, smoking status, alcohol drinking status, marital status, survey year.

Error bars represent 95% confidence intervals.

Figure 9.2 Multivariable Adjusted Diabetes Prevalence by Length of Residence Stratified by Age at Immigration



*significantly different from <5 year category at P<0.05.

†These estimates are unreliable (relative SE >30%) and results should be interpreted with caution.

P for trend <0.01 for each panel.

Estimates were weighted to reflect national population estimates.

Adjusted for sex, poverty income ratio, region of birth, BMI, smoking status, alcohol drinking status, marital status, survey year.

Error bars represent 95% confidence intervals.

Summary

In Chapters 5 and 8, we highlighted the heterogeneity in overweight by region of birth. However, more detailed information, such as specific country of birth, might provide additional insights into specific differences among immigrants. Therefore, we used Asian Americans as a case study to further explore heterogeneity in overweight and diabetes among immigrants that are typically grouped together in one race/ethnicity category.

CHAPTER 10: ASIAN AMERICANS: DIABETES PREVALENCE BY U.S. AND WHO WEIGHT CLASSIFICATIONS

(See Appendix D for 'Brief Report' version)

Asian Americans: Diabetes Prevalence by U.S. and WHO Weight Classifications

Running Title: Asian-specific body mass index considerations

REENA OZA-FRANK, MS-MPH, RD[1]

MOHAMMED K. ALI, MBChB, MSc[2]

VIOLA VACCARINO, MD, PhD[1, 3]

K.M. VENKAT NARAYAN, MD[1,2,3]

[1]Emory University, Nutrition and Health Sciences Program, Graduate Division of Biomedical and Biological Sciences, Atlanta, GA

[2]Emory University, Hubert Department of Global Health, Rollins School of Public Health, Atlanta, GA

[3]Emory University, School of Medicine, Atlanta, GA.

Corresponding Author:
Reena Oza-Frank
Emory University
Rollins School of Public Health
1518 Clifton Road, NE
Atlanta, GA 30322
Phone: 614-327-3629
Fax: 404-727-4590
E-mail: roza@emory.edu

Word Count: 2430

Number of Tables = 3

Number of Figures = 2

Abstract

Objective: To compare mean BMI and prevalence of overweight, obesity and diabetes across U.S. Asian subgroups using a nationally representative sample.

Research Design and Methods: Nationally representative data on Asian Americans aged 18-74 years (n=7414) drawn from the National Health Interview Survey 1997-2005 were used to estimate age- and sex- standardized prevalence of overweight, obesity, and diabetes using general and Asian-specific definitions. Multivariable logistic regression was used to determine differences in diabetes prevalence.

Results: Compared to non-Hispanic whites, Asian men and women generally had lower mean BMI but higher diabetes prevalence. Among Asians, regardless of BMI definition, Asian Indians and Filipinos had the highest overweight prevalence (34-47%, 35-47%, respectively, compared to 20-38% in Chinese) and Chinese had the lowest obesity prevalence (4-9% compared to 7-21% in Asian Indians and Filipinos) ($P<0.05$). Across all weight categories and regardless of BMI definition, Asian Indians had the highest diabetes prevalence (Normal weight: 6-7%; Overweight: 8-9%; Obese: 19-33%, $P<0.05$). Compared to whites, multivariate adjusted odds ratios (95% CI) were 3.5 (1.5-6.6) for Asian Indians, 2.3 (1.1-4.5) for Chinese, and 2.2 (1.2-4.0) for Filipinos.

Conclusions: Asian Indian ethnicity is associated with diabetes, and the strength of association changes only marginally after adjustment for BMI. For other Asian subgroups, BMI is an important explanatory factor in the association between ethnicity and diabetes. The utility of the Asian-specific BMI definition may not be equivalent across different Asian subgroups.

In 2005-2006, the U.S. Asian population grew by 3.2%, to 14.9 million, the highest percentage growth of any race group during that time period (1). The three largest subgroups are Chinese (3.6 million), Filipino (2.9 million), and Asian Indian (2.7 million). Despite continued growth of the Asian American population, there are few nationally representative U.S. data comparing the differences in the frequency of overweight and associated outcomes, such as diabetes, across Asian subgroups.

Previous studies have shown that compared to other race/ethnic groups, Asians have higher adiposity per unit body mass index (BMI) (2), resulting in increased risk of type 2 diabetes and cardiovascular disease at lower BMIs (3). This led to the 2002 consensus statement from the World Health Organization (WHO) expert consultation on BMI in Asian populations, which defined the following Asian-specific BMI cutoffs: normal weight 18.5-22.9 kg/m^2; overweight 23.0-27.4 kg/m^2; obese $\geq$27.5 kg/m^2 (3). These are in contrast to the widely used general BMI definitions: normal weight 18.5-24.9 kg/m^2; overweight 25.0-29.9 kg/m^2; obese $\geq$30.0 kg/m^2. Despite continued discussion and prominence in the literature, the utility of these Asian-specific BMI definitions remains unresolved.

The existing literature typically compares different Asian subgroups individually to white or black groups, but not to each other, thereby potentially missing differences within the large and heterogeneous Asian population. The main objectives of this study, therefore, were to use nationally representative data to examine mean BMI by age and sex across Asian subgroups and to compare overweight and obesity prevalence by both general and Asian-specific BMI definitions. Since BMI is a commonly used screening tool for diabetes risk, diabetes prevalence in Asian Americans was also examined to determine associations independent of BMI.

Research Design and Methods

Data Source

Data on 7,414 non-pregnant, Asian American adults aged 18+ years representing four Asian subgroups (Asian Indian (n=1357), Chinese (n=1510), Filipino (n=1485), Other Asians (n=3062)) were pooled from the nationally representative National Health Interview Survey (NHIS) 1997-2005. The NHIS is a continuous, in-person health survey of civilian, non-institutionalized adults, aged 18 years and older, administered by the U.S. Bureau of the Census for the National Center for Health Statistics (NCHS) (4). The survey uses a multistage probability design and includes approximately 43,000 households and about 106,000 persons annually (4). Respondents provide information regarding socio-demographic characteristics, basic measures of health status, and utilization of health services. In addition, one randomly selected adult per household is asked to complete the Sample Adult Module which elicits more detailed information on use of health care services, health-related behavior, and health status (including height, weight, and diabetes). For the years included in the analysis, data from the Sample Adult Module on Asian Indians, Chinese, Filipinos, and Other Asians were used.

Data were pooled to improve reliability of statistical estimates (5) by merging the adult person-level files for each year surveyed. NCHS guidelines were applied to combine NHIS data with the same sample design from years 1997-2005 into one data set (5). For this analysis, 2001 was the midpoint of the time interval of the pooled data, and thus estimates represent this time point (5). Sample weights provided by NCHS were used to account for complex sampling design and for unequal probabilities of selection resulting from sample design, non-response, and planned over-sampling of certain subgroups.

The NHIS calculates BMI from self-reported information on height (“How tall are you without shoes?”) and weight (“How much do you weigh without shoes?”). These measures have been validated, especially when used in combination with adjustments for age (6). For diabetes, all sampled adults were asked “[Other than during pregnancy], have you EVER been told by a doctor or health professional that you have diabetes or sugar diabetes?”. Responses to this question were coded as a dichotomous outcome (yes vs. no). Covariates of interest included: age (continuous) , sex, education level (less than high school, high school diploma or equivalent, some college, college degree), poverty income ratio (PIR) (< 1.00 (below federal poverty line), 1.00-1.99, 2.00-2.99, 3.00-4.99, and ≥5.00), foreign-birth (born in the U.S. or U.S. territory or not), physical activity (sedentary, moderate, high), alcohol use (lifetime abstainer, former, current drinker), and smoking status (never, former, current) . Persons with missing BMI data were excluded (9% of the sample).

Statistical Analysis

Sampling weights were adjusted to account for pooled data (5). Differences in subgroup characteristics were assessed using chi-square tests for categorical variables and ANOVA for continuous variables. Two-tailed P-values of ≤0.05 were considered significant for all analyses.

Mean BMI was estimated by age group and sex and compared to those of non-Hispanic whites. The age- and sex-standardized proportions of overweight, obesity, and diabetes using both BMI definitions were computed and compared across Asian subgroups and with non-Hispanic whites. Multivariable logistic regression was used to calculate odds ratios for diabetes among Asian subgroups. All analyses were completed using SAS-callable SUDAAN software (version 9.0 Research Triangle Institute, Research Triangle Park, NC).

Results

Characteristics of survey participants are shown in Table 10.1. Asian Indians had lower mean age and higher proportions of females, college graduates, and individuals born outside the U.S., compared with other subgroups. Filipinos had the lowest proportion below the federal poverty level.

All Asian subgroups had lower mean BMIs compared to whites in both men and women, except among men aged 18-24 where Asian Indians, Filipinos, and non-Hispanic whites had statistically similar mean BMIs (Figure 10.1) ($P<0.05$). Among women, whites had the highest BMI across all age categories ($P<0.05$). Asian Indian and Filipino women aged 25-34 years had the highest mean BMI among Asian groups ($P<0.05$).

Prevalence of both overweight and obesity was higher in all subgroups when using the Asian-specific BMI definition compared to the general definition (Table 10.2). Regardless of definition used, Asian Indians and Filipinos had statistically similar proportions of overweight and obese subjects, both of which were significantly higher than either Chinese or Other Asians categories ($P<0.05$).

Across every weight category, Asian Indians had the highest diabetes prevalence compared to all other Asian subgroups and non-Hispanic whites ($P<0.05$) (Figure 10.2). Diabetes prevalence in other Asian subgroups and non-Hispanic whites was statistically similar within the different weight categories. One exception was the high diabetes prevalence among normal weight Filipinos, equaling the prevalence seen in Asian Indians of that weight category.

As shown in Table 10.3, compared to non-Hispanic whites, Asian Indians were more likely to report diabetes, even independent of BMI (OR=2.0; 95%CI:1.5-2.6) and the odds ratio changes only marginally after adjustment for BMI and other covariates. After adjusting for BMI, Chinese (OR=1.5; 95%CI:1.1-2.1), and Filipinos (OR=1.6; 95%CI:1.3-2.2) were each more likely to report diabetes, compared to non-Hispanic whites.

Discussion

Variations in mean BMI across Asian subgroups were small. Although general and Asian-specific BMI definitions vary the prevalence of overweight and obesity, Asian Indians and Filipinos consistently have higher overweight prevalence and Chinese have lower obesity prevalence. Independent of BMI definition, the association between Asian subgroups and diabetes is consistent: higher proportions of Asian Indians report having diabetes, compared to other Asian subgroups and whites. In addition, Asian Indian ethnicity is associated with diabetes, and the strength of association changed only marginally after adjustment for BMI. For other Asian subgroups, BMI is an important explanatory factor in the association between ethnicity and diabetes. For all Asian subgroups, the association between obesity and diabetes is similar, regardless of BMI definition. All Asian subgroups were more likely to have diabetes compared to non-Hispanic whites. BMI has been questioned as an anthropometric measure because of poor correlation with adiposity (7) and its inability to adequately predict body fat specifically in Asians (8). However, BMI is routinely used, and the results of this study provide support for Asian Indian-specific ethnicity as an additional consideration in assessing diabetes risk.

Our findings are consistent with the few studies that have assessed differences in overweight/obesity among Asian American subgroups. A study using NHIS data found that Filipinos (men and women) and Asian Indian women had higher median BMI than other Asian subgroups (9). Studies have consistently shown Chinese populations have lower BMIs compared to other Asian subgroups (10), while results regarding Filipino and Asian Indian populations demonstrate variation in overweight/obesity proportions, but are still lower than non-Hispanic whites (11).

The results from this study are supported by research suggesting that diabetes risk may vary by country of ancestry. For example, the associations between BMI and diabetes as well as between age and diabetes have been shown to be modified by ethnicity (12). Studies have shown Filipinos have higher diabetes prevalence compared to Chinese (13). Asian Indians have higher prevalence of diabetes compared to Europeans (12), Caucasians (14), African-Americans (15), and other Asian subgroups (11) and risk increases at lower BMI thresholds (12). Country-specific data indicates that India has a higher prevalence and also higher absolute number of people with diabetes as compared to China (16).

Several studies (17) have supported the use of Asian-specific BMI definitions for identifying groups at risk of diabetes based on epidemiological evidence of higher risk and increased adiposity at lower BMIs. However, waist circumference has a stronger association with diabetes than BMI in Asian Indians (18) and Chinese (19). In addition, the WHO expert consultation on BMI in Asian populations has recommended a range of BMI cutoff points across Asian populations from 22 to 25 kg/m^2 and 26 to 31 kg/m^2 for higher cardio-metabolic risk (3). Therefore, the use of one Asian-specific BMI definition may not be appropriate for heterogeneous Asian subgroups.

In our study, Asian Indians consistently had higher prevalence and odds of diabetes than other Asian groups, while most Asian subgroups exhibited higher odds of diabetes compared to whites. Although this study cannot determine why there are differences in diabetes prevalence among Asian subgroups, a possible explanation is the differential associations between quantity and distribution of adiposity and metabolic risk. For example, increased susceptibility to diabetes in Asian Indians when compared to Europeans despite lower BMIs is attributed to central adiposity. Similarly, Filipinos have been shown to have similar BMIs to blacks and whites, but higher visceral adipose tissue deposition and diabetes prevalence (20). Higher adiposity in these populations may be attributed to lifestyle and/or genetic/intra-uterine predisposition.

Between 1992-4 and 2004-6, the proportions of foreign-born stayed the same in the U.S. among Chinese (82.7% vs. 81.2%) and Asian Indian populations (95.8% vs. 93.1%) (11, 21). However, among Filipinos, the proportion of foreign-born decreased by almost 20% in this same time period. The distinction between native born and foreign-born is important to consider as acculturation (including exposure to contemporary lifestyles) has been shown to increase obesity and diabetes risk (14, 22). Since a large proportion of individuals in this study were foreign-born, small sample sizes prevented us from making comparisons between native- and foreign-born, within and across Asian subgroups.

The use of BMI as a measure of body proportion is a limitation because of its inability to provide information on body fat distribution and central adiposity, which are associated with cardio-metabolic risk, independent of overall obesity. Continued, routine use of BMI in research and clinical practice is related to logistical ease in collecting height and weight (measured or self-reported). The Asian-specific BMI definition is viewed as acceptable when measures of adiposity are not available (23), however this study indicates that for Asian Indians, ethnicity may be equally informative as BMI.

Another limitation of this study includes the use of self-reported data, including self-reported height, weight, and diabetes. The accuracy of self-reporting for diabetes is reasonably high in population surveys (24). Although undiagnosed diabetes cannot be assessed using NHIS, a study in New York found that Asians had a similar rate of undiagnosed diabetes to non-Hispanic whites (25). As a result, the current study most likely underestimates the total diabetes prevalence in these populations. Regardless, NHIS is cross-sectional and thus does not have body weight at the time of diabetes diagnosis. Finally, NHIS is administered in English or Spanish only, and thus Asian Americans who do not speak these languages would be underrepresented. The main strength of this study is the use of nationally representative data with a large Asian sample. Because NHIS is serial cross-sectional, data could be pooled, increasing sample sizes to allow examination of different Asian subgroups.

In conclusion, this study demonstrates that Asian Indian ethnicity, on its own and independent of BMI, is associated with diabetes risk. We also find that the utility of the Asian-specific BMI definition may not be equivalent across different Asian subgroups. Prospective studies assessing the complex relationships between body shape, size, fat distribution, and development of cardio-metabolic diseases across heterogeneous Asian groups are needed (3).

