Essays on the Effect of Environmental Factors on Health Choices and Health Behavior of Individuals

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Dedication

To Nirmal.

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Chapter 1.

Introduction

Obesity is one of the most expensive and preventable diseases. Hence, understanding the causes of the spread of obesity is quite important for addressing this public health concern and formulating related public policy. While some studies identify changes in individual behavior, such as an increased consumption of high-calorie food and a sedentary lifestyle, other studies consider weight gain and obesity prevalence through peer-to-peer networks to be responsible for increased obesity prevalence. In response, some studies have argued that, along with social networks, environmental factors have a confounding effect on individuals' weight gain. My dissertation attempts to isolate the effect of environmental factors and to study their impact on the spread of obesity.

Many obesity prevention efforts are concentrated on individual health behavior modification through education. Regulating individual behavior is ineffective if the surrounding environment is obesogenic. Hence, it is important to understand the effect of the surrounding environment on the health of individuals. Foreign individuals offer a unique opportunity to study the effect of different environmental factors on health. Most immigrants and international students coming to the United States have not been exposed to the social and environmental characteristics of the regions to which they migrate. Upon arrival foreign individuals undergo a process of assimilation and adopt the life-styles and habits of the local populations in the surrounding areas. In other words, foreign individuals make choices based on the options available in their new environments. In turn, these choices have an effect on the health of the individuals.

Causally identifying factors that influence the spread of obesity is difficult. Specifically, it is difficult to disentangle the contextual effects or environmental factors that drive individuals' weight gain from the self-selection of individuals into groups that share common, potentially unobserved, characteristics. In my first paper, I try to disentangle these competing explanations by collecting data from a unique population of international students. International students offer a unique opportunity to study the extent to which the environment causes obesity. Because international students have an imperfect ability to choose their destinations and are less aware of the social and cultural conditions in and around their university campuses, I argue that the prevalence of obesity in the surrounding area is plausibly exogenous to international students' university

choices. In this study, I surveyed international graduate students at 48 public universities across the United States. I used these data to investigate the effect of obesity prevalence in a particular region on international students' weight gain. I found statistically significant effects on the changes in students' weights. Students studying in areas with lower obesity rate showed significantly lower increases in their weights compared to students studying in areas with higher obesity rate. Evidence suggests that a region's environmental characteristics have a direct impact on individuals' weight gain.

In the second essay, I used the restricted-use New Immigrant Survey (NIS) 2003 data to study the association between the surrounding environmental factors and the body mass index (BMI) levels of recent immigrants to the United States. Immigrants also offer a unique opportunity to disentangle the self-selection and contextual effects while studying the effect of environmental factors on individuals' weight gain. I find statistically significant effects on the immigrants' BMI levels. Immigrants residing in areas with a lower obesity rate have significantly lower BMI levels compared to those residing in areas with a higher obesity rate. Results show that dietary change in immigrants is influenced by local environmental factors and that dietary change affects the immigrants' BMI levels.

The first two essays make two main contributions. First, they offer unique insight into the obesity epidemic by studying the effects of different environmental factors on the health of foreign populations —immigrants and international students— whose context makes it possible to identify these effects. Second, this paper contributes to the literature by collecting primary data collected from a less—studied population of international graduate students studying at universities in the United States.

The third essay is an intervention study designed to promote physical exercise among freshmen at a university in the Midwest. I investigated the effect of social norming and financial incentives on promoting physical exercise among randomly selected freshmen.

Previous studies have found that social norming and financial incentives have proved effective in modifying individual behavior. However, based on the results from my studies using these interventions, they have little effect on individuals' frequency of

physical exercise. One interpretation of my results is that social norming can cause students to reduce their positive behavior and might lead to an unintended boomerang effect.

The first two essays help to further understand how environmental factors drive the spread of obesity and mechanisms for the spread of obesity. Through the third essay, I investigate the effectiveness of two policies that have been proved to modify individual behaviors in encouraging healthy behavior. The results from the three series of essays add to our understanding of factors that influence individual choices and the subsequent effects of these factors on individual health.

Data collection and data access methods for all three essays have been approved by the Institutional Review Board at the University of Minnesota.

Chapter 2.

Do Environmental Factors Drive Obesity?

2.1 Introduction

Almost two-thirds of adults in the United States are obese or overweight (Catenacci et al. 2009). Obesity accounts for 5% to 10% of health care costs in the United States; obese men incur $1,152 more in health care expenditures than do men of normal weight, while obese women incur $3,613 more than do women of normal weight (Cawley and Meyerhoefer 2012). Further, obesity is the leading cause of premature death in the United States (Jia and Lubetkin 2010). Understanding the drivers of obesity is important.

Recent research has sought to identify mechanisms that explain the rise in obesity. Such mechanisms include: changes in diet and lifestyles (Mozaffarian et al. 2011), reduced physical activity (Ladabaum et al. 2014), reduced intake of fruits and vegetables (Popkin et al. 2012), and increased intake of fast food (Anderson et al. 2011). Studies also suggest obesity can spread through induction via social and geographical networks (Christakis and Fowler 2007). Some studies have argued that, along with social networks there is a confounding effect of environmental factors on weight gain and consequently spread of obesity among individuals (Cohen-Cole and Fletcher 2008). This research attempts to isolate the effect of environmental factors on individual weight gain.

Despite its pervasiveness, there is considerable regional variation in obesity rate across the United States (Wang et al. 2007). These range from 20.5% in Colorado to 35.1% in West Virginia (CDC 2012). This variation in the prevalence of obesity suggests that environmental factors, such as socio-economic, dietary and physical characteristics of a region, affect the local obesity rate (Chi et al. 2013; Hendrickson et al. 2006; Gordon-Larsen et al. 2006; Morland et al. 2006; Holsten 2009; Larsen and Gilliland 2009; Ford et al. 2010; Russell et al. 2011). The built environment of a region is responsible for the choices available to the individuals, which in turn affects their health. In this paper, I treat the local obesity rate as the outcome of the social, cultural, physical and dietary environment of a region. I ask the following question: if two otherwise similar individuals were assigned to environments with different obesity rate, would their weight-gain trajectories diverge?

Immigrants offer a unique opportunity to study the role played by the environmental mechanisms—considered broadly—that drive obesity. Upon arrival, immigrants are exposed to a new environment and social habits and thus undergo a process of assimilation that may induce them to adopt the native lifestyle and habits. This has a knock on effect on immigrant health. Indeed, while upon arrival immigrants are typically healthier than the native population, over time, their health status converges to that of the native population (Antecol and Bedard 2006; Malmusi et al. 2010).

International students are of particular interest as they have only limited control in choosing their destination environment. First, when applying to universities in the United States, international students may be less aware of the social and cultural conditions that characterize particular university campuses and therefore may apply to universities without regard to such conditions. Moreover, students may not be offered admission or funding at the universities they most want to attend. Because of this, environmental factors that drive obesity are likely unrelated to a student's choice of university.

By studying international students, I am able to offer novel and credible evidence about the ways in which environment drives obesity. To reiterate, I ask if two otherwise similar international students arrive in the United States but wind up in environments where prevailing obesity rate differ would their BMI or weight gain trajectories diverge. For example, does studying at a university in Mississippi where obesity rate is above 35 percent, have a different effect on students' health than studying at a university in Colorado where obesity rate is 20.5 percent?

This paper makes two main contributions. First, it offers unique insight into the obesity epidemic by studying the effects of different environments on a specific population—international students—whose particular circumstances make it possible to identify these effects. Second, to the best of my knowledge, this paper is the first broad study of how international students acculturate. Previous studies on international students have used samples from a single university (Almohanna et al. 2015; Brown et al. 2010). However, this study collected a nationally representative sample from 48 universities. The unique data for this study was gathered through an online survey of international graduate students currently studying at various public research universities. The survey

asked students' weight at the time they first entered the United States and at the time of the survey. It also asked students about the changes in their eating habits and changes in their lifestyle, social values and other behaviors since coming to the United States.

Estimating the causal effects of environmental characteristics is challenging. Following Manski (1993), this type of empirical analysis potentially conflates two different effects: contextual effects and self-selection. I am interested in the contextual effects of the exposure of international students to the common environmental factors that influence the native population in a given area. In this way, the behavior of international students may converge to that of the native population because they are influenced by the same physical or environmental factors. Self-selection is a threat to the identification of these effects, i.e. that people select into social groups that consists of individuals with similar observable and unobservable characteristics. If international students with higher BMI levels tend to select universities because they are located in regions with a higher prevalence of obesity, then it will be difficult to distinguish the effect of the local obesity rate on students' BMI levels.

The key identifying assumption, examined in greater detail below, is that the environmental factors that might lead to obesity are unrelated to the factors that affect students' choice of universities. When applying to universities in the United States, international students may be less aware of the social and cultural conditions inside and outside the university campus than would be the native population. While a student may choose to apply to universities with desirable environmental characteristics, acceptance and funding at any one university is uncertain and is exogenous to a student's desire. For example, students aspiring to pursue a graduate degree might apply to MIT. But MIT's graduate school acceptance rate is only 16% (MIT Annual Report 2007) and is not a function of the student's intensity of preferences. Hence, for students, the decision to attend the specific university is constrained by the set of universities to which they have been admitted and for many international graduate students the set of universities willing to offer funding. It can therefore be reasonably argued that international students are as if randomized with regard to the prevalence of obesity in the surrounding area.

The study evaluates whether being introduced to an environment with a more obese population affects the BMI levels of the international graduate student population as they assimilate into the new environment. The study also examines whether this effect differs across the regions of residence of the students in the United States. Results indicate that students who were introduced into a population with high obesity prevalence had a significantly larger increase in their BMI levels compared to those introduced into a population with lower obesity prevalence.

The paper proceeds as follows: First, I describe the research design that motivates my survey methodology, and I fully describe the variables of interest, then I describe the empirical approach and subsequently discuss results. The final section summarizes my conclusions.

2.2 Research Design and Methods

In principle, identifying the effect of environmental and social factors on health might require conducting randomized controlled trials in which specific individuals are assigned to different environments. Obviously such an experiment is neither feasible nor ethical.

To identify the effect of environmental factors on the weight changes of individuals, the research design must fulfill two main requirements. First, the design must consist of individuals with similar characteristics who have not been exposed to the environmental factors of the area in which they go to school in the United States. Second, the design must ensure that these individuals are randomly distributed across different regions of the country.

International graduate students constitute a unique population to address this question. In general, these students are in the same age range, have similar educational qualifications[1] and income levels[2], and they arrived in the United States considerably more physically fit[3] than the native population. This population also offers three advantages with respect to estimating environmental effects. First, to the extent that the

[1] International graduate students come to the United States with at least a four-year university degree.

[2] Graduate assistants are paid comparable wages across universities.

[3] International students are comparable to immigrants who enter the United States. According to the healthy immigrant theory, immigrants who come to the United States are healthier than the native population (Antecol and Bedard, 2006).

students are exogenously distributed across the landscape, the environmental effects on their BMI can be estimated without a self-selection bias. Second, as international students are a foreign population, they do not share the same initial environmental conditions shared by a university's pre-existing population. Third, because data on students' health characteristics is collected at the time of arrival in the country, the effect of intrinsic physical factors and extrinsic environmental factors on the change in their health characteristics was able to be examined. As a result, the self-selection bias is less of a factor driving the weight gain trajectory of international students and allowed for relative isolation of the contextual or shared environmental factor.

2.2.1 Survey Data Collection and Sample Characteristics

I contacted 214 public universities that had a graduate school and a dedicated office for international students. The basic information about the universities in each state was obtained from the National Center for Education Statistics. Universities were recruited by sending an initial inquiry email to the administrative unit responsible for international students (which I will refer to as International Students Office) or to another equivalent office at the university. The International Students Office is the administrative office primarily responsible for communicating with international students at a university and maintains a database of all international students studying at the university. If the International Students Office did not reply, I then proceeded to contact other administrative units at the university, such as the Office of Student Affairs, the Registrar's office, or the Office of Graduate Studies at the university. A consent form, an invitation letter to participate in the survey, and a link to access the survey were distributed to international graduate students through an email sent by an official at the university. The students could access the survey by clicking on the survey link contained within the email. The invitation letter states that survey participation was voluntary but if a student completed the survey, they would be entered into a lottery[4] to win one of 500 Amazon

[4] A lottery incentive is a chance to win a postpaid reward (gift cards are one such example) and is offered to survey participants for completing a survey. Findings from a survey of institutional researchers indicate that lottery incentives are a common and effective method of improving students' response rate to surveys (Porter and Whitcomb, 2003). In this study, every survey participant was automatically entered into a lottery.

gift cards[5] valued at $10 each. The lottery incentive was adopted to increase the completion and participation rate of the survey.

The survey was conducted between March 2013 and March 2014. The survey questions were adapted from the New Immigrant Survey 2003 and the Longitudinal Survey of Immigrants to Canada 2005. The survey questionnaire is available in Appendix A. Seventy-four universities granted permission to conduct the survey, of which only 54 universities actually participated in the survey. Nine universities circulated the survey through other channels[6] instead of via direct emails to students. These surveys had almost zero response rates from the students. Therefore, the final sample consists of survey data from 45 universities. The survey was emailed to every graduate student at each participating university. The response rate varied from 3 percent to 20 percent. In all, 3,758 students completed the survey. Of these, 232 were not graduate-degree seeking students and were dropped from the data set. Appendix Table A.6 reports the complete geographical distribution of the sample. It details the number of students who voluntarily participated in the survey at each university.

I conducted the survey using an online (web-based) survey tool to collect data from international graduate students at public universities in the 48 contiguous states of the United States. Relative to other methods (paper-based surveys, telephone surveys, and face-to-face surveys) a web-based survey, is inexpensive, fast, and can cover a wide geographical range. In addition, research has shown that web-based surveys have a higher completion rate and that the data collected from such surveys is equivalent to the data collected from other modes (Denscombe 2006). The survey questionnaire was made available online, and a link to the survey was sent to students at their institutional email addresses by officials at their respective universities (typically the International Students Office). The target population had internet access and by virtue of their attending a

[5] On completion of the survey, participants were directed to an external web-page where they were asked to enter their email addresses. These email addresses were entered into the drawing for Amazon gift cards. The information about the incentive on the first page of the survey was intended to increase the participation rate of the survey. The provision to enter the email addresses at the end of the survey was intended to increase the completion rate of the survey. I have given away more than 540 Amazon gift cards to the survey participants.

[6] Some universities put my survey on their blog, Facebook page or in the newsletter.

United States university, was well versed with using the internet on a day-to-day basis; hence an online survey posed little issue for data collection. The data collection process in this essay is approved by the Institutional Review Board at the University of Minnesota.

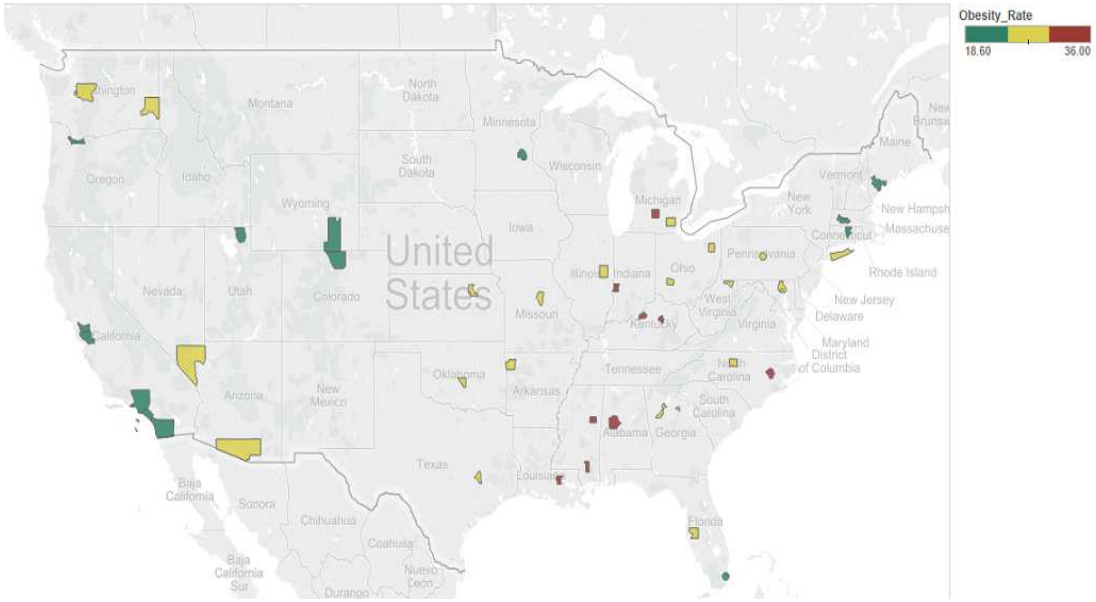
Table 2.1: Summary Statistics of Survey Participants' Socio-demographic Variables (n=3,526)

Variable	Mean/Frequency (Std. Dev.)	Min	Max
Male	0.464 (0.498)	0	1
Age (years)	27.51 (4.38)	22	36
Years spent at current university	2.24 (1.70)	1	7
Unmarried/Single	54.07	0	1
Number of adults in household	2.69 (1.46)	1	9
Funded by university	71.04	0	1
From India	28.25	0	1
From China	25.32	0	1
From SE Asia	11.51	0	1
From SW Asia	10.33	0	1
From Latin America and Caribbean	8.67	0	1
From Africa	5.65	0	1
From Europe and Canada	10.32	0	1

Table 2.1 summarizes the characteristics of the sample collected from all the universities. Men comprised roughly 46 percent of the sample, and the average student was 27 years old. Students in the sample had spent an average of 2 years at their respective universities, and 70 percent received some form of university funding to

support their studies. Almost 70 percent of the international graduate students came from India, China, and other Asian countries. Comparing this sample to the population of international graduate students in the United States (Open Doors Report, 2013) suggests that the survey data is broadly representative of the current international student population (Appendix Table A.7). According to the report 67 percent of the international graduate students are from Asian countries (Open Doors Report, 2013).

