View metadata, citation and similar papers at core.ac.uk
brought to you by CORE
provided by epublications@Marquette

Marquette University
e-Publications@Marquette

Economics Faculty Research and Publications | Economics, Department of

1-1-2014

Obesogenic Environmental Influences on Young Adults: Evidence From Randomized Dormitory Assignment

Kandice A. Kapinos
University of Michigan - Ann Arbor

Olga Yakusheva
Marquette University, olga.yakusheva@marquette.edu

Daniel Eisenberg
University of Michigan - Ann Arbor

Accepted version.*Economics and Human Biology*, Vol. 12 (January 2014): 98-109. DOI. © 2014 Elsevier B.V. Used with permission.

Marquette University

e-Publications@Marquette

Economics Faculty Research and Publications/College of Business Administration

***This paper is NOT THE PUBLISHED VERSION;* but the author's final, peer-reviewed manuscript.**
The published version may be accessed by following the link in the citation below.

Economics and Human Biology, Vol. 12 (January, 2014): 98-109. DOI. This article is © Elsevier and permission has been granted for this version to appear in e-Publications@Marquette. Elsevier does not grant permission for this article to be further copied/distributed or hosted elsewhere without the express permission from Elsevier.

Obesogenic environmental influences on young adults: Evidence from college dormitory assignments

Kandice A. Kapinos
Abt Associates Inc., US Health, Bethesda, MD
Olga Yakusheva
Marquette University, College of Business and Graduate School of Management, Department of Economics, Milwaukee, WI
Daniel Eisenberg
University of Michigan, School of Public Health, Health Management and Policy Department, Ann Arbor, MI

Abstract
This study utilizes a natural experiment—conditionally random dormitory assignments of first-year US college students—to investigate the influence of obesogenic environmental factors in explaining changes in weight and exercise behavior during the 2009–2010 academic year. The design addresses potential selection biases resulting from the likelihood that individuals sort into built environments that

match their preferences for exercise and healthy eating. We find some evidence that the food environment, specifically access to campus dining, significantly affected the weight of female students in our study. Females assigned to dormitories where the nearest campus dining hall was closed on the weekends gained about 1 lb less over the course of the year than females assigned to dormitories near dining halls that were open 7 days a week. We also find some evidence that female who lived in close proximity to a grocery store gained less weight over the course of the year. Finally, females who lived closer to campus gym reported more frequent exercise over the course of the year. We do not find significant effects of the built environment on weight changes of males in our sample, but we are cautious to draw strong conclusions from this because the male weight change in our sample was quite small.

Keywords
Weight gain; Built environment effects; Obesity

1. Introduction

The prevalence of obesity in the United States among children and young adults has increased dramatically over the last three decades, with nearly 18% of adolescents aged 12–19 and 26% of young adults aged 18–29 classified as obese in 2006 (based on calculations from NHANES III (1988–1994) and continuous NHANES (1999–2006); also see Mokdad et al., 1999, Mokdad et al., 2001). In 2007, over one-third of adolescents between ages 12 and 19 were either overweight or obese (BMI greater than 85th percentile for age and sex) (Ogden et al., 2010). Overweight children are at a greater risk of becoming obese as adults (Serdula et al., 1999, Whitaker et al., 1997) and suffer an increased risk of numerous obesity-related health conditions. This has led to an increase in public health initiatives aimed at curbing this problem.

While reasons for this growing trend are complex, behavioral researchers and policymakers are increasingly interested in understanding non-biological and modifiable factors (Lakdawalla and Philipson, 2009). Many recent studies have focused on the role of the built environment in explaining increased rates of overweight and obesity. The term “built environment” typically refers to an individual's surroundings that are man-made, such as transportation, architectural design, and features of public spaces, as opposed to naturally occurring. We refer to obesogenic attributes of the built environment that facilitate physical (in)activity and the consumption of (non)healthful foods as the *physical activity* environment and the *food environment*, respectively.

Food environments that expose individuals to energy dense foods (Neumark-Sztainer et al., 2005), sugar-sweetened beverages (Berkey et al., 2004, Ludwig et al., 2001, Malik et al., 2006, Welsh et al., 2005) and fast food, buffet-style or all you can eat dining (Levitsky et al., 2004, Niemeier et al., 2006) have been linked to greater consumption of less healthful foods and weight gain, whereas exposure to more healthful alternatives (e.g., fruits and vegetables) have been linked to improved dietary intake (Laska et al., 2010, Li et al., 2000). Several studies investigating the presence of vending machines in schools and workplaces have suggested that when vending machines provide convenient access to less healthful foods, consumption of such foods increases (Berkey et al., 2004, Kubik et al., 2003, Neumark-Sztainer et al., 2005).

Similarly, specific aspects of the physical activity environment, including “walkability,” access to exercise facilities, parks, trails, and low crime, have been associated with increased physical activity and lower rates of overweight and obesity (Bell et al., 2008, Ewing et al., 2006, Franzini et al., 2009, Sallis et al., 1998). For example, San Diego residents who lived in neighborhoods with more exercise facilities were more likely to exercise than residents who lived in neighborhoods with fewer exercise facilities (Sallis et al., 1998).

These documented associations between environmental factors and obesity have prompted a number of public policy recommendations to modify the food and physical activity environments to promote healthy eating and regular physical activity. For example, researchers have recommended that state and local governments provide funding and other incentives for new fitness venues (e.g., bicycle paths, recreation centers, and parks), modify zoning requirements to create pedestrian malls and designated automobile-free zones, encourage architectural designs with easily accessible stairs and parking spaces placed farther away from the entrance, and regulate the fast-food industry (French et al., 2001, Hill et al., 2003, Nestle and Jacobson, 2000, Philipson and Posner, 2003, Philipson and Posner, 2008).

Whether these policies can be successful, however, depends on the extent to which a change in the built environment is capable of eliciting a behavioral response from individuals, and current research is far from definitive in this regard (Diez Roux and Mair, 2010, Oakes, 2004, Subramanian, 2004). A recent systematic review of studies published between 1966 and 2007 noted that most investigations reporting a significant link between the built environment and weight-related behaviors and outcomes were non-experimental and that little attempt has been made to try to tease out the causal path of influence (Papas et al., 2007). In particular, addressing the selection bias created by individuals sorting into physical environments best suited for their lifestyles or retailers non-randomly choosing locations for their businesses is challenging in non-experimental studies. More recent studies that have attempted to account for this selection problem with panel data methods or instrumental variable approaches have found mixed support that the physical environment causally affects obesity related behaviors and prevalence (Courtemanche and Carden, 2011, Eid et al., 2008, Ewing et al., 2006, Kostova, 2011, Ng et al., 2009, Plantinga and Bernell, 2007, Zhao and Kaestner, 2010).