Author Contributions: R. Oza-Frank completed the analyses and led the writing of the article. R. Oza-Frank and K.M.V. Narayan originated ideas. K.M. V. Narayan supervised analyses. All authors helped to interpret findings and review drafts of the article.

Acknowledgements: This manuscript was supported by Grant/Cooperative Agreement Number 1R36SH000008-01 from CDC. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of CDC.

The authors would like to thank Solveig Argeseanu Cunningham, PhD and Mary Beth Weber, MPH for their thoughtful review of the manuscript.

Disclosure: Authors have no relevant conflicts of interest to disclose.

References

1. U.S. Census Bureau. Asian/Pacific American Heritage Month, May 2008. Available from: http://www.census.gov/Press-Release/www/releases/archives/cb08ff-05.pdf. Accessed March 24, 2009.

2. Bhansali A, Nagaprasad G, Agarwal A, Dutta P, Bhadada S: Does body mass index predict overweight in native Asian Indians? A study from a North Indian population. *Ann Nutr Metab* 50:66-73, 2006

3. World Health Organization: Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. *Lancet* 363:157-163, 2004

4. National Center for Health Statistics: National Health Interview Survey. Available from: http://www.cdc.gov/nchs/about/major/nhis/hisdesc.htm. Accessed March 24, 2009

5. National Center for Health Statistics: Variance Estimation and Other Analytic Issues in the 1997-2005 NHIS (Adapted from Appendices III and VII of the 2005 NHIS Survey Description Document, and Appendix III of the 2006 NHIS Survey Description Document). Available from: http://www.cdc.gov/nchs/data/nhis/9705var.pdf. Accessed March 24, 2009

6. Kuczmarski MF, Kuczmarski RJ, Najjar M: Effects of age on validity of self-reported height, weight, and body mass index: findings from the Third National Health and Nutrition Examination Survey, 1988-1994. *J Am Diet Assoc* 101:28-34; quiz 35-26, 2001

7. Roubenoff R, Dallal GE, Wilson PW: Predicting body fatness: the body mass index vs estimation by bioelectrical impedance. *Am J Public Health* 85:726-728, 1995

8. Deurenberg-Yap M, Schmidt G, van Staveren WA, Deurenberg P: The paradox of low body mass index and high body fat percentage among Chinese, Malays and Indians in Singapore. *Int J Obes Relat Metab Disord* 24:1011-1017, 2000

9. Lauderdale DS, Rathouz PJ: Body mass index in a US national sample of Asian Americans: effects of nativity, years since immigration and socioeconomic status. *Int J Obes Relat Metab Disord* 24:1188-1194, 2000

10. Diaz VA, Mainous AG, 3rd, Baker R, Carnemolla M, Majeed A: How does ethnicity affect the association between obesity and diabetes? *Diabet Med* 24:1199-1204, 2007

11. Barnes PM, Adams PF, Powell-Griner E: Health characteristics of the Asian adult population: United States, 2004-2006. *Adv Data*:1-22, 2008

12. Nakagami T, Qiao Q, Carstensen B, Nhr-Hansen C, Hu G, Tuomilehto J, Balkau B, Borch-Johnsen K: Age, body mass index and Type 2 diabetes-associations modified by ethnicity. *Diabetologia* 46:1063-1070, 2003

13. Gomez SL, Kelsey JL, Glaser SL, Lee MM, Sidney S: Immigration and acculturation in relation to health and health-related risk factors among specific Asian subgroups in a health maintenance organization. *Am J Public Health* 94:1977-1984, 2004

14. Mohanty SA, Woolhandler S, Himmelstein DU, Bor DH: Diabetes and cardiovascular disease among Asian Indians in the United States. *J Gen Intern Med* 20:474-478, 2005

15. Misra A, Ganda OP: Migration and its impact on adiposity and type 2 diabetes. *Nutrition* 23:696-708, 2007

16. Qiao Q, Hu G, Tuomilehto J, Nakagami T, Balkau B, Borch-Johnsen K, Ramachandran A, Mohan V, Iyer SR, Tominaga M, Kiyohara Y, Kato I, Okubo K, Nagai

M, Shibazaki S, Yang Z, Tong Z, Fan Q, Wang B, Chew SK, Tan BY, Heng D, Emmanuel S, Tajima N, Iwamoto Y, Snehalatha C, Vijay V, Kapur A, Dong Y, Nan H, Gao W, Shi H, Fu F: Age- and sex-specific prevalence of diabetes and impaired glucose regulation in 11 Asian cohorts. *Diabetes Care* 26:1770-1780, 2003

17. Huxley R, James WP, Barzi F, Patel JV, Lear SA, Suriyawongpaisal P, Janus E, Caterson I, Zimmet P, Prabhakaran D, Reddy S, Woodward M: Ethnic comparisons of the cross-sectional relationships between measures of body size with diabetes and hypertension. *Obes Rev* 9 Suppl 1:53-61, 2008

18. Deepa M, Farooq S, Deepa R, Manjula D, Mohan V: Prevalence and significance of generalized and central body obesity in an urban Asian Indian population in Chennai, India (CURES: 47). *Eur J Clin Nutr* 63:259-267, 2009

19. Li G, Chen X, Jang Y, Wang J, Xing X, Yang W, Hu Y: Obesity, coronary heart disease risk factors and diabetes in Chinese: an approach to the criteria of obesity in the Chinese population. *Obes Rev* 3:167-172, 2002

20. Araneta MR, Barrett-Connor E: Ethnic differences in visceral adipose tissue and type 2 diabetes: Filipino, African-American, and white women. *Obes Res* 13:1458-1465, 2005

21. Kuo J, Porter K: Health status of Asian Americans: United States, 1992-94. *Advance Data*:1-16, 1998

22. Roshania R, Venkat Narayan KM, Oza-Frank R: Age at Arrival and Risk of Obesity Among US Immigrants. *Obesity (Silver Spring)*, 2008

23. Banerji MA, Faridi N, Atluri R, Chaiken RL, Lebovitz HE: Body composition, visceral fat, leptin, and insulin resistance in Asian Indian men. *J Clin Endocrinol Metab* 84:137-144, 1999

24. Saydah SH, Geiss LS, Tierney E, Benjamin SM, Engelgau M, Brancati F: Review of the performance of methods to identify diabetes cases among vital statistics, administrative, and survey data. *Ann Epidemiol* 14:507-516, 2004

25. Thorpe LE, Upadhyay UD, Chamany S, Garg R, Mandel-Ricci J, Kellerman S, Berger DK, Frieden TR, Gwynn C: Prevalence and control of diabetes and impaired fasting glucose in New York City. *Diabetes Care* 32:57-62, 2009

Table 10.1 Sample Characteristics

	Asian Subgroup			
	Asian Indian	Chinese	Filipino	Other Asian
n	1357	1510	1485	3062
Weighted sum*	1,234,233	1,284,405	1,312,902	2,628,140
% of all Asians	17.0	20.1	20.8	42.2
% of total population	0.6	0.7	0.7	1.5
Current age, mean (SE), y	37.6 (0.4)	40.7 (0.6)	41.2 (0.4)	39.3 (0.5)
Female, % (SE)	43.8 (1.5)	47.5 (1.5)	52.8 (1.6)	50.4 (1.2)
Below federal poverty level, % (SE)	10.8 (1.7)	12.0 (1.4)	6.4 (1.0)	15.8 (1.1)
Education, % (SE)				
< high school	10.3 (1.4)	11.4 (1.0)	8.1 (0.9)	13.4 (1.1)
college	61.0 (2.4)	54.5 (2.0)	44.4 (1.8)	36.2 (1.1)
Current smoker, % (SE)	7.8 (0.7)	11.2 (1.1)	15.3 (1.2)	18.4 (0.8)
Sedentary physical activity, % (SE)	39.0 (1.7)	37.0 (1.3)	33.7 (1.5)	37.9 (1.3)
Foreign-born, % (SE)	92.5 (1.0)	80.7 (1.3)	77.7 (1.5)	78.8 (2.0)

*Weighted sum = number of individuals data represents

Estimates are based on weighted, unadjusted data; Estimates are proportions (Standard Error)

All p-values<0.05 when comparing each row of data across Asian subgroups

Table 10.2 Prevalence of Normal Weight, Overweight, and Obese Individuals by Asian Subgroup

	BMI Definition	Asian Indian	Chinese	Filipino	Other Asian
Normal weight	General	59.3 (1.6)	75.2 (1.1)	55.3 (1.4)	66.8 (1.4)
	Asian-specific	36.8 (1.5)	53.0 (1.5)	32.7 (1.4)	44.8 (1.3)
Overweight	General	34.1 (1.6)	20.6 (1.1)	34.5 (1.4)	25.9 (1.2)
	Asian-specific	46.7 (1.8)	38.2 (1.3)	46.5 (1.7)	40.7 (1.0)
Obese	General	6.7 (0.9)	4.2 (0.6)	10.2 (1.0)	7.3 (0.7)
	Asian-specific	16.6 (1.4)	8.8 (0.8)	20.8 (1.3)	14.5 (1.0)

Prevalence estimates are age- and sex-standardized to the 2000 U.S. population

Estimates are based on weighted data; Estimates are proportions (Standard Error)

Table 10.3 Odds Ratios* of Diabetes by Asian Subgroup

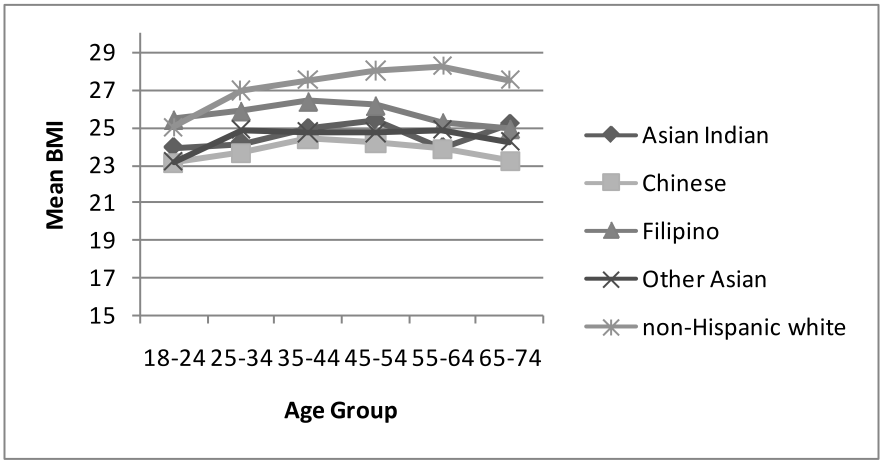
	Model 1	Model 2	Model 3	Model 4
White	1.0	1.0	1.0	1.0
Asian Indian	2.0 (1.5-2.6)	3.1 (2.4-4.0)	3.0 (2.0-4.5)	3.5 (1.9-6.6)
Chinese	0.8 (0.6-1.2)	1.5 (1.1-2.1)	1.6 (1.0-2.4)	2.3 (1.1-4.5)
Filipino	1.2 (0.9-1.5)	1.6 (1.3-2.2)	1.6 (1.1-2.5)	2.2 (1.2-4.0)
Other Asian	0.8 (0.7-1.0)	1.3 (1.0-1.7)	1.3 (1.0-1.7)	1.3 (0.8-2.2)
R squared	0.04125	0.06659	0.06427	0.04312

Model 1 adjusted for sex, age (continuous); Model 2 = Model 1 + BMI (continuous); Model 3 = Model 2 + education, poverty income ratio; Model 4 = Model 3 + physical activity, smoking and alcohol drinking status

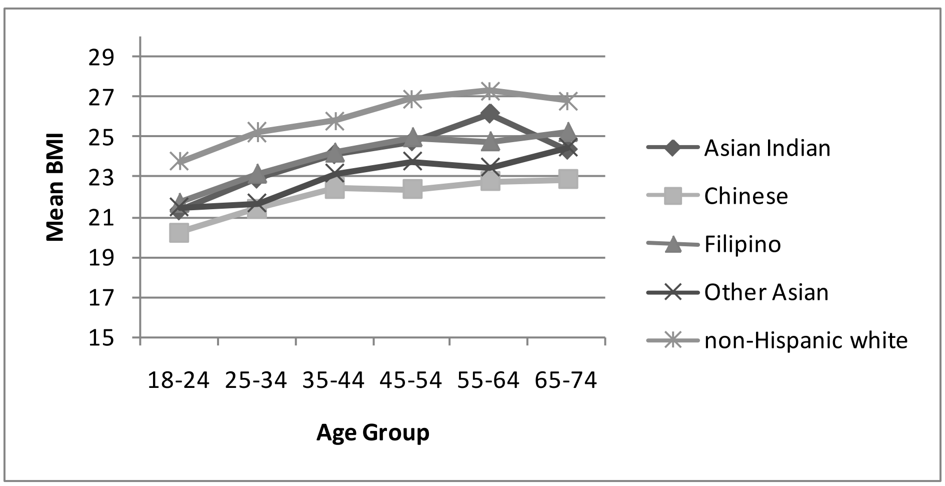
*Odds ratio for diabetes (95% confidence interval)

Figure 10.1 Mean BMI by Ethnic Subgroup, Age Group, and Sex

A. Men



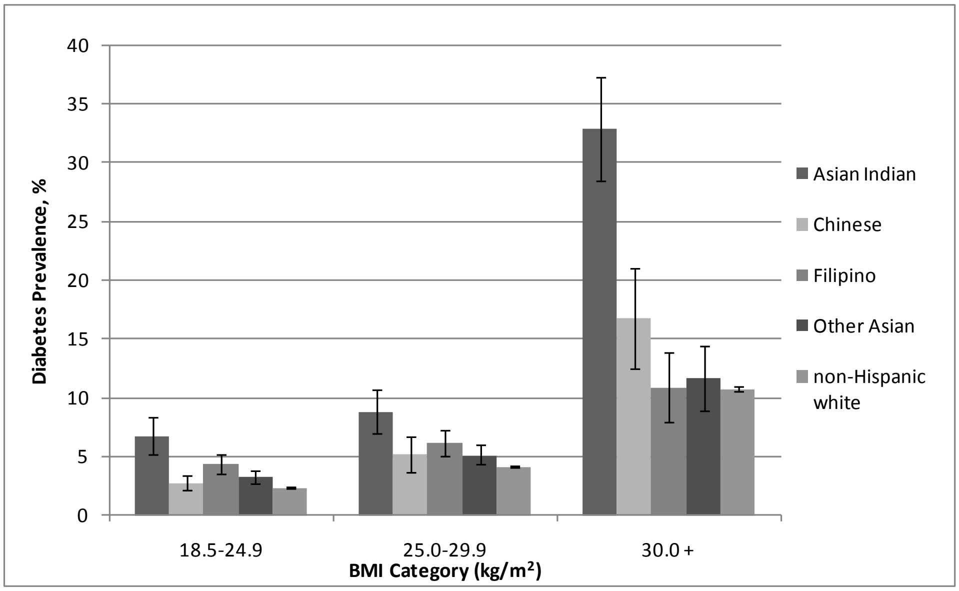
B. Women



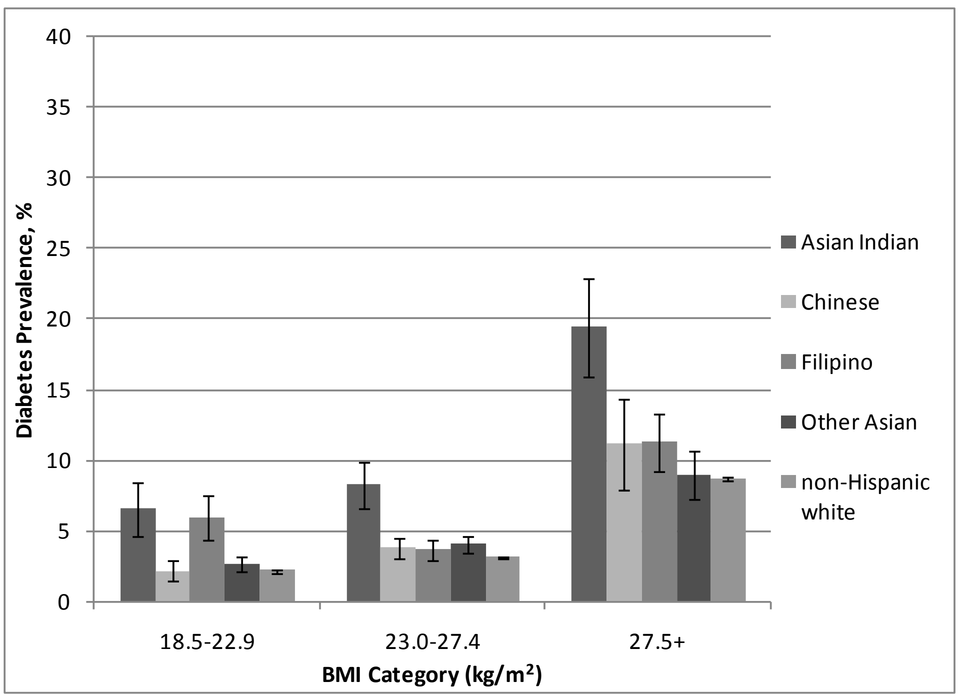
Estimates are based on weighted, unadjusted data