Figure 2.1: Geographical Distribution of Survey Respondents



I link each university to the county and the health and demographic information for the county. The county-level data was obtained from the County Health Rankings and Roadmaps program (County Health Rankings National Data, 2013). Figure 2.1 shows the universities/counties in which the survey was conducted. The obesity rate is defined as the percentage of adults who are obese or overweight.[7] The local obesity rate is the obesity rate of the county in which each university is located. For example, the University

[7] Body Mass Index (BMI) is calculated as the weight of an adult in kilograms divided by the square of their height in meters. An adult with a BMI between 25 and 29.9 is considered overweight. An adult with a BMI of 30 or higher is considered obese.(Source: www.cdc.gov)

of Illinois at Urbana Champaign (UIUC) is located in Champaign County. The local obesity rate faced by the students studying at UIUC reflects the obesity rate of Champaign County (i.e., 27). Note that in the sample of 3,526, 432 students were residing in a different part of the United States before starting their graduate school program at the current university. For these students, the local obesity rate was calculated as the weighted average of the local obesity rate of the previous region and the current region.

BMI levels are calculated from the students' self-reported weight and height measurements. In the survey I asked the students their weight at the time of their arrival in the country and their weight at the time of the survey. The change in weight variable is the difference between these two self-reported weights. Note that there might be a reporting bias due to the self-reported height and weight. I am unable to adjust the self-reported BMI measures as there is no reference data with measured height and weight available for international students or even for the broader immigrant population (Cawley et al., 2009). Despite the potential for misreporting, previous studies have found no difference in estimates using self-reported data and corrected data for height and weight (Cawley, 2000; Antecol and Bedard, 2006).

To compare the health characteristics of the students, I conducted simple tests for equality between the changes in weight of the students across three regions. Results listed in the Appendix Table A.1 show that the average change in weight was different between the low obesity regions and high obesity regions and the medium obesity regions and high obesity regions. Appendix Table A.2 shows that the weight and BMI of the students at the time of their arrival to the United States are significantly lower than their weight and BMI at the time of the survey. This indicates that there is variation in the change in weight of the students across the regions. It also shows a significant difference in the weight of the students at the time of arrival and their weight at the time of the survey.

To examine the heterogeneous effects in the relationship between the students' change in weight and the local obesity rate, I stratify the sample into three groups based on the percentile distribution of local obesity. These were: 1) **low** obesity regions, in which the obesity rate was less than equal to 25% (less than 33 percentile); 2) **medium** obesity regions, in which the obesity rate was between 25% and 28% (between 34 to 66

percentile); and 3) **high** obesity regions, in which the obesity rate was greater than 28 (higher than 66 percentile). Table 2.2 below shows the descriptive statistics for weight and the BMI characteristics of the sample. Students studying in low obesity regions have the lowest average change in their BMI and weight as compared to those studying in regions with medium and high obesity rate. It also shows that the average weight and BMI of the students increased with the amount of time spent at the university.

Table 2.2: Descriptive Statistics for Health Variables

Variable	All	Obesity Regions		
		Low <= 25	Medium 25 < x <= 28	High >28
Avg. Change in BMI (kg/m^2)	0.65 (1.93)	0.52 (1.69)	0.57 (1.88)	1.04 (2.12)
Avg. Change in Weight (in lbs.)	4.17 (12.66)	3.21 (12.02)	3.64 (12.28)	6.45 (13.85)
Sample Size	3,526	1,222	1,435	875

2.2.2 Empirical Analysis and Results

The key identifying assumption is that a graduate student's choice of school is not affected by the local obesity rate. I, now investigate that assumption empirically. I, then analyze the environmental effects on the change in weight and BMI of the students.

a. Selection Bias

I examined the maintained assumption in two different ways. First, I empirically tested the correlation of the baseline values of students' characteristics with local obesity rate. Then, using the survey data, I analyzed the reasons given by international students for their institution selection.

The key identifying assumption for this study is that international students do not choose their university based on the surrounding environment as represented by the local obesity rate. To test for the exogeneity of students' choice of university, I look at the correlation between baseline characteristics, such as initial weight or initial BMI, and the

local obesity rate. This method is a variant of the test for random assignment described by Sacerdote (2001) and Carell et al. (2010). Specifically, I estimate the following equation.

$$(Initial\ Weight)_i = \beta_0 + \beta_1(Current\ Height)_i + \beta_2(Local\ Obesity\ Rate)_{ig} + \beta_3\,\theta_i + u_i \quad (1)$$

where θ_i is a vector of individual controls for student *i* studying at university *g*. Included controls are age, time spent at university, gender, number of adults in household, county population, rural or urban surroundings, access to parks, availability of recreation facilities in the area, food environment variables and average number of sunny days in the region. The dependent variables in the equation consist of initial weight, initial BMI, and region of origin. Results are displayed in Table 2.3.

If the maintained assumption is incorrect and selection bias is an issue in the data, I would expect baseline characteristics to be significant predictors of local obesity rate. This would suggest that international students are aware of the local obesity rate in a region and this would affect their decision of which university to attend.

However, I find no statistical evidence that any of the international graduate students' baseline characteristics are correlated with the local obesity rate. The point estimate coefficient on the local obesity rate is essentially zero, implying that selection bias is unlikely to drive the main results shown in the empirical model section below. This test provides some evidence that the international students are not aware of the local obesity rate when they apply to universities and likely do not make their university choices primarily based on that knowledge.

Table 2.3: Test for Exogenous Distribution of the Students

Variable	Correlation Co-efficient	Standard Error
Initial BMI	-0.016	0.009
Initial Weight	-0.048	0.305
From India	-0.003	0.003
From China	0.001	0.004
From Asia	-0.004	0.005
From Africa	0.004	0.003
From Europe	-0.001	0.001
From Latin America	0.001	0.002

Standard Errors are corrected for heteroscedasticity and clustered at student level. p<0.1, 0.05, 0.01 *, **, ***

Further, to investigate why students chose to enroll in a particular university, I asked the students to select the main factor for choosing their current university. In Table 2.4, we can see that availability of funding and university ranking were the two most important reasons for students selecting their university. Location of the university was an important factor for only 8 percent of the students. The findings in Table 2.3 are also supported by survey data from other sources. The I-Graduate 2009 survey of international students shows that 45 percent of students choose their universities based on recommendations from friends, while 41 percent of students make their decision based on the information provided on a university website (I-Graduate, 2009). Survey data, from mine and others provide support for the notion that local environmental factors are not predictive of where students choose to enroll.

Table 2.4: Reasons for Selecting a University

Reason	Percentage of Students
Availability of funding from the University	38.51
University Ranking	32.83
Location of University	8.42
Relatives in the nearby area	3.98
Friends studying at the University	2.48
Other Reasons	11.35

b. Empirical Model

Because international students' choice of university is not likely driven by local obesity rate, it is possible to investigate the role of local environment plays in weight gain. In the survey I asked the students their weight at the time of their arrival in the country and their current weight at the time of the survey. I estimated the environmental or contextual effects using a simple linear model where students' weight change as a function of the local obesity rate. The specification is as follows:

$$\Delta Weight_i = \beta_0 + \beta_1(Current\ Height)_i + \beta_2(Local\ Obesity\ Rate)_i + u_i \qquad (2)$$

where *i* is the individual student. As the students in the sample are adults, instead of using the BMI, I focus on change in weight conditional on height as the explanatory variable.

There are several possible explanations for why the coefficient on the local obesity rate is different from zero in this model. When international students arrive at a university, they not only interact with the students from their own country, they also interact with domestic students. This interaction with the native population transmits information about the social, cultural and physical environment. These contextual effects have an influence on the behaviors of the international students, a relationship referred to as assimilation in the social science literature. Numerous studies have shown the positive effect of assimilation on the BMI levels of foreign populations (Antecol and Bedard 2004; Basu and Insler 2013). Within the context of the neighborhood in which an

international student performs daily activities, the neighborhood's native population may influence the student's behavior. This influence can have a positive or negative effect on a student's health. For instance, consider a case of physical activity comparison between Minnesota and Arkansas. According to America's Health Rankings (2013), 83 percent of Minnesota's population engages in some kind of physical activity or exercise compared to 69 percent of Arkansas's population. It is possible that, compared to the less active environment in Arkansas, the more physically active environment in Minnesota influences foreign individuals to adopt the prevailing physically fit lifestyle. Similarly, if the obesity rate—that is, the percentage of obese people—is higher in a region, that rate might have a positive influence on the international student's weight as compared to a region with a lower obesity rate.

In addition to calculating the local environmental or contextual effects on the weight gain in international student population, I also investigated the interaction between local obesity rate and the time international students spent in a particular region in the United States. I therefore estimate the following Equation 3.

$$\Delta Weight_i = \beta_0 + \beta_1(Current\ Height)_i + \beta_2(Low\ Obese\ Regions)_i * Time_i + \beta_3(Medium\ Obese\ Regions)_i * Time_i + \beta_4(High\ Obese\ Regions)_i * Time_i + u_i \quad (3)$$

I estimated three specifications of equations 2 and 3 using ordinary least squares. In the first specification, I estimated the influence of the local obesity rate on the change in weight (BMI) of international students. In the second specification, I included individual students' characteristics as control variables. In the third specification, I performed a validity check by adding the environmental variables, such as access to parks, recreation facilities, rural areas, food environment and average number of sunny days to equation 3, as these factors might be correlated to the local obesity rate. The data for the county-level environmental variables is obtained from the County Health Rankings and Roadmaps program (County Health Rankings National Data, 2013).

Table 2.5: Influence of Local Obesity Rate on Weight Gain in International Graduate Students

Dependent Variable: ΔBMI	(1)	(2)	(3)
Local Obesity Rate	0.043***	0.046***	0.039**
	(0.009)	(0.010)	(0.013)
Dependent Variable: $\Delta Weight$ (in lbs)	(1)	(2)	(3)
Local Obesity Rate	0.284***	0.302***	0.285***
	(0.060)	(0.068)	(0.088)
Height	-0.267	0.112	0.117
	(0.694)	(0.745)	(0.771)
Individual Control Variables	No	Yes	Yes
Environmental Variables	No	No	Yes
Observations	3,526	3,526	3,526

Standard Errors are corrected for heteroscedasticity and clustered at student level. p<0.1, 0.05, 0.01 *, **, ***. The individual control variables are age, time spent at the university, gender, number of adults in the household, number of children, region of origin. The environmental variables are access to parks, if rural area, recreation facilities per capita, weather, grocery stores per 1000, if classified food desert, percent of population with limited access to healthy food, per capita fast food restaurants, and physical inactivity rate. Complete estimation result is presented in Appendix Table A.4

Table 2.5 displays the results for all specifications of equation 2. The results show that local obesity rate has a positive and significant effect on weight changes of international graduate students. In fact, the students' weight increases by 0.3 lbs for every one percent increase in the obesity rate, which is equivalent to 0.75 lbs of weight gain and a 0.15 point increase in BMI for international students for every standard deviation increase in the local obesity rate. Consider for example, instead of being admitted to a university in Colorado (20 percent obesity rate), if a student was admitted to a university in Texas (30 percent obesity rate), he or she would gain 3 lbs more weight in Texas than he or she would have gained in Colorado.

Table 2.6 presents the estimation results for the same three specifications of Equation 3. Almost 60 percent of international students living in high obesity regions experienced weight gain as compared to 52 percent of students in medium obesity regions and 47 percent in low obesity regions. Results show that the students living in high obesity regions gained weight faster relative to students living in other. For every additional year, a student in low obesity region (ex. Colorado) gains 1.2 lbs as compared to a student in high obesity region (ex. Texas) gains 1.8 lbs. For instance, instead of being

admitted to a university in Colorado, if a student was admitted to a university in Texas, he or she would gain 50 percent more weight in Texas that she would gain in Colorado. Results also show that students in the country for a longer period of time gained more weight. This result is similar to previous research which has found that the weight of immigrants increases with the increase in their time of residence in the United States (Antecol and Bedard 2006; Kaushal 2009). The magnitude of the coefficients is robust across all the three specifications. One important thing to emphasize in this section is that all the students gained weight. The rate of weight gain is higher in high obesity regions.

Test results for the comparison of the estimates in Table 2.6 are presented in Appendix Table A.3. They show that the coefficient for a high obesity region is statistically different than the coefficients for the low and medium obesity regions. The coefficients from the low and medium obesity regions are not statistically different from each other.

To verify the increase in change in weight with respect to the increase in the local obesity rate, I plotted the coefficients for the university against the local obesity rate. To do this, I plotted the average weight change by region against the local obesity rate. The graph is represented in Figure 2.2, which shows that the effect of the local obesity rate on the weight change of the international students is positive and increasing.

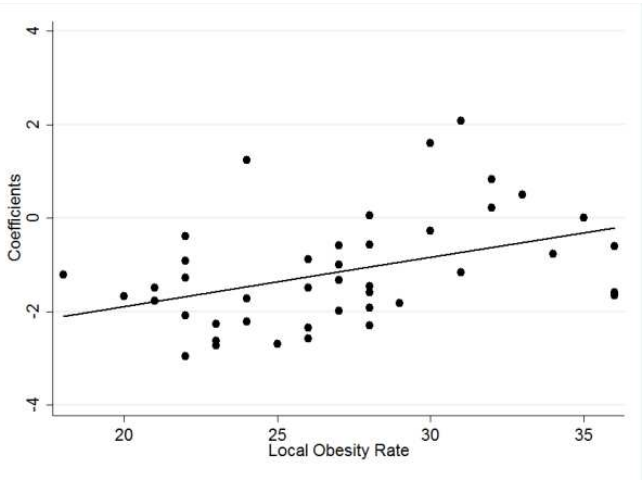
Table 2.6: Influence of Interaction between Local Obesity Rate and Time of Residence on Weight Gain in International Graduate Students

Dependent Variable: ΔBMI	(1)	(2)	(3)
Low Obesity Regions * Time of Residence	0.184*** (0.029)	0.154*** (0.036)	0 .154** (0.036)
Medium Obesity Regions* Time of Residence	0.200*** (0.037)	0.180*** (0.037)	0.176*** (0.039)
High Obesity Regions * Time of Residence	0.278*** (0.027)	0.252*** (0.032)	0.247*** (0.035)
Dependent Variable: ΔWeight	(1)	(2)	(3)
Low Obesity Regions * Time of Residence	1.210*** (0.203)	0.976*** (0.258)	1.025*** (0.271)
Medium Obesity Regions* Time of Residence	1.271*** (0.201)	1.122*** (0.243)	1.077*** (0.272)
High Obesity Region * Time of Residence	1.833*** (0.186)	1.647*** (0.219)	1.595*** (0.249)
Individual Control Variables	No	Yes	Yes
Environmental Variables	No	No	Yes
Observations	3,526	3,526	3,526

Standard Errors are corrected for heteroscedasticity and clustered at student level. p<0.1, 0.05, 0.01 *, **, ***. Individual control variables are age, time spent at the university, gender, number of adults in the household, number of children, region of origin. The environmental variables are access to parks, if rural area, recreation facilities per capita, weather, grocery stores per 1000, if classified food desert, percent of population with limited access to healthy food, per capita fast food restaurants, and physical inactivity rate. Complete estimation result is presented in Appendix Table A.5

The estimates in all columns of Tables 2.5 and 2.6 are consistent with the argument that students exposed to environments with higher obesity rate gained more weight than students exposed to an environment with lower obesity rate.

Figure 2.2: Estimates of University Fixed Effects by Local Obesity Rate



2.3 Mechanism of Environmental Influence on Weight Gain

Results have shown that students who are enrolled in universities where the obesity rates are higher gain more weight than those who enroll in universities where the obesity rates are lower. I try to understand the mechanism of weight gain by looking at the changes in the behaviors of international students after their arrival. In the survey, the students were asked about changes in their dietary and physical exercise behavior subsequent to their arrival in the United States. The answers for these questions were based on a five-point Likert scale. In particular, the questions asked students to provide the degree of change in their eating and exercising habits after their arrival in the United States, such as changes in their consumption of meat, sweets, fast food, restaurant food, and changes in their physical activity. The survey also asked questions based on lifestyle changes, such as changes in values and cultural beliefs.

I first tested several eating, exercising, and social behavior characteristics as potential mechanisms by estimating the effect of local obesity rate on each characteristic individually. I then re-estimated Equation 2, including the behavioral characteristics. This follows Yakusheva et al. 2014, where researchers studied the influence of behavioral characteristics on the mechanism for weight gain. By estimating Equation 2 I am able to see how local obesity rate is correlated with the changes in specific individual behavior associated with weight gain.

Table 2.7: Change in Dietary and Physical Exercise Behavior

Variable	All	Low Obesity Region	Medium Obesity Region	High Obesity Region
Change in Diet	0.87	0.85	0.86	0.87
Change in Values	0.76	0.74	0.77	0.79
Unhealthy Behavioral Change				
Increase in Fast Food	0.60	0.48	0.59	0.64
Increase in Television and movies	0.30	0.28	0.27	0.36
Increase in Sweets	0.53	0.50	0.52	0.56
Increase in Meat	0.37	0.37	0.37	0.39
Increase in Energy Drinks	0.22	0.20	0.21	0.25
Increase in Soda	0.49	0.46	0.48	0.53
Healthy Behavioral Change				
Increase in Exercising	0.53	0.60	0.53	0.48
Increase in Cooking at home	0.61	0.62	0.62	0.52
Increase in Food at home	0.40	0.40	0.50	0.32
Increase in Fresh Vegetables	0.38	0.40	0.40	0.34

Table 2.7 shows the percentage of students who underwent dietary and physical exercise behavior changes in each obesity region. I converted the Likert scale responses into binary measures to indicate a change in a particular behavior or activity after arrival in the United States. Results show that a lower percent of students living in low obesity regions underwent a change in diet as compared to students living in high obesity regions.

For the purpose of this study, unhealthy activities are defined as an increase in consumption of fast food, sweets, meat, energy drinks and soda, and an increase in television and movie viewing. Healthy activities are defined as increases in exercising, increases in cooking at home, increases in food consumed at home, and increases in consumption of fresh vegetables.

Roughly 33 percent more students living in high obesity regions than in low obesity regions reported an increase in fast food consumption. Similarly, 20 percent more students living in the high obesity regions reported an increase in soda, and 18 percent more students in these regions reported an increase in energy drink consumption. Twenty-five percent more students living in low obesity regions reported an increase in exercising; 20 percent more students in these regions reported an increase in cooking meals at home, and 18 percent more students reported an increase in consumption of fresh vegetables as compared to students in high obesity regions.