One recent long-term study uses an experimental design, similar to one used in this study, to overcome the selection bias in linking the environment to obesity. Ludwig et al. (2011) describe the Moving to Opportunity program, where females were randomly assigned to live in different census tracts, and those assigned to low-poverty areas had lower prevalence of extreme obesity (BMI of 35 or more) and lower levels of glycated hemoglobin than did controls approximately 13 years after assignment. However, there were no differences across groups in the rate of females with BMIs of 30 or more (the standard cut-off defining obesity). Furthermore, while the social environment measures utilized in these aforementioned studies likely correlate with various aspects of the built environment, the measures reveal little about what specific features of the built environment matter in explaining the observed differences in the prevalence of extreme obesity (i.e., what characteristic of the food environment in low poverty areas explains obesity rates).

Identification issues aside, measurement of obesogenic attributes of the built environment frequently also presents a significant challenge in studies investigating the influence of the environment on obesity and related behaviors (Diez Roux and Mair, 2010). Several of the aforementioned studies rely on sociodemographic measures aggregated to a neighborhood or census tract (e.g., poverty) as proxies for the physical or social environment as opposed to using actual measures that characterize the food and physical activity environment. Others utilize measures of residential sprawl (the share of undeveloped land in one's neighborhood), counts of mixed-use retail shops within a certain buffer of an individual's address or zip code, park density (count per square mile in zip code), or census tract level poverty rates (Eid et al., 2008, Ewing et al., 2006, Kostova, 2011, Ludwig et al., 2011, Plantinga and Bernell, 2007).

The present study contributes to the literature by investigating specific characteristics of the food and physical activity environments and by relying on a quasi-experimental design to allow for more convincing causal inference. Thus, we are able to address selection bias and utilize better measures of the food and physical activity environment. This work builds on and extends an earlier pilot study that surveyed 388 college freshmen randomly assigned to live in seven different dormitories at a Catholic university and found evidence of environmental effects on both behaviors and weight/BMI (Kapinos and Yakusheva, 2011). Females randomly assigned to dormitories with on-site dining halls weighed more and exercised less at the end of the first year, while males consumed more food than students otherwise assigned (Kapinos and Yakusheva, 2011). The study also found that proximity to the gym was associated with more frequent exercise. The present study investigates the role of gym proximity and more detailed measures of aspects of the campus dining and overall food environment among first-year students at a large university to understand better the underlying relationship between weight gain and exercise behavior and the obesogenic environment.

2. Methods

2.1. Sampling and data

This study uses data collected initially for a study of peer influences on mental health outcomes among college students (Eisenberg et al., 2012). First-year students at a large public university were surveyed at two time points: during the three-week period prior to the start of the fall semester in 2009, and during the three-week period prior to the spring final exam week in 2010. Students were given the incentive to participate with a recruitment letter and a $10 bill (see Eisenberg et al., 2012) for more details about these data).[1] A total of 3825 students (68% response rate overall) completed the baseline survey and provided their weight and height. Among those who completed the baseline survey, 2172 provided their height and weight at follow-up. The survey data were linked to administrative data on housing preferences, dormitory and room assignments, and demographic characteristics.

For students who submitted their housing applications by a certain deadline—which included 90% of our sample—housing officials generated a random lottery number for each student and then assigned students to housing (matched to the students' preferences to the extent possible) in the order of the lottery numbers. This process implies that for any given students with identical housing preferences, any differences in housing assignments were entirely random. Thus, by controlling completely for the preference variables, we could simulate a random experiment. For the remaining 10% of the sample who submitted late housing applications, the housing officers assigned students to remaining housing in the order in which applications were received. For these students we controlled flexibly for the date of housing application by including dummy variables for each week in which the applications were received, in addition to housing preferences.

Student housing preferences included geographic area of campus, co-ed versus same sex residence, room type, and substance use environment. There were three geographic areas or neighborhoods of dormitories on campus, but we restricted our sample to those requesting the central area of campus (89% of our final sample requested the central area of campus). Most of the students in our sample who requested a non-central area were granted their requests. Similarly, virtually all of the female students in our sample who requested female only dormitories were placed in female only dormitories. Therefore, because these students were essentially non-randomly assigned housing, we excluded students who requested a non-central area of campus or a female dormitory from our analytic sample (*n* = 237). The remainder of the housing preference variables (room type: single, double, triple, and quad; substance use: whether the student is a smoker, non-smoker and/or whether the student preferred to live in a substance free residence) are included as controls in all of our analyses. Our final sample consists of 1935 students (1064 females and 871 males). Because our final sample represents only 50% of the sample surveyed at baseline, we investigate potential biases due to non-response in Table A1. Overall, our final sample has similar means for baseline weight and height as compared to the initial sample of students surveyed. We base our analysis on the initial assignment of dormitories. We view our estimates as "intention-to-treat," thus ignoring changes in rooms during the year. A very small fraction (<5%) of students in our sample change dormitories over the course of the year.

The university, located in an urban area, had approximately 6000 first-year students most of whom lived in one of 14 campus dormitories. The dormitories varied significantly with respect to the hours of operation of nearby campus eateries, the number of vending machines in each dormitory, and the proximity to grocery stores and other restaurants unaffiliated with the university. Most of the dormitories had an on-site dining hall offering all-you-can-eat (buffet style) dining (10 out of 14) and were located within half a mile or less of a campus gym (see Table 1). The campus had three main recreational gyms with similar amenities. There was a campus and city mass transit system. Most dormitories had at least one bus stop within a 1/10th of a mile buffer.

Dorm #	Dining hall	Dining hall closed	Nearby store	Dining hall hours	Distance to gym	Nearby rests	Vending machines	ΔWeight	
								Males ($n = 871$)	Females ($n = 1064$)
1	Yes	No	No	14.00	0.37	1	4	0.34 (7.90)	2.57*** (6.07)
2	Yes	Yes	No	9.50	0.47	0	9	0.35 (6.88)	1.00 (7.07)
3	No	Yes	No	9.50	0.28	0	9	2.5** (7.56)	0.65 (6.53)
4	Yes	Yes	Yes	4.75	0.52	29	4		0.86 (5.31)
5	Yes	No	No	14.00	0.39	1	7	2.29*** (9.03)	2.15*** (7.40)
6	Yes	No	No	14.00	0.47	4	0	0.71 (12.07)	2.91*** (7.11)
7	Yes	No	No	14.00	0.55	20	7	−0.39 (9.50)	2.25*** (7.21)
8	No	No	No	14.00	0.07	12	2	3.0 (6.97)	1.1 (5.40)
9	Yes	No	No	7.25	0.44	19	2		3.42 (10.15)
10	Yes	Yes	Yes	6.50	0.32	0	7	1.94*** (6.27)	1.29*** (6.80)
11	Yes	No	No	14.00	0.15	2	3	3.73** (8.25)	3.25*** (5.40)
12	Yes	No	No	6.00	0.50	1	3	1.73 (12.84)	1.88 (7.46)
13	Yes	No	No	14.00	0.45	13	9	2.22*** (5.90)	1.47** (5.38)
14	Yes	Yes	Yes	4.50	0.47	29	7	1.32 (7.01)	1.08 (4.52)

Notes: Distances to nearest campus gym are measured in miles. Weight is measured in pounds. Note that dormitories 4 and 9 are female only dormitories. Please see the text for a more detailed discussion of the dormitory characteristics.