Figure 10.2 Diabetes Prevalence by Ethnic Subgroup and BMI Categories

A. Diabetes Prevalence: General BMI Definition



B. Diabetes Prevalence: Asian-specific BMI Definition



Prevalence estimates are age- and sex-standardized to the 2000 U.S. population

Error bars represent 95% confidence intervals

CHAPTER 11: SUMMARY AND CONCLUSIONS

Main findings

At a time of growing size and diversity of the foreign-born population in the U.S., this dissertation assessed the magnitude of overweight and diabetes in this population and examined the relationships between migration-specific characteristics and these conditions. First, we systematically reviewed the literature on the relationship between overweight and *length of residence* and found a consistent, positive association across studies, leading to the conclusion that this is an important characteristic to consider in terms of immigrant health.

Next, overweight and diabetes prevalence was described by *region of birth*. Overall, we found that both overweight and diabetes prevalence varies by region of birth: overweight prevalence was highest among migrants from Mexico/Central America/Caribbean and lowest among migrants from Central Asia; diabetes prevalence was highest among migrants from the Indian subcontinent and lowest among migrants from the Middle East. Although overweight prevalence typically corresponds with diabetes prevalence, we found that among Asian migrants, this was not the case. Asian migrants were among the least likely to be overweight, but most likely to report diabetes.

We followed this analysis with an examination of how *age at immigration* may modify the association between overweight and length of residence. Previous literature speculated that length of residence likely relates differently to health depending on whether the immigrant arrived as an adult or as a child (107). Our results support this hypothesis based on our finding that arriving at younger ages is associated with higher overweight prevalence compared to immigrants who arrive at later ages. As a potential explanatory factor, we also found that arriving at younger ages was associated with higher levels of dietary change, and that those immigrants reporting higher levels of dietary change were more likely to be overweight.

Depending on region of birth, U.S. exposure correlated differently with overweight, providing support for the hypothesis that the ‘intensity’ of gene-environment interactions varies by region of birth. Specifically, Asian immigrants did not experience any association between length of residence and overweight, potentially highlighting stronger influence of genes rather than environment. Among Hispanic immigrants, arriving at younger ages and residing for longer periods of time in the U.S. were both associated with overweight.

Additionally, we examined the relationship between diabetes and length of residence, stratified by age at immigration. Diabetes prevalence increased with longer length of residence, independent of age and obesity, and this relationship was consistent across different ages at immigration.

Finally, using Asian Americans as a case study, we examined heterogeneity in overweight and diabetes. We found that Asian Indians have the highest prevalence of diabetes compared to Filipinos, Chinese, other Asians, and non-Hispanic whites. Among Asians and contrary to previous reports, Asian Indians also have the highest overweight and obesity prevalence, similar to that of Filipinos, although prevalence is still lower than that of non-Hispanic whites.

The characteristics examined in this dissertation aid in describing the patterns of overweight and diabetes, however, these factors alone most likely do not account entirely for the disparities in prevalence, indicating there must be other explanations (26). One such explanation may be differences in socioeconomic status (SES) indicators. One study (141) found that immigrants with a college degree did not experience any change in obesity prevalence with increased length of residence, whereas for those without a college degree, obesity increased with length of residence. Another study (142) found that foreign-born Asians and Hispanics did not exhibit changes in mean BMI with increasing education or income. Conversely, their U.S. born counterparts showed an inverse relation.

It has been speculated that SES-BMI patterns may differ among immigrants based on whether they migrated from countries where the SES-BMI association is positive or negative (142). Due to the 1965 amendments to the Immigration and Nationality Act (INA), large numbers of migrants were arriving to the U.S. from Latin America (mainly Mexico) and Asia, regions typically experiencing positive associations between SES and both BMI and diabetes. This is of particular importance to the findings of this dissertation because immigrants from these regions comprise ~75% of the immigrant respondents in the surveys used, and thus would play a significant role in shaping immigrant SES-BMI patterns in the U.S. However, immigrants from Mexico and Asia differ substantially in terms of their SES circumstances. Almost half of all Asian migrants work in management, professional, and related occupations (143) compared to only 8% of Mexican immigrants (144). The majority of Mexican immigrants work in production, transportation, and material moving, or service occupations (144).

In addition to these differences in occupation, there are also differences in education among immigrants. Although the percentage of high school dropouts among immigrants has fallen somewhat, the gap between foreign-born and native born has grown significantly (31% vs. 8%), with immigrants more than twice as likely as native-born Americans not to have completed high school (48). In general, length of residence affects the earnings of the college educated foreign-born, with earnings increasing the longer they live in the U.S., and even surpassing native born earnings once in the U.S. for 20+ years (145). However, more foreign-born college educated are likely to be unemployed than native born (145), indicating the potential loss of status immigrants might experience if educational attainment in source countries is not equivalent or comparable to that of the host country. This loss of status can potentially impact the SES patterning of both BMI and diabetes (i.e. food choices, availability, and access).

These differences in SES could potentially lead to differential bias in diagnosis of overweight and diabetes. Specifically, Asian migrants who have a higher SES (through professional employment and higher education), may be more likely to access and utilize health care, increasing the likelihood of being diagnosed. Mexican immigrants, on the other hand, not only have a lower SES, but also almost half are unauthorized (48), which is linked to high rates of poverty, lack of health insurance, and welfare use (48) decreasing the likelihood of being diagnosed. In the context of the findings of this dissertation, such assumptions might imply that estimates for Asians are more reliable than estimates for Mexicans and more importantly, prevalence for Mexicans may have been underestimated because a larger proportion may be undiagnosed.

Limitations

One of the main limitations of both surveys is the use of self-reported data, which could bias the prevalence and effect estimates for overweight and diabetes. As mentioned in Chapters 6-9, immigrant women underreport weight less than native women, while immigrant and native men both underreport weight equally (66), indicating that underreported weight likely biased our estimates. Regarding diabetes, the accuracy of self-reporting for diabetes is reasonably high in population surveys (146), but the proportion of undiagnosed diabetes cannot be assessed using NHIS. As a result, our study may underestimate the total diabetes prevalence in this population. However, a study conducted in New York found no statistical difference in undiagnosed diabetes between foreign- and native born (147). Additionally, recent surveillance data suggest that the proportion of undiagnosed cases of diabetes in the general U.S. population has declined over recent decades, although not statistically significantly (148). Finally, blood glucose cutoffs for diabetes and impaired fasting glucose have changed in the time frame being studied, possibly leading to increased awareness and/or diagnosis of diabetes.

The cross-sectional nature of the data sources does not allow assessment of *when* diagnoses were made. This is particularly important for diabetes, where amount of weight gain in relation to diabetes incidence would be useful information. Additionally, the data do not provide information on whether diabetes was diagnosed in source or host countries. The mean age at arrival was approximately 20 for all migrant groups (Table 11.1), indicating that if they were diagnosed prior to migrating, the diagnosis was not likely to have been type 2 diabetes. Thus, the diagnosis of type 2 diabetes is dependent on access and utilization of health care in the U.S., which as discussed previously, is less likely among migrants with lower education or SES. Using NHIS data, there is one question that could provide additional insight into differentiating between type 1 an type 2 diabetes in this population. Sample adults who respond that they do have diabetes are also asked: “How old were you when a doctor FIRST told you that you had diabetes or sugar diabetes?” Based on the assumption that respondents diagnosed under the age of 35 are more likely to have type 1 diabetes, this information could be used to generalize respondents who have type 1 diabetes and had been diagnosed in their home country.

Table 11.1 Mean age at arrival by region of birth, NHIS 1997-2005

Region of Birth	Mexico	South America	Europe	Russia	Africa	Middle East	Indian subcontinent	Central Asia	SE Asia
Mean age at arrival (Std Dev)	22.4 (10.9)	25.3 (11.9)	19.3 (13.2)	32.5 (15.6)	24.8 (10.6)	24.8 (12.6)	26.1 (10.5)	24.9 (13. 9)	23.5 (13.3)

Although it is a good epidemiological tool in large surveys, BMI is most likely not the best measure of adiposity and does not provide information on the location of adiposity (visceral vs. subcutaneous fat), which has implications for diabetes risk (149). Adiposity measures, such as waist circumference, would strengthen some of our findings. However, NHIS does not collect information on other measures of adiposity such as waist circumference, which has been argued to be a better predictor of metabolic disease (150).

Similarly, the use of overweight (defined as BMI >25 kg/m^2), as an outcome in this dissertation, may not be appropriate for comparisons across different race/ethnicity categories. For example, Asians have higher body fat percentage at lower BMI compared to Caucasians (11). Conversely, compared to Caucasians, blacks have a higher bone mineral density, bone mineral content, and higher muscle mass (151). Furthermore, matched for age, BMI, and waist circumference, blacks have less visceral fat than Caucasians (152). Thus, adiposity may be more informative for assessing disease risk across diverse populations.

Another limitation is associated with grouping countries of birth into regions. For example, it is not necessarily appropriate to group the African continent into one category because Northern African countries seem to have different risks for overweight/obesity than other African countries (153). Similarly, Puerto Ricans are not considered foreign-born in the analyses presented here, but the burden of obesity and diabetes is relatively high compared to others typically grouped in the same category (Mexico, Central America, Caribbean) such as Cubans, where a lighter burden of diabetes and obesity is observed (104). In future studies, additional information can be gained by further disaggregating regions of birth by country.

Because NHIS is a cross-sectional survey, we did have the ability to assess incidence or individual risk for developing diabetes during a defined period. Also, the changing cohorts moving to the U.S. between surveys may influence analyses (46, 73). One of the ways to address this limitation would be to identify individuals pre-migration to ascertain (a) changes in behavior and health post-migration and (b) differences in immigrants who stay in the country of origin and those who move. Until more complete, accurate data from pre-migration time points are collected, researchers are forced to maximize the use of post-migration data.

There is potential for several forms of selection bias. First, volunteer bias for healthy participants may exist since healthy individuals are more likely to participate in surveys than unhealthy individuals. Second, in the case of NHIS, immigrant populations may be somewhat less inclined to participate compared to native-born residents due to language barriers, fear of being interviewed because of illegal status, and unstable or nonhousehold living arrangements. In addition, these may vary by immigrant group (61).

One study specifically addressed whether racial/ethnic minorities were less willing to participate in NCHS studies. The authors found that they are actually underrepresented among the invited participants despite being as willing to participate in health research as the rest of the population (154). Along these lines, immigrants in particular may be less likely to be included in NHIS.

In asking respondents to rate how much their diet has changed from pre- to post-migration, there is also potential for recall bias with the dietary data collected in NIS. This specific question was not validated, highlighting the uncertainty in what information the question is capturing.

Among the immigrants represented in NHIS, it cannot be determined whether they are unauthorized, temporary residents, or refugees and this may influence individual health status. Additionally, NHIS does not include questions on migration history, leading to a possible underestimation of exposure time outside of the home country (155). Although NIS does include migration history, it is limited to immigrants with LPR status, and thus does not include unauthorized or temporary residents.

Finally, the external validity of our results is questionable in the context of migrants in countries outside the U.S. because NHIS and NIS are specific to U.S. immigrants. These limitations, though, are outweighed by the advantages of utilizing existing data sources to answer research questions specific to migrant health given the limited availability of existing migrant data. It has been argued that establishing new cohorts is too costly and that meaningful results would not be available for at least 10 years (156), as is the case with data from the New Immigrant Survey. Thus, recognizing and accounting for gaps in data in existing cohorts, and even filling these gaps with more modest investments, is currently a necessity.

Strengths

The overall strengths of this dissertation include the use of two surveys with large, nationally representative samples of foreign-born individuals, allowing stratification of analyses by pertinent variables of interest (region of birth, age at immigration, length of residence). Such stratified analyses are limited in the literature, yet are necessary to provide insights into heterogeneity among immigrants. Additionally, in both surveys, in person interviews were utilized, maximizing the potential response rates. Both surveys also included extensive demographic detail and a broad range of health issues. In the case of NHIS, it is an ongoing annual survey, with consistency in survey questions. In the case of NIS, migration history information was collected, allowing exclusive assessment of duration of stay in the U.S.

Challenges to studying immigrant health

The work presented in this dissertation highlights several of the methodological and empirical challenges related to studying immigrant health. First, this work was based on cross-sectional data and thus cannot disentangle age/period/cohort (APC) effects. It is difficult to identify these three effects separately because although the relationship is linear (cohort=period-age), these distinct time dimensions are not independent. Age effects are variation associated with different age groups (i.e. we know that weight gain, overweight/obesity/diabetes are associated with increasing age). Period effects are variation over time periods that effect all age groups simultaneously (i.e. globalization, urbanization happening at the same time in countries around the world, which is associated with weight gain/diabetes).

Cohort effects are changes across groups of individuals who experience some initial event, such as birth, during the same year or years (i.e. exposure in utero or environmental influence to which other cohorts may not have been exposed). Standard regression models do not account for the possibility that individuals in the same survey year or cohort may be similar in their responses because random errors unique to each survey year or cohort are common to every survey respondent in those years or cohorts (157).

These issues relate to the use of the pooled NHIS data. Despite different immigrant cohorts being surveyed each year, the selection criteria for migration generally stays the same (health, wealth, etc), minimizing some cohort differences. One of the main issues, though, that cannot be addressed with these analyses is that immigrants with longer residence could represent earlier immigrant cohorts that may have exhibited higher BMI upon arrival, resulting in an artificial observation of increased weight with longer residence (158). Alternatively, more recent immigrant cohorts are arriving from countries experiencing the economic and social effects of globalization, including changes in nutrition and physical activity. This could result in more recent cohorts arriving with higher BMI than did earlier cohorts (159).