Results show that international students who increased their consumption of meat, sweets, fast food, soda and energy drinks subsequent to their arrival at a United States university displayed a positive weight gain trajectory. Similarly, students who increased their levels of physical activity or exercise and who increased their levels of consumption of fresh vegetables displayed a non-increasing weight gain trajectory after coming to the United States. Behavioral changes such as learning local values, socializing with local people or consumption of ice-cream and sweets do not have a significant effect on changes in students' weight.

Table 2.8: Mechanism for Environmental Effect on Weight through Change in Behavior

Dependent Variable:	$\Delta Weight$	ΔBMI
Local Obesity Rate	0.102***	0.033***
	(0.056)	(0.031)
Increase in consumption of Food at home	-0.338***	-1.042***
	(0.067)	(0.220)
Increase in Exercise at the Gym	-0.258***	-0.734***
	(0.064)	(0.193)
Increase in consumption of Fresh Vegetables	-0.158**	-0.445**
	(0.061)	(0.185)
Increase in consumption of Cooking at home	-0.069	-0.110
	(0.087)	(0.212)
Increase in consumption of Soda or Carbonated Drinks	0.308***	0.928***
	(0.066)	(0.192)
Increase in consumption of Energy Drinks	0.138***	0.468***
	(0.069)	(0.208)
Increase in consumption of Fast Food	0.257**	0.795**
	(0.108)	(0.326)
Increase in consumption of Sweets and Ice-creams	0.470***	1.352***
	(0.077)	(0.239)
Learn New Values	0.013	0.031
	(0.064)	(0.132)
Socialize with people from the US	0.019	0.041
	(0.058)	(0.180)
Observations	3,526	3,526

Standard Errors in parentheses are corrected for heteroscedasticity and clustered at county level. * p < 0:10, ** p < 0:05, *** p < 0:01. The individual control variables are age, time spent at the university, gender, number of adults in the household, number of children, region of origin. The environmental variables are access to parks, if rural area, recreation facilities per capita, weather, grocery stores per 1000, if classified food desert, percent of population with limited access to healthy food, per capita fast food restaurants, and physical inactivity rate.

The change in magnitude of the local obesity rate coefficient is smaller after inclusion of the change in behavior variables. But the behavioral variables are significant with the expected signs. Given these results, it is likely that changes in eating and exercising behaviors after coming to the United States affects the weight gain mechanics of international graduate students.

Results from Table 2.8 show that the behavioral change variables reduced the magnitude of the local obesity rate coefficient for change in weight from 0.284 to 0.102. Even though individual behavior factors explain weight gain, there is still some information in the environmental factor which is responsible for weight gain. This again supports the earlier findings that environmental factors drive weight gain in individuals.

2.4 Robustness Check

While local obesity rate does not seem to drive students' enrollment decision, I now turn to a series of additional factors that may bias results. The first bias is the possibility of obtaining a higher survey response rates from students at universities in regions with higher obesity rate. To investigate this, I regressed the response rate from each university on the local obesity rate of region. Response rate is calculated as the number of responses divided by the number of students to whom the survey was emailed. Results displayed in Table 2.9 show the local obesity rate is not a significant predictor of the response to the survey, thus suggesting that selection bias is not driving the results.

Table 2.9: Test for Bias due to Response Rate (N =3,526)

Variable	Correlation Co-efficient	Standard Error
Response Rate	0.194	0.224
R-square	0.11	

Standard Errors in parentheses are corrected for heteroscedasticity and clustered at county level. * p < 0:10, ** p < 0:05, *** p < 0:01. The demographic control variables are Age, time spent at the university, gender, number of adults in the household, number of children, region of origin

A second concern could be due to oversampling of certain types of students. The sample descriptive statistics in Table 2.1 show that the sample consists of more students from India than from China. According to the Institute of International Education (2013) data, the population of international graduate students consists of more students from China than from India. This raises the question whether the results from this paper are generalizable to a broader set of students or population.

In order to understand if oversampling was an issue in the data, I constructed weights for the sample with country of origin as the auxiliary variable. The weights for the sample from each country were calculated as

$$w_i = \frac{percentage\ of\ population\ from\ country\ i}{percentage\ of\ sample\ from\ country\ i}$$

The percentage of international students' population for a country was calculated using the data from Open Doors Report 2013.Using these weights, I re-estimated equations 2 and 3. The results are displayed in Table 2.10 and 2.11, which show that the results in Table 2.5 and 2.6 are not significantly different from the results in Table 2.10 and 2.11. This suggests that results are generalizable to the broader population of international students at public universities.

Table 2.10: Influence of Local Obesity Rate on Weight Gain using Sample Weighing

Dependent Variable: ΔBMI	(1)	(2)	(3)
Local Obesity Rate	0.045***	0.047***	0.039**
	(0.008)	(0.010)	(0.013)
Dependent Variable: $\Delta Weight$ (in lbs)	(1)	(2)	(3)
Local Obesity Rate	0.232***	0.240***	0.249***
	(0.056)	(0.070)	(0.082)
Height	-1.245	-0.720	-0.855
	(1.095)	(1.136)	(1.176)
Individual Control Variables	No	Yes	Yes
Environmental Variables	No	No	Yes
Observations	3,526	3,526	3,526

Standard Errors in parentheses are corrected for heteroscedasticity and clustered at county level. * p < 0:10, ** p < 0:05, *** p < 0:01. The individual control variables are age, time spent at the university, gender, number of adults in the household, number of children, region of origin. The environmental variables are access to parks, if rural area, recreation facilities per capita, weather, grocery stores per 1000, if classified food desert, percent of population with limited access to healthy food, per capita fast food restaurants, and physical inactivity rate.

Table 2.11: Influence of Interaction between Local Obesity Rate and Time of Residence on Weight Gain using Sample Weighing

Dependent Variable: ΔBMI	(1)	(2)	(3)
Low Obesity Regions * Time of Residence	0.190*** (0.024)	0.174*** (0.034)	0 .175** (0.035)
Medium Obesity Regions* Time of Residence	0.201*** (0.028)	0.190*** (0.034)	0.185*** (0.035)
High Obesity Region * Time of Residence	0.297*** (0.029)	0.275*** (0.033)	0.270*** (0.035)
Dependent Variable: ΔWeight (in lbs)	(1)	(2)	(3)
Low Obesity Regions * Time of Residence	1.266*** (0.179)	1.207*** (0.208)	1 .207** (0.209)
Medium Obesity Regions* Time of Residence	1.284*** (0.184)	1.247*** (0.202)	1.230*** (0.205)
High Obesity Region * Time of Residence	1.876*** (0.096)	1.808*** (0.106)	1.793*** (0.115)
Individual Control Variables	No	Yes	Yes
Environmental Variables	No	No	Yes
Observations	3,526	3,526	3,526

Standard Errors in parentheses are corrected for heteroscedasticity and clustered at county level. * p < 0:10, ** p < 0:05, *** p < 0:01. The individual control variables are age, time spent at the university, gender, number of adults in the household, number of children, region of origin. The environmental variables are access to parks, if rural area, recreation facilities per capita, weather, grocery stores per 1000, if classified food desert, percent of population with limited access to healthy food, per capita fast food restaurants, and physical inactivity rate.

2.5 Discussion and Conclusion

Understanding the causes that contribute to the spread of obesity is important for developing appropriate policies to curb obesity. The results of this study show that the local environmental factors drive the weight gain in international students. Individuals make decisions from the choices available to them through their environment. These choices have an effect on the health of the individuals, in this case weight gain. Hence the environment factors directly or indirectly influence the health of the population.

The results of this research make it clear that a region's obesity rate has a positive effect on the weight gain of an individual. When an individual is introduced into an environment with a higher obesity rate, the individual often adopts the behaviors prevalent in the environment, which can influence the individual's weight or BMI. I collected primary data from the international graduate students studying at public universities across the United States. I considered that students' choice of university was not motivated by the existing obesity rate at the university or the obesity rate of the region in which the university is located.

As international students acculturate to new environments, they adopt the lifestyle of the people in that environment with whom they directly or indirectly interact. International students interact with the surroundings in the form of consuming local food, adopting social and cultural habits, or communicating with the native population. Statistically strong evidence indicates that highly obese environment has a positive effect on the students' weight. I also find that international students who spend more time in regions with higher obesity rate gain more weight as compared to students in regions with lower obesity rate. This study takes us a step closer in understanding the impact of environmental factors on spread of obesity. It also raises question on the kind of policies that need to be implemented to fight the obesity epidemic.

An obesogenic environment provides fewer healthy choices for individual behavior modifications. Hence, an unhealthy environment may prohibit or slow the effect of individual-level interventions. In addition, it is difficult to implement policies that regulate individual behaviors such as food choices and dietary and physical activity habits. A more realistic approach to developing public policy to slow the rising rates of obesity will focus on modifying the environment to provide individuals with healthier options so that individuals are motivated to make healthier choices, thus modifying their behavior and potentially contributing to a healthier lifestyle.

While this study offers important findings, there are a few drawbacks as well. The main drawback is the use of self-reported weight as a dependent variable. There is a chance of recall bias in students reporting their weight at the time of their arrival at a United States university and in misreporting their current weight. As both measures of

weight were reported at the same time, and the dependent variable is the difference between the two weights, the time invariant reporting bias is differenced out (Burkhauser and Cawley 2008). I discuss other possible sources of bias in the results, including oversampling and response rate, in the next section.

Even though the research design of this study is such that it many that plague prior estimates of contextual effects, these findings might not be generalized to a broader population. International students are a unique population and they are placed in an unknown environment where they are obligated to make their own decisions in response to the options offered by novel surroundings. Hence the results might hold for similar populations such as the immigrant population in the United States or in other developed countries. The results from the behavior mechanism for weight gain show that changes in dietary and physical activity behaviors, which are caused by exposure to a new environment, drive weight changes in students.

It is important to note that weight gain is happening, even for international students in areas of lower obesity rate. There might be several competing reasons for weight gain. Over half of the students in the survey indicated increase in exercise since coming to the United States. Weight gain in such individuals might be due to increase in their muscle weight. Further research on the mechanisms causing behavior changes in high obesity regions as compared to low obesity regions is vital in order to understand the spread of obesity and the implementation of optimal public policies. There is a possibility that international graduate students might be experiencing a phenomenon similar to Freshmen 15. Further research is required to evaluate this graduate weight gain phenomenon. This research also underlines the need for designing specific intervention for international students to educate them about the healthier choices available in their environment and increase their awareness about the diet-related diseases.

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Chapter 3.

Effect of Environment on Obesity Prevalence: Evidence from Recent Immigrants

3.1. Introduction

The rising rate of obesity is a policy concern as it is associated with increased health risks and health costs. Obesity has been linked to chronic diseases such as coronary heart diseases, hypertension, type 2 diabetes, cancer, hypertension and depression (Dixon 2010; Hu 2008). These diseases account for 21 percent of health care cost in the United States (Cawley and Meyerhoefer 2012).

Obesity is largely viewed as an individual outcome originating from individual choices (Swinburn et al. 2011; Olander et al. 2013; Pulsford et al. 2013). Changes in individual behavior, such as increases in fast-food consumption (Rosenheck 2008), increases in the consumption of sweetened beverages (Malik et al. 2010), unhealthy eating habits (Deshmukh-Taskar et al. 2010), physical inactivity (Scarborough et al. 2011), and increases in television viewing time (Boulous et al. 2012), have been associated with the rise in obesity. Research has also found that in addition to social networks, confounding environmental factors are responsible for the spread of obesity (Cohen-Cole and Fletcher 2008), but isolating the effect of environmental factors has been challenging. My research focuses on trying to isolate environmental factors and study their effect on obesity prevalence in the immigrant population.

The local environment is a function of factors such as the socio-economic status in the area, access to supermarkets and grocery stores, concentration of fast food restaurants, physical infrastructure, economic policy, cultural environment and proximity to recreational centers and parks. These characteristics define choices available to individuals and in turn affect their health. Previous research has shown that characteristics of the local built environment influence the local obesity rate (Hendrickson et al. 2006; Gordon-Larsen et al. 2006; Morland et al. 2006; Holsten 2009; Larsen et al. 2009; Ford et al. 2010). For this paper we consider the local obesity rate as the long run outcome of the general equilibrium process by which inhabitants affect their environment and, in turn are affected by it. They specifically might be affected by the social, cultural, and physical environments of a region.

For this paper, the local obesity rate of a region is defined as the percent of overweight and obese adults in a given region. Even though the obesity rate in the United

States is 35.7 percent there is heterogeneity in the regional obesity rate (Ogden 2014). The state-level obesity rate varies from 21.3 percent in Colorado to 35.1 percent in West Virginia (Center for Disease Control and Prevention (CDC) 2013). Within a state there is a variation between obesity rates of the counties. In Texas, for example, the county adult obesity rates vary from 21 percent to 37 percent (County Health Rankings Data 2015).

According to the healthy immigrant theory, immigrants on arrival are healthier than the native population is. With the passage of time, the health status of these immigrants converges to that of the natives (Antecol and Bedard 2006; Malmusi et al. 2010). Immigrants are a unique population in that before arrival, they are not exposed to the local environment of the region, to which they are immigrating. Upon arrival in the United States, they are potentially influenced by the habits and life-style of their new region of residence. Indeed, two identical immigrants may face very different local environments if they move to different parts of the United States. As a result, they may adopt different life-styles and dietary habits because they are exposed to different environments in the United States. These choices have an effect on the health of the immigrants. This paper seeks to understand if varying environmental factors that are a function of local obesity rates have a varying effect on the body mass index (BMI) levels of the immigrants. Consider two new immigrants who have similar characteristics. One of them immigrates to Mississippi where the obesity rate is more than 32 percent, while the other individual immigrates to Colorado, where the obesity rate is 20 percent. Environmental factors that affect the obesity rate in Mississippi are different from those in Colorado. We ask the question, how does exposure to different environments affect the health status of otherwise similar individuals?

Assimilation has been shown to strongly influence the diets of immigrants (Neuhouser et al. 2004; Edmonds 2005). On arrival, immigrants adopt the dietary pattern of the native population, which leads to the increased consumption of meat, fast food and soda (Lesser et al. 2014). One explanation for these changes is the set of food options available to immigrants in their new region of residence. Change in diet has shown to affect the health of the immigrant population (Larsen et al. 2003; Fitzgerald et al. 2006;

Akresh 2007). We also try to evaluate the effect of environmental factors on the dietary change of immigrants and its effect on the health of the immigrants.

The paper adds to the literature by studying the association between the local obesity rate and the prevalence of obesity in new immigrants. Consider this: if people were to choose their place of residence independent of the local obesity rate and the factors that influence it, then the regression of people's BMI on the local obesity rate would yield causal results. However, this is a very strong assumption, mainly for two reasons. First, people's choice of a place of residence is a choice of that place's local environmental characteristics, which also influence the local obesity rate. Second, the place of residence has a contextual effect on people. They adapt to the local environment prevalent in the surrounding, which is influenced by the observable and unobservable preferences of other people living in that area. As immigrants are born abroad, they are not exposed to the cultures of the regions of the United States. Hence, they are unaware of the local characteristics of the different regions. If we assume that new immigrants choose to live in a region independent of the local obesity rate and the factors that drive it, then we can causally identify the role that environmental factors play in obesity prevalence.

To the best of the authors' knowledge, this is one of the first papers that attempt to isolate the effect of local environmental characteristics on the BMI levels of immigrants. The effect of the duration of residence in the United States on immigrants' BMI levels has been studied (Kaushal, 2009). The current paper extends prior work by considering how the weight gain rate is affected by the local obesity rate. In other words, do immigrants gain more weight faster in regions with higher obesity rate? We also study the mechanism of obesity prevalence by considering the effect of additional environmental factors on immigrants' dietary change and its effect on their health.

This paper proceeds as follows. Section 2 describes data and the variables used in the analysis. Section 3 presents empirical evidence for the effect of the local obesity rate on the BMI of immigrants; the effect of local obesity on the dietary change of immigrants; and the effect of dietary change on the BMI of immigrants. Section 4 discusses and interprets the results for policy implication and provides a conclusion.

3.2. Data and Variables: New Immigrant Survey, 2003 (NIS 2003)

3.2.1 Data

We use the restricted-use version of the New Immigrant Survey, 2003 (NIS 2003), a nationally representative survey of legal immigrants to the United States. The survey was conducted in 2003–2004 and is a random sample of the full cohort of immigrants who have newly acquired their legal permanent residency. The data consist of 8,573 respondents who were sampled from electronic administrative records assembled by the United States Citizenship and Immigration Services (USCIS). The geographic sampling design includes the largest 38 counties, a random sample of 15 county pairs from the remaining counties, the top 85 metropolitan statistical areas (MSAs) and a random sample of 10 MSAs from the remaining MSAs.

NIS 2003 data include self-reported weight and height, demographic characteristics, and immigration-related information such as country of origin, county of current residence, and duration of residence in the United States. The actual sample consists of 8,573 individuals who completed the interview; the resulting response rate was 68.6%. Those individuals who reported to have migrated to the United States directly from their origin countries (7,247) are included in the sample. Those individuals who were overseas during the interview are removed from the sample (217). Respondents with data missing for age, height, weight, and units of height and weight are also dropped, leading to a sample size of 6,673. In the end, respondents missing a country of origin, state of current residence, or unreal BMI ($\leq 12.5\ \mathrm{kg/m^2}$ or $\geq 42.5\ \mathrm{kg/m^2}$) are excluded from the analysis (Roshnia et al. 2008). The final sample consists of 5,493 individuals with 2,710 men and 2,783 women.

We use restricted[8]-use NIS data available through the Princeton Population Center, as they contain detailed geographical identifiers. Access to restricted files enables us to measure the local obesity rate at the county and city levels. The access to restricted-

[8] The author would like to thank Dr. Timothy Beatty and the Minnesota Population Center (NIH/NICHD R24HD041023) for helping her obtain access to and providing a secure place to use the New Immigrant Survey Restricted Use Data.

use NIS-2003 data us approved by the Institutional Review Board at the University of Minnesota.

3.2.2 Variable Description

Health Outcome

Body mass index (BMI) is used as a measure of excess weight. NIS 2003 includes self-reported height and weight data. Self-reported height and weight can be used to calculate the BMI. All of the measurement units for weight and height are converted into kilograms and meters. BMI is calculated as the weight of an individual in kilograms divided by the square of height in meters.