*** Statistical significance at the 1% level.

** Statistical significance at the 5% level.

2.2. Measures

2.2.1. Physical activity environment

The main measure of the physical activity environment for each dormitory that we evaluated in this study was its proximity to the nearest campus gym. We measure this as the “runner's distance” between the dormitory and the nearest campus gym. We experimented with using straight-line distances, but felt that the runner's distance would more accurately characterize the route a typical student would take.

2.2.2. Food environment

Characteristics of the food environment evaluated were: (1) the presence of an on-site dining hall in the dormitory (dichotomous), (2) whether the nearest campus dining facility was closed during the weekends (dichotomous), (3) typical number of hours of weekday operation of the nearest campus dining facility (continuous), (4) number of vending machines in each dormitory, (5) number of nearby (within ¼ of a mile) restaurants (including fast food, sit-down, and coffee shops), and (6) number of nearby (within ¼ of a mile) grocery stores.

2.2.3. Outcomes

The outcome variables include measures of weight status and exercise frequency. Weight status variables include self-reported weight in pounds, and the body mass index (BMI), calculated in the standard way using self-reported weight (pounds) and height (inches): the ratio of weight to the square of height multiplied by 703. Exercise frequency equals one for those who reported exercising five or more times per week and zero, otherwise. This variable was based on a multiple choice survey question that asked how many hours per week on average the respondent exercised during the last 30 days, with the options of “Less than 1”, “1–2”, “3–4” and”5 or more.” We focus on weekly exercise frequency of “5 or more” hours because the Center for Disease Control and Prevention recommends daily exercise. However, results using the categorical measure (using ordered probits) are consistent with those presented here.[2]

We note that there may be other unmeasured dormitory attributes that may both explain weight and exercise behaviors and correlate with the measures we use. For example, unobserved characteristics, such as “walkability” of the dormitory to other campus buildings or jogging trails, fraternity/sorority membership of the students in the dorms, and prevalence of alcohol and other substance use in the dormitory likely influence eating and exercise behaviors. Because we are limited by the number of dormitories in our study, we focus on the aforementioned observable measures and estimate their effects separately to prevent multicollinearity from potentially biasing our estimates downward (see correlations among dormitory characteristics in Table A3).

2.3. Empirical model

To investigate the effect of the food and physical activity environments on students’ weight gain during the first year, we estimate:

$$Y_{i2} = \beta_0 + \beta_1 Y_{i1} + \Gamma Environment_{i2} + \emptyset X_{i1} + \varepsilon_{i2}$$

where Y_{ik} represents the outcome measure (BMI, weight, and exercise frequency) for student *i* at time *k* (*k* = 1 for baseline and 2 for follow-up), Environment$_i$ is one of the environment measures (physical activity and food environment measures) pertaining to student *i*'s dormitory, and *X*is a vector of controls for student's dormitory preferences. Conditional on dormitory preferences and the lagged outcome variable, the estimated coefficients of the built environment variables will measure the incremental impact of a unit change in the respective dormitory characteristic on the change in the student's BMI, weight, or exercise frequency during the first year. For the housing preference variables, we utilize a set of dummy variables that correspond to all possible permutations of the choices on the housing application for each campus as described above.

We estimate linear regression models where BMI and weight are the dependent variables and logistic regressions where frequent exercise (5+ hours per week) is the dependent variable. In models with weight as the main outcome variable, we also control for the student's baseline height. In all specifications, we cluster standard errors by the dormitory. We estimate Eq. (1) separately by gender due to evidence that suggests that males and females exhibit different eating behaviors and body image and may respond differently to triggers in the obesogenic environment (Boyington et al., 2008, Chang and Christakis, 2003, Croll et al., 2002).

Based on the previous literature discussed above, we hypothesize that living closer to a campus gym would result in greater exercise frequency and a lower BMI/weight, on average. Similarly, we expect that having greater access to on-site dining facilities, vending machines, and restaurants would result in a higher BMI/weight while greater access to a full service grocery store would result in a lower BMI/weight. We note that the relationship between access to a grocery store and weight may be more complicated as access to a grocery store may result in purchasing more food and the quality of food available and purchased at nearby grocery stores is unobserved. Thus, it may be the case that students are purchasing less healthy, ready-to-eat snacks from the grocery stores, which would be consistent with previous work that found that students stash approximately 20,000 calories on average in snack food items in their dorm rooms (Nelson and Story, 2009).

3. Results and discussion

Our empirical strategy relies on the assumption of conditional random assignment of the students in our sample to the different campus dormitories. As a first check of this, we examine the baseline weights of students across dormitories controlling for dormitory preferences and find no difference in baseline weights across dormitories for females (both from pairwise comparisons of baseline weight across dormitories and from *F*-tests of the joint significance of dormitory fixed effects in explaining baseline weight). We did find differences in baseline weights for males in one dormitory. However, our estimates are robust to excluding these males. Additionally, we find mostly non-significant associations between dormitory characteristics and baseline weight (results not reported here, but available upon request). We note that the lack of significant findings does not necessarily imply that these characteristics are not important, just that we are unable to detect significant effects in this sample.

Table 1 shows mean weight gain and changes in exercise behavior in each dormitory by gender in our final sample. On average, males and females gained about l.7–1.8 lbs over the course of the year, but this varied considerably by dormitory and gender. This average weight gain is slightly lower than the 2.5–6 lb average weight gain documented in other studies (Anderson et al., 2003, Butler et al., 2004, Hajhosseini et al., 2006, Hoffman et al., 2006, Holm-Denoma et al., 2008, Kapinos and Yakusheva, 2011, Levitsky et al., 2004, Levitsky et al., 2006, Lloyd-Richardson et al., 2009, Matvienko et al., 2001, Megel et al., 1994, Morrow et al., 2006). In Table 2, we present means for the entire sample stratified by gender. In addition to increases in weight, because height did not change much, BMI also increased over the course of the year for both males and females. Both males and females reported significant decreases in the proportion who reported exercising five or more hours per week: 14% and 6% point decrease for males and females, respectively. Note that our baseline measure of exercise was obtained prior to college entry, when students may have had more free time for exercise and when the weather may have facilitated more outdoor exercise.

Table 2. Descriptive statistics, by gender.