A key challenge of this work is how to disentangle age from migration. One piece of information that would help us gain more insight into the APC effects is if/how overweight and diabetes rates differ across nativity groups. If we can show that, independent of age, there is a difference in these rates, then we could conclude that there are other explanations for the difference in rates. Using NHIS data, prevalence of overweight and diabetes by combined race/nativity (i.e. U.S. born Hispanics vs. foreign-born Hispanics) in separate age categories, stratified by sex could be determined. Then, intercepts and slopes of each line could be estimated. We might hypothesize that foreign-born intercepts are lower across all race/nativity categories, indicating that at the same starting age (i.e. 18-24), foreign-born have lower prevalence. However, we might also hypothesize that the slopes for foreign-born are different and steeper compared to U.S. born, indicating there is an explanation beyond age for the difference in 'prevalence rate'.

Another method (160) might be to model the prevalence rates of overweight and diabetes using an APC Poisson regression model (methodology developed by Holford (161)). In this method, we would create categorical variables for age (18-24, 25-29, 30-34, 35-39, 40-44, 45-49, 50-54, 55-59, 60-64, 65-69, 70-74 giving a total of 11 age groups), period (because we pooled 9 years of data, the 3 periods could be 1997, 2000, and 2003), and cohort (ranging from those born in 1931 to those born in 1987 and grouping these into 5 year intervals); giving 13 cohorts. Then, we would calculate overweight and diabetes prevalence rates for each 5-year age category and period for total population of men and women separately. This method would allow us to see if prevalence increased for more recent cohorts for any given age, and if so, then the increase in prevalence more recent immigrants may be experiencing may be an extension of what they would have experienced in their home country. This method of modeling can give simultaneous effects of age, period, cohort on outcomes, allowing us to hypothesize that all 3 are independent predictors of overweight/diabetes prevalence and that more recent cohorts are heavier at same ages, with younger cohorts becoming more overweight more rapidly than older cohorts.

Finally, if longitudinal data sources were available, there are two potential ways of examining migration independent of age. In comparing age-matched cohorts in the source country and home country, one might be able to track weight gain and diabetes incidence over time and compare diabetes rates. We might hypothesize that immigrants in the host country experience a higher rate of diabetes over a defined time period, supporting the notion that there is an effect of migration beyond age. Similarly, in comparing age-matched cohorts of foreign-born and native born within the host country, we might hypothesize that the diabetes rate among foreign-born is higher, again supporting the notion that there is an effect of migration beyond age.

A related issue to consider is the lack of studies combining pre- and post-migration data. Immigrants experience a range of exposures before and after they migrate, both of which influence health. Interestingly, the collective results from this dissertation show that regardless of pre-migration exposure, there is a pattern in terms of overweight and diabetes among immigrants, a pattern that can be measured without taking pre-migration exposures (other than region of birth) into account.

Another issue that must be considered is the concept of acculturation.[6] Globalization is likely making it more difficult to measure acculturation, and challenging the assumption that acculturation is a post-migration process (159). What is considered to be post-migration effects might actually be a reflection of changes that are taking place in home countries. The body of work in this dissertation based on the assumption that

[6] Acculturation has been defined as changes in the behaviors and cultural values of an individual or group as a result of contact with another culture.

life/environment in the country of origin/prior to moving to the U.S. is different from life in the U.S. The only true way to assess this is to systematically measure conditions of interest (access/availability of specific foods, urbanization, etc) pre- and post-migration.

Attempting to measure acculturation has been called ‘ambitious…at best’ due to the lack of uniform methodologies and definitions (162). This highlights the need for the development of contextually specific definitions that will aid in improving acculturation measurement. Another criticism is the fact that acculturation is always measured using proxy measures (107, 162), as seen in this dissertation. In reality, proxy measures cannot capture the complex social, cultural, economic, and political aspects that acculturation encompasses (162). However, more multidimensional assessments of acculturation and standardized scales that characterize acculturation more fully have not yet been widely adopted in population or clinical studies (163).

It is also necessary to clarify that the findings from this dissertation are not that all acculturation is detrimental to health because acculturation is based on changes in an individual’s behavior. What we can assume is that the individual would benefit from research monitoring migration related changes and promoting positive behavior changes, whether that means retaining traditional behaviors or adopting new ones.

The final challenge in studying immigrants identified in this dissertation is how to determine the best comparison group. Are migrants more similar to each than to native born? Is country of birth more important than race/ethnicity? As shown in the presented analyses, we would argue the answer to both of these questions is yes. However, the appropriate comparison group may actually be those left behind in the source country, and it has been hypothesized that individuals with shorter duration of residence in the host country (i.e. less than 5 years) are more similar to individuals left behind in the country of origin compared to those who have had a longer duration of residence (73). In the same vein, longer residing immigrants are more appropriate to compare to each other versus those in source country (African Americans in U.S. vs. Africans in Africa). Comparisons to individuals in home countries would allow assessment of health selection as well as the influence of a different environment. This type of comparison, though, is very difficult given the diversity of sending countries (46).

Public health significance and policy implications

Data Gaps

The work presented in this dissertation highlights the lack of sufficient data on the U.S. foreign-born both in size and content. With regard to size, immigrants as a subgroup should be oversampled in national surveys to enhance national surveillance efforts. Even with pooling nine years of NHIS data, our foreign-born sample size was just over 30,000. Although this represented approximately 16 million individuals, the number of events of diabetes and obesity (BMI $>30 kg/m^2$) were relatively small. Beginning in 2006 NHIS began oversampling Asians in addition to the already oversampled Hispanics and non-Hispanic blacks, however, this oversampling by race/ethnicity does not necessarily differentiate by foreign-born status. Thus, immigrants as a subgroup should be oversampled in national surveys to enhance national surveillance efforts. The growing interest in immigrant health, especially in relation to cardio-metabolic diseases (164) has not yet translated into incorporating immigrants as a subgroup into national research agendas.

Current national programs and policies aimed at preventing obesity and diabetes often overlook the growing U.S. immigrant population, which can have significant impact on national objectives. Specifically, as overweight/obesity prevalence among immigrants increases, greater morbidity is expected (158). Two of the focus areas of Healthy People 2010 are to reduce the prevalence of overweight/obesity and the rate of diagnosed diabetes. Yet prevalence and incidence of weight and diabetes are currently the only cardiovascular disease risk factors that are still increasing over time (36). In order to comprehensively approach such objectives, all segments of the population must be considered.

With regard to NHIS migration content, we exhausted the data with regard to overweight and diabetes. As the longitudinal data of NIS becomes available, different research questions can be examined, but even then, NIS health data is somewhat sparse. In addition, as mentioned in the limitations, both surveys are based on self-reported data. More detailed health data collected through examinations are necessary to improve data quality and reduce bias in findings such as those presented in this dissertation. There are certainly additional costs associated with oversampling immigrants and collecting more detailed health data, however, adding a clinical component to existing surveys is a less expensive alternative to setting up and following a new cohort. Such data will help researchers and policy makers better understand the scale of the problem, identify data gaps as this population continues to grow, and inform prevention programs and interventions.

Prevention

The work presented in this dissertation highlights the point of entry of an immigrant an opportune time to begin prevention efforts. These prevention efforts might be the same as those developed for the native born, but the difference is that migrants are on average younger than the non-migrant population, and are typically part of the workforce (productive members of society). If exposure to the U.S. environment increases the risk of these overweight and diabetes, as supported by the findings of this dissertation, migrants may experience earlier onset of disease, and increased morbidity and mortality at earlier ages. Preventing costly diseases in this population would aid in decreasing stresses on health care systems and improving national health outcomes.

Another result of this work is the identification of potential high risk migrants (i.e. Mexican migrants are more likely to be overweight and have diabetes; migrants the Indian subcontinent and Africa are more likely to have diabetes). This information can be useful in clinical settings where better care can be provided to those at highest risk. There is fortunately a wide body of literature supporting primary prevention of diabetes. By slowing the trajectory of weight gain that immigrants experience after arrival, related morbidity and mortality can be prevented or delayed.

Future Studies

In the next 5-10 years, it will be beneficial to utilize longitudinal data from NIS to assess weight change among immigrants, what factors contribute to weight change, and how this weight change is related to diabetes incidence. This data can also provide insights into what factors are related to weight gain and diabetes incidence among migrants, if these factors are the same as U.S. born, and target points of prevention efforts. In order to test the effectiveness of implementing prevention efforts at point of entry, a randomized control trial with two groups (intensive weight gain/diabetes prevention program versus standard prevention program) could be developed. Along the same lines, it would be beneficial to compare U.S. longitudinal migrant data to that of migrants in source countries or comparable cohorts in the U.S. to determine if/how weight change and diabetes are different.

Another area of research that warrants more attention is gene-environment interactions. The study of immigrants presents a possible method of differentiating genetic from environmental causes of geographic variation in disease (128). More specifically, identifying more recent Asian subgroups in the U.S., such as those from India and China and following a Framingham model, it would be beneficial to follow a cohort of foreign-born and their eventual offspring to disentangle gene-environment interactions.

Future studies should look beyond race/ethnicity when groups with large proportions of migrants are included and focus more on region/country of birth. As shown by the findings of this dissertation, health may differ by region of birth, and this may be attributable to differences in acculturation patterns, leading to the necessity to develop measures specific by country/region of birth.

Future studies should also work towards the development of more contextually specific definitions of acculturation with regard to immigrant health. This is necessary in order to create uniform measures, allowing for increased comparability across studies. In submitting manuscripts for publication, reviewers disagreed with our use of the term acculturation in conjunction with variables such as length of residence and age at arrival.

Currently, NHIS and NIS are the only surveys collecting this level of migration history and health information, thereby giving researchers the opportunity to provide insight into a topic not very well represented in the literature, but deserves more attention due to the nature of the large migrant population. More research is necessary to compare these measures to other measures of acculturation. Also, more work is needed to assess the reliability and validity of different measures of acculturation. Such research can be enhanced by looking to the social sciences for appropriate ways to measure acculturation.

Summary

In summary, the studies represented in this dissertation significantly contribute to the literature by examining the magnitude of overweight and diabetes and exploring the relationships between migrant-specific characteristics and these conditions in nationally representative samples of U.S. immigrants. Our findings highlight three specific variables (region of birth, length of residence, and age at arrival) as important characteristics that shape health patterns among immigrants. We found variable patterns of overweight and diabetes by region of birth and increasing patterns with increasing length of residence and younger ages at arrival. Whether these variables directly or indirectly influence health has yet to be determined. We also identified challenges to studying immigrant health, public health significance, policy implications, and potential future studies to enhance research efforts in this growing, substantial segment of the U.S. population.

CHAPTER 12: LITERATURE CITED

(Chapters 1-4, 11)

1. Martin P, Zurcher G. Managing Migration: The Global Challenge. Population Bulletin 2008;63:1-22.

2. Organization for Economic Co-operation and Development. International Migration Outlook: SOPEMI; United States. 2008. Available from: http://www.oecd.org/dataoecd/57/60/41256817.pdf. Accessed May 19, 2009.

3. Steele L. Immigrants to play a key role in U.S. growth. Kiplinger Business Resource Center, 2007.

4. U.S. Census Bureau. Foreign-Born Population Tops 34 Million, Census Bureau Estimates, 2005. Available from: http://www.census.gov/Press-Release/www/releases/archives/foreignborn_population/003969.html. Accessed May 19, 2009.

5. Centers for Disease Control and Prevention. National diabetes fact sheet: general information and national estimates on diabetes in the United States, 2007. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, 2008.

6. Argeseanu Cunningham S, Ruben JD, Venkat Narayan KM. Health of foreign-born people in the United States: a review. Health Place 2008;14:623-35.

7. National Center for Health Statistics. National Health Interview Survey. 2009. Available from http://www.cdc.gov/nchs/about/major/nhis/hisdesc.htm. Accessed May 19, 2009.

8. Jasso G, Massey DS, Rosenzweig MR, Smith JP. The New Immigrant Survey 2003 Round 1 (NIS-2003-1) public release data. March 2006. Available from http://nis.princeton.edu/data.html. Accessed May 19, 2009.

9. Centers for Disease Control and Prevention. Overweight and Obesity. 2009. Available from http://www.cdc.gov/nccdphp/dnpa/obesity/index.htm. Accessed May 19, 2009.

10. World Health Organization. BMI Classification. 2006. Available from http://apps.who.int/bmi/index.jsp?introPage=intro_3.html. Accessed May 19, 2009.

11. World Health Organization. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. Lancet 2004;363:157-63.

12. Hossain P, Kawar B, El Nahas M. Obesity and diabetes in the developing world--a growing challenge. N Engl J Med 2007;356:213-5.

13. Flegal KM, Carroll MD, Ogden CL, Johnson CL. Prevalence and trends in obesity among US adults, 1999-2000. JAMA 2002;288:1723-7.

14. Ogden CL, Carroll MD, McDowell MA, Flegal KM. Obesity among adults in the United States— no change since 2003–2004. 2007. NCHS data brief no 1. Hyattsville, MD: National Center for Health Statistics.

15. Ogden CL, Flegal KM, Carroll MD, Johnson CL. Prevalence and trends in overweight among US children and adolescents, 1999-2000. JAMA 2002;288:1728-32.

16. Hedley AA, Ogden CL, Johnson CL, Carroll MD, Curtin LR, Flegal KM. Prevalence of overweight and obesity among US children, adolescents, and adults, 1999-2002. JAMA 2004;291:2847-50.

17. Office of the Surgeon General. The Surgeon General's Call to Action to Prevent and Decrease Overweight and Obesity: Overweight in Children and Adolescents. 2007. Available from http://www.surgeongeneral.gov/topics/obesity/calltoaction/fact_adolescents.htm. Accessed May 19, 2009.

18. Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults--The Evidence Report. National Institutes of Health. Obes Res 1998;6 Suppl 2:51S-209S.

19. Finkelstein EA, Fiebelkorn IC, Wang G. National medical spending attributable to overweight and obesity: How much, and who's paying? Health Affairs 2003;W3:219–226.

20. Wang Y, Beydoun MA. The obesity epidemic in the United States--gender, age, socioeconomic, racial/ethnic, and geographic characteristics: a systematic review and meta-regression analysis. Epidemiol Rev 2007;29:6-28.

21. Popkin BM, Gordon-Larsen P. The nutrition transition: worldwide obesity dynamics and their determinants. International Journal of Obesity & Related Metabolic Disorders: Journal of the International Association for the Study of Obesity 2004;28 Suppl 3:S2-9.

22. Zimmet P, Alberti KG, Shaw J. Global and societal implications of the diabetes epidemic. Nature 2001;414:782-7.

23. Wild S, Roglic G, Green A, Sicree R, King H. Global prevalence of diabetes: estimates for the year 2000 and projections for 2030.[see comment]. Diabetes Care 2004;27:1047-53.

24. World Health Organization. Diabetes Action Now. 2004. Available from http://www.who.int/diabetes/BOOKLET_HTML/en/print.html. Accessed May 19, 2009.

25. United Nations, Department of Economic and Social Affairs/Population Division. World Urbanization Prospects: The 2003 Revision. 2004. New York: UN Population Division.

26. Harris MI. Diabetes in America: epidemiology and scope of the problem. Diabetes Care 1998;21 Suppl 3:C11-4.

27. National Institute of Diabetes and Digestive and Kidney Diseases, National Diabetes Information Clearing House. Diagnosis of Diabetes. 2008. National Institutes of Health.

Available from http://diabetes.niddk.nih.gov/dm/pubs/diagnosis/. Accessed May 19, 2009.