Dietary Change Variables

We attempt to measure the changes in diet quality using three questions from the NIS survey. The first question asks about the change in diet after immigration. Answers are provided on a scale of 1, indicating a completely different diet to 10 indicating exact same diet. The second is an open-ended question. It asks about the most important food item the immigrants rarely ate before. Respondents were allowed to provide more than one response to these questions, and their answers were recorded verbatim. The third question is a mirror image of the second question that asks about the most important food item the immigrants rarely get a chance to eat. We developed five variables using these three questions which are summarized in the change in diet section of Table 3.1. Construction of these variables is adopted from Akresh (2007).

Local Obesity Rate

The local obesity rate is the outcome variable of the local environmental characteristics of a region. It is defined as the percent of obese and overweight adults in a county. County-level obesity rates are obtained from the Centers for Disease Control and Prevention's county-level list of indicators data (CDC 2004). NIS 2003 data were collected in 2003–2004, and the county-level obesity rates used are for the year 2004.

3.2.3 Descriptive Statistics

Table 3.1 reports summary statistics for the demographic variables of the entire sample of male and female respondents separately. The important characteristic is that more male immigrants have a college degree and are employed compared to female immigrants. The average duration of residence in the United States for the entire sample is six years, and 70 percent are married. The highest numbers of immigrants are from Latin America, Mexico, and the Caribbean followed by Asian countries. Very little difference exists between the male and the female immigrants with respect to their self-reported measures of dietary change ($p > 0.1$). Data show that women reported a higher consumption of vegetables and fruits and a lower consumption of meat and fish as compared to men. Men have spent more time studying in the United States than women have and a higher percentage of male immigrants report employer-sponsored citizenship than do female immigrants.

Acculturation as a measure of English language preference has been found to be a risk factor affecting the obesity trajectory among immigrants (Unger et al. 2004). More than 50 percent of immigrants consider themselves to speak English “well” or “very well”. At work and with friends, a higher percent of male immigrants than female immigrants report using English.

Table 3.1 Descriptive Statistics of the Adult Immigrants in NIS-2003 (part 1 of 2)

Variable	Entire Sample	Female	Male
Age	38.50 (13.16)	38.93 (13.25)	37.92 (12.32)
College Degree (=1)	30.77%	31.94%	37.92%
Employed (= 1)	59.39%	46.15%	73.29%
Married (=1)	70.31%	69.48%	71.19%
Number of Children	1.44 (1.68)	1.57 (1.71)	1.30 (1.64)
Duration of Residence in the United States	6.01 (6.75)	5.48 (6.79)	6.12 (7.05)
Citizenship sponsored through employer (=1)	27.90%	21.25%	35.33%
From Asia	33.08%	24.66%	32.04%
From Africa	12.08%	9.28%	15.01%
From Europe	16.43%	1.75%	2.72%
From Latin America and the Caribbean	42.33%	45.96%	48.05%
<u>Health Variables</u>			
BMI (kg/m^2)	24.99	24.35	25.83
Obese/Overweight (=1)	43.83%	38.48%	49.52%
<u>Change in Diet</u>			
Dietary Change Variables since coming to the US 1 = very different 10 = very similar	5.66 (3.10)	5.71 (3.14)	5.61 (3.06)
Reduction in Ethnic Food	24.01%	18.33%	30.98%
More Fast Food	20.99%	19.99%	22.11%
More Meat	13.53%	11.98%	15.15%
More Fruits and Vegetables	17.58%	19.40%	15.69%
<u>Acculturation Variables</u>			
Speaks English Well/Very Well	52.13%	47.58%	56.86%
Speak English with Spouse	26.10%	25.72%	26.50%

Table 3.1 Descriptive Statistics of the Adult Immigrants in NIS-2003 (part 2 of 2)

Variable	Entire Sample	Female	Male
Speaks English at Work	67.51%	60.47%	74.82%
Speaks English with Friends	50.93%	45.96%	56.09%
Education in US (years)	0.875 (2.31)	0.785 (2.21)	0.967 (2.41)
N	5,493	2,710	2,783

Table 3.2 shows the relationship between BMI and the time spent in the United States by the respondents. As noted in prior work (Bharmal et al. 2014; Afable et al. 2015; Ro et al. 2015) BMI increases as a function of duration of residence for men and women. To examine the heterogeneous effects in the relationship between the BMI levels and the time of residence, we divide the sample into three groups based on the percentile distribution of time of residence. The average BMI for the three categories is statistically different ($p < 0.01$) for the male and female immigrants.

Table 3.2 Descriptive Statistics for BMI with Respect to Time of Residence in the United States

BMI (kg/m^2)	Time of Residence < = 2 years	2 years < Time of Residence <= 7 years	Time of Residence > 7 years
Male	24.39	25.22	26.92
N	1,094	713	933
Female	23.45	24.01	26.13
N	1,243	747	856

3.3. Empirical Analysis

Previous research indicates that the process of acculturation varies by gender (Cerrutti and Massey 2001); hence the analysis is performed separately for men and women.

An individual's behavior is influenced by his or her interaction with the environment. Prior work has found that local obesity rates are affected by local

environmental factors (Cohen-Cole and Fletcher 2008). Community-level effects, or contextual effects, arise due to shared experiences. In other words, individuals living in the same area are exposed to the same fast food restaurants, the same exercise and wellness facilities, and the same obesity rate. These factors affect the health or BMI levels of all individuals who might or might not be in one another's social circles. When a foreign individual is introduced into a population, he/she voluntarily or involuntarily adapts to the given social and physical infrastructure there.

We want to quantify the contribution of each level of variation (individual-level effects, acculturation effects and environmental effects) on immigrants' BMI levels. We estimate equation (1) by ordinary least squares. We use probability weights so that the estimates are representative of the population of the immigrants. Standard errors are corrected for heteroscedasticity and are clustered at the county level to correct for arbitrary within county correlation

$$BMI_i = \beta_1(local\ obesity\ rate)_i + \beta_2 Z_i + u_i \quad (1)$$

where the local obesity rate corresponds to the percent of adults who are obese or overweight in the county of residence of immigrant *i* and *Z* is a vector of individual-level control variables corresponding to immigrant *i*.

We estimate three versions of equation (1) using ordinary least squares. In the first specification, we estimate the influence of the local obesity rate on BMI measures of immigrants. We control for individual specific demographic variables such as age, level of education, annual household income, employment status, number of children, and region of origin.

In the second version, we augment the first version with acculturation variables such as English speaking skills; language spoken with friends, with a spouse, and at work; and years of education in the United States. This is summarized by equation (2)

$$BMI_i = \beta_1(local\ obesity\ rate)_i + \beta_2 Z_i + \beta_3 Acculturation_i + u_i \quad (2)$$

In the third version, we control for environmental variables that are likely to be correlated with the local obesity rate, such as rural areas, percentage of immigrant population in the county, poverty rate in the county, and percentage of people belonging to the White/Caucasian race. It is represented by equation (3)

$$BMI_i = \beta_1(local\ obesity\ rate)_i + \beta_2 Z_i + \beta_3 WAcculturation_i + \beta_4 W_i + u_i \quad (3)$$

where W is a vector of environmental variables in the region of residence of immigrant *i*. The duration of residence in the United States is considered to be one of the major acculturation factors related to weight gain and higher BMI levels among immigrants (Kaushal 2008). To account for the effect of the local obesity rate coupled with the time spent in the country on the BMI levels, we also estimate the interaction of the duration of residence in the United States with the local obesity rate using equation (4).

$$BMI_i = \beta_1(local\ obesity\ rate)_i * (Time\ of\ Residence)_i + \beta_2 Z_i + \beta_3 Acculturation_i + \beta_4 W_i + u_i \quad (4)$$

Time of Residence is a vector of three categories of time of residence of the immigrants namely 1) time of residence <= 2 years; 2) 2 years < time of residence <= 7 years; and 3) time of residence > 7 years. This model was estimated using ordinary least squares for the same three specifications as in equation (1).

3.3.1 Effect of Dietary Change on Prevalence of Obesity

Using the variables of change in diet after immigrating to the United States, we try to establish a mechanism for the prevalence of obesity among the immigrants. Changes in diet have shown to have an effect on the health of the immigrant population (Satia-About et al. 2010). Dietary assimilation can result from the adoption of healthy or unhealthy eating habits resulting in a positive or negative effect on the health of immigrants. To understand the effect of dietary assimilation on the health of the immigrants, we estimate the influence of change in diet and physical exercise of the immigrants on their BMI using the following equation (5)

$$Y_i = \beta_1(local\ obesity\ rate)_i + \beta_2 Z_i + \beta_3 Acculturation_i + \beta_4 W_i + \beta_5 Y_i + u_i \quad (5)$$

All equations are estimated using ordinary least squares separately for the male and female immigrants. The standard errors are corrected for heteroscedasticity and clustered at county level.

3.4. Results

Table 3.3 presents the estimation results for equations 1, 2 and 3, predicting the BMI of the immigrants with respect to the variable of interest, the local obesity rate. The coefficient for the local obesity rate is statistically significant and positive only for male immigrants. The result implies that for every one percent increase in the local obesity rate the BMI of male immigrants increases by 0.046 kg/m^2. Consider this: Instead of immigrating to Colorado (obesity rate: 20%) if a person would have immigrated to Texas (obesity rate: 30%), his BMI would be 0.46 kg/m^2 more than his BMI in Colorado would have been. Translating this into weight will mean that instead of immigrating to Colorado if a person would have immigrated to Texas, he would have gained 2.67 lbs more weight in Texas than he would have gained in Colorado.

The inclusion of acculturation variables in column 2 does not change the magnitude of the estimate, indicating that the acculturation variables are not correlated to the local obesity rate. The correlation coefficient between the local obesity rate and BMI for male participants is 0.04. The inclusion of environmental variables increases the magnitude of the estimated coefficient for the local obesity rate by almost 58%, from 0.046 to 0.073. This implies that 67.5% i.e., (0.046-0.073)/0.04, of the correlation between the local obesity rate and male respondents' BMI level can be attributed to the heterogeneity among counties rather than the heterogeneity among respondents.

Results show that male immigrants who are employed are more likely to have higher BMI levels. This might be helpful in explaining the difference in effect of environmental factors on male and female immigrants. Male immigrants may be more exposed to the local environmental factors as a result of their employment as compared to

the female immigrants. Hence they are more affected by the local environment compared to the female immigrants.

Table 3.3. OLS Estimates for Effect of Environment on BMI of Immigrants (NIS 2003) (Appendix B, Table B.1)

	Male			Female		
(BMI)	(1)	(2)	(3)	(1)	(2)	(3)
Local Obesity Rate	0.046**	0.045**	0.073**	0.005	0.007	0.036
	(0.026)	(0.027)	(0.030)	(0.032)	(0.032)	(0.033)
Duration of Residence in the United States	0.087***	0.087***	0.082***	0.064***	0.086***	0.079***
	(0.014)	(0.018)	(0.019)	(0.015)	(0.018)	(0.018)
R-squared	0.148	0.157	0.160	0.209	0.217	0.222
Individual Controls	Yes	Yes	Yes	Yes	Yes	Yes
Acculturation Variables	No	Yes	Yes	No	Yes	Yes
Environmental Variables	No	No	Yes	No	No	Yes
N	2,710	2,710	2,710	2,783	2,783	2,783

Standard errors in parentheses are corrected for heteroscedasticity and clustered at the county level. *p < 0:10, ** p < 0:05, *** p < 0:01. The entire table is presented in the Appendix B, Table B.1. The individual controls are immigrant demographic variables such as age, employment status, number of children, marital status, year, if citizenship was sponsored and the region of origin. The acculturation-level variables are English-speaking proficiency; the usage of English while conversing at work, with friends, and with a spouse and years of education in the United States. The environmental variables are poverty rate, percent of immigrants, percent of White population, and percent of physically active population in the county.

Table 3.4, shows the estimates for the interaction between local obesity rate and time of residence in the United States. For male immigrants, the interaction between the local obesity rate and time of residence less than or equal to two years is positive and significant. For instance if an immigrant had immigrated to Texas instead of immigrating to Colorado, in the first couple of years, his BMI would have increased $0.7 kg/m^2$ more than in Colorado. To understand this better, consider a person with a weight of 50 kgs and a height of 1.62 m. The impact of the increase in BMI of 0.7 kg/m^2 on his weight would be an increase of almost 4.4 lbs in his weight in the first couple of years. Similarly an increase of 1.3 kg/m^2 would result in an increase of almost 8 lbs in his weight in the first couple of years. Thus a person would have gained 8lbs more if he had immigrated to

Texas rather than Colorado during the first couple of years of his residence in the United States. The interaction between the local obesity rate and variables for longer stay in the country are not significant.

Table 3.4: OLS Estimates for Effect of Interaction between Local Obesity Rate and Time of Residence on BMI of Immigrants (NIS 2003) (Appendix Table B.2)

	Male			Female		
Variable: BMI	(1)	(2)	(3)	(1)	(2)	(3)
Local Obesity Rate * Time of Residence < = 2 yrs.	0.070** (0.035)	0.075** (0.027)	0.130** (0.042)	0.026 (0.049)	0.024 (0.049)	0.057 (0.047)
Local Obesity Rate * 2 yrs. < Time of Residence < = 7 yrs.	-0.033 (0.053)	-0.052 (0.018)	-0.021 (0.056)	0.058 (0.054)	0.053 (0.057)	0.090 (0.060)
Local Obesity Rate* Time of Residence > 7 yrs	0.078 (0.065)	0.084 (0.073)	0.113 (0.106)	-0.078 (0.055)	-0.071 (0.056)	-0.046 (0.053)
R-squared	0.148	0.157	0.167	0.209	0.219	0.224
Individual Controls	Yes	Yes	Yes	Yes	Yes	Yes
Acculturation Variables	No	Yes	Yes	No	Yes	Yes
Environmental Variables	No	No	Yes	No	No	Yes
N	2,710	2,710	2,710	2,783	2,783	2,783

Standard errors in parentheses are corrected for heteroscedasticity and clustered at the county level. *p < 0:10, ** p < 0:05, *** p < 0:01. The entire table is presented in the Appendix B, Table B.1. The individual controls are immigrant demographic variables such as age, employment status, number of children, marital status, year, if citizenship was sponsored and the region of origin. The acculturation-level variables are English-speaking proficiency; the usage of English while conversing at work, with friends, and with a spouse and years of education in the United States. The environmental variables are poverty rate, percent of immigrants, percent of White population, and percent of physically active population in the county.

3.4.1. Results for Effect of Dietary Change on Prevalence of Obesity

Changes in food habits are one of the most important drivers of immigrant assimilation into the local culture (Akresh 2007). Dietary assimilation has been linked to changes in immigrants' health (Holmboe-Ottesen and Wandel 2012). In this section we try to establish a mechanism for explaining immigrants' BMI levels. Table 3.5 reports the

relationship between dietary change and BMI levels of the immigrants. One of the important points to note is that the magnitude of the estimate for local obesity rate remains almost unchanged with the inclusion of change in diet variables. This suggests that the local obesity rate has an effect on the BMI levels of the immigrants, which is independent of the effect of measures of dietary change on the BMI levels.

For male immigrants, an increase in the consumption of fast food is positively associated with their BMI, and the reduction in ethnic food is negatively associated with their BMI. For female immigrants, a change in dietary pattern since immigration is positively related to their BMI levels and a decrease in the consumption of vegetables and fruits is negatively related to their BMI levels. Given these results, it is likely that changes in dietary habits after coming to the United States affect the BMI levels of the immigrant population.

Even though the dietary assimilation variables explain the BMI levels of individuals, the effect of environmental factors is responsible for immigrants' BMI levels when they are introduced into a new environment. This provides supportive evidence that the local obesity rate is responsible for the increase in BMI levels of the immigrant population.

Table 3.5: OLS Estimates for Effect of Environmental Factors and Dietary Change on BMI of Immigrants (NIS 2003)

BMI	Male	Female
Local Obesity Rate	0.071**	0.004
	(0.031)	(0.034)
Change in Dietary Pattern	-0.088	-0.060**
	(0.301)	(0.033)
Increase in Fast Food	0.358*	0.274
	(0.219)	(0.248)
Increase in Vegetables and Fruits	-0.338	-0.347*
	(0.287)	(0.228)
Increase in Meat and Seafood	0.305	0.212
	(0.261)	(0.267)
Reduction in Ethnic Food	-0.295*	0.053
	(0.165)	(0.190)
R-squared	0.205	0.219
N	2,783	2,783

Standard errors in parentheses are corrected for heteroscedasticity and clustered at the county level. *p < 0:10, ** p < 0:05, *** p < 0:01. The entire table is presented in the Appendix B, Table B.4. The individual controls are immigrant demographic variables such as age, employment status, number of children, marital status, year, if citizenship was sponsored and the region of origin. The acculturation-level variables are English-speaking proficiency; the usage of English while conversing at work, with friends, and with a spouse and years of education in the United States. The environmental variables are poverty rate, percent of immigrants, percent of White population, and percent of physically active population in the county.

3.5. Discussion and Conclusion

This paper uses the restricted use NIS 2003 data to examine the relationship between immigrants' BMI levels and local obesity rates. Results show that BMI levels among male immigrants increased with an increase in the local obesity rate. For immigrants located in environments with a higher percentage of the obese population, the local environmental characteristics have a positive effect on their BMI levels. We control for behavior change through the self-reported change in food habits and the degree of dietary change in the immigrants. To some extent, we also see that the local obesity rate influences the choice of food habits and dietary change in the immigrants.

The BMI levels of male immigrants increased with the increase in the local obesity rate. The higher the percent of obese people in their environment, the higher the

increase in their BMI levels. Results also show that with recent male immigrants who have been living in the United States for a shorter period of time, there was a significant effect of environmental factors on their BMI. This implies that the effect of the environment is significant in the initial years of the immigration, and it evens out as the time of residence increases. One explanation for this could be that as immigrants arrive in their new environment, they adapt to the habits and culture of the surrounding environment. With the passage of time, the effect of the environment is replaced by the effect of the behavioral change. Another important result is that even if people in different regions have spent the same amount of time in the country, the influence of different environments has different effects on their BMI levels. This result is important because it provides additional support for our initial hypothesis. Even if male immigrants have stayed in the United States for the same amount of time, their BMI levels increase with the increase in local obesity rate in their region of residence. Results show that the change in dietary pattern for women affects their BMI levels. This implies that a change in behavior, driven by local environmental factors, also affects the health of immigrants.