	Males		Females	
	Mean	Std. dev.	Mean	Std. dev.
Variable				
Baseline weight (lbs)	**162.48**	26.59	**134.11**	23.74
Follow-up weight (lbs)	**164.13**	*25.51*	**135.95**	*23.73*
Difference	1.65***	8.19	1.83***	6.69
Baseline BMI	**22.91**	3.45	**22.19**	3.45
Follow-up BMI	**23.08**	*3.16*	**22.50**	*3.47*
Difference	**0.16*** **	1.45	**0.31*** **	1.17
Baseline-exercised > 5 hours/wk	**0.43**	0.50	**0.29**	0.45
Follow-up-exercised ≥ 5 hours/wk	**0.29**	*0.46*	**0.23**	*0.43*
Difference	−**0.14*** **	0.56	−**0.06*** **	0.50
Height (inches)	**70.58**	2.72	**65.13**	2.62
Black (%)	0.03	0.17	0.04	0.20
White (%)	0.75	0.44	0.75	0.43
Asian (%)	0.12	0.33	0.12	0.32
Latino/Hispanic (%)	0.03	0.17	0.04	0.19
Other race[a] (%)	0.04	0.20	0.05	0.21
Dorm characteristics				
On-site dining hall (%)	**0.80**	0.40	**0.82**	0.39
Dining hall closed (%)	0.43	0.50	0.38	0.49
Dining hall hours	10.56	3.80	10.82	3.71
Dist. to gym (miles)	0.39	0.10	0.40	0.10
Nearby grocery Store (%)	0.32	0.47	0.28	0.45
# Nearby restaurants	6.21	8.34	6.25	8.52
# Vending machines	**6.40**	2.53	**6.16**	2.53
n	871		1064	

Notes: All distance variables are in miles. Bolded values are statistically different across genders ($p < 0.05$).
Please see text for more details on dormitory characteristics.
[a] "Other race" includes identification with multiple racial/ethnic categories.
*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.10$.

In Table 3, we report our estimates of the effect of the food environment on BMI and weight stratified by gender. Note that each cell represents a separate regression with adjustments for baseline measures of the dependent variables, housing preferences and the week the housing application was received, and includes robust standard errors in parentheses. In other words, we are separately estimating the effect of each food environment measure. None of the food environment measures influenced follow-up BMI or weight for males, which may also be due to the small observed weight change for males in our sample (1.65 lbs). We note that we cannot rule out the possibility that exposure to different food environments may have resulted in significant differences in underlying eating behaviors that could produce differences in body weight if captured over a longer period.

Table 3. The effect of the food environment on BMI and weight, by gender.

	Males		Females	
	Dependent variable measured at follow-up			
	BMI (1)	Weight (2)	BMI (3)	Weight (4)
1. On-site dining hall	0.13	−0.06	−0.18	−0.91
	(0.18)	(0.63)	(0.21)	(1.30)
2. Dining hall closed	0.04	0.08	−0.18***	−1.06**
	(0.12)	(0.45)	(0.06)	(0.37)
3. Dining hall hours	−0.01	−0.03	0.03***	0.12**
	(0.02)	(0.05)	(0.01)	(0.04)
4. Nearby grocery store	0.07	0.14	−0.12**	−0.55
	(0.09)	(0.27)	(0.05)	(0.30)*
5. Nearby restaurants	−0.001	−0.01	−0.001	−0.003
	(0.005)	(0.02)	(0.003)	(0.02)
6.# Vending machines	0.03	0.06	−0.04*	−0.28**
	(0.03)	(0.10)	(0.02)	(0.12)
Observations	871	871	1064	1064

Notes: Each cell represents a separate regression with adjustments for baseline measures of the dependent variables, housing preferences and week the housing application was received included. Models with weight as the outcome also adjust for baseline and follow-up height. Robust standard errors in parentheses (clustered by dormitory). Distance is measured in miles.

*** $p < 0.01$.

** $p < 0.05$.

* $p < 0.10$.

For females, decreased access to campus dining and increased access to a grocery store resulted in less weight gain over the course of the year (Table 3). Females living in dormitories where the nearest campus dining facility was closed on the weekend gained about 1 lb less over the course of year (row 2). While this may seem like a small effect, this is equivalent to 58% of the average weight gain among the females in our sample (1.06 of 1.83 lbs) over the course of approximately nine months.[3]Similarly, each additional hour of operation of the nearest campus dining hall was associated with a 0.12 ($p < .05$) pound greater weight gain among females (row 3). This coefficient is equivalent to a 1.14 lb smaller weight gain among females living near dining halls open the shortest number of hours (4.5 h per day) compared to females living near dining halls open the longest number of hours (14 h per day), suggesting that around the clock access to campus dining may facilitate greater food intake. Females living near a grocery store gained about a half a pound (0.55, $p = 0.09$) less than females living farther than ¼ of a mile from the nearest grocery store (row 4). This finding is consistent with previous studies that suggest that having greater access to fresh fruits and vegetables leads to improved dietary intake and lower obesity rates. However, we note that the campus dining facilities at the university we studied reported having numerous “healthy,” including vegan and vegetarian, options. Nonetheless, we find considerable variation across campus dining facilities in our review of menus suggesting that there could be large differences in what was offered in a campus dining hall on any given day and what would be available at a nearby grocery store. We also attempted to parse out the types of restaurants, as some types may be less healthy than others, but still found no significant effect of the number of restaurants within a ¼ of a mile for both males and females.[4] A more systematic comparison of campus dining facilities with non-campus restaurants and other food retailers is needed.

Having more vending machines in the dormitory resulted in less weight gain for females: females living in dormitories with 6 (the average) vending machines gained about 1.7 lbs less over the course of the year than females living in dormitories with no vending machines (row 6). While this seems inconsistent with previous studies that suggested that vending machines offer convenient access to less healthful fare (sugar-sweetened beverages and high energy dense snacks), we do not know exactly how the presence of vending machines altered students eating behaviors. For example, in one recent study, approximately 18% of middle school students reported purchasing food from vending machines *instead* of buying lunch (Park et al., 2010). If students were substituting snacks for meals by using the vending machines, we might observe this decrease in weight gain in dormitories with more vending machines. Additionally, we do not know exactly what was offered for sale in each of these vending machines. Vending machines that offer healthier fare are becoming increasingly common and may improve dietary intake. We endeavored to explore this issue further by testing for interaction effects between campus dining measures and the number of vending machines in the dormitories (Table A2). The presence of vending machines tended to decrease BMI in dormitories without on-site dining halls for females, but had little influence on BMI for females in dormitories with on-site dining halls. While this appears to be consistent with the substitution hypothesis (i.e., in dormitories without access to meals, students may have been using the vending machines instead of buying a full meal from a nearby restaurant), the inconsistent results from models using other measures of the food environment make it difficult to draw strong conclusions about how vending machines might affect meal substitution and healthful eating.

In Table 4 (rows 1 and 2), we present estimates of the linear effect of gym proximity. Each numbered row represents a separate regression. We find a negative effect of the proximity to a campus gym on BMI but not on weight for males. This effect persisted in models where we controlled for the number of bus stops within 1/10th of a mile of the dormitory (row 2). However, the proximity to a campus gym had no effect on exercise frequency for males. Disentangling these effects is particularly challenging for males who may still be growing as we do not have a way of differentiating between changes in their muscle mass and changes in their adiposity. As with male students, we find no effect of proximity to the campus gym on exercise frequency for females. These findings are also robust to operationalizing our exercise measure as a categorical measure and estimating an ordered probit for both males and females.[5]

Table 4. The effect of gym proximity on weight status and exercise frequency in spring, by gender.