28. International Diabetes Federation. Did you know? Facts and Figures. 2008. Available from http://www.idf.org/node/1130?unode=3B96906B-C026-2FD3-87B73F80BC22682A. Accessed May 19, 2009.

29. Geiss LS, Pan L, Cadwell B, Gregg EW, Benjamin SM, Engelgau MM. Changes in incidence of diabetes in U.S. adults, 1997-2003. Am J Prev Med 2006;30:371-7.

30. Mokdad AH, Ford ES, Bowman BA, et al. Diabetes trends in the U.S.: 1990-1998. Diabetes Care 2000;23:1278-83.

31. Centers for Disease Control and Prevention. National diabetes fact sheet: general information and national estimates on diabetes in the United States, 2005. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, 2006.

32. Narayan KMV, Boyle JP, Thompson TJ, Sorensen SW, Williamson DF. Lifetime risk for diabetes mellitus in the United States. JAMA 2003;290:1884-90.

33. Murray C, Lopez AD. Chapter 8: Gender and Nutrition in the Global Burden of Disease, 1990 to 2020. Challenges for the 21st Century: A Gender Perspective on Nutrition Through the Life Cycle - Nutrition Policy Paper No. 17: ACC/SCN 1998.

34. Egede LE, Dagogo-Jack S. Epidemiology of type 2 diabetes: focus on ethnic minorities. Med Clin North Am 2005;89:949-75, viii.

35. Wan H, Sengupta M, Velkoff V, DeBarros K. 65+ in the United States: 2005,Current Population Reports, P23-209. US Census Bureau, 2005.

36. Gregg EW, Cheng YJ, Cadwell BL, et al. Secular trends in cardiovascular disease risk factors according to body mass index in US adults. JAMA 2005;293:1868-74.

37. Harris MI, Flegal KM, Cowie CC, et al. Prevalence of diabetes, impaired fasting glucose, and impaired glucose tolerance in U.S. adults. The Third National Health and Nutrition Examination Survey, 1988-1994. Diabetes Care 1998;21:518-24.

38. Gregg EW, Cadwell BL, Cheng YJ, et al. Trends in the prevalence and ratio of diagnosed to undiagnosed diabetes according to obesity levels in the U.S. Diabetes Care 2004;27:2806-12.

39. Fox CS, Pencina MJ, Meigs JB, Vasan RS, Levitzky YS, D'Agostino RB, Sr. Trends in the incidence of type 2 diabetes mellitus from the 1970s to the 1990s: the Framingham Heart Study. Circulation 2006;113:2914-8.

40. Ford ES, Williamson DF, Liu S. Weight change and diabetes incidence: findings from a national cohort of US adults. Am J Epidemiol 1997;146:214-22.

41. Gregg EW, Cheng YJ, Narayan KM, Thompson TJ, Williamson DF. The relative contributions of different levels of overweight and obesity to the increased prevalence of diabetes in the United States: 1976-2004. Prev Med 2007;45:348-52.

42. Prevalence of overweight and obesity among adults with diagnosed diabetes--United States, 1988-1994 and 1999-2002. MMWR Morb Mortal Wkly Rep 2004;53:1066-8.

43. Sturm R. Increases in clinically severe obesity in the United States, 1986-2000. Arch Intern Med 2003;163:2146-8.

44. Herman WH, Hoerger TJ, Brandle M, et al. The cost-effectiveness of lifestyle modification or metformin in preventing type 2 diabetes in adults with impaired glucose tolerance. Ann Intern Med 2005;142:323-32.

45. Department of Economic and Social Affairs, Population Division. United Nations. Trends in total migrant stock: The 2005 revision. 2006. Available from http://www.un.org/esa/population/publications/migration/UN_Migrant_Stock_Documentation_2005.pdf. Accessed June 20, 2008.

46. Jasso G, Massey D, Rosenzweig M, Smith J. Immigrant Health-Selectivity and Acculturation. In: Norman B, Anderson R, Bulatao A, Cohen B, eds. Critical Perspectives on Racial and Ethnic Differences in Health in Late Life. Washington, DC: National Academy Press, 2004.

47. Center for Immigration Studies. Three Decades of Mass Immigration: The Legacy of the 1965 Immigration Act. 1995. Available from http://www.cis.org/articles/1995/back395.html. Accessed May 19, 2009.

48. Camarota SA. Immigrants in the United States, 2007: A profile of America's foreign-born population. Center for Immigration Studies, 2007.

49. Jasso G, Rosenzweig M. The new chosen people: Immigrants in the United States. New York: Russell Sage Foundation, 1990.

50. Gex J. Key facts about international migration. TESOL, 2005.

51. Passel JS, Cohn D. U.S. Population Projections: 2005-2050. Pew Research Center, 2008.

52. Jernegan K. A new century: Immigration and the US. Migration Information Source, 2005.

53. Terrazas A, Batalova J, Fan V. Frequently requested statistics on immigrants in the United States. Migration Information Source.

54. Peng N. US population hits 300 million. China news, 2006. Available from http://news.xinhuanet.com/english/2006-10/17/content_5215770.htm. Accessed May 19, 2009.

55. Simanski J. Mapping Trends in U.S. Legal Immigration: 1980 to 2003. Office of Immigration Statistics. 2005.

56. U.S. Census Bureau. Census Bureau Data Show Characteristics of the U.S. Foreign-Born Population. 2009. Available from http://www.census.gov/Press-Release/www/releases/archives/american_community_survey_acs/013308.html. Accessed May 19, 2009.

57. Schmidley D. Profile of the foreign-born population in the United States: 2000, Series P23-206: US Census Bureau, 2000.

58. Batalova J, Terrazas AM. The Recently Arrived Foreign Born in the United States 2007.

59. Larsen, Luke J. 2004. The Foreign-Born Population in the United States: 2003. Current Population Reports, P20-551, U.S. Census Bureau, Washington, D.C.

60. Lu Y. Test of the 'healthy migrant hypothesis': a longitudinal analysis of health selectivity of internal migration in Indonesia. Soc Sci Med 2008;67:1331-9.

61. Stephen EH, Foote K, Hendershot GE, Schoenborn CA. Health of the foreign-born population: United States, 1989-90. Advance Data 1994:1-12.

62. Singh G, Siahpush M. Ethnic-immigrant differentials in health behaviors, morbidity, and cause-specific mortality in the United States: An analysis of two national data bases. Human Biology 2002;74:83-109.

63. Singh GK, Hiatt RA. Trends and disparities in socioeconomic and behavioural characteristics, life expectancy, and cause-specific mortality of native-born and foreign-born populations in the United States, 1979-2003. International Journal of Epidemiology 2006;35:903-19.

64. Singh GK, Siahpush M. All-cause and cause-specific mortality of immigrants and native born in the United States. American Journal of Public Health 2001;91:392-9.

65. Huh J, Prause JA, Dooley CD. The impact of nativity on chronic diseases, self-rated health and comorbidity status of Asian and Hispanic immigrants. J Immigr Minor Health 2008;10:103-18.

66. Antecol H, Bedard K. Unhealthy assimilation: why do immigrants converge to American health status levels? Demography 2006;43:337-60.

67. Lauderdale DS, Rathouz PJ. Body mass index in a US national sample of Asian Americans: effects of nativity, years since immigration and socioeconomic status. Int J Obes Relat Metab Disord 2000;24:1188-94.

68. Popkin B, Udry J. Adolescents obesity increases significantly in second and third generation U.S. immigrants: The National Longitudinal Study of Adolescent Health. J Nutr 1998;128:701-6.

69. Sundquist J, Winkleby M. Country of birth, acculturation status and abdominal obesity in a national sample of Mexican-American women and men. International Journal of Epidemiology 2000;29:470-7.

70. Jasso G MD, Rosenzweig M, Smith J. Immigration, health, and New York City: Early results based on the US New Immigrant Cohort of 2003. Economic Policy Review - Federal Reserve Bank of New York. 2005;11(2):127.

71. Dey AN, Lucas JW. Physical and mental health characteristics of U.S.- and foreign-born adults: United States, 1998-2003. Advance Data 2006:1-19.

72. Palloni A, Arias E. Paradox lost: explaining the Hispanic adult mortality advantage. Demography 2004;41:385-415.

73. Goel MS, McCarthy EP, Phillips RS, Wee CC. Obesity among US immigrant subgroups by duration of residence. JAMA 2004;292:2860-7.

74. Gordon-Larsen P, Harris KM, Ward DS, Popkin BM, National Longitudinal Study of Adolescent H. Acculturation and overweight-related behaviors among Hispanic immigrants to the US: the National Longitudinal Study of Adolescent Health. Social Science & Medicine 2003;57:2023-34.

75. Kaplan MS, Huguet N, Newsom JT, McFarland BH. The association between length of residence and obesity among Hispanic immigrants. American Journal of Preventive Medicine 2004;27:323-6.

76. Mooteri SN, Petersen F, Dagubati R, Pai RG. Duration of residence in the United States as a new risk factor for coronary artery disease (The Konkani Heart Study). Am J Cardiol 2004;93:359-61.

77. Singh GK, Siahpush M. Widening socioeconomic inequalities in US life expectancy, 1980-2000. International Journal of Epidemiology 2006;35:969-79.

78. McDonald JT, Kennedy S. Is migration to Canada associated with unhealthy weight gain? Overweight and obesity among Canada's immigrants. Social Science & Medicine 2005;61:2469-81.

79. Caprio S, Daniels SR, Drewnowski A, et al. Influence of race, ethnicity, and culture on childhood obesity: implications for prevention and treatment: a consensus statement of Shaping America's Health and the Obesity Society. Diabetes Care 2008;31:2211-21.

80. Williams DR. Race and health: basic questions, emerging directions. Ann Epidemiol 1997;7:322-33.

81. Dallo FJ, Borrell LN. Self-reported diabetes and hypertension among Arab Americans in the United States. Ethn Dis 2006;16:699-705.

82. Araneta MR, Barrett-Connor E. Ethnic differences in visceral adipose tissue and type 2 diabetes: Filipino, African-American, and white women. Obes Res 2005;13:1458-65.

83. Araneta MR, Morton DJ, Lantion-Ang L, et al. Hyperglycemia and type 2 diabetes among Filipino women in the Philippines, Hawaii, and San Diego. Diabetes Research & Clinical Practice 2006;71:306-12.

84. Venkataraman R, Nanda NC, Baweja G, Parikh N, Bhatia V. Prevalence of diabetes mellitus and related conditions in Asian Indians living in the United States. Am J Cardiol 2004;94:977-80.

85. Scheder JC. A Sickly-Sweet Harvest: Farmworker Diabetes and Social Equality. Medical Anthropology Quarterly 1988;2:251-277.

86. Jasso G MD, Rosenzweig M, Smith J. Immigration, health, and New York City: Early results based on the US New Immigrant Cohort of 2003. Economic Policy Review - Federal Reserve Bank of New York. 2005;11(2):127.

87. Mujahid MS, Diez Roux AV, Borrell LN, Nieto FJ. Cross-sectional and longitudinal associations of BMI with socioeconomic characteristics. Obesity Research 2005;13:1412-21.

88. Robbins JM, Vaccarino V, Zhang H, Kasl SV. Socioeconomic status and type 2 diabetes in African American and non-Hispanic white women and men: evidence from the Third National Health and Nutrition Examination Survey. American Journal of Public Health 2001;91:76-83.

89. Larsen L. The foreign-born population in the United States: 2003. Current Population Reports, P20-551. US Census Bureau, 2004.

90. Holmes SM. An ethnographic study of the social context of migrant health in the United States. PLoS Med 2006;3:e448.

91. Sandhaus S. Migrant health: a harvest of poverty. Am J Nurs 1998;98:52-4.

92. Huang ZJ, Yu SM, Ledsky R. Health status and health service access and use among children in U.S. immigrant families. American Journal of Public Health 2006;96:634-40.

93. Lucas JW, Barr-Anderson DJ, Kington RS. Health status, health insurance, and health care utilization patterns of immigrant Black men. American Journal of Public Health 2003;93:1740-7.

94. Frisbie WP, Cho Y, Hummer RA. Immigration and the health of Asian and Pacific Islander adults in the United States. American Journal of Epidemiology 2001;153:372-80.

95. Elliott SJ, Gillie J. Moving experiences: a qualitative analysis of health and migration. Health Place 1998;4:327-39.

96. Kandula NR, Wen M, Jacobs EA, Lauderdale DS. Low rates of colorectal, cervical, and breast cancer screening in Asian Americans compared with non-Hispanic whites: Cultural influences or access to care? Cancer 2006;107:184-92.

97. Kandula NR, Kersey M, Lurie N. Assuring the health of immigrants: what the leading health indicators tell us. Annu Rev Public Health 2004;25:357-76.

98. Thamer M, Richard C, Casebeer AW, Ray NF. Health insurance coverage among foreign-born US residents: the impact of race, ethnicity, and length of residence.[see comment]. American Journal of Public Health 1997;87:96-102.

99. Mohanty SA, Woolhandler S, Himmelstein DU, Pati S, Carrasquillo O, Bor DH. Health care expenditures of immigrants in the United States: a nationally representative analysis. American Journal of Public Health 2005;95:1431-8.

100. Feliciano C. Educational selectivity in U.S. immigration: how do immigrants compare to those left behind? Demography 2005;42:131-52.

101. Monteiro C, Moura E, Conde W, Popkin BM. Socioeconomic status and obesity in adult populations of developing countries: a review. Bull World Health Organ 2004;82:940-946.

102. Sanchez-Vaznaugh EV, Kawachi I, Subramanian SV, Sanchez BN, Acevedo-Garcia D. Do socioeconomic gradients in body mass index vary by race/ethnicity, gender, and birthplace? Am J Epidemiol 2009;169:1102-12.

103. Singh GK, Miller BA. Health, life expectancy, and mortality patterns among immigrant populations in the United States. Can J Public Health 2004;95:I14-21.

104. Popkin BM, Udry JR. Adolescent obesity increases significantly in second and third generation U.S. immigrants: the National Longitudinal Study of Adolescent Health. J Nutr 1998;128:701-6.

105. Abraido-Lanza AF, Armbrister AN, Florez KR, Aguirre AN. Toward a theory-driven model of acculturation in public health research. American Journal of Public Health 2006;96:1342-6.

106. Abraido-Lanza A, Chao M, Florez K. Do healthy behaviors decline with greater acculturation? Implications for the Latino paradox. Social Science & Medicine 2005;61:1243-55.

107. Salant T, Lauderdale DS. Measuring culture: a critical review of acculturation and health in Asian immigrant populations. Social Science & Medicine 2003;57:71-90.

108. Akresh IR. Dietary assimilation and health among hispanic immigrants to the United States. J Health Soc Behav 2007;48:404-17.

109. Barcenas CH, Wilkinson AV, Strom SS, et al. Birthplace, years of residence in the United States, and obesity among Mexican-American adults. Obesity (Silver Spring) 2007;15:1043-52.

110. Himmelgreen DA, Perez-Escamilla R, Martinez D, et al. The longer you stay, the bigger you get: length of time and language use in the U.S. are associated with obesity in Puerto Rican women. Am J Phys Anthropol 2004;125:90-6.

111. Kandula NR, Diez-Roux AV, Chan C, et al. Association of acculturation levels and prevalence of diabetes in the multi-ethnic study of atherosclerosis (MESA). Diabetes Care 2008;31:1621-8.

112. Hazuda HP, Haffner SM, Stern MP, Eifler CW. Effects of acculturation and socioeconomic status on obesity and diabetes in Mexican Americans. The San Antonio Heart Study. American Journal of Epidemiology 1988;128:1289-301.