In this paper, we are assuming that prior to arriving in the United States immigrants are unaware of the local conditions of their places of immigration. This assumption can fail for several reasons. For instance, it is possible that the immigrants are aware of the local environmental characteristics in a region, and this knowledge motivates them to move to a certain region. It is also possible that immigrants move to a place with a high percentage of their co-ethnic population. This may shield immigrants from the social and cultural environments in the region. We cannot show that the immigrants were distributed all over the United States exogenous of the local obesity rate of the region. Hence one should be cautious while interpreting these results as causal.

NIS 2003 data consists of self-reported weight and height. As there is no validation data available for immigrants from developing countries (Cawley et al. 2009), we are not able to correct for reporting bias of self-reported height and weight. Previous studies have found no difference in estimates using self-reported data and corrected data for height and weight (Cawley 2000; Antecol and Bedard 2006). Immigrants are a unique population and they are placed in an unknown environment where they are forced to

make choices available to through their environment. Hence there results might not be generalizable to other populations. Regardless of the above problems, this paper contributes both to the obesity and immigration literature by examining the influence of local environment on the BMI levels among the immigrants. Results establish a robust and non-trivial relation between the local environmental factors in the form of the local obesity rate and the BMI levels of the immigrants.

Understanding the causes of the spread of obesity is important for developing appropriate policies to curb the obesity epidemic. Results from this study support the idea that public policy for reducing obesity should be aimed toward environmental interventions that affect a larger population. An obesogenic environment provides unhealthy choices for individuals and hence provides a hindrance in individual behavior modification. Hence, if public policies are directed toward individuals, an unhealthy environment prohibits or slows down the effect of individual-level intervention. Similarly, it is difficult to implement policies that regulate individual behavior, such as food, dietary, and physical activity habits. Thus a realistic approach will be of one that modifies the environment by providing healthier options for individuals, thus motivating them to make healthier choices, therefore modifying their behavior towards leading a healthier lifestyle.

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Chapter 4.

Do Peer Comparison Feedback and Financial Incentives Induce Healthy Behavior? Evidence from Dormitory Roommate Assignments

4.1. Introduction:

Physical inactivity has been linked to increased risks of health problems. Some of these problems include obesity, cardiovascular diseases, diabetes, cancer, arthritis, hypertension, and depression (Lee et al. 2012; Warburton et al. 2006). On the contrary, increase in physical exercise has shown to benefit individuals in prevention of heart diseases and strokes, reduction of body weight and body fat (Beavers et al. 2014), reduction of psychological distress (Hurwitz et al. 2005), higher self-esteem, and improved self-image (Hallal et al. 2006).

In 2008, the U.S. Department of Health and Human Services (HHS) in its first federal physical activity guidelines, recommended 150 minutes of moderate physical activity or 90 minutes of vigorous physical activity per week (Centers for Disease Control (CDC) 2015). Despite such recommendations, less than half the adult population is still physically inactive (CDC 2014). According to the Behavioral Risk Factor Surveillance System (BRFSS) data, only one in five US adults meets the CDC physical activity recommendation (CDC 2013). As a result, it is important to evaluate interventions that promote physical activity.

In this essay, I report results from two interventions based on field experiments to encourage freshmen at a university in the Midwest to visit the recreation center. The first experiment nudged a randomly selected group of students by providing them with information on a measure of their own physical activity and how it compared against that of physical activity of their peers. In the second experiment, financial incentives were provided to randomly selected freshmen. For this study, physical activity behavior was measured as the number of visits a student made per week to the university recreation center.

First intervention is a type of social norming method that provides feedback to individuals in the form of peer comparisons. This type of intervention has been shown to have a significant effect on health behaviors such as alcohol consumption (Borsari and Carey 2003), drug abuse (Larimer and Neighbors 2003), eating disorders (Neighbors et al. 2004), and environmentally conscious behavior such as reduction in energy

consumption (Ayres et al. 2012). In contrast to prior work, I find that social norming had no effect on the physical exercise behavior of individuals.

In the second intervention, I provide financial incentives in the form of a lottery to reward students to visit the university recreation center. Providing financial incentives to motivate individuals to engage in a healthy activity (ex. weight loss, smoking cessation) has been studied extensively in the economics literature (Volpp et al. 2006; 2009). Prior work has also shown that financial incentives motivate people to cross the inactivity threshold and start exercising at the gym (Charness et al. 2008; Royer et al. 2013). Results show that the financial incentive was little effective in encouraging freshmen to visit the recreation center.

To the best the author's knowledge, this is the first study to use a continuous social norming (peer feedback) approach to promote, or increase, physical exercise behavior in individuals. Previous studies have relied on fixed financial incentives, a single individual nudge as the main manipulation throughout the experiment's duration (Charness et al. 2008; Royer et al. 2013) to encourage physical exercise. There are three main differences between financial intervention in this study and previous studies. The differences are 1) the use of a lottery as a mode of financial incentive, 2) the incentive information's being sent to the participants every week, and 3) the amount of incentive increases over time. The automated data collection process used in this study has the advantage of being less prone to reporting bias as compared with other methods of data collection.

4.2. Background

Social norming method has shown to have mixed effects in behavior modification (Schultz et al. 2007). While some studies have shown statistically significant effects of social norming (Dwyer et al. 2015; Ayres et al. 2010), other studies have been unsuccessful in encouraging behavior change (Earp et. al. 2013) or have produced negative effect (Henriksen et al. 2006; Kingsury et. al. 2015). Social norm theory provides a potential explanation for the lack of effect, or negative effect. For instance, in the case of on-campus alcohol consumption, students who are aware of the prevalence of

alcohol consumption underestimate its presence (Hilton 1993). As social norming messages provide normative information on peers' behavior, those students who consumed less alcohol than average might be encouraged to increase consumption, so that their behavior is consistent with the social norm (Schultz et al. 2007). Drawing parallel to the current study, those students who exercised more than their fellow students did might have been motivated to reduce their exercise frequency to the social norm mentioned in the messages. Social norming is intended to reduce unwanted behavior or increase healthy behavior and in this case it was meant to increase physical exercise. However, by conveying a message that positive behavior is occurring less often than what students think, normative information can result in an unintended boomerang effect (Cialdini et al. 2004) for students who display positive behavior greater than the norm.

Previous research has shown that lottery-type financial incentives also have shown mixed results in changing health behavior. Although many studies confirm effectiveness of lottery-type financial incentive (Curry 1991; Moran et al. 1996; Jeffery 1999), other studies have failed to produce significant effects in changing behavior (Owen 1990; Edmont 1992; Wing 1996). Research has shown that the effectiveness of financial incentives depends on their magnitude, and a smaller magnitude incentive can lead to a negative effect (Gneezy and Rustichini 2000).

This paper proceeds as follows. Section 2 describes experimental design and methodology. Section 3 presents empirical analysis for the experiments and summarizes the results. The final section interprets and discusses the results and offers a conclusion with direction for further research. This study is approved by the Institutional Review Board at the University of Minnesota.

4.3. Experimental Design

The experiments were conducted in the fall semester of 2014 at a public university in the Midwest, with the incoming class of freshmen residing in on-campus dormitories. The interventions spanned a ten-week period beginning in September 2014 and ending in December 2014. Students in the treatment group received nudges via email every Monday morning over the ten-week period. I surveyed the freshmen at the

beginning of the semester to collect data on their initial physical activity level and could observe students' physical activity level during and after the interventions.

The university's Department for Housing and Residential Life provided data on the dormitory allocation of all freshmen. Note that students did not choose their dormitories or their roommates, hence selection bias is likely not an issue in this study. In all, there were 4,850 freshmen living in the dormitories at the time of the intervention. I didn't include the students who lived in housing provided for the athletes (191), Greek fraternities and sororities (15), apartments (87) and in single rooms (473) for the study. The final sample included 4,084 students living in 1,810 rooms with two or more occupants[9].

I used batch randomization process for allocating students to treatment and control groups. All the rooms in a dormitory are divided into houses. All rooms on a floor belong to a house. The rooms in the sample are divided into 139 houses. On average, each residence hall consists of 15 houses. These houses were used as batch blocks. Descriptive statistics for the dormitory halls are reported in Appendix C, Table C.4. Houses were randomly divided into three groups and assigned to one of the two treatments and a control group. All rooms in a house were assigned to their respective treatment or control groups. In all, 566 rooms were assigned to the social norming treatment, 599 rooms were assigned to the financial incentive treatment and 645 were assigned to the control group. For this experiment, I considered only those rooms that were occupied by two or more students. Batch randomization was used to increase the likelihood of dorm neighbors comparing emails to provide additional motivation to use the recreation center.

Descriptive statistics of students' base characteristics in both the treatment groups and control group are displayed in Table 4.1. A single student from each room was randomly selected into a treatment or control group. The social norming treatment had 566 students, the financial incentive group had 599 students, and the control group had 645

[9] Students who complained about receiving the weekly emails were removed from the study. Only two students were removed from the study due to this reason.

students. From the table, it can be seen that the sample is well-balanced in the control and in both treatment groups. There is no statistical difference in the pre-treatment base level variables.

Table 4.1 Mean/Frequency Comparison of the Pre-Treatment Base Variables

Variable Name	Control Group	Social Norming Group	Financial Incentive Group
Age	18.06 (0.386)	18.06 (0.370)	18.03 (0.374)
Female	0.51	0.48	0.55
Local Student	0.63	0.63	0.64
Race= White	0.81	0.79	0.79
Race = Asian	0.11	0.11	0.12
Race = Other	0.09	0.10	0.09
Number of Students	645	566	598

The Department of University Recreation and Wellness at the university provided daily recreation center usage data for students, every week. The data capture was automatic. Every time a student entered the recreation center this created a record. As a result I do not rely on students' ex-post subjective recall.

All students who are registered for a full-time course load receive a membership for the University recreation center as a part of their tuition. All freshmen are given a tour of and information about the recreation center facilities during their mandatory university orientation. Hence, I assume that every student in this study was aware, of the existence, and membership access to the university recreation center.

4.2.1. Experiment Using Social Norming Tool

All 566 students randomly assigned to the social norming treatment group received physical exercise e-mails weekly. Each e-mail consisted of the following three components:

1) A bar chart comparing the individual's number of visits to the recreation center to that of the group of comparable peers and to the peer with the highest number of recreation center visits over the previous week.
2) A normative message to motivate physical exercise.
3) Information on the university recreation center and the benefits of exercising.

All emails followed the same format and contained bar graphs with same size and color legends. An example is shown in Appendix C.

Values required for producing the bar graphs were obtained from the weekly recreation center attendance data that the Department of University Recreation and Wellness provided. A bar graph was created for each individual using his or her individual recreation center attendance data. Appearance, size, colors, and placement of the bar graphs were similar for all e-mails sent throughout to the students in the treatment group.

4.2.2. Experiment Using Financial Incentive

The 599 students randomly assigned to the financial incentive intervention were further randomly divided into two groups— a high financial incentive group (299), and a low financial incentive group (300). The higher financial incentive progressed from $20 to $120. The lower incentive was consistently half the amount of the higher incentive, in progression from $10 to $60. Probability of winning the lottery for each student in the treatment group was 1 percent and remained the same throughout the duration of the intervention and did not depend on the number of times other students went to the recreation center. Each email consisted of the following two components:

1) A message mentioning that every time a student visited the recreation center, s/he would be entered into a lottery to win an Amazon gift card and the actual probability of winning the lottery
2) Normative information on the benefits of exercising.

An example of the email messages is displayed in the Appendix C.

The amount of incentive increased over the period as mentioned below.

- Week 1 – Week 4
  - The higher incentive group was told that it would be entered into a lottery to win a gift card worth $20
  - The lower incentive group was told that it would be entered in a lottery to win a gift card worth $10

- Week 5 – Week 7
  - The higher incentive group was told that it would be entered into a lottery to win a gift card worth $60
  - The lower incentive group was told that it would be entered in a lottery to win a gift card worth $30

- Week 8 – Week 10
  - The higher incentive group was told that it would be entered into a lottery to win a gift card worth $120
  - The lower incentive group was told that it would be entered in a lottery to win a gift card worth $60

Similar to the social norming group, the financial nudges were also e-mailed to the students every Monday morning for the same period of ten weeks. The probability of winning the lottery for each student in the both the financial treatment groups was 1% and remained the same through the duration of the intervention and did not depend on the number of times other students went to the recreation center. The lottery results for all the monetary values were communicated to the winners through emails along with online Amazon gift cards during the last week of December 2014.

4.4. Empirical Methods

4.3.1. Pre-intervention Characteristics: Balance Test

The two treatment groups and control group had similar pre-intervention characteristics. Table 4.2 shows the regression estimates of base student characteristics on a constant, and a dummy variable for being in the treatment group (Glewwe et al. 2009). The estimations are performed separately for each treatment group with dormitory hall fixed effects.

Table 4.2 Difference between the Base Characteristics of Students in the Treatment and Control Groups

	Social Norming Treatment				
	Age	Female	Local Student	Race = White	Race = Asian
Difference between Treatment and Control Group Students	-0.01 (0.022)	0.045 (0.511)	0.006 (0.031)	-0.021 (0.022)	0.005 (0.053)
	Financial Incentive Treatment				
Difference between Treatment and Control Group Students	0.014 (0.021)	0.025 (0.028)	0.008 (0.027)	-0.015 (0.022)	-0.003 (0.018)

Standard Errors are corrected for heteroscedasticity and clustered on student id. p<0.1, 0.05, 0.01 *, **, ***

Results from table 4.2 suggest that the difference between the base characteristics of students in the control group and treatment group are not significant for either intervention.

4.3.2. Effect of Interventions on Visits to the Recreation Center

I estimate the effect of both interventions using a linear model as follows:

$$visits_i = \beta_0 + \beta_1 * (treatment) + u_i \quad (1)$$

where $visits_i$ is the number of times student *i* went to the recreation center in each week. The *treatment* variable is a dummy indicating whether a student belongs to the treatment group. The demographic control variables are age, local student status, race and whether the student lives in a double occupancy room.

The nudge was sent to the students every week. Following equation (2) explores the treatment effect for every week, by interaction between the dummy variable for treatment with the dummy variables for each week. The interaction term between the week and treatment captures the effect of being in the treatment group for each week.

$$visits_{ij} = \beta_0 + \beta_1(week_j) * (treatment_i) + \beta_2 week_j + \beta_3(demographic\ variables)_i + u_{ij} \quad (2)$$

where $visits_{ij}$ is the number of visits to the recreation center by student i in week j.

To explore the additional influence of external factors such as the dormitory characteristic or the student's self-reported physical exercise behavior characteristics, I interact those characteristics with the random treatment summarized in the following model

$$visits_i = \beta_0 + \beta_1(treatment_i) * (Z)_i + \beta_2(treatment_i) + \beta_3 Z_i + \beta_4(demographic\ variables)_i + u_i \quad (3)$$

where Z_i is the external factor or the self-reported physical exercise behavior for student *i*. I estimate the effect of each intervention separately. Standard errors are corrected for heteroscedasticity and clustered at student level. Analysis is performed on the data from first nine weeks[10] of the experiments. As prior research has shown that there is a difference in the physical exercise behavior of female students and males students (Kapinos and Yakusheva 2011) hence, I perform the analysis separately for female and male students.

4.3.3. Effect of Social Norming Intervention on Visits to the Recreation Center

Table 4.3 investigates the effect of the social norming intervention on the frequency of visits to the recreation center for male and female students separately according equation (1). To account for the variation in behavior of students across dormitories, the regression was performed with the dormitory fixed effects. The social

[10] Week 10 of the experiment was the week of Thanksgiving. The university is officially closed for two days during that week and many students leave the university during the week. Hence data for week 10 are dropped from the analysis.

norming treatment did not have a statistically significant effect on visits to the recreation center for male or female students.

Table 4.3 OLS Estimation Results for Impact of Social Norming Treatment on Visits to the Recreation Center for Freshmen

Number of Visits to the recreation center during each intervention week	Male (1)	Female (2)
Social Norming Treatment	0.057	-0.059
	(0.102)	(0.115)
N	605	606

Standard Errors are corrected for heteroscedasticity and clustered at student level. p<0.1, 0.05, 0.01 *, **, ***. This follows equation 1 controlling for student demographic variables and the dormitory fixed effects. The entire table is available in Appendix C Table C.1.

Table 4.4 shows the analysis using equation 2 for the interaction between the dummy for the treatment and the weeks. The social norming nudge did not have any significant effect on the female students' visits to the recreation center. For male students the point estimates for the effect of social norming treatment are consistently positive. Even though the estimates are imprecise, they suggest that social norming had some positive influence on the male students' visits to the recreation center. For male students, the coefficients for the interaction terms of all the other weeks were not statistically different from one another ($p > 0.1$). This implies that male students' responded positively to the social norming treatment, the results were not always statistically significant.

Table 4.4 OLS Estimation Results for Impact of Social Norming Treatment by Week

Number of Visits to the recreation center during each intervention week	Male	Female
Social Norming Treatment	-0.026 (0.122)	-0.084 (0.129)
Week1 * Treatment	Base	Base
Week2 * Treatment	0.173** (0.086)	0.096 (0.098)
Week3 * Treatment	0.067 (0.091)	0.087 (0.102)
Week4*Treatment	-0.027 (0.099)	-0.027 (0.097)
Week5*Treatment	0.078 (0.098)	-0.004 (0.104)
Week6*Treatment	0.176* (0.096)	-0.030 (0.105)
Week7*Treatment	0.117 (0.097)	0.085 (0.104)
Week8*Treatment	0.065 (0.106)	-0.064 (0.113)
Week9*Treatment	0.107 (0.105)	0.073 (0.109)
N	605	606

Standard Errors are corrected for heteroscedasticity and clustered at student level. p<0.1, 0.05, 0.01 *, **, *** This follows equation 2 controlling for student demographic variables and the dormitory fixed effects. The entire table is available in Appendix C Table C.2.