	Males		Females	
	BMI	Exercise	BMI	Exercise
1.Dist. gym (miles)	−0.67*	0.28	0.37	0.40
	(0.32)	(0.24)	(0.38)	(0.43)
2. Dist. gym (miles)	−0.82**	0.51	0.30	0.52
Plus # of bus stops control	(0.37)	(0.26)	(0.41)	(0.52)
3. Spline: dist. < 0.39 miles	0.16	−0.50	0.62	0.43**
	(0.97)	(0.42)	(0.54)	(0.21)
Spline: dist. ≥ 0.39	−1.80*	0.08	0.09	−0.82***
	(0.92)	(0.64)	(0.67)	(0.24)
4. Spline: dist. < 0.39 miles	0.17	−0.53**	0.56	0.47*
	(0.70)	(0.20)	(0.50)	(0.29)
Spline: dist. ≥ 0.39	−2.24**	0.42	0.01	−0.77***
Plus # of bus stops control	(0.78)	(0.46)	(0.63)	(0.23)

Notes: Each numbered section represents a separate regression with adjustments for baseline measures of the dependent variables, housing preferences and week the housing application was received included. Models (rows) #2 and 4 also control for the number of bus stops within 1/10th of a mile from the dormitory (results reported are robust to using the number of bus stops within ¼ of a mile). Robust standard errors in parentheses (clustered by dormitory). Distance is measured in miles. Exercise equals one if the student reported exercising 5 or more times per week; odds ratios are reported in those models.

*** $p < 0.01$.

** $p < 0.05$.

* $p < 0.10$.

We investigated the presence of non-linear gym proximity effects by using a linear spline (with a knot at 0.39) (rows 3 and 4 of Table 4). Consistent with the linear specifications, males who lived farther than 0.39 miles from the nearest campus gym had significantly lower BMIs and males who lived closer were significantly less likely to exercise. As noted above, we should interpret these findings with caution due to our limited ability to differentiate between changes in muscle mass and fat, which could confound our estimates, particularly for males. We observed no evidence of non-linear effects of gym proximity on females' BMI, but we find that females who lived closer than 0.39 miles to a campus gym had greater odds of frequent exercise (5+ hours per week) whereas females living 0.39 miles or farther had lower odds of frequent exercise.

4. Conclusion

Overall, our findings provide some tentative evidence that exogenous changes to the physical activity environment may lead to changes in weight and related behaviors. However, like most of the earlier studies of the impact of the physical environment on obesity, we fall short of providing clear and robust evidence of such a link. Understanding spatial effects is challenging as simple linear distances may not capture the implicit cost to individuals to utilize nearby physical activity amenities. Further research and policy efforts need to consider transportation options and the possibility of non-linear relationships between proximity and behaviors.

Because our identification essentially comes from 14 different dormitories, we are limited in our ability to examine all of these characteristics simultaneously. However, we re-estimated models using one measure of the fitness environment (proximity to gym) and one measure of the food environment (various measures). The results are largely consistent with the models estimating effects separately though magnitudes tend to decrease (results not reported here, but available upon request).[6] Nonetheless, there may be other dormitory characteristics that are correlated with the measures we use that explain eating and exercise behaviors.

While there are well-documented racial/ethnic disparities in obesity rates and we might expect the influence of the physical built environment to vary by race/ethnicity (Komlos and Brabec, 2011, Kumanyika, 2008, Sallis et al., 1996), we are underpowered to examine this carefully in this particular dataset. Restricting our sample to only white students or including a white interaction term does not yield significantly different results from those presented here (results available upon request). However, we are cautious to draw conclusions about how the environmental impacts might vary by race from this study and believe this is an important area for future research.

Although our design allows us to eliminate bias due to individuals sorting into environments that fit their preferences, it is important to bear in mind the following limitations of this study. First, all of our outcome measures are self-reported, which may result in non-classical measurement error as other studies have noted that individuals tend to understate their weight (Rowland, 1990) and that self-report error might be systematically correlated with behavioral changes (e.g., students who go to the gym weigh themselves more often than those who do not). While we are unable to account for measurement error resulting from behavioral changes during the first year, the fact that our model controls for baseline measures makes it robust to any time-invariant self-report biases. Students in our study report how many hours a week they typically exercise, but what actually constitutes "exercise" and the intensity of exercise may vary across individuals. The questionnaire does, however, specify for students to count only "moderate or higher intensity" exercise with moderate exercise being defined as equivalent to brisk walking or biking. We are unable to account for developmentally appropriate changes in weight or differentiate between weight gain due to gaining muscle mass or increased adiposity (Burkhauser and Cawley, 2008). The fact that students at this age, particularly males, may not be finished growing implies that we should be cautious making conclusions about obesity based on the observed weight changes. In particular, because we examine changes in exercise behavior, some students may be gaining weight because of increased exercise.

We are unable to characterize the physical activity and food environment completely and we do not know much about the students specific eating (e.g., type of campus meal plan purchased) and exercise behaviors in this study. A potentially large set of attributes of the dormitories, such as distance to other campus buildings or jogging trails, fraternity/sorority membership of the students in the dorms, and prevalence of alcohol and other substance use in the dormitory, to name a few, likely influence eating and exercise behaviors but are not examined in this study. Previous research on peer effects has shown that the social environment is also an important factor in explaining eating and exercise behaviors (Carrell et al., 2011, Christakis and Fowler, 2007, Christakis and Fowler, 2008, Cohen-Cole and Fletcher, 2008, Halliday and Kwak, 2009, Trogdon et al., 2008, Yakusheva et al., 2011, Yakusheva et al., 2014). Although we do find the presence of peer effects using these data in a related study (Yakusheva et al., 2014), we do not have enough statistical power to examine these effects jointly in this study. Attempts to fully characterize the obesogenic environment are often problematic as measures may be related (i.e., the locations of restaurants may be correlated with the locations of grocery stores). While exploring a more detailed set of environmental characteristics was beyond the scope of our study, our results point out to the importance of these types of analysis in large diversified study design where such effects can be identified more credibly. While evaluating these multiple measures with our subgroup analysis (by gender) may suggest that multiple testing adjustments are appropriate (Schochet, 2008), we point out the large literature that suggests that health behaviors in general and eating disorders and body image in particular differ by gender (Boyington et al., 2008, Chang and Christakis, 2003, Croll et al., 2002).

Finally, our sample consisted of first year college students at a large academically competitive university. Furthermore, to leverage the quasi-random assignment of students to dormitories, we had to restrict the sample to students who did not request a non-central area of campus and did not request a male- or female-only or an honor dorm. While quasi-randomization allowed us to combat unobserved selection and is a major strength and novelty of the study, it may result in a loss of representativeness of our study sample and limit generalizability of our findings to other populations.