113. Mainous AG, 3rd, Majeed A, Koopman RJ, et al. Acculturation and diabetes among Hispanics: evidence from the 1999-2002 National Health and Nutrition Examination Survey. Public Health Rep 2006;121:60-6.

114. Jaber LA, Brown MB, Hammad A, Zhu Q, Herman WH. Lack of acculturation is a risk factor for diabetes in arab immigrants in the US. Diabetes Care 2003;26:2010-4.

115. Cho J, Juon HS. Assessing overweight and obesity risk among Korean Americans in California using World Health Organization body mass index criteria for Asians. Prev Chronic Dis 2006;3:A79.

116. John EM, Phipps AI, Davis A, Koo J. Migration history, acculturation, and breast cancer risk in Hispanic women. Cancer Epidemiol Biomarkers Prev 2005;14:2905-13.

117. Kaplan MS, Huguet N, Newsom JT, McFarland BH. The association between length of residence and obesity among Hispanic immigrants. Am J Prev Med 2004;27:323-6.

118. Cairney J, Ostbye T. Time since immigration and excess body weight. Canadian Journal of Public Health Revue Canadienne de Sante Publique 1999;90:120-4.

119. Himmelgreen DA, Perez-Escamilla R, Martinez D, et al. The longer you stay, the bigger you get: length of time and language use in the U.S. are associated with obesity in Puerto Rican women. American Journal of Physical Anthropology 2004;125:90-6.

120. Marin G, Sabocal F, Marin B, Otero-Sabogal R, Perez-Stable EJ. Development of short acculturation scale for Hispanics. Hispanic Journal of Behavioral Sciences 1987;9:183-205.

121. Kato H, Tillotson JL, Nichaman MZ, Rhoads GG, Hamilton HB. Epidemiologic studies of coronary heart disease and stroke in Japanese men living in Japan, Hawaii and California: Serum lipids and diet. American Journal of Epidemiology 1973;97:372-385.

122. Park SY, Murphy SP, Sharma S, Kolonel LN. Dietary intakes and health-related behaviours of Korean American women born in the USA and Korea: the Multiethnic Cohort Study. Public Health Nutr 2005;8:904-11.

123. Yang EJ, Chung HK, Kim WY, Bianchi L, Song WO. Chronic diseases and dietary changes in relation to Korean Americans' length of residence in the United States. J Am Diet Assoc 2007;107:942-50.

124. Akresh I. Dietary assimilation and heatlh among Hispanic immigrants to the United States. J Health and Soc Behavior 2007;48:404-17.

125. Dixon LB, Sundquist J, Winkleby M. Differences in energy, nutrient, and food intakes in a US sample of Mexican-American women and men: findings from the Third National Health and Nutrition Examination Survey, 1988-1994. American Journal of Epidemiology 2000;152:548-57.

126. Koya DL, Egede LE. Association between length of residence and cardiovascular disease risk factors among an ethnically diverse group of United States immigrants. J Gen Intern Med 2007;22:841-6.

127. Groop LC, Tuomi T. Non-insulin-dependent diabetes mellitus--a collision between thrifty genes and an affluent society. Ann Med 1997;29:37-53.

128. British Medical Journal. Ecological studies. Available from http://www.bmj.com/epidem/epid.6.html. Accessed May 19, 2009.

129. CDC. National Health Interview Survey: Description. National Center for Health Statistics, 2007.

130. National Center for Health Statistics. Data File Documentation, National Health Interview Survey, 1997 (machine readable data file and documentation). Hyattsville, MD: National Center for Health Statistics, 2000.

131. National Center for Health Statistics. Data File Documentation, National Health Interview Survey, 1998 (machine readable data file and documentation). Hyattsville, MD: National Center for Health Statistics, 1999.

132. National Center for Health Statistics. Data File Documentation, National Health Interview Survey, 1999 (machine readable data file and documentation). Hyattsville, MD: National Center for Health Statistics, 2000.

133. National Center for Health Statistics. Data File Documentation, National Health Interview Survey, 2000 (machine readable data file and documentation). Hyattsville, MD: National Center for Health Statistics, 2001.

134. National Center for Health Statistics. Data File Documentation, National Health Interview Survey, 2001 (machine readable data file and documentation). Hyattsville, MD: National Center for Health Statistics, 2002.

135. National Center for Health Statistics. Data File Documentation, National Health Interview Survey, 2002 (machine readable data file and documentation). Hyattsville, MD: National Center for Health Statistics, 2003.

136. National Center for Health Statistics. Data File Documentation, National Health Interview Survey, 2003 (machine readable data file and documentation). Hyattsville, MD: National Center for Health Statistics, 2004.

137. National Center for Health Statistics. Data File Documentation, National Health Interview Survey, 2004 (machine readable data file and documentation). Hyattsville, MD: National Center for Health Statistics, 2005.

138. National Center for Health Statistics. Data File Documentation, National Health Interview Survey, 2005 (machine readable data file and documentation). Hyattsville, MD: National Center for Health Statistics, 2006.

139. National Center for Health Statistics. Variance Estimation and Other Analytic Issues in the 1997-2005 NHIS (Adapted from Appendices III and VII of the 2005 NHIS Survey Description Document, and Appendix III of the 2006 NHIS Survey Description Document). Available from http://www.cdc.gov/nchs/data/nhis/9705var.pdf. Accessed May 19, 2009.

140. National Center for Health Statistics. Research Data Center. Available from http://www.cdc.gov/nchs/r&d/rdc.htm. Accessed May 19, 2009.

141. Kaushal N. Adversities of acculturation? Prevalence of obesity among immigrants. Health Econ 2009;18:291-303.

142. Sanchez-Vaznaugh EV, Kawachi I, Subramanian SV, Sanchez BN, Acevedo-Garcia D. Do Socioeconomic Gradients in Body Mass Index Vary by Race/Ethnicity, Gender, and Birthplace? Am. J. Epidemiol. 2009;169:1102-1112.

143. Dixon D. Characteristics of the Asian Born in the United States. Migration Information Source, Migration Policy Institute, 2006.

144. Grieco E, Ray B. Mexican Immigrants in the US Labor Force. Migration Information Source, Migration Policy Institute, 2004.

145. Batalova J. College Educated FB in the US Labor Force. Migration Information Source, Migration Policy Institute, 2005.

146. Saydah SH, Geiss LS, Tierney E, Benjamin SM, Engelgau M, Brancati F. Review of the performance of methods to identify diabetes cases among vital statistics, administrative, and survey data. Ann Epidemiol 2004;14:507-16.

147. Thorpe LE, Upadhyay UD, Chamany S, et al. Prevalence and control of diabetes and impaired fasting glucose in New York City. Diabetes Care 2009;32:57-62.

148. Gregg EW, Gu Q, Cheng YJ, Narayan KM, Cowie CC. Mortality trends in men and women with diabetes, 1971 to 2000. Ann Intern Med 2007;147:149-55.

149. Tran TT, Yamamoto Y, Gesta S, Kahn CR. Beneficial effects of subcutaneous fat transplantation on metabolism. Cell Metab 2008;7:410-20.

150. Ho SC, Chen YM, Woo JL, Leung SS, Lam TH, Janus ED. Association between simple anthropometric indices and cardiovascular risk factors. Int J Obes Relat Metab Disord 2001;25:1689-97.

151. Society TE. Widely Used Body Fat Measurements Overestimate Fatness In African-Americans, Study Finds., 2009.

152. Deurenberg P, Deurenberg-Yap M. Differences in body-composition assumptions across ethnic groups: practical consequences. Curr Opin Clin Nutr Metab Care 2001;4:377-83.

153. Kelly T, Yang W, Chen CS, Reynolds K, He J. Global burden of obesity in 2005 and projections to 2030. International Journal of Obesity 2008;32:1431-7.

154. Wendler D, Kington R, Madans J, et al. Are racial and ethnic minorities less willing to participate in health research? PLoS Medicine / Public Library of Science 2006;3:e19.

155. Redstone I, Massey DS. Coming to stay: an analysis of the U.S. census question on immigrants' year of arrival. Demography 2004;41:721-38.

156. Willett WC, Blot WJ, Colditz GA, Folsom AR, Henderson BE, Stampfer MJ. Merging and emerging cohorts: not worth the wait. Nature 2007;445:257-8.

157. Yang Y, Land KC. Age-Period-Cohort Analysis of Repeated Cross-Section Surveys: A Multi-level Regression Models Approach. 2003.

158. Sanchez-Vaznaugh EV, Kawachi I, Subramanian SV, Sanchez BN, Acevedo-Garcia D. Differential effect of birthplace and length of residence on body mass index (BMI) by education, gender and race/ethnicity. Social Science & Medicine 2008;67:1300-10.

159. Park Y, Neckerman KM, Quinn J, Weiss C, Rundle A. Place of birth, duration of residence, neighborhood immigrant composition and body mass index in New York City. Int J Behav Nutr Phys Act 2008;5:19.

160. Allman-Farinelli MA, Chey T, Bauman AE, Gill T, James WP. Age, period and birth cohort effects on prevalence of overweight and obesity in Australian adults from 1990 to 2000. Eur J Clin Nutr 2008;62:898-907.

161. Holford TR. The estimation of age, period and cohort effects for vital rates. Biometrics 1983;39:311-24.

162. Hunt LM, Schneider S, Comer B. Should "acculturation" be a variable in health research? A critical review of research on US Hispanics. Soc Sci Med 2004;59:973-86.

163. Eamranond PP, Legedza AT, Diez-Roux AV, et al. Association between language and risk factor levels among Hispanic adults with hypertension, hypercholesterolemia, or diabetes. Am Heart J 2009;157:53-9.

164. National Heart, Lung, and Blood Institute, National Institutes of Health. Cardiovascular Disease in Asian and Pacific Islander Populations in the U.S.: Meeting Summary. 2008. Available from https://www.nhlbi.nih.gov/meetings/workshops/cvd-pacificislandar.htm. Accessed May 19, 2009.

APPENDIX A: Characteristics and Results of Clinical Trials that Assessed Effect of Lifestyle Interventions with Diet and/or Exercise on Type 2 Diabetes Prevention

Study Author (Year)	Type of Intervention		Relative Risk (95%CI)	Weight Change		NNT[a]	Follow up
	Intervention type (N)	Control group (N)		Interven-tion Group	Control Group		
Knowler, et al. (2002) DPP	Intensive Lifestyle intervention (1079)	Standard Lifestyle advice (1082)	0.42(0.34-0.52)	-5.45kg (12lbs)	-0.23kg (<0.5lb)	7	3yrs
Lindstrom, et al. (2003) Finnish DPS	Individual dietary session and exercise training (265)	General diet and exercise advice (257)	0.46(0.3-0.7)	-3.5kg	-0.9kg	9	3yrs
Li, et al. (2002) Da Qing study	Diet and exercise (126)	General health advice (133)	0.56(0.40-0.80)	-1.55 kg	-3.33kg	5	6yrs
Ramachandran, et al. (2006) IDPP	Life Style Modification (133)	Standard health care advice (136)	0.72(0.63-0.80)	+ 0.15 kg	+ 0.5 kg	6	3yrs
Kosaka, et al. (2004)	Intensive lifestyle intervention (102)	Standard lifestyle advice (356)	0.33(0.1-1.01)	-2.18kg	-0.39 kg	16	4yrs
Oldroyd, et al. (2005) UK	Intensive lifestyle intervention (37)	General advice (32)	0.76(0.31-1.85)	-1.8kg	+1.5kg	17	2yrs
Watanabe, et al. (2004)	New dietary education (86)	Regular diet (87)	0.51(0.13-1.96)	-	-	29	1yr
Wein, et al. (1999)	Intensive diet and exercise advice (100)	Routine diet advice (100)	0.86(0.30-2.46)	-	-	-	4.25yrs
Liao, et al. (2002)	Endurance exercise for 1hr three times a wk+ AHA step2 diet (32)	Stretching exercise three times a wk.+ AHA Step1 diet (32)	0.5(0.05-5.24)	-1.8±0.5	+0.7±0.6	29	2yrs

a: number need to be treated to prevent one case of type 2 diabetes in x (follow up) yrs.

APPENDIX B: National Health Interview Survey Questions

To provide an example of the types of questions used to define variables in NHIS analyses (Chapters 5 and 8-10), questions from NHIS 2005 are listed below. The variable name is listed first, followed by the specific questionnaire and section in which it can be found, the question, and possible responses.

Outcomes of Interest

BMI (kg/m^2)

This variable will be calculated from the following variables:
AHGT_FT, Sample Adult, Adult Health Behaviors
How tall are you without shoes?
02-07 2-7 feet
97 Refused
99 Don’t know
M Metric
Sample adults 18+

AHGT_IN, Sample Adult, Adult Health Behaviors
How tall are you without shoes?
*Enter ‘0’ if exactly AHGT_FT feet tall
00-11 0-11 inches
97 Refused
99 Don’t know
Sample adults 18+ who answered their height in feet

AHGT_M, Sample Adult, Adult Health Behaviors
How tall are you without shoes?
*Enter height in metric
0-2 0-2 meters
7 Refused
9 Don’t know
Sample adults 18+ who choose to give their height in metric measurements

AHGT_CM, Sample Adult, Adult Health Behaviors, page 13
*Enter centimeters
000-241 0-241 centimeters
997 Refused
999 Don’t know
Sample adults 18+ who answered their height in meters

AWGT_LB, Sample Adult, Adult Health Behaviors, page 13
How much do you weigh without shoes?
*Enter '500' for 500 pounds or more

050-500	50-500 pounds
997	Refused
999	Don't know
M	Metric

Sample adults 18+

AWGT_KG, Sample Adult, Adult Health Behaviors, page 13
How much do you weight without shoes?
*Enter weight in kilograms

022-226	22-226 kilograms
997	Refused
999	Don't know

Sample adults 18+ who choose to give their weight in metric measurements

Diabetes Status
DIBEV, Sample Adult, Adult conditions
Other than during pregnancy, have you EVER been told by a doctor or health professional that you have diabetes or sugar diabetes?/Have you EVER been told by a doctor or health professional that you have diabetes or sugar diabetes?

1	Yes
2	No
3	Borderline
7	Refused
9	Don't know

Sample adults 18+

Migration Variables

Foreign-born Status
PLBORN, Family, Family Socio-demographic
Were you/Was ALIAS born in the United States?

1	Yes
2	No
7	Refused
9	Don't know

All persons

Country of Origin
PLBORN2, Family, Family Socio-demographic
In what country were you/was ALIAS born?

60-696	Choices of countries
996	Country not listed
997	Refused

999 Don’t know
All persons not born in the United States

Age at Migration
This variable will be derived from the following variables:
AGEDOB_1, Household Composition
How old are you?

01-120	Age in years
997	Refused
999	Don’t know

USYR, Family, Family Socio-demographic
Earlier I recorded your/ALIAS’s date of birth as [fill AGEDOB].
In what year did you/ALIAS come to the United States to stay?

1880-Current Year	1880-Current Year
9997	Refused
9999	Don’t know

All persons not born in the United States

USLONG, Family, Family Socio-demographi
About how long have you/has ALIAS been in the United States?
*Enter ‘95’ for 95 or more years
*If less than 1 year given as a response, code the answer as ‘0’

00-94	00-94 years
95	95+ years
97	Refused
99	Don’t know

All persons not born in the United States and refused or don’t know was reported for USYR.