4.3.4. Effect of Financial Incentive on Visits to the Recreation Center

Table 4.5 investigates the effect of a financial incentive on the frequency of visits to the recreation center, using equation (1) for male and female students respectively. The financial nudge did not have any statistically significant effect on the frequency of visits to the recreation center for female or male students.

Table 4.5 OLS Estimation Results for Impact of Financial Incentive on Visits to the Recreation Center of Freshman Students

Number of Visits to the recreation center during each intervention week	Male (1)	Female (2)
Lower Financial Incentive	0.092	-0.003
	(0.056)	(0.062)
Higher Financial Incentive	-0.040	-0.024
	(0.055)	(0.060)
N (Low Treatment)	136	164
N (High Treatment)	129	170
N (Control)	315	330

Standard Errors are corrected for heteroscedasticity and clustered at student level. p<0.1, 0.05, 0.01 *, **, ***. This follows equation 1 controlling for student demographic variables and the dormitory fixed effects. The entire table is available in Appendix C Table C.3

For the estimation in table 4.6, I pooled the data for weeks that have the same financial incentive values. Weeks 1 through 4 had the same financial incentive value and are pooled as period 1. Similarly, weeks 5 through 7 are pooled as period 2 and weeks 8 and 9 are pooled as period 3. I present a fully interacted model between the periods and the financial treatment to understand the effect of the financial nudge throughout the duration of the experiment.

The higher incentives progressed from $20 to $120 and the lower incentives progressed from $10 to $120. Results show that neither of the financial treatments had a statistically significant effect on the students' visits to the recreation center. The coefficients of the interaction terms for all the periods are not significantly different than one another (p >0.1). The increase in the incentive does not seem to have any effect on students' visit to the recreation center.

Table 4.6 OLS Estimation Results for Impact of Financial Incentive on Students' Visit to the Recreation Center by Week

Number of Visits to the recreation center during each intervention week	Male	Female
Period 1 * Low Treatment	0.148	-0.102
	(0.095)	(0.083)
Period 2 * Low Treatment	-0.079	0.141
	(0.102)	(0.096)
Period 3 * Low Treatment	-0.000	-0.021
	(0.125)	(0.113)
Period 1 * High Treatment	-0.001	0.016
	(0.093)	(0.081)
Period 2 * High Treatment	-0.010	-0.118
	(0.102)	(0.095)
Period 3 * High Treatment	-0.164	0.034
	(0.125)	(0.113)
Number of Students	578	665

Standard Errors are corrected for heteroscedasticity and clustered at student level. p<0.1, 0.05, 0.01 *, **, ***. This follows equation 2 controlling for student demographic variables and dormitory fixed effects. The entire table is available in Appendix C Table C.4.

To summarize the findings from this section, neither randomized experiment yielded convincing evidence that sending nudges every week using social norming tool or financial incentives increased the frequency of students' recreation center visits. The social norming nudge did not have any effect on students to visit to recreation center. The financial incentive nudge had a little effect on students' visits to the recreation center. Because prior research has found these two interventions to be effective in modifying behavior, it is interesting to see these interventions were ineffective in this case.

4.5. Further Exploration

I conducted a baseline survey of the students at the beginning of the semester, prior to the intervention study, to collect data on students' initial physical activity and physical fitness level. The online survey was sent to all incoming freshmen. Students were given an incentive of being entered into a lottery to win an Amazon.com gift card for submitting the survey. The survey questions were adopted from the 2010 National Youth Physical Activity and Nutrition Survey and the questionnaire for the roommate

study conducted for Eisenberg et al. 2009–2010. Survey questions are presented in Appendix C.

Table 4.7 displays descriptive statistics for student characteristics from data obtained from the baseline survey. Not all students who were subjects for the intervention study opted to take the survey. Therefore, the sample size for this analysis, using the survey data is markedly smaller than that of the actual experiment. The response rate for the survey was 33% for the control group, 50% for the social norming treatment group, and 46% for the financial incentive group. Because not all the students from the experiment answered the survey, the sample may be prone to selection bias. Even though results cannot be interpreted as causal, they give us information about relationship between students' behavioral characteristics and the influence of behavior modifying interventions.

Table 4.7 Mean/Frequency Comparison of the Baseline Survey Variables

Variable Name	Control Group	Social Norming Group	Financial Incentive Group
Number of days/week exercise intention at the Recreation Center (Number of days a week)	3.666 (1.669)	3.526 (1.459)	4.766 (1.640)
Perception of self's current health (1 = Excellent/Good)	0.404	0.512	0.534
Self-reported Number of days exercised in the past 7 days	4.753 (2.057)	3.149 (2.125)	2.747 (1.947)
Self-reported Number of days/week exercised in the past 30 days	2.209 (1.050)	1.820 (0.994)	1.842 (1.015)
Perception of self's current fitness level compared to their cohort (1= better than the cohort)	0.131	0.204	0.270
Number of Students	215	285	277

Table 4.8 OLS Estimates for the Effect of Social Norming and Previous Exercise Frequency

Number of Visits to the recreation center during each intervention week	Male (1)	Female (2)	Male (1)	Female (2)
Social Norming Treatment	-0.145 (0.242)	-0.137 (0.315)	-	-
Self-reported days exercised in the last 7 days	0.128** (0.051)	0.140** (0.056)	0.019 (0.020)	-0.034* (0.021)
Social Norming * Self-reported days exercised in the last 7 days	0.085 (0.063)	0.035 (0.078)	-	-
Financial Treatment	-	-	0.158 (0.137)	-0.208* (0.123)
Financial Treatment * Self-reported days exercised in the last 7 days	-	-	-0.016 (0.030)	0.052** (0.028)
Age	0.400** (0.165)	0.107 (0.175)	0.010 (0.059)	-0.107 (0.081)
Local Student	0.057 (0.129)	-0.063 (0.174)	-0.105 (0.065)	0.066 (0.053)
Race= White	0.105 (0.238)	-0.084 (0.336)	0.171 (0.120)	-0.070 (0.089)
Race = Asian	-0.243 (0.247)	-0.029 (0.432)	0.149 (0.142)	-0.093 (0.125)
Room with double occupancy	0.022 (0.128)	0.169 (0.171)	-0.000 (0.065)	-0.026 (0.057)
Constant	-6.821** (2.935)	-1.370 (3.145)	0.671 (1.089)	3.173** (1.475)
N	271	224	208	283

Standard Errors are corrected for heteroscedasticity and clustered at student level. p<0.1, 0.05, 0.01 *, **, ***

The students' self-reported measures of exercise frequency are reported using two variables: "past seven days", and "past 30 days". It is important to note that the survey was conducted in the first couple of weeks of the academic year. Therefore, there is a

difference between the self-reported exercise frequency in "past seven days" and "past 30 days". Students reporting exercise frequency in "past seven days" is students' exercise behavior immediately after arriving at the university. Students' reporting exercise frequency in "past 30 days" is a combination of their exercise behavior prior to their arrival at the university and immediately after arriving at the university.

Table 4.8 reports the estimated effect based on the regression coefficients from equation 3, with interaction terms between self-reported frequency of exercising in the last seven days and the dummy variable for treatment. Results in columns 1 and 2 show that students with self-reported 'past seven days', exercised at the recreation center. However, the social norming treatment did not have any additional effect in inducing these students to exercise at the recreation center. As I have mentioned before, there is a possibility that the social norming intervention produced an unintentional boomerang effect. Students, who were physically active before the experiment, might have realized that they were exercising more than the norm after receiving the social norm messages. Hence it is possible that they might have reduced their exercising at the recreation center.

From columns 3 and 4, results show that financial treatment had a negative effect on the visits to the recreation center for the female students with self-reported exercise frequency in 'past seven days'. This result follows the previous research findings that a smaller magnitude incentive can lead to a negative effect (Gneezy and Rustichini 2000).

4.6. Discussion and Conclusion

The essay employs two different interventions to encourage freshmen to visit the university recreation center. Previous studies have shown that social norming and financial incentives using a lottery are two successful interventions when it comes to modifying individual behavior. However, results from my study show that the interventions didn't have a significant effect in encouraging freshmen to visit the university recreation center.

Neither of the financial incentives had a statistically significant effect in promoting physical exercise behavior in freshmen. An increase in the value of the incentive did not motivate students to increase their visits to the recreation center. A

couple of the reasons for negligible effect of financial incentive on students' behavior might be the magnitude of the incentive as well as the probability of winning the lottery. The message mentioned a 1% chance of winning the lottery every time the student went the recreation center. The probability of winning may not have been large enough to create interest among the students. The initial amounts of incentives offered were $10 and $20. The repetitiveness of the message and the similarity of the content in the emails might have resulted in the fading away of the effect. As such, even when the amount of the incentive was increased, students failed to take notice.

The social norming treatment had no effect on the students' physical exercise. One reason for this might be the boomerang effect discussed earlier. Students who noticed through the messages that they were performing better than their dormitory mates, might have reduced their visits to the recreation center. One of the ways to avoid the unintended boomerang effect is to improve the normative message by adding an inductive message (Cialdini et al., 1991), which provides an approval or disapproval of the behavior in a given group or setting (Schutlz et al. 2007). A simple way of implementing an inductive message to the social norming tool would be to add encouraging text about the student's physical exercise with a positive and smiling emoticon (Ayres et al. 2012; Schutlz et al. 2007). Another reason social norming treatment was ineffective could be that the weekly messages might have become repetitive, and students may have chosen to ignore them. It is also possible that the students might have considered the messages as a performance evaluation of their physical fitness and or appearance and therefore reacted in the opposite manner to that of the socially acceptable or recommended behavior.

Students involve themselves in a variety of physical activities and the university recreation center is just one of them. It is possible that some students prefer outdoor physical fitness activities to exercising at the university recreation center. If the university recreation center were the only place where students involve themselves in physical activities, then the effect of the interventions would be measured accurately. Due to presence of alternative option, the effect of interventions on students' frequency of visits to the recreation center is not measured accurately.

In case of social norming treatment, it is also difficult to know whether the students read the entire message. Hence, the effect of the different parts of the message, such as the text message or the bar chart, is difficult to segregate. A post intervention survey would have been helpful in understanding the experiment's nuances.

The findings from these interventions should be generalized with caution. Freshmen are a unique population. Most of them are outside of their comfort zones and independent of their parents for the first time. This might make their decision making more prone to peer-effects (Dolgin and Rice 2011). This is a first-evidence study for the treatments and methods used in promoting physical exercise and therefore not a tool for policy implementation.

Even though the interventions were ineffective in encouraging freshmen to visit the university recreation center, the findings from this essay provide a direction for future study. Social norming and financial incentives in the form of a lottery are well established policies employed towards behavior modification. Studying the mechanism for economic incentives is important in understanding their effectiveness. Big enough financial incentives can provide extrinsic motivation to influence changes in behavior, however the size of incentive required to bring sustained change is untested (Kane et al. 2004). Hence further research is required to understand the size of incentive to motivate change as well as to lead a cost-effective intervention. Social norming can be implemented through various channels. In this essay, I used a private channel where the information was delivered to the individuals privately in their mail box. Another way of implementing social norming is through public display of the norms (Delmas et al. 2012), by using public dashboards and posters. A relative rating system can be used to display the information publically and protect participant privacy.

It is important to note that the two well established interventions were not successful in motivating students to adopt a healthy behavior. However, the results from the current study should be considered a guide for designing further experiments.

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Chapter 5.

Conclusion

In this dissertation, I have studied factors that affect the choices of individuals and the influence of those choices on individuals' health. In each of the three essays I have used a different method to study health behavior among individuals.

In the first essay, I collected primary data from international graduate students to study the extent to which environmental factors cause obesity. Results show that students' weights increase by 0.3 lbs for every one-unit increase in the obesity rate. In summary, if a student went to a university in Colorado (20% obesity rate) instead of a university in Texas, the student would gain 3 lbs more in Texas than s/he would in Colorado.

In the second essay, I used the restricted-use NIS data to study the effect of environmental factors on the health and dietary change of recent immigrants to the United States. Results show that local environmental factors have a statistically significant effect on the immigrants' BMI levels. The BMI levels of immigrants increase with the increase in the local obesity rate. For every one-point increase in the local obesity rate, the BMI levels of male immigrants' increase by 0.046 points. Instead of immigrating to Colorado (20% obesity rate), if a person had immigrated to Texas (30% obesity rate), his BMI would increase by 0.46 points more in Texas than it would in Colorado. This translates into an increase of 2.64 lbs more weight in Texas as compared to the weight in Colorado. The magnitude of weight gain in immigrants is similar to the findings in the first essay about international students.

Results from the first two essays show that weight gain in foreign individuals is driven by local environmental factors. These results raise important questions about policy implementation. They suggest that public policy aimed at reducing obesity should be applied towards environmental interventions that can affect larger populations and provide them with a healthy environment allowing them to make healthier choices.

The third essay is an intervention study, where I used social norming and financial incentives to promote healthy behavior in the form of physical exercise in randomly selected freshmen. The analysis suggests that there is a difference in how female and male adolescents react to financial incentives. Female students were not influenced by incentives, whereas male students reacted positively to higher financial incentives. In the

case of social norming, we do not find any significant effect on the students'. The gender difference with regard to the students' behavior and reaction towards interventions are important findings with respect to policy implications. Little research has been dedicated to propagating physical exercise. Hence, the findings from this research are a good starting point towards that direction.

By using different populations, I have attempted to understand the effect of the environment and previously used tools for studying individual choices and health behavior. Findings from these populations should be used with caution. International students, immigrants, and freshmen are special populations, and hence, their behavior cannot be generalized to the average population.

To summarize, my dissertation successfully establishes that individuals' choices are influenced by their surrounding environment and these choices have an effect on their health. It also shows that the social norming method can be used to promote healthy behavior in individuals. Further research is needed to understand optimal policies required to modify the environment and to provide healthy choices to individuals. Additional research is required to generate a sophisticated social norming message technique in order to increase its effectiveness in promoting healthy behavior.

Chapter 6.

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Appendices

Appendix A

Do Environmental Factors Drive Obesity?

Appendix Table A.1: Comparison between Obesity Regions for Average Change in Weight

	Low	Medium	High
Low	-	-0.729	-5.94***
Medium	-	-	-4.93***

Standard Errors in parentheses. * p < 0:10, ** p < 0:05, *** p < 0:01

Appendix Table A.2: Comparison between Weight at arrival and Current Weight

	Low	Medium	High
Previous Weight vs Current Weight	-9.33***	-11.52***	-13.72***
Previous BMI vs Current BMI	-9.58***	-11.46***	-13.88***

Standard Errors in parentheses. * p < 0:10, ** p < 0:05, *** p < 0:01

Appendix Table A.3: Comparison between Coefficients for Obesity Regions

	Low	Medium	High
Low	-	-0.28	2.52**
Medium	-	-	2.33**

Standard Errors in parentheses. * p < 0:10, ** p < 0:05, *** p < 0:01

Appendix Table A.4: Influence of Local Obesity Rate on Weight Gain in International Graduate Students

Dependent Variable	$\Delta Weight$ (lbs)					
	(1)	Std Err	(2)	Std Err	(3)	Std Err
Local Obesity Rate	0.283***	(0.060)	0.302***	(0.068)	0.285***	(0.088)
Height(feet)	-0.267	(0.694)	0.112	(0.745)	0.117	(0.771)
Female	-	-	0.168	(0.382)	0.194	(0.390)
Age (years)			0.041	(0.053)	0.029	(0.051)
Length of Stay at the University			1.185***	(0.114)	1.198***	(0.142)
Number of Adults in the household			-0.168	(0.151)	-0.181	(0.162)
Number of Children			0.922*	(0.512)	0.899*	(0.518)
From Asia			-1.498*	(0.759)	-1.457*	(0.750)
From Africa			2.151*	(1.247)	2.087	(1.253)
From Europe			-2.070**	(0.944)	-2.053**	(0.943)
From Latin America			Base		Base	
Access to Parks					-0.020	(0.022)
Rural Area					-0.047	(0.048)
Recreation Facilities per capita					-0.095	(0.138)
Number of Sunny days					-0.005	(0.127)
Grocery Store per 1000					3.172	(8.851)
If a Food Desert					0.044	(0.891)
Percent of population with limited access to health food					0.022	(0.114)
Percent of Fast Food Restaurants					0.085	(0.061)
Physical Inactivity Rate					-0.213	(0.169)
Constant	-1.189	(4.053)	-5.095	(8.035)	-7.318	(9.849)
Individual Control	No		Yes		Yes	
Environment Variables	No		No		Yes	
R-Squared	0.02		0.076		0.091	

Standard Errors are corrected for heteroscedasticity and clustered at student level. p<0.1, 0.05, 0.01 *, **, ***

Appendix Table A.5: Influence of Interaction between Local Obesity Rate and Time of Residence on Weight Gain (part 1 of 2)

Dependent Variable	$\Delta Weight$ (lbs)					
	(1)	Std Err	(2)	Std Err	(3)	Std Err
Low Obesity Region* Length of Stay at the University	1.210***	(0.224)	0.976***	(0.258)	1.025***	(0.273)
Medium Obesity Region* Length of Stay at the University	1.271***	(0.259)	1.122***	(0.243)	1.077***	(0.272)
High Obesity Region* Length of Stay at the University	1.833***	(0.249)	1.647***	(0.219)	1.595***	(0.249)
Low Obesity Region	Base		Base		Base	
Medium Obesity Region	-0.583	(0.699)	-0.615	(0.743)	-0.386	(1.014)
High Obesity Region	2.113**	(0.911)	1.849**	(0.910)	2.667	(1.604)
Height(feet)	-0.267	(0.694)	0.139	(0.703)	0.265	(0.715)
Female			0.241	(0.364)	0.311	(0.382)
Age (years)			0.006	(0.053)	-0.016	(0.052)
Number of Adults in the household			-0.151	(0.148)	-0.152	(0.152)
Number of Children			0.756	(0.522)	0.799	(0.518)
From Asia			-1.480*	(0.728)	-1.443*	(0.703)
From Africa			1.875	(1.234)	1.835	(1.260)
From Europe			-2.130**	(0.982)	-2.078**	(0.969)
From Latin America			Base		Base	
Access to Parks					-0.007	(0.018)
Rural Area					-0.019	(0.049)
Recreation Facilities per capita					-0.010	(0.106)
Number of Sunny days					0.002	(0.008)
Grocery Store per 1000					-2.007	(5.954)
If a Food Desert					-0.328	(0.693)
Percent of population with limited access to health food					0.085	(0.059)

Standard Errors are corrected for heteroscedasticity and clustered at student level. p<0.1, 0.05, 0.01 *, **, ***

Appendix Table A.5: Influence of Interaction between Local Obesity Rate and Time of Residence on Weight Gain (part 2 of 2)

Dependent Variable	$\Delta Weight$ (lbs)					
	(1)	Std Err	(2)	Std Err	(3)	Std Err
Percent of Fast Food Restaurants					-0.043	(0.061)
Physical Inactivity Rate					-0.019	(0.104)
Constant	1.798	(3.856)	-0.068	(5.198)	1.492	(7.471)
Individual Control	No		Yes		Yes	
Environment Variables	No		No		Yes	
R-Squared	0.07		0.09		0.11	

Standard Errors are corrected for heteroscedasticity and clustered at student level. p<0.1, 0.05, 0.01 *, **, ***

Appendix Table A.6: Geographical Distribution of Survey Respondents (part 1 of 2)

State	Sample	Obesity Rate
Alabama	72	35
Arizona	179	26
California I	150	21
California II	115	23
California III	91	21
California IV	39	21
Colorado	58	18.6
Connecticut	53	23
Florida I	77	26
Florida II	73	24
Georgia I	103	28
Georgia II	30	28
Illinois	278	27
Indiana	29	33
Kansas	60	27
Kentucky I	29	34
Kentucky II	75	31
Louisiana	104	32
Maine	32	22
Maryland	29	27
Massachusetts	108	22
Michigan I	139	25
Michigan II	85	31
Minnesota	327	21
Mississippi I	75	36
Mississippi II	52	32
Missouri	264	28
Nevada	37	26
New York	84	26
North Carolina	29	28
Ohio I	189	29.7
Ohio II	50	30

Appendix Table A.6: Geographical Distribution of Survey Respondents (part 2 of 2)

State	Sample	Obesity Rate
Oklahoma	61	30
Oregon	28	24
Pennsylvania	199	27
Utah	42	23
Washington I	100	28
Washington II	31	28
West Virginia	103	28
Wyoming	61	22

Appendix Table A.7: Summary Statistics of Survey Participants' Socio-demographic Variables (n=3,526)

Variable	Survey Data Mean/Frequency	National Data Mean/Frequency
Male	0.464 (0.498)	0.52
From India	28.25	18.51
From China	25.32	35.08
From SE Asia	11.51	13.72
From SW Asia	10.33	11.87
From Latin America and Caribbean	8.67	5.99
From Africa	5.65	3.59
From Europe and Canada	10.32	11.24

The national data sources are Open Doors Report 2013; National Council for Education Research, 2011; SEVIS by numbers by USCIS.