Using conditionally random dormitory assignment of freshman students as a natural experiment, this study finds evidence that the food environment influences weight gain for first-year college students. In particular, access to a dining facility that is open longer hours or on weekends, as well as living in a closer proximity to campus eateries was associated with a greater amount of weight gain for females (approximately 1 lb more), while access to grocery stores resulted in smaller weight gain (approximately ½ pound less). We find that vending machines were associated with a smaller weight gain, but only when they were likely to be used instead, and not in addition to, a full meal. We also find some tentative evidence of a link between the physical activity environment, as measured by proximity to the gym (e.g., OR = −0.82 for females living more than 0.39 miles from the campus gym, $p < 0.01$), and exercise frequency and weight, but more research is needed to understand fully the relationship between the physical activity environment and exercise. As previously noted, we do not find significant effects for males, but we are cautious to draw strong conclusions from this because the male weight change in our sample was quite small.

These findings have the potential to guide campus-wide interventions aimed at increasing physical activity and encouraging more healthful eating. However, our findings do not necessarily suggest that dramatic changes to the built environment are required to elicit behavioral changes. Consistent with libertarian paternalistic policy prescriptions (Thaler and Sunstein, 2009), our results suggest that even minor tweaks, such as changing the hours of the campus dining facilities or assessing the healthful options in the dormitory vending machines, can result in changes in students' weight. Policymakers should be cautious, however, as the underlying behavioral mechanisms are not fully understood. Environmental influences on exercise and weight gain are particularly important for young adults because for many of them, the college years are the first time they are making independent decisions and forming lifelong habits. Further research efforts should focus on investigating the generalizability of these findings to other populations, the persistence of these effects over time, the interaction of the physical environmental effects with social environment effects, and other environmental characteristics in a way that addresses the selection bias.

Acknowledgment

The authors are grateful to Jody Sindelar, Kevin Stange, Rusty, Tchernis, three anonymous reviewers, session participants at the Health Economics Interest Group meeting at Academy Health, the Midwest Health Economics Conference, the Southern Economic Association meetings, and seminar participants at Abt Associates Inc., the University of Maryland, Washington University, and the Department of Veterans Affairs for their comments. This research was undertaken while Kapinos was a postdoctoral fellow the Minneapolis Veterans Affairs Medical Center and the University of Minnesota. Yakusheva thanks Marquette University College of Business for funding support from faculty research grants, and AHRQ for funding support from the T-32 Postdoctoral Training Grant in Health Services Research (5 T32 HS 17589-4). The views expressed herein are those of the authors and do not necessarily reflect the views of the Department of Veterans Affairs or the United States government. This project uses data from a research project funded by the W.T. Grant Foundation.

Appendix A.

Table A1, Table A2, Table A3, Table A4

Table A1
Baseline characteristics of alternative samples (examining non-response bias).

	Responded to baseline survey (col. 1)	Responded to baseline survey and provided BMI (col. 2)	Responded to both surveys and provided BMI (col. 3)	Final (col.4)
n	3891	3825	2172	1935
% of all baseline responders	100%	98%	56%	50%
Age	18.50	18.49	18.5	18.52
Female (%)	**0.50**	0.5	0.54	**0.54**
Black (%)	0.04	0.05	0.04	0.04
White (%)	**0.72**	0.72	0.74	**0.75**
Asian (%)	0.13	0.12	0.12	0.12
Latino/Hispanic (%)	0.03	0.03	0.03	0.03
Other race[a] (%)	0.06	0.05	0.05	0.05
On-site dining hall (%)	0.79	0.80	0.81	0.81
Dist. to dining hall (miles)	0.02	0.02	0.02	0.02
Dist. to gym (miles)	0.39	0.39	0.40	0.39
Dining hall hours	10.72	10.72	10.75	10.70
Dining hall closed (0/1)	0.42	0.42	0.41	0.40
Nearby restaurants	**5.54**	5.54	5.93	**6.23**
Nearby grocery stores	**0.27**	0.27	0.27	**0.30**
Baseline weight (lbs)		148.52	147.53	148.58
Baseline height (in.)		**67.85**	67.63	**67.58**
Baseline BMI		22.57	22.58	22.52
Baseline exercise > 5 h/wk		0.34	0.34	0.35

Notes: "Provided BMI" means the student provided his height and weight (we calculated BMI). From columns 3 to 4 (our final sample), we excluded individuals who requested and were placed in non-central areas of campus or female only dormitories. Bolded values are statistically significantly different in the baseline (or baseline with BMI sample) and final samples at the 5% level.

[a] "Other race" includes identification with multiple racial/ethnic categories.

Table A2
Substitution between campus dining and vending machines, by gender.

	BMI at follow-up	
	Males (1)	Females (2)
1.On-site dining hall	0.49	−0.58***
	(0.38)	(0.16)
# of vending machines	0.05**	−0.08***
	(0.02)	(0.02)
Interaction	−0.07	0.09***
	(0.05)	(0.02)
2. Dining hall closed	0.64	−0.30
	(0.37)	(0.18)
# of vending machines	0.04	−0.04
	(0.03)	(0.02)
Interaction	−0.09	0.02
	(0.05)	(0.02)
3. Dining hall hours	−0.05	0.07***
	(0.03)	(0.01)
# of vending machines	−0.06	0.03
	(0.06)	(0.02)
Interaction	0.01	−0.01***
	(0.005)	(0.002)

Notes: Each numbered section represents a separate linear regression with controls for housing preferences and baseline BMI. Robust standard errors in parentheses (clustered by dormitory).

*** $p < 0.01$.

** $p < 0.05$.

* $p < 0.10$.

Table A3
Pairwise correlations—dormitory characteristics ($n = 14$).

	1	2	3	4	5	6
2	0.14					
3	0.33	0.70				
4	−0.41	−0.68	−0.71*			
5	0.43	0.13	0.19	−0.35		
6	0.30	0.11	0.45	−0.34	0.37	
7	0.32	0.51	0.14	−0.09	0.19	−0.09

Dormitory characteristics:
1.On-site dining hall?
2. Nearest campus dining closed on weekend.
3. Grocery store within ¼ mile.
4. Hours of nearest campus dining.
5. Distance to nearest gym.
6. # of other restaurants with ¼ mile.
7. # of vending machines.

*** $p < 0.01$.

** $p < 0.05$.

* $p < 0.10$.

Table A4
Distribution of BMI/weight change by whether dining hall is opened during weekends.

	Min	20th %	40th %	60th %	80th%	Max	*n*
Males							
Opened on weekends							
ΔBMI	−26.46	−0.64	0.00	0.43	1.01	4.66	493
ΔWeight	−83.00	−3.00	0.00	4.40	7.00	40.00	
Closed on weekends							
ΔBMI	−3.31	−0.66	0.00	0.45	0.81	4.26	378
ΔWeight	−17.00	−5.00	0.00	4.00	6.00	23.00	
Females							
Opened on weekends							
ΔBMI	−6.49	−0.34	0.00	0.63	0.98	8.32	660
ΔWeight	−24.00	−1.00	0.00	3.00	5.00	50.00	
Closed on weekends							
ΔBMI	−7.60	−0.55	0.00	0.47	0.87	3.21	404
ΔWeight	−50.00	−2.00	0.00	2.00	5.00	20.00	

Notes: We present the change in BMI/weight by whether the dining hall was opened during the weekends for both males and females, respectively. The 20th to 80th percentiles, represent the BMI/weight changes at the respective percentile, exactly (i.e., these are not quintile means).