Region of Birth
This variable was recoded for public data use so there is no direct question relating to this variable in the questionnaire, but the categories for this variable are as follows:

United States	All persons born in one of the 50 United States or the District of Columbia
Mexico, Central America,Caribbean	Mexico, all countries in Central America and the Caribbean Island area, including Puerto Rico;Central America = Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, Panama
South America	All countries on the South American continent

Europe	Albania, Austria, Azores Islands, Belgium, Bosnia, Bulgaria, Corsica, Crete, Croatia, Czechoslovakia, Denmark, Finland, France, Germany, Great Britain, Greece, Herzegovina, Holland, Hungary, Iceland, Ireland, Italy, Liechtenstein, Luxembourg, Macedonia, Majorca, Malta, Monaco, Montenegro, Netherlands, Norway, Poland, Portugal, Prussia, Romania, Scotland, Serbia, Sicily, Slovakia, Spain, Sweden, Switzerland, Yugoslavia
Russia	Russia, Lithuania, Latvia, Ukraine, and all places formerly a part of (and former USSR areas) the USSR
Africa	All countries on the African continent, plus the Canary Islands, Comoros, Madagascar, Madeira Islands
Middle East	Aden, Arab Palestine, Arabia, Armenia, Bahrain, Cyprus, Gaza Strip, Iran, Iraq, Israel, Jordan, Kuwait, Syria, Lebanon, Oman, Palestine, Persia, Qatar, Saudi Arabia, Syria, Turkey, United Arab Emirates, West Bank, Yemen
Indian Subcontinent	Afghanistan, Bangladesh, Bhutan, British Indian Ocean Territory, Ceylon, East Pakistan, India,, Maldives, Nepal, Pakistan, Sri Lanka, Tibet,West Pakistan
Central Asia	Asia, Asia Minor, China, Japan, Mongolia, North Korea, South Korea
SE Asia	Borneo, Brunei, Burma, Cambodia, Christmas Island, Hong Kong, Indonesia, Laos, Malaysia, Myanmar, North Vietnam, Philippines, Singapore, South Vietnam, Taiwan, Thailand
Elsewhere	Guam, Bermuda, Canada, Greenland, Oceania, as well as “At sea,” “High seas,” “International waters,” “North America”
Unknown	Places that could not be classified in the above categories.

Socio-demographic characteristics

Ethnicity

There are 2 questions needed for this variable:
NATOR, Household Composition
Do you/Does ALIAS consider yourself/himself/herself to be Hispanic or Latino?
Where did your/ALIAS’s ancestors come from?

1	Yes
2	No

7 Refused
9 Don't know

RACE, Household Composition
What race or races do you/does ALIAS consider yourself/himself/herself to be? Please select 1 or more of these categories.

01	White
02	Black/African American
03	Indian (American)
04	Alaska Native
05	Native Hawaiin
06	Guamanian
07	Samoan
08	Other Pacific Islander
09	Asian Indian
10	Chinese
11	Filipino
12	Japanese
13	Korean
14	Vietnamese
15	Other Asian
16	Some other race
97	Refused
99	Don't know

***Note: The categories for the proposed analysis will be: Non-Hispanic white, Hispanic, Black, and Asian

Age
AGEDOB_1, Household Composition
How old are you?

01-121	Age in years
997	Refused
999	Don't know

Sex
SEX, Household Composition

1	Male
2	Female

Level of education
EDUC, Family, Family Socio-demographic
What is the HIGHEST level of school you have/ALIAS has completed or the highest degree you have/ALIAS has received?

00	Never attended/kindergarten only
01-11	1^{st} -11^{th} grade

12	12th grade, no diploma
13	GED or equivalent
14	High school graduate
15	Some college, no degree
16	Associate degree: occupational, technical, or vocational program
17	Associate degree: academic program
18	Bachelor’s degree
19	Master’s degree
20	Professional school degree (MD, DDS, DVM, JD)
21	Doctoral degree (PhD, EdD)
22	Child under 5 years old
97	Refused
99	Don’t know

Marital status
MARITAL, Family, Family Identification
Are you/Is ALIAS now married, widowed, divorced, separated, never married, or living with a partner?

00	Married
01	Widowed
02	Divorced
03	Separated
04	Never married
05	Living with partner
06	Refused
09	Don’t know

Ratio of Family Income to Poverty Threshold
This variable was calculated recoded for public data use so there is no direct question relating to this variable in the questionnaire, but the categories for this variable are as follows:

01	= "Under .50"
02	= ".50 to .74"
03	= ".75 to .99"
04	= "1.00 to 1.24"
05	= "1.25 to 1.49"
06	= "1.50 to 1.74"
07	= "1.75 to 1.99"
08	= "2.00 to 2.49"
09	= "2.50 to 2.99"
10	= "3.00 to 3.49"
11	= "3.50 to 3.99"
12	= "4.00 to 4.49"
13	= "4.50 to 4.99"
14	= "5.00 and over"

96 = "Undefinable"
99 = "Unknown"

Measures of access to health care
FHICOV, Family, Family Health Insurance
Are you/Is anyone in the family covered by any kind of health insurance or some other kind of health care plan?

1 Yes
2 No
7 Refused
9 Don’t know

All families

HIKIND, Family, Family Health Insurance
What kind of health insurance or health care coverage do you/does ALIAS have? Include those that pay for only one type of service (nursing home care, accidents, or dental care). EXCLUDE private plans that only provide extra cash while hospitalized.
*Enter all that apply.

01 Private health insurance
02 Medicare
03 Medi-Gap
04 Medicaid
05 SCHIP
06 Military Health Care
07 Indian Health Service
08 State-sponsored health plan
09 Other government program
10 Single service plan (eg dental, vision, prescriptions)
11 No coverage of any type
97 Refused
99 Don’t know

All persons in families where FHICOV=yes, don’t know, refused
***Note: This variable will be categorized as no insurance, Medicare, Medicaid, private, other

Region of Residence
This variable was recoded for public data use so there is no direct question relating to this variable in the questionnaire, but the categories for this variable are as follows:

Northeast – Maine, Vermont, New Hampshire, Massachusetts, Connecticut, Rhode Island, New York, New Jersey, and Pennsylvania

Midwest – Ohio, Illinois, Indiana, Michigan, Wisconsin, Minnesota, Iowa, Missouri, North Dakota, South Dakota, Kansas, and Nebraska

South – Delaware, Maryland, District of Columbia, West Virginia, Virginia, Kentucky, Tennessee, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, Oklahoma, Arkansas, and Texas

West – Washington, Oregon, California, Nevada, New Mexico, Arizona, Idaho, Utah, Colorado, Montana, Wyoming, Alaska, and Hawaii

Lifestyle characteristics

Smoking status
SMKNOW, Sample Adult, Adult Health Behaviors
Do you NOW smoke cigarettes every day, some days, or not at all?

1 Every day
2 Some days
3 Not at all
7 Refused
8 Don’t know

Sample adults 18+ who ever smoked 100 cigarettes

Alcohol use
ALC1YR, Sample Adult, Adult health behaviors
The next questions are about drinking alcoholic beverages. Included are liquor such as whiskey or gin, beer, wine, wine coolers, and any other type of alcoholic beverage.
In any ONE YEAR, have you had at least 12 drinks of any type of alcoholic beverage?

1 Yes
2 No
7 Refused
9 Don’t know

Sample adults 18+

ALCLIFE, Sample Adult, Adult health behaviors
In your ENTIRE LIFE, have you had at least 12 drinks of any type of alcoholic beverage?

1 Yes
2 No
7 Refused
9 Don’t know

Sample adults 18+ who have not had 12 drinks in any one year or don’t know if they did or refused to answer

ALC12MNO, Sample Adult, Adult Health Behaviors
In the PAST YEAR, how often did you drink any type of alcoholic beverage?

000 Never
001-365 1-365 day(s)
997 Refused
999 Don’t know

Sample adults 18+ who have had at least one drink in any one year or at least 12 drinks in their entire life

ALC12MTP, Sample Adult, Adult Health Behaviors
Enter time period for how often alcoholic beverages were consumed in the past year.
0 Never/None
1 Week
2 Month
3 Year
7 Refused
9 Don’t know
Sample adults 18+ who drank at least once in the past year

ALCAMT, Sample Adult, Adult Health Behaviors
In the PAST YEAR, on those days that you drank alcoholic beverages, on the average, how many drinks did you have?
*Enter ‘1’ if less than 1 drink
*Enter ‘95’ if 95 or more drinks
01-94 1-94 drinks
95 95+ drinks
97 Refused
99 Don’t know
Sample adults 18+ who have had at least 1 drink in the past year
***Note: This variable will be categorized as rare (<1 drink/week), moderate (between 1 drink/week and 2 drinks/day), heavy (>2 drinks/day)

Physical activity
VIGNO, Sample Adult, Adult Health Behaviors
The next questions are about physical activities (exercise, sports, physically active hobbies…) that you may do in your LEISURE time.

How often do you do VIGOROUS leisure-time physical activities for AT LEAST 10 MINUTES that cause HEAVY sweating or LARGE increases in breathing or heart rate?
000 Never
001-995 1-995 time(s)
996 Unable to do this type of activity
997 Refused
999 Don’t know
Sample adults 18+

VIGTP, Sample Adult, Adult Health Behaviors
Enter time period for vigorous leisure-time physical activities.
0 Never
1 Per day
2 Per week
3 Per month

4 Per year
6 Unable to do this activity
7 Refused
9 Don't know

Sample Adults 18+ who do vigorous activities

VIGLNGNO, Sample Adult, Adult Health Behaviors
About how long do you do these vigorous leisure-time physical activities each time?
01-995 1-995
997 Refused
999 Don't know
Sample adults 18+ who do vigorous activities

VIGLNGTP, Sample Adult, Adult Health Behaviors
Enter time period for length of vigorous leisure-time physical activities

1 Minutes
2 Hours
7 Refused
9 Don't know

Sample adults 18+ who do vigorous activities

MODNO, Sample Adult, Adult Health Behaviors
How often do you do LIGHT OR MODERATE LEISURE-TIME physical activities for AT LEAST 10 MINUTES that cause only LIGHT sweating or a SLIGHT to MODERATE increase in breathing or heart rate?
000 Never
001-995 1-995 time(s)
996 Unable to do this type of activity
997 Refused
999 Don't know
Sample adults 18+

MODTP, Sample Adult, Adult Health Behaviors
Enter time period for light or moderate leisure-time physical activities.

1 Never
2 Per day
3 Per week
4 Per month
5 Per year
6 Unable to do this activity
7 Refused
9 Don't know

Sample Adults 18+ who do light or moderate activities

MODLNGNO, Sample Adult, Adult Health Behaviors

About how long do you do these light or moderate leisure-time physical activities each time?

01-996	1-995
997	Refused
999	Don't know

Sample adults 18+ who do light or moderate activities

MODLNGTP, Sample Adult, Adult Health Behaviors
Enter time period for length of light or moderate leisure-time physical activities

1 Minutes
2 Hours
7 Refused
9 Don't know

Sample adults 18+ who do vigorous activities

APPENDIX C: New Immigrant Survey Questions

Below is a list of the survey questions from NIS that were used to define variables in the analyses found in Chapter 7.

Section A: Demographics

A6. [INTERVIEWER INSTRUCTION: CODE OR ASK IF NECESSARY:] I need to ask these questions of everyone, are you male or female?
MALE... 1
FEMALE...2
REFUSED..-1
DON'T KNOW..-2

A7. In what year were you born?
YEAR: #### [SOFT CHECK RANGE: 1890 TO present]
REFUSED..-1
DON'T KNOW..-2

A20. Now, I have a few questions about your education. How many years of schooling in total have you completed? ACCEPT BEST ESTIMATE
ENTER NUMBER: ## [SOFT CHECK RANGE=0 TO LESSER OF 30 OR AGE FROM A7] IF ZERO GO TO A29
REFUSED..-1
DON'T KNOW..-2

A24. What is the highest degree, diploma or certificate that you have received?
[INTERVIEWER: ENTER 995 IF NOT APPLICABLE]
(____________________) [MAX RANGE=80]
REFUSED..-1
DON'T KNOW..-2

0 = None
1 = Elementary
2 = Middle/junior high
3 = High school
4 = Associates
5 = Bachelors
6 = Masters
7 = Doctorate
8 = JD/MD
9 = Unspecified degree/diploma

A52. Are you now: [IWER: IF R IS MARRIED AND ALSO LIVING TOGETHER WITH SOMEONE ELSE IN A MARRIAGE-LIKE RELATIONSHIP, CODE "MARRIED" HERE.]

Married..1
Living together in a marriage-like relationship but not married 2
Separated..3 GO TO A141
Divorced...4 GO TO A141
Widowed...5 GO TO A141
Never married,not living with someone in a marriage like relationship 6 GO TO A141
REFUSED...-1 GO TO A141
DON'T KNOW..-2 GO TO A141

Section D: Health

D74 Have you ever smoked cigarettes? [Interviewer Instructions: BY SMOKING WE MEAN MORE THAN 100 CIGARETTES IN YOUR LIFETIME. DO NOT INCLUDE PIPES OR CIGARS.]
1.YES [D75]
2. NO [D81]
-2. DK [D81]
-1. RF [D81]

D75 Do you smoke cigarettes now?
1.YES [D76]
2. NO [D77]
-2. DK [D77]
-1. RF [D77]

D76 About how many cigarettes or packs do you usually smoke in a day now?
[IWER: PROBE A RANGE]
_______ [D76a] (number of cigarettes or packs per day)
-2. DK [D77]
-1. RF [D77]

D76a (unit)

1. CIGARETTES [D77]
2. PACKS [D77]

-2. DK [D77]
-1. RF [D77]

D81 Do you ever drink any alcoholic beverages such as beer, wine, or liquor?
(INTERVIEWER INSTRUCTION: REFERS TO CURRENT ALCOHOL CONSUMPTION)
1.YES [D82]
2. NO [D84]
-2. DK [D84]
-1. RF [D84]

D82 In the last three months, on average, how many days per week have you had any alcohol to drink? (For example, beer, wine, or any drink containing liquor.) (INTERVIEWER INSTRUCTION: EXACT NUMBER OF DAYS)
______________ [if 1-7: D83; if 0: D85]
-2. DK [D85]
-1. RF [D85]

D83 In the last three months, on how many days have you had four or more drinks on one occasion? [IWER: USE ZERO FOR NONE]
_____________________ [D85]
-2. DK [D85]
-1. RF [D85]

D84 Have you ever drunk alcoholic beverages?
1.YES [D85]
2. NO [D86]
-2. DK [D86]
-1. RF [D86]

D87 How often do you participate in vigorous physical exercise or sports such as Aerobics, running, swimming, or bicycling.
_____________ (digits) [D87a]
-2. DK [D88]
-1. RF [D88]

D87a (UNIT FROM D87)
1. PER WEEK [D88]
2. PER MONTH [D88]
3. PER YEAR [D88]
4. OTHER PERIOD (SPECIFY) [D87b]
-2. DK [D88]
-1. RF [D88]

D87b ____________________ [D88]
-2. DK [D88]
-1. RF [D88]

D114 Using a scale from one to ten where 10 indicates exactly the same and 1 means completely different, how would you compare the similarity in the diet in the food you now normally eat in the United States with the food you normally ate in your home country?
_______ [D115]
-2. DK [D115]
-1. RF [D115]

D129 About how much do you weigh?