Survey Questionnaire

Section 1: Please answer the following questions based on your current health status.

1. In general, would you say your current health is ….?
   a. Excellent
   b. Very good
   c. Good
   d. Fair Poor

2. As compared to your health in your native country, has your health…….. since you have come to the US?
   a. Improved by a lot
   b. Improved
   c. Remained the same
   d. Decreased
   e. Decreased by a lot

3. Has your weight ….. since you have come to the US?
   a. Increased by a lot
   b. Increased
   c. Remained the same
   d. Decreased
   e. Decreased by a lot

4. About how tall are you?
   __ cms or
   ____ ft ___ inches

5. About how much do you weigh?
   ____ lbs or
   ____ Kgs

6. About how much did you weigh at the time you came to the US? (Report approximate value)
   ____ lbs or
   ____ Kgs

7. As compared to you current weight, would you like to weigh _____
   a. More
   b. The Same
   c. Less

Section 2: Following questions are about the change in your eating habits after moving to the United States.
Please answer them as precisely as you can.

8. Do you feel you have changed your eating habits since you have come to the US?
   a. Yes
   b. No

9. If you answered yes to the above question, what was the reason for change in your eating habits in the US?
   a. Availability of more and different food choices
   b. Availability of cheaper food options
   c. Un-availability of the food you were used to eating
   d. You changed your food habits to adjust with those who were living with you.
   e. Other, please explain _____

10. Has your consumption of following items changed since you came to the US?

Food Products	Increased by a lot	Increased	Remained the same	Decreased	Decreased by a lot	Do not consume
a. Fresh green vegetables						
b. Fresh fruits and juices						
c. Canned beans and vegetables						
d. Canned fruits and bottled juices						
e. Sweets and ice-creams						
f. Milk and eggs						
g. Meat and poultry						
h. Soda and carbonated drinks						
i. Alcohol						
j. Cigarettes						
k. Meals cooked at home						
l. Fast food						

11. Since coming to the US has there been a change in the following activities

Activities	Increased by a lot	Increased	Remained the same	Decreased	Decreased by a lot	NA
a. Exercising in the gym						
b. Playing field games ex: soccer, running, tennis badminton						
c. Watching television and movies at home						
d. Working on the computer						
g. Cooking at home						
h. Eating at fast food restaurants						
i. Eating out at restaurants						
j. Eating out, in general						
e. Your waist line						
f. Your Body Weight						

Section 3: Following questions are based on your student life at your current University.

12. What is your current degree program?

    a. Undergraduate degree
    b. Masters' degree
    c. PhD degree
    d. Post-doctoral fellow
    e. Other (Please specify) _____

13. How long have you been a student/fellow at this University?
    a. Less than a year
    b. 1-2 years
    c. 2-4 years
    d. 5-6 years
    e. More than 6 years

14. Which factor contributed in your selecting this University for your degree?
    a. Location of the University
    b. Funding/Finances
    c. University/Department Ranking
    d. Convenience of being close to a relative
    e. Convenience of attending the same university as your friends
    f. Prospective job placement
    g. Other. please explain. _____

15. What year did you come to United States?
    _____

16. Were you living in the US before starting your degree program at this University?
    a. Yes
    b. No

17. If you answered 'Yes' to the above question, please mention the number of years you have lived in the US before starting your degree program?

    a. Less than a year
    b. 1-2 years
    c. 2-4 years
    d. 5-6 years
    e. More than 6 years

18. What were you doing in the US before starting your degree program?
    a. Studying at a different university/school
    b. Working
    c. Unemployed / self-employed
    d. Others. Please describe _____

Section 4: Following questions focus on the change in your life style after you moved to the United States.

19. How important is it for you to learn and practice the values and traditions of the US?
    a. Very important
    b. Important
    c. Indifferent
    d. Not very important
    e. Not important at all

20. Do you feel that you had to change your values or your way of thinking or behaving in order to adapt to living in the US?
    a. Yes
    b. No

21. Outside of work and school, people you socialize with are
    a. Mostly from your native country

b. Mostly from United States
c. Mostly from other countries
d. All of the above

22. Please indicate the percentage of time you speak in the following languages, with the people you socialize with (outside of your work and school)

a. English ☐

b. Your native language ☐

c. Other language (specify) _____ ☐

23. What is your GRE score (percentile)?

Quantitative: _____ percentile
Verbal: _____ percentile
Writing: ____/6

24. What is your field of study?

_____

25. Do you have a graduate assistantship or a scholarship/fellowship?
a. Yes
b. No

Section 5: Demographic Data

26. What country were you born in?

_____

27. What year were you born?

_____

28. Please indicate your gender.
a. Female
b. Male

29. Please indicate your marital status
a. Single
b. In a relationship
c. Married
d. Separated/Divorced

30. Currently you live with ….. (choose all the applicable options)
a. roommates from your native country
b. roommates from the US
c. roommates from other countries
d. live by yourself

e. live with your partner
f. live with your family
g. Others, please explain _____

31. Currently there are …… adults living in your house (excluding you)
_____

32. Currently there are …… children living in your house
_____

Consent Form/Invitation Letter

Subject: Get a Chance to Win a $10.00 Amazon Gift Coupon by Participating in Research on International Graduate Students

My name is Bhagyashree Katare and I am a Ph.D. student in the Department of Applied Economics at the University of Minnesota.
I request ***International Graduate Students at the University of XXXX*** to participate in my doctoral thesis study "Effect of Acculturation on International Students". This study has been approved by the Institutional Review Board at the University of Minnesota (IRB Code Number: 1302E28141).

Your answers will provide valuable information and insight on the effect of acculturation on the change in food consumption, and on the health of international students after arrival in the United States.

As a part of this survey, you will be asked to answer questions about the change in your eating habits since your arrival in United States. The survey should not take more than 5 - 7 minutes to answer.

On completing this survey, you can enter your valid email address, which will be entered in a lottery to win one of the 500 Amazon gift cards. Winners will receive a $10 Amazon e-gift card through the official university email address they have entered on the webpage.

Link for the survey: http://z.umn.edu/XX

All information gathered will be anonymous. There will be no record of respondents, and upon completion of the survey there is no way for researchers to contact or identify individual participants.

If you have questions or are interested in the results of the study, please contact me at kata0029@umn.edu.

Thank you.

Appendix B

Effect of Environment on Obesity Prevalence: Evidence from Recent Immigrants

Appendix Table B.1. OLS Estimates for Effect of Environment on BMI of Immigrants (NIS 2003) (part 1 of 2)

	MALE			FEMALE		
(BMI)	(1)	(2)	(3)	(1)	(2)	(3)
Local Obesity Rate	0.046**	0.045**	0.073**	0.005	0.007	0.036
	(0.026)	(0.027)	(0.030)	(0.032)	(0.032)	(0.033)
Duration of Residence in the United States	0.087***	0.087***	0.082***	0.064***	0.086***	0.079***
	(0.014)	(0.018)	(0.019)	(0.015)	(0.018)	(0.018)
From Asia and Oceania	-0.867*	-0.897	-0.906	-1.82***	-1.29**	-1.263**
	(0.479)	(0.806)	(0.806)	(0.291)	(0.736)	(0.742)
From Africa	-0.089	-0.326	-0.269	0.462	0.574	0.792
	(0.533)	(0.830)	(0.825)	(0.658)	(0.770)	(0.774)
From Europe and Canada	Base	Base	Base	Base	Base	Base
From Latin America and the Caribbean	0.942**	1.308	0.998	0.690**	1.044**	1.033
	(0.491)	(0.837)	(0.835)	(0.322)	(0.777)	(0.780)
Income/1000	0.404	-0.275	0.404	-0.007	-0.005	-0.002
	(0.704)	(0.761)	(0.810)	(0.015)	(0.015)	(0.015)
Employed	0.506**	0.494**	0.516**	-0.224	-0.118	-0.076
	(0.199)	(0.209)	(0.211)	(0.173)	(0.173)	(0.173)
Has a College Degree	0.269	0.169	0.194	-0.141	-0.105	-0.106
	(0.210)	(0.223)	(0.224)	(0.210)	(0.209)	(0.206)
Age	0.046***	0.050***	0.051***	0.078***	0.066***	0.067***
	(0.009)	(0.009)	(0.009)	(0.010)	(0.011)	(0.010)
Sponsor for citizenship	0.390	-0.368**	-0.380**	-0.67***	-0.68***	-0.69***
	(0.185)	(0.182)	(0.182)	(0.204)	(0.213)	(0.214)
Number of Children	0.039	0.050	0.046	0.435***	0.420***	0.420***
	(0.060)	(0.062)	(0.062)	(0.061)	(0.068)	(0.067)
Married	0.879***	0.656***	0.647***	0.032	0.023	0.121
	(0.209)	(0.235)	(0.236)	(0.196)	(0.234)	(0.208)

Standard Errors are corrected for heteroscedasticity and clustered at student level. p<0.1, 0.05, 0.01 *, **, ***

Appendix Table B.1. OLS Estimates for Effect of Environment on BMI of Immigrants (NIS 2003) (part 2 of 2)

	MALE			FEMALE		
(BMI)	(1)	(2)	(3)	(1)	(2)	(3)
English Proficiency	-	-0.148 (0.136)	-0.164 (0.136)		0.033 (0.125)	0.013 (0.124)
Years of Education in the United States	-	-0.055 (0.036)	-0.057 (0.037)		-0.030 (0.042)	-0.044 (0.041)
Speak English with Spouse	-	0.172 (0.210)	0.173 (0.212)		-0.189 (0.044)	-0.194 (0.042)
Speak English with Friends	-	0.038 (0.235)	0.073 (0.235)		-0.137 (0.223)	-0.107 (0.210)
Speak English at Work	-	-0.084 (0.223)	-0.082 (0.222)		-0.339 (0.218)	-0.329 (0.217)
County Poverty Rate	-	-	-0.009 (0.036)			0.019 (0.042)
Percentage of Immigrant Population	-	-	0.030** (0.013)			0.044*** (0.013)
Percent of White population in the county	-	-	0.027** (0.017)			0.018 (0.016)
Constant	21.26*** (0.893)	21.86*** (1.240)	18.700*** (1.752)	21.45*** (0.808)	21.31*** (1.411)	18.335*** (2.117)
R-squared	0.148	0.157	0.160	0.209	0.217	0.222
Individual Controls	Yes	Yes	Yes	Yes	Yes	Yes
Acculturation Variables	No	Yes	Yes	No	Yes	Yes
Environmental Variables	No	No	Yes	No	No	Yes
N	2,710	2,710	2,710	2,783	2,783	2,783

Standard Errors are corrected for heteroscedasticity and clustered at student level. p<0.1, 0.05, 0.01 *, **, ***

Appendix Table B.2. OLS Estimates for Effect of Environment and Time of Residence on BMI of Immigrants (NIS 2003) (part 1 of 2)

	MALE			FEMALE		
(BMI)	(1)	(2)	(3)	(1)	(2)	(3)
Local Obesity Rate * Time of Residence < = 2 yrs.	0.070**	0.075**	0.130**	0.026	0.024	0.057
	(0.035)	(0.027)	(0.042)	(0.049)	(0.049)	(0.047)
Local Obesity Rate * 2 yrs. < Time of Residence < = 7 yrs.	-0.033	-0.052	-0.021	0.058	0.053	0.090
	(0.053)	(0.018)	(0.056)	(0.054)	(0.057)	(0.060)
Local Obesity Rate* Time of Residence > 7 yrs.	0.078	0.084	0.113	-0.078	-0.071	-0.046
	(0.055)	(0.053)	(0.056)	(0.055)	(0.056)	(0.053)
Time of Residence < = 2 yrs.	Base	Base	Base	Base	Base	Base
2 yrs. < Time of Residence < = 7 yrs.	3.191**	3.531**	3.466**	-0.309	-0.191	-0.235
	(1.378)	(1.508)	(1.486)	(1.629)	(1.651)	(1.630)
From Asia and Oceania	-1.73***	-1.78***	-1.767***	-2.47***	-2.26***	-2.243***
	(0.186)	(0.243)	(0.240)	(0.223)	(0.264)	(0.258)
From Africa	-0.906***	-1.159***	-1.068***	-0.644**	-0.374	-0.166
	(0.297)	(0.341)	(0.338)	(0.324)	(0.364)	(0.367)
From Europe and Canada	Base	Base	Base	Base	Base	Base
Age	0.053***	0.056***	0.056***	0.080***	0.068***	0.067***
	(0.009)	(0.010)	(0.010)	(0.010)	(0.011)	(0.011)
Sponsor for citizenship	-0.284	-0.370**	-0.37**	-0.64***	-0.64***	-0.65***
	(0.186)	(0.182)	(0.183)	(0.206)	(0.216)	(0.217)
Number of Children	0.055	0.064	0.061	0.433***	0.418***	0.413***
	(0.061)	(0.065)	(0.064)	(0.061)	(0.068)	(0.067)
Married	0.730***	0.622***	0.612***	0.003	-0.009	0.007
	(0.269)	(0.254)	(0.255)	(0.200)	(0.234)	(0.235)

Standard Errors are corrected for heteroscedasticity and clustered at student level. p<0.1, 0.05, 0.01 *, **, ***

Appendix Table B.2. OLS Estimates for Effect of Environment and Time of Residence on BMI of Immigrants (NIS 2003) (part 2 of 2)

	MALE			FEMALE		
(BMI)	(1)	(2)	(3)	(1)	(2)	(3)
English Proficiency		-0.095 (0.135)	-0.108 (0.135)		0.038 (0.126)	0.017 (0.125)
Years of Education in the United States		-0.057 (0.036)	-0.059 (0.037)		-0.033 (0.042)	-0.044 (0.042)
Speak English with Spouse		0.120 (0.208)	0.121 (0.210)		-0.139 (0.224)	-0.185 (0.213)
Speak English at Work		-0.131 (0.222)	-0.127 (0.221)		-0.377 (0.218)	-0.371* (0.217)
County Poverty Rate			-0.018 (0.036)			0.012 (0.042)
Percentage of Immigrant Population			0.031** (0.012)			0.046** (0.013)
Percent of White population in the county			0.022* (0.013)			0.018 (0.016)
Constant	21.26*** (0.893)	21.86*** (1.240)	19.09*** (1.752)	21.45*** (0.808)	21.31*** (1.411)	18.80*** (1.997)
R-squared	0.148	0.157	0.160	0.209	0.217	0.222
Individual Controls	Yes	Yes	Yes	Yes	Yes	Yes
Acculturation Variables	No	Yes	Yes	No	Yes	Yes
Environmental Variables	No	No	Yes	No	No	Yes
N	2,710	2,710	2,710	2,783	2,783	2,783

Standard Errors are corrected for heteroscedasticity and clustered at student level. p<0.1, 0.05, 0.01 *, **, ***

Appendix Table B.3: OLS Estimates for Effect of Environmental Factors and Dietary Change on BMI of Immigrants (NIS 2003) (part 1 of 2)

	Male	Female
Variable: BMI	(1)	(2)
Local Obesity Rate	0.071**	0.004
	(0.031)	(0.034)
Change in Dietary Pattern	-0.077	-0.060**
	(0.319)	(0.034)
Increase in Fast Food	0.358*	0.274
	(0.219)	(0.248)
Increase in Vegetables and Fruits	-0.338	-0.351*
	(0.287)	(0.228)
Increase in Meat and Seafood	0.305	0.212
	(0.261)	(0.267)
Reduction in Ethnic Food	-0.295*	0.053
	(0.165)	(0.190)
Duration of Residence in the United States	0.087***	0.068***
	(0.011)	(0.020)
From Asia and Oceania	-0.682***	-1.608***
	(0.398)	(0.900)
From Africa	-0.168	0.302
	(0.861)	(0.925)
From Europe and Canada	Base	Base
From Latin America and the Caribbean	1.677**	1.048**
	(0.850)	(0.725))
Income/1000	0.005	0.030
	(0.008)	(0.015)
Employed	0.618**	-0.073
	(0.214)	(0.176)
Has a College Degree	0.239	-0.106
	(0.224)	(0.213)
Age	0.066***	0.081***
	(0.009)	(0.010)