References

Anderson et al., 2003 D.A. Anderson, J.R. Shapiro, J.D. Lundgren. **The freshman year of college as a critical period for weight gain: an initial evaluation.** Eating Behaviors, 4 (4) (2003), pp. 363-367

Bell et al., 2008 J.F. Bell, J.S. Wilson, G.C. Liu. **Neighborhood greenness and 2-year changes in body mass index of children and youth.** American Journal of Preventive Medicine, 35 (6) (2008), pp. 547-553

Berkey et al., 2004 C.S. Berkey, H.R. Rockett, A.E. Field, M.W. Gillman, G.A. Colditz. **Sugar-added beverages and adolescent weight change.** Obesity Research, 12 (5) (2004), pp. 778-788

Bosker et al., 2003 R.J. Bosker, T.A.B. Snijders, H. Guldemond. **PINT (Power IN Two-level Designs): Estimating Standard Errors of Regression Coefficients in Hierarchical Linear Models for Power Calculations.** Version 2.1 User's Manual (2003). Available at http://www.stats.ox.ac.uk/~snijders/multilevel.htm

Boyington et al., 2008 J.E. Boyington, L. Carter-Edwards, M. Piehl, J. Hutson, D. Langdon, S.McManus. **Cultural attitudes toward weight, diet, and physical activity among overweight African American girls.** Preventing Chronic Disease, 5 (2) (2008), p. A36

Butler et al., 2004 S. Butler, D. Black, C. Blue, R. Gretebeck. **Change in diet, physical activity, and body weight in female college freshmen.** American Journal of Health Behaviour, 28 (2004), pp. 24-32

Burkhauser and Cawley, 2008 R.V. Burkhauser, J. Cawley. **Beyond BMI: the value more accurate measures of fatness and obesity in social science research.** Journal of Health Economics, 27 (2) (2008), pp. 519-529

Carrell et al., 2011 S.E. Carrell, M. Hoekstra, J.E. West. **Is poor fitness contagious?: evidence from randomly assigned friends.** Journal of Public Economics, 95 (7–8) (2011), pp. 657-663

Chang and Christakis, 2003 V.W. Chang, N.A. Christakis. **Self-perception of weight appropriateness in the United States.** American Journal of Preventive Medicine, 24 (4) (2003), pp. 332-339

CDC, 1988–1994 Centers for Disease Control Prevention (CDC). **National Center for Health Statistics (NCHS). National Health and Nutrition Examination Survey Data.** U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, Hyattsville, MD (1988–1994)

CDC, 1999–2006 Centers for Disease Control Prevention (CDC). **National Center for Health Statistics (NCHS). National Health and Nutrition Examination Survey Data.** U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, Hyattsville, MD (1999–2006)

Christakis and Fowler, 2007 N.A. Christakis, J.H. Fowler. **The spread of obesity in a large social network over 32 years.** New England Journal of Medicine, 357 (4) (2007), pp. 370-379

Christakis and Fowler, 2008 N.A. Christakis, J.H. Fowler. **The collective dynamics of smoking in a large social network.** New England Journal of Medicine, 358 (21) (2008), pp. 2249-2258

Cohen-Cole and Fletcher, 2008 E. Cohen-Cole, J.M. Fletcher. **Is obesity contagious? Social networks vs. environmental factors in the obesity epidemic.** Journal of Health Economics, 27 (5) (2008), pp. 1382-1387

Courtemanche and Carden, 2011 C. Courtemanche, A. Carden. **Supersizing supercenters? The impact of walmart supercenters on body mass index and obesity.** Journal of Urban Economics, 69 (2) (2011), pp. 165-181

Croll et al., 2002 J. Croll, D. Neumark-Sztainer, M. Story, M. Ireland. **Prevalence and risk and protective factors related to disordered eating behaviors among adolescents: relationship to gender and ethnicity.** Journal of Adolescent Health, 31 (2) (2002), pp. 166-175

Diez Roux and Mair, 2010 A.V. Diez Roux, C. Mair. **Neighborhoods and health.** Annals of the New York Academy of Sciences, 1186 (2010), pp. 125-145

Eid et al., 2008 J. Eid, H.G. Overman, D. Puga, M.A. Turner. **Fat city: questioning the relationship between urban sprawl and obesity.** Journal of Urban Economics, 63 (2) (2008), pp. 385-404

Eisenberg et al., 2012 D. Eisenberg, E. Golberstein, J.L. Whitlock, M.F. Downs. **Social contagion of mental health: Evidence from college roommates.** Health Economics (2012), 10.1002/hec.2873

Ewing et al., 2006 R. Ewing, R.C. Brownson, D. Berrigan. **Relationship between urban sprawl and weight of United States youth.** American Journal of Preventive Medicine, 31 (6) (2006), pp. 464-474

Franzini et al., 2009 . Franzini, M.N. Elliott, P. Cuccaro, M. Schuster, M.J. Gilliland, J.A.Grunbaum, F. Franklin, S.R. Tor tolero. **Influences of physical and social neighborhood environments on children's physical activity and obesity.** American Journal of Public Health, 99 (2) (2009), pp. 271-278, 10.2105/AJPH.2007.128702

French et al., 2001 S.A. French, M. Story, R. Jeffrey. **Environmental influences on eating and physical activity.** Annual Review of Public Health, 22 (2001), pp. 309-335

Hajhosseini et al., 2006 . Hajhosseini, T. Holmes, P. Mohamadi, V. Goudarzi, L. McProud, C.B. Hollenbeck. **Changes in body weight, body composition and resting metabolic rate (RMR) in first-year university freshmen students.** Journal of the American College Nutrition, 25 (2) (2006), pp. 123-127

Halliday and Kwak, 2009 T.J. Halliday, S. Kwak. **Weight gain in adolescents and their peers.** Economics and Human Biology, 7 (2) (2009), pp. 181-190

Hill et al., 2003 J.O. Hill, H.R. Wyatt, G.W. Reed, J.C. Peters. **Obesity and the environment: where do we go from here?** Science, 299 (5608) (2003), pp. 853-855

Hoffman et al., 2006 D.J. Hoffman, P. Policastro, V. Quick, S.-K. Lee. **Changes in body weight and fat mass of men and women in the first year of college: a study of the "Freshman 15".** Journal of American College Health, 55 (1) (2006), pp. 41-45