_###.##__________ [D129a]
-2. DK [D130]
-1. RF [D130]

D129a (unit)

1. POUNDS [D130]

2. KILOGRAMS [D130]

-2. DK [D130]
-1. RF [D130]

D130 About how tall are you? (IWER: IF ANSWER IN FEET AND
INCHES OR METERS AND CENTIMETERS, FIRST COLLECT FEET/METERS AND
INCHES/CENTIMETERS NEXT)
___###.##_________ [D130a]
-2. DK [next module]
-1. RF [next module]

D130a (unit)

1. CENTIMETERS [next module]
2. METERS [D130b]
3. FEET [D130b]
4. INCHES [next module]

-2. DK [next module]
-1. RF [next module]

D130b ___####.##__________ [D130c](if additional centimeters or inches)
-2. DK [next module]
-1. RF [next module]

D130c (unit)

1. CENTIMETERS [next module]
2. INCHES [next module]

Section E: Health and Life Insurance

E2. Not including any government provided healthcare insurance including Medicare, Medicaid, CHAMPUS, CHAMPS-VA, are you covered by any private health insurance?

1. YES [E3]
2. NO [E9; unless C22_X=1: E12]

-2. DON'T KNOW [E9; unless C22_X=1: E12]
-1. REFUSED [E9; unless C22_X=1: E12]

E19. The next questions are about public health insurance in the United States. In the United States, Medicare is a public health insurance program for people 65 or older and for disabled persons. [Medicaid/*STATE NAME FOR MEDICAID*] is a public health insurance program for people with low incomes.
Are you currently covered by Medicare health insurance?

1. Yes [E20]
2. No [E20]
-2. Don't Know [E20]
-1. Refused [E20]

E20. Are you currently covered by your state's Medicaid program ?

1. YES [E21; unless A10=1 or if A15_XX does not equal biological, adopted or step-child in any loop: E22]
2. NO [E21; unless A10=1 or if A15_XX does not equal biological, adopted or step-child in any loop: E22]
-2. Don't Know [E21; unless A10=1 or if A15_XX does not equal biological, adopted or step-child in any loop: E22]
-1. Refused [E21; unless A10=1 or if A15_XX does not equal biological, adopted or step-child in any loop: E22]

Section K: Migration

K1. In what country were you born?
[COUNTRY PICK LIST WITH COUNTRY OF ORIGIN ON TOP] GO TO K2a_X
OTHER SPECIFY.............................97 GO TO K2
REFUSED...-1 GO TO K2a_X
DON'T KNOW...................................-2 GO TO K2a_X

38 = Canada
44 = China, Peoples Republic
47 = Colombia
55 = Cuba
62 = Dominican Republic
65 = El Salvaldor
69 = Ethiopia
88 = Guatemala
92 = Haiti
98 = India

105 = Jamaica
111 = Korea
135 = Mexico
152 = Nigeria
163 = Peru
164 = Philippines
166 = Poland
172 = Russia
215 = Ukraine
217 = United Kingdom
218 = United States
224 = Vietnam
301 = Europe and Central Asia
302 = East Asia, South Asia and the Pacific
304 = Other North America

305 = Latin America and the Caribbean
306 = Africa Sub-Saharan
307 = Middle East and North Africa
308 = Oceania
310 = Arctic region

The questions relating to the following data were not available from the questionnaires:

K4_1 Num 8 YEAR LEFT COUNTRY OF BIRTH
K5_1 Num 8 AGE LEFT COUNTRY OF BIRTH

APPENDIX D: Asian-Americans: Diabetes prevalence across U.S. and WHO weight classifications

Diabetes Care. June 9, 2009, doi: 10.2337/dc09-0573 [epub ahead of print].

Asian-Americans: Diabetes prevalence across U.S. and WHO weight classifications

Running Title: Asian-specific body mass index considerations

REENA OZA-FRANK, MS-MPH, RD[1]

MOHAMMED K. ALI, MBChB, MSc[2]

VIOLA VACCARINO, MD, PhD[1, 3]

K.M. VENKAT NARAYAN, MD[1,2,3]

[1]Emory University, Nutrition and Health Sciences Program, Graduate Division of Biomedical and Biological Sciences, Atlanta, GA

[2]Emory University, Hubert Department of Global Health, Rollins School of Public Health, Atlanta, GA

[3]Emory University, School of Medicine, Atlanta, GA.

Corresponding Author:
Reena Oza-Frank
1518 Clifton Road, NE
Atlanta, GA 30322
E-mail: roza@emory.edu

Word Count: 957

Number of Tables = 1

Abstract

Objective: To compare diabetes prevalence by WHO and U.S. BMI classifications among Asian Americans.

Research Design and Methods: Data on Asian American adults (n=7,414) from NHIS 1997-2005 were analyzed. Diabetes prevalence was estimated across weight and ethnic group strata.

Results: Regardless of BMI classification, Asian Indians and Filipinos had the highest overweight prevalence (34-47%, 35-47%, respectively, compared to 20-38% in Chinese; $P<0.05$). Asian Indians also had the highest ethnic-specific diabetes prevalence (ranging from 6-7% among normal weight to 19-33% among obese; compared to non-Hispanic whites, odds ratios (95% CI) for Asian Indians were 2.0 (1.5-2.6, adjusted for age and sex), and 3.1 (2.4-4.0) with additional adjustment for BMI.

Conclusions: Asian Indian ethnicity on its own, but not other Asian ethnicities, was strongly associated with diabetes. Weight classification as a marker of diabetes risk may need to accommodate differences across Asian subgroups.

In 2005-2006, the U.S. Asian population grew by 3.2%, to 14.9 million, the highest percentage growth of any race/ethnic group during that time period (1). Compared to other race/ethnic groups, Asians have higher adiposity per unit body mass index (BMI) (2), leading to increased risk of type 2 diabetes at lower BMIs (3). This led to the 2002 consensus statement from the World Health Organization (WHO) on BMI in Asian populations, which uses lower cut-points for BMI standards among Asians (normal weight 18.5-22.9 kg/m^2; overweight 23.0-27.4 kg/m^2; obese $\geq$27.5 kg/m$^{2)}$ compared with the traditional standards (normal weight 18.5-24.9 kg/m^2; overweight 25.0-29.9 kg/m^2; obese $\geq$30.0 kg/m^2): (3). Despite continued attention to this issue, the utility of the WHO Asian BMI standard as a marker of diabetes risk remains unresolved.

Research Design and Methods

Data on 7,414 Asian American and 140,291 non-Hispanic white adults aged 18-74 years were pooled from the nationally representative National Health Interview Survey (NHIS), for the years 1997-2005. One randomly selected adult per household was asked detailed information on use of health care services, health-related behavior, and health status (including height, weight, and diabetes).

Data were pooled to improve reliability of statistical estimates (4) by merging the adult person-level files for each year surveyed. National Center for Health Statistics (NCHS) guidelines were applied to combine NHIS data with the same sample design from years 1997-2005 into one data set (4). For this analysis, estimates represent the midpoint of the time interval of the pooled data (2001) (4). Sample weights provided by NCHS were used to account for the sampling design and non-response.

The proportions of overweight, obesity (using each BMI standard), and diabetes were age- and sex-standardized to the 2000 U.S. population. Proportions were then compared across Asian subgroups and with non-Hispanic whites. Multivariable logistic regression was used to calculate odds ratios for diabetes among Asian subgroups compared to non-Hispanic Whites. Two-tailed P-values of $\leq$0.05 were considered significant for all analyses. All analyses were done using SAS-callable SUDAAN software (version 9.0 Research Triangle Institute, Research Triangle Park, NC).

Results

Overweight and obesity prevalence were higher in all Asian subgroups and among non-Hispanic whites when using the WHO Asian standard compared to the general standard. Regardless of standard, Asian Indians and Filipinos had statistically similar proportions of overweight and obese subjects, but significantly higher than either Chinese or Other Asians categories (P<0.05) (online appendix). Non-Hispanic whites had the highest proportions of obese individuals (P<0.05) (online appendix).

Across either BMI standard, Asian Indians had the highest diabetes prevalence compared to all other Asian subgroups and non-Hispanic whites (P<0.05 for each) (Table 1). Diabetes prevalence in other Asian subgroups and non-Hispanic whites was statistically similar within the different weight categories.

Adjusted only for age and sex and compared to non-Hispanic whites, Asian Indians were more likely to report diabetes, (OR=2.0; 95%CI:1.5-2.6), but other Asian groups were not (Table 1). After adjusting for BMI, Asian Indians (OR=3.1; 95% CI:2.4-4.0), Chinese (OR=1.5; 95%CI:1.1-2.1), and Filipinos (OR=1.6; 95%CI:1.3-2.2) were each more likely to report diabetes, compared to non-Hispanic whites.

Conclusions

Although the prevalence of overweight and obesity are a function of BMI standard used, a consistent pattern of higher overweight prevalence was demonstrated in

Asian Indians and Filipinos compared to Chinese. Regardless of BMI standard, higher proportions of Asian Indians reported diabetes compared to other Asian subgroups or Whites. In addition, compared to non-Hispanic whites, Asian Indian ethnicity on its own was associated with diabetes, but other Asian ethnicities were not. After adjusting for BMI, all Asian subgroups were more likely to have diabetes compared to non-Hispanic whites.

Associations between BMI and diabetes have been previously shown to be modified by ethnicity (5). Studies have shown Filipinos have higher diabetes prevalence compared to Chinese (6). Asian Indians have higher prevalence of diabetes compared to several other subgroups and risk increases at lower BMI thresholds (5). Although we do not know why there are differences in diabetes prevalence across Asian subgroups, a possible explanation is the differential associations between quantity and distribution of adiposity and metabolic risk. For example, increased susceptibility to diabetes in Asian Indians when compared to Europeans (7) despite lower BMIs (8) is attributed to central adiposity, which may be due to lifestyle and/or genetic/intra-uterine predisposition.

The use of BMI as a measure of body proportion is a limitation because of its inability to provide information on body fat distribution and central adiposity. Continued, routine use of BMI in research and clinical practice is related to logistical ease in collecting height and weight (measured or self-reported) data. The WHO Asian weight standard is viewed as acceptable when more precise measures of adiposity are not available, however this study indicates that for Asian Indians, ethnicity alone may be as informative as BMI with regard to diabetes risk.

A limitation of this study is the use of self-reported data, including self-reported height, weight, and diabetes. Although undiagnosed diabetes cannot be assessed using NHIS, a study in New York found that Asians had a similar rate of undiagnosed diabetes to non-Hispanic whites (9). As a result, the current study most likely underestimates the total diabetes prevalence in these populations. Furthermore, NHIS is a cross-sectional survey and does not have body weight at the time of diabetes diagnosis. The main strength of this study is the use of nationally representative data with a relatively large Asian sample.

In conclusion, this study demonstrates that Asian Indian ethnicity, on its own, is associated with diabetes risk. We also find that the utility of the WHO Asian weight standard as a marker of diabetes risk may not be equivalent across different Asian subgroups. Prospective studies assessing the complex relationships between body shape, size, fat distribution, and development of cardio-metabolic diseases across heterogeneous Asian groups are needed.

Acknowledgements: This manuscript was supported by Grant/Cooperative Agreement Number 1R36SH000008-01 from CDC. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of CDC.

The authors would like to thank Solveig Argeseanu Cunningham, PhD and Mary Beth Weber, MPH for their thoughtful review of the manuscript.

Disclosure: Authors have no relevant conflicts of interest to disclose.

References

1. U.S. Census Bureau. Asian/Pacific American Heritage Month, May 2008. Available from: http://www.census.gov/Press-Release/www/releases/archives/cb08ff-05.pdf. Accessed March 24, 2009.

2. Bhansali A, Nagaprasad G, Agarwal A, Dutta P, Bhadada S: Does body mass index predict overweight in native Asian Indians? A study from a North Indian population. *Ann Nutr Metab* 50:66-73, 2006

3. World Health Organization: Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. *Lancet* 363:157-163, 2004

4. National Center for Health Statistics: Variance Estimation and Other Analytic Issues in the 1997-2005 NHIS (Adapted from Appendices III and VII of the 2005 NHIS Survey Description Document, and Appendix III of the 2006 NHIS Survey Description Document). Available from: http://www.cdc.gov/nchs/data/nhis/9705var.pdf. Accessed March 24, 2009

5. Nakagami T, Qiao Q, Carstensen B, Nhr-Hansen C, Hu G, Tuomilehto J, Balkau B, Borch-Johnsen K: Age, body mass index and Type 2 diabetes-associations modified by ethnicity. *Diabetologia* 46:1063-1070, 2003

6. Gomez SL, Kelsey JL, Glaser SL, Lee MM, Sidney S: Immigration and acculturation in relation to health and health-related risk factors among specific Asian subgroups in a health maintenance organization. *American Journal of Public Health* 94:1977-1984, 2004

7. McKeigue PM, Marmot MG: Mortality from coronary heart disease in Asian communities in London. *BMJ* 297:903, 1988

8. Raji A, Seely EW, Arky RA, Simonson DC: Body fat distribution and insulin resistance in healthy Asian Indians and Caucasians. *J Clin Endocrinol Metab* 86:5366-5371, 2001

9. Thorpe LE, Upadhyay UD, Chamany S, Garg R, Mandel-Ricci J, Kellerman S, Berger DK, Frieden TR, Gwynn C: Prevalence and control of diabetes and impaired fasting glucose in New York City. *Diabetes Care* 32:57-62, 2009

Table 1. Diabetes prevalence by BMI standard and odds ratios of diabetes by ethnic groups

		Diabetes Prevalence						Odds Ratios			
	n	Normal Weight (kg/m^2)		Overweight (kg/m^2)		Obese (kg/m^2)		Model 1	Model 2	Model 3	Model 4
		General: 18.5-24.9	WHO: 18.5-22.9	General: 25.0-29.9	WHO: 23.0-27.4	General: $\geq$30.0	WHO: $\geq$27.5				
White	140,291	2.4 (0.1)	2.2 (0.1)	4.2 (0.1)	3.11 (0.1)	10.8 (0.2)	8.7 (0.1)	1.0	1.0	1.0	1.0
Asian Indian	1357	6.8 (1.5)	6.5 (1.9)	8.8 (1.8)	8.3 (1.7)	32.9 (4.4)	19.4 (3.5)	2.0 (1.5-2.6)	3.1 (2.4-4.0)	3.0 (2.0-4.5)	3.5 (1.9-6.6)
Chinese	1510	2.7 (0.6)	2.2 (0.7)	5.2 (1.5)	3.8 (0.8)	16.8 (4.3)	11.2 (3.2)	0.8 (0.6-1.2)	1.5 (1.1-2.1)	1.6 (1.0-2.4)	2.3 (1.1-4.5)
Filipino	1485	4.4 (0.9)	5.9 (3.7)	6.2 (1.1)	3.7 (0.7)	10.9 (3.0)	11.3 (2.0)	1.2 (0.9-1.5)	1.6 (1.3-2.2)	1.6 (1.1-2.5)	2.2 (1.2-4.0)
Other Asian	3062	3.3 (0.5)	2.7 (0.5)	5.2 (0.8)	4.1 (0.6)	11.7 (2.8)	9.0 (1.7)	0.8 (0.7-1.0)	1.3 (1.0-1.7)	1.3 (1.0-1.7)	1.3 (0.8-2.2)

Prevalence estimates are age- and sex-standardized to the 2000 U.S. population (standard error)

Odds ratio for diabetes (95% confidence interval)

Model 1 adjusted for sex, age (continuous); Model 2 = Model 1 + BMI (continuous); Model 3 = Model 2 + education, poverty income ratio; Model 4 = Model 3 + physical activity, smoking and alcohol drinking status