Standard Errors are corrected for heteroscedasticity and clustered at student level. p<0.1, 0.05, 0.01 *, **, ***

Appendix Table B.3: OLS Estimates for Effect of Environmental Factors and Dietary Change on BMI of Immigrants (NIS 2003) (part 2 of 2)

	Male	Female
Variable: BMI	(1)	(2)
Sponsor for citizenship	-0.566*** (0.177)	-0.813*** (0.223)
Number of Children	0.080 (0.065)	0.448*** (0.071)
Married	0.744*** (0.258)	-0.006 (0.234)
English Proficiency	-0.205 (0.134)	-0.029 (0.127)
Years of Education in the United States	0.016 (0.034)	0.055 (0.040)
Speak English with Spouse	0.220 (0.206)	-0.194 (0.213)
Speak English with Friends	0.075 (0.240)	-0.219 (0.229)
Speak English at Work	0.050 (0.228)	-0.294 (0.219)
County Poverty Rate	-0.008 (0.036)	0.030 (0.044)
Percentage of Immigrant Population	0.037** (0.012	0.047** (0.013)
Percent of White population in the county	0.031* (0.013)	0.019 (0.017)
R-squared	0.209	0.153
N	2,783	2,710

Standard Errors are corrected for heteroscedasticity and clustered at student level. p<0.1, 0.05, 0.01 *, **, ***

Appendix C

Do Peer Comparison Feedback and Financial Incentives Induce Healthy Behavior? Evidence from Dormitory Roommate Assignments

Appendix Table C1: OLS Estimation Results for Impact of **Social Norming** Treatment on Physical Exercise Frequency for Freshmen

Number of Visits to the recreation center during each intervention week	Male (1)	Female (2)
Age	0.221**	0.009
	(0.125)	(0.129)
Local Student	-0.063	-0.191*
	(0.088)	(0.111)
Race= White	0.203	-0.188
	(0.149)	(0.236)
Race = Asian	-0.106	-0.175
	(0.154)	(0.268)
Race = Others	Base	Base
Room with double occupancy	0.089	0.076
	(0.135)	(0.144)
Social Norming Treatment	0.057	-0.059
	(0.102)	(0.115)
Dorm 1	Base	Base
Dorm 2	-0.554***	-0.258
	(0.207)	(0.200)
Dorm 3	-0.013	0.115
	(0.271)	(0.548)
Dorm 4	-0.620***	0.339
	(0.227)	(0.336)
Dorm 5	-0.296	-0.284*
	(0.190)	(0.154)
Dorm 6	-0.492***	-0.501**
	(0.163)	(0.206)
Dorm 7	-0.082	0.027
	(0.219)	(0.252)
Dorm 8	-0.217	-0.354*
	(0.214)	(0.181)
Dorm 9	-0.007	-0.206
	(0.206)	(0.361)
Constant	-3.047	1.410
	(2.220)	(2.303)

Standard Errors are corrected for heteroscedasticity and clustered at student level p<0.1, 0.05, 0.01 *, **, ***

Appendix Table C2. OLS Estimation Results for Impact of Social Norming by Week (part 1 of 3)

Number of Visits to the recreation center during each intervention week	Male	Female
Age	0.221* (0.125)	0.066 (0.127)
Local Student	-0.063 (0.088)	-0.173 (0.111)
Race= White	0.203 (0.149)	-0.205 (0.227)
Race = Asian	-0.106 (0.154)	-0.156 (0.267)
Race = Others	Base	Base
Room with double occupancy	0.089 (0.135)	0.186* (0.104)
Social Norming Treatment	-0.026 (0.122)	-0.084 (0.129)
Week1 * Treatment	Base	Base
Week2 * Treatment	0.173** (0.086)	0.096 (0.098)
Week3 * Treatment	0.067 (0.091)	0.087 (0.102)
Week4*Treatment	0.027 (0.099)	-0.027 (0.097)
Week5*Treatment	0.078 (0.098)	-0.004 (0.104)
Week6*Treatment	0.176* (0.096)	-0.030 (0.105)
Week7*Treatment	0.117 (0.097)	0.085 (0.104)
Week8*Treatment	0.065 (0.106)	-0.064 (0.113)
Week9*Treatment	0.107 (0.105)	0.073 (0.109)

Standard Errors are corrected for heteroscedasticity and clustered at student level. p<0.1, 0.05, 0.01 *, **, ***

Appendix Table C2. OLS Estimation Results for Impact of Social Norming by Week (part 2 of 3)

Number of Visits to the recreation center during each intervention week	Male	Female
Week1	Base	Base
Week2	-0.093* (0.056)	-0.038 (0.064)
Week3	-0.151*** (0.056)	-0.019 (0.069)
Week4	-0.161** (0.064)	-0.092 (0.064)
Week5	-0.176*** (0.063)	-0.057 (0.067)
Week6	-0.191*** (0.064)	0.009 (0.071)
Week7	-0.179*** (0.064)	-0.085 (0.070)
Week8	-0.094 (0.071)	-0.031 (0.073)
Week9	-0.173** (0.071)	-0.114 (0.072)
Dorm 1	0.007 (0.207)	0.206 (0.361)
Dorm 2	-0.543*** (0.157)	-0.258 (0.200)
Dorm 3	-0.006 (0.241)	0.115 (0.585)
Dorm 4	-0.613*** (0.183)	0.339 (0.336)
Dorm 5	-0.288* (0.173)	-0.284* (0.155)
Dorm 6	-0.485** (0.182)	-0.501** (0.206)
Dorm 7	-0.074 (0.192)	0.025 (0.252)

Standard Errors are corrected for heteroscedasticity and clustered at student level. p<0.1, 0.05, 0.01 *, **, ***

Appendix Table C2. OLS Estimation Results for Impact of Social Norming by Week (part 3 of 3)

Number of Visits to the recreation center during each intervention week	Male	Female
Dorm 8	-0.209 (0.187)	-0.353* (0.182)
Dorm 9	Base	Base
Constant	-2.911 (2.223)	1.458 (2.309)

Standard Errors are corrected for heteroscedasticity and clustered at student level. p<0.1, 0.05, 0.01 *, **, ***

Appendix Table C3. OLS Estimation Results for Impact of Financial Incentive on Physical Exercise Frequency of Students (part 1 of 2)

Number of Visits to the recreation center during each intervention week	Male (1)	Female (2)
Age	-0.038	-0.035
	(0.036)	(0.050)
Local Student	-0.028	-0.039
	(0.038)	(0.038)
Race= White	0.037	0.077
	(0.069)	(0.063)
Race = Asian	0.057	-0.001
	(0.083)	(0.078)
Race = Others	Base	Base
Room with double occupancy	0.022	-0.024
	(0.037)	(0.060)
Lower Financial Incentive	0.092	-0.003
	(0.056)	(0.062)
Higher Financial Incentive	-0.040	-0.024
	(0.055)	(0.060)
Dorm 1	Base	Base
Dorm 2	-0.076	-0.076
	(0.127)	(0.127)
Dorm 3	-0.114	-0.011
	(0.132)	(0.135)
Dorm 4	-0.153	-0.153
	(0.143)	(0.143)
Dorm 5	0.013	0.013
	(0.126)	(0.1260
Dorm 6	-0.150	-0.150
	(0.111)	(0.111)
Dorm 7	-0.176	-0.176
	(0.117)	(0.117)
Dorm 8	-0.155	-0.155
	(0.133)	(0.133)

Standard Errors are corrected for heteroscedasticity and clustered at student level. $p<0.1$, 0.05, 0.01 *, **, ***

Appendix Table C3. OLS Estimation Results for Impact of Financial Incentive on Physical Exercise Frequency of Students (part 2 of 2)

Number of Visits to the recreation center during each intervention week	Male (1)	Female (2)
Dorm 9	-0.075	-0.075
	(0.129)	(0.129)
Constant	1.737**	1.478*
	(0.669)	(0.669)

Standard Errors are corrected for heteroscedasticity and clustered at student level. p<0.1, 0.05, 0.01 *, **, ***

Appendix Table C4. OLS Estimation Results for Impact of Financial Incentive on Physical Exercise Frequency by Week (part 1 of 2)

Number of Visits to the recreation center during each intervention week	Male (1)	Female (2)
Age	-0.037	-0.035
	(0.036)	(0.050)
Local Student	-0.025	0.039
	(0.038)	(0.035)
Race= White	0.032	0.077
	(0.071)	(0.063)
Race = Asian	0.050	0.010
	(0.084)	(0.077)
Room with double occupancy	-0.033	-0.024
	(0.061)	(0.056)
Period 1 * Low Treatment	0.148	-0.102
	(0.095)	(0.083)
Period 2 * Low Treatment	-0.079	0.141
	(0.102)	(0.096)
Period 3 * Low Treatment	-0.000	-0.021
	(0.125)	(0.113)
Period 1 * High Treatment	-0.001	0.016
	(0.093)	(0.081)
Period 2 * High Treatment	-0.010	-0.118
	(0.102)	(0.095)
Period 3 * High Treatment	-0.164	0.034
	(0.125)	(0.113)
Period 1	Base	Base
Period 2	-0.046	0.040
	(0.058)	(0.067)
Dorm 1	0.065	-0.086
	(0.129)	(0.096)
Dorm 2	-0.005	-0.042
	(0.070)	(0.073)
Dorm 3	-0.041	0.082
	(0.081)	(0.085)

Standard Errors are corrected for heteroscedasticity and clustered at student level. p<0.1, 0.05, 0.01 *, **, ***

Appendix Table C4. OLS Estimation Results for Impact of Financial Incentive on Physical Exercise Frequency by Week (part 2 of 2)

Number of Visits to the recreation center during each intervention week	Male (1)	Female (2)
Dorm 4	-0.082	-0.027
	(0.086)	(0.090)
Dorm 5	-0.082	0.079
	(0.064)	(0.060)
Dorm 6	-0.082	0.012
	(0.085)	(0.074)
Dorm 7	-0.107	-0.110
	(0.076)	(0.072)
Dorm 8	-0.082	0.031
	(0.085)	(0.066)
Dorm 9	Base	Base
Constant	1.749***	1.599*
	(0.662)	(0.905)
Number of Students	578	665

Standard Errors are corrected for heteroscedasticity and clustered at student level. p<0.1, 0.05, 0.01 *, **, ***

Appendix Table C5.Mean/Frequency Comparison of the Residence Hall Variables

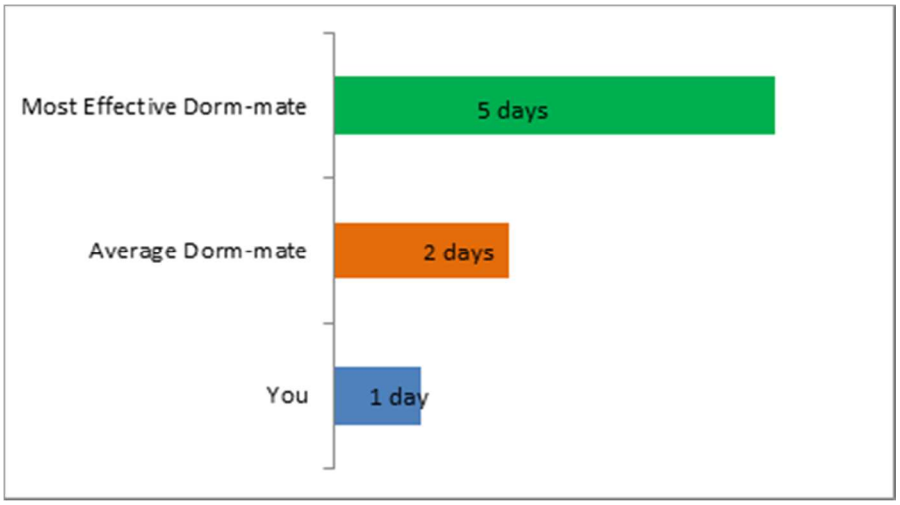
Dormitories	Distance from the Recreation Center	Number of houses	Number of rooms with at least double occupancy
Dorm 1	0.3 miles	12	97
Dorm 2	0.2 miles	14	149
Dorm 3	0.2 miles	16	73
Dorm 4	0.6 miles	13	119
Dorm 5	0.4 miles	19	365
Dorm 6	1 mile	16	305
Dorm 7	0.4 mile	16	187
Dorm 8	0.7 mile	15	174
Dorm 9	0.3 mile	18	341

Example of Email Messages to the Social Norming Group

Dear XYZ,

Welcome to the seventh week of the Physical Fitness Study conducted at the University of Minnesota. As a part of this study, I'd like to provide you some information about your own physical activity and how it compares to other freshmen in your dorm.

Last week you went to the recreation center for **1** day compared to your dorm neighbors who, on average, went to the recreation center for **2** different days. The most active of your dorm neighbors went to the recreation center on **5** different days.
Roughly 40 percent of your neighbors went to the recreation center more than you.



The Center for Disease Control (CDC) recommends that every US adult should accumulate 30 minutes of more of moderate-intensity physical activity on most, preferably all, days of the week.(Journal of American Medical Association 1995;273:402-407).

The university has state-of-art recreation centers. There are two locations, one on the East Bank campus and another one on St Paul campus. Visiting the recreation center will help you enrich your campus experience and help you adopt a healthy lifestyle.

Have a great week!

Example of Email Messages to the Financial Incentive Group

Dear XYZ

Welcome to the fifth week of the Physical Fitness Study. You guys are doing great.

As part of this study, **every day that you visit the recreation center**, you will have a 1% chance of winning a **$60 gift card**. For example, if you visit the recreation center three times in a week you will have three separate chances to win a gift card.

Every time you visit the recreation center, you will automatically have a 1% chance to win a gift card. No other action is required from on your part.

Winners will be contacted in the first week of December, 2014.

The university has a state-of-art recreation center. There are two locations, one on the east bank campus and another one on St Paul campus. Visiting the recreation center will help you enrich your campus experience and help you adopt a healthy lifestyle.

If you have any questions, please feel free to reply to this email.

Have a great week ahead.

Survey Questionnaire

Section A: Physical Activity Information

1. Yesterday, were you physically active for a total of at least 60 minutes? (Add up all the time you spent in any kind of physical activity that increased your heart rate and made you breathe hard some of the time.)

    - Yes
    - No

2. During the past 7 days, on how many days were you physically active for a total of at least **60 minutes** per day? (Add up all the time you spent in any kind of physical activity that increased your heart rate and made you breathe hard some of the time.)

    - 0 days
    - 1 day
    - 2 days
    - 3 days
    - 4 days
    - 5 days
    - 6 days
    - 7 days

3. During the past 7 days, did you exercise or participate in a physical active for a total for at least 20 minutes that made you sweat and breathe hard, such as basketball, soccer, running, swimming laps, fast bicycling, fast dancing, or similar aerobic activities?

    - 0 days
    - 1 day
    - 2 days
    - 3 days
    - 4 days
    - 5 days
    - 6 days
    - 7 days

4. In the past 30 days, about how many days per week on average did you spend exercising? (include any exercise of moderate or higher intensity, where "moderate intensity" would be roughly equivalent to brisk walking or bicycling)

- 0 days
- 1 day
- 2 days
- 3 days
- 4 days
- 5 days
- 6 days
- 7 days

5. Are you aware of the university recreation center on campus?
   - Yes
   - No

6. Do you see yourself exercising at the university recreation center during this semester?

   - Yes
   - No

7. Roughly in a week how often would you like to go and exercise at the university recreation center?

   - 0 days
   - 1 day
   - 2 days
   - 3 days
   - 4 days
   - 5 days
   - 6 days
   - 7 days

8. How would you rate your physical fitness level as compared to the students living on your floor ?

   - At a higher physical fitness level than most of the students
   - At a higher physical fitness level than some of the students
   - At a similar physical fitness level
   - At a lower physical fitness level than some of the students
   - At a lower physical fitness level than most of the students

9. In general, would you say your current health is ….?

- Excellent
- Very good
- Good
- Fair Poor

(Source: 2010 National Youth Physical Activity and Nutrition Survey)

Section B: Social Information

The last few questions of this survey will ask you about your roommate(s). If you have more than one roommate, please think about your roommates collectively when answering the questions.

10. How much do you agree with the following statements:
    Strongly agree
    Agree
    Neither agree nor disagree
    Disagree
    Strongly disagree

    A. I am a close friend with my roommate(s).
    B. I enjoy being in the room at the same time as my roommate(s).
    (Source: Winston, R. B. & Yaranovich, M.F. (1994). Quality of roommate relationships: Development of the Roommate Relationship Inventory. Journal of College and University Student Housing, 24, 6-11.)

11. Do you socialize with your current roommate(s)?

    - Yes
    - No

12. Do you socialize with other students living on your floor?
    - Yes
    - No

13. Would you like to change your room?

    - Yes
    - No

14. Please indicate the percentage of time you socialize with the following people:

    - Your roommate ☐

-
- Other students on your floor ☐
-
- Students you met in your classes ☐

15. During this school year, about how much time per day on average have you spent doing things or hanging out with your roommate(s)?

    - Less than 15 minutes
    - 15-30 minutes
    - 30 minutes-1 hour
    - 1-2 hours
    - 2-4 hours
    - 4 or more hours

16. During this school year, about how often have you discussed any of your personal or emotional problems with your roommate(s)?
    - Never
    - Once or twice total
    - Once every month or two
    - Once every week or two
    - A couple times per week
    - Almost every day

17. During this school year, about how often have you discussed any of your roommate(s)'s personal or emotional problems with him/her?
    - Never
    - Once or twice total
    - Once every month or two
    - Once every week or two
    - A couple times per week
    - Almost every day

18. Before you moved into your campus residence last fall, about how much time in total had you spent corresponding with and/or hanging out with your roommate(s)?
    - None
    - Less than 2 hours
    - 2-5 hours
    - 6-10 hours
    - 11-20 hours
    - More than 20 hours