Holm-Denoma et al., 2008 J.M. Holm-Denoma, T.E. Joiner Jr., K.D. Vohs, T.F. Heatherton. **The "freshman fifteen" (the "freshman five" actually): predictors and possible explanations.** Health Psychology, 27 (1) (2008), pp. S3-S9

Kapinos and Yakusheva, 2011 K.A. Kapinos, O. Yakusheva. **Environmental influences on young adult weight gain: evidence from a natural experiment.** Journal of Adolescent Health, 48 (1) (2011), pp. 52-58

Komlos and Brabec, 2011 J. Komlos, M. Brabec. **The trend of BMI values of US adults by deciles, birth cohorts 1882–1986 stratified by gender and ethnicity.** Economics and Human Biology, 9 (3) (2011), pp. 234-250

Kostova, 2011 D. Kostova. **Can the built environment reduce obesity? The impact of residential sprawl and neighborhood parks on obesity and physical activity.** Eastern Economic Journal, 37 (2010), pp. 390-402. (Summer 2011)

Kubik et al., 2003 M.Y. Kubik, L.A. Lytle, P.J. Hannan, C.L. Perry, M. Story. **The association of the school food environment with dietary behaviors of young adolescents.** American Journal of Public Health, 93 (7) (2003), pp. 1168-1173, 10.2105/AJPH.93.7.1168

Kumanyika, 2008 S.K. Kumanyika. **Environmental influences on childhood obesity: ethnic and cultural influences in context.** Physiology & Behavior, 94 (1) (2008), pp. 61-70

Lakdawalla and Philipson, 2009 D. Lakdawalla, T. Philipson. **The growth of obesity and technological change.** Economics and Human Biology, 7 (3) (2009), pp. 283-293

Laska et al., 2010 M.N. Laska, M.O. Hearst, A. Forsyth, K.E. Pasch, L. Lytle. **Neighborhood food environments: are they associated with adolescent dietary intake, food purchases, and weight status?** Public Health Nutrition, 13 (11) (2010), pp. 1757-1763

Levitsky et al., 2006 D.A. Levitsky, J. Garay, M. Nausbaum, L. Neighbors, D.M. DellaValle. **Monitoring weight daily blocks the freshman weight gain: a model for combating the epidemic of obesity.** International Journal of Obesity, 30 (6) (2006), pp. 1003-1010

Levitsky et al., 2004 D.A. Levitsky, C.A. Halbmaier, G. Mrdjenovic. **The freshman weight gain: a model for the study of the epidemic of obesity.** International Journal of Obesity, 28 (11) (2004), pp. 1435-1442

Li et al., 2000 R. Li, M. Serdula, S. Bland, A. Mokdad, B. Bowman, D. Nelson. **Trends in fruit and vegetable consumption among adults in 16 US states: behavioral risk factor surveillance system, 1990–1996.** American Journal of Public Health, 90 (5) (2000), pp. 777-781

Lloyd-Richardson et al., 2009 E.E. Lloyd-Richardson, S. Bailey, J.L. Fava, R. Wing. **A prospective study of weight gain during the college freshman and sophomore years.** Preventive Medicine, 48 (3) (2009), pp. 256-261

Ludwig et al., 2001 D.S. Ludwig, K.E. Peterson, S.L. Gortmaker. **Relation between consumption of sugar-sweetened drinks and childhood obesity: a prospective, observational analysis.** Lancet, 357 (9255) (2001), pp. 505-508

Ludwig et al., 2011
. Ludwig, L. Sanbonmatsu, L. Gennetian, E. Adam, G.J. Duncan, L.F. Katz, R.C. Kessler, J.R. Kling, S. T. Lindau, R.C. Whitaker, T.W. McDade. **Neighborhoods, obesity, and diabetes—a randomized social experiment.** New England Journal of Medicine, 365 (2011), pp. 1509-1519, 10.1056/NEJMsa1103216

Malik et al., 2006 V.S. Malik, M.B. Schulze, F.B. Hu. **Intake of sugar-sweetened beverages and weight gain: a systematic review.** American Journal of Clinical Nutrition, 84 (2) (2006), pp. 274-288

Matvienko et al., 2001 O. Matvienko, D.S. Lewis, E. Schafer. **A college nutrition science course as an intervention to prevent weight gain in female college freshmen.** Journal of Nutrition Education, 33 (2) (2001), p. 95

Megel et al., 1994 M. Megel, P. Hawkins, S. Sandstrom, M. Hoefler, K. Willrett. **Health promotion, self-esteem, and weight among female college freshmen.** Health Values, 18 (1994), pp. 10-19

Mokdad et al., 2001 A.H. Mokdad, B.A. Bowman, E.S. Ford, F. Vinicor, J.S. Marks, J.P. Koplan. **The continuing epidemics of obesity and diabetes in the United States.** Journal of American Medical Association, 286 (10) (2001), pp. 1195-1200

Mokdad et al., 1999 A.H. Mokdad, M.K. Serdula, W.H. Dietz, B.A. Bowman, J.S. Marks, J.P.Koplan. **The spread of the obesity epidemic in the United States, 1991–1998.** Journal of American Medical Association, 282 (16) (1999), pp. 1519-1522

Morrow et al., 2006 M.L. Morrow, K.C. Heesch, M.K. Dinger, H.R. Hull, A.W. Kneehans, D.A.Fields. **Freshman 15: fact or fiction?** Obesity, 14 (8) (2006), pp. 1438-1443

Nelson and Story, 2009 M.C. Nelson, M. Story. **Food environments in university dorms: 20,000 calories per dorm room and counting.** American Journal of Preventive Medicine, 36 (6) (2009), pp. 523-526

Nestle and Jacobson, 2000 M. Nestle, M.F. Jacobson. **Halting the obesity epidemic: a public health policy approach.** Public Health Reports, 115 (1) (2000), pp. 12-24

Neumark-Sztainer et al., 2005 D. Neumark-Sztainer, S. French, P. Hannan, M. Story, J.Fulkerson. **School lunch and snacking patterns among high school students: associations with school food environment and policies.** International Journal of Behavioral Nutrition and Physical Activity, 2 (1) (2005), p. 14, 10.1186/1479-5868-2-14

Niemeier et al., 2006 H.M. Niemeier, H.A. Raynor, E.E. Lloyd-Richardson, M.L. Rogers, R.R.Wing. **Fast Food consumption and breakfast skipping: predictors of weight gain from adolescence to adulthood in a nationally representative sample.** Journal of Adolescent Health, 39 (6) (2006), pp. 842-849

Ng et al., 2009 S.W. Ng, E.C. Norton, B.M. Popkin. **Why have physical activity levels declined among Chinese adults? Findings from the 1991–2006 China health and nutrition surveys.** Social Science & Medicine, 68 (2009), pp. 1305-1314

Oakes, 2004 J.M. Oakes. **The (mis)estimation of neighborhood effects: causal inference for a practicable social epidemiology.** Social Science & Medicine, 58 (10) (2004), pp. 1929-1952

Ogden et al., 2010 C.L. Ogden, M.D. Carroll, L.R. Curtin, M.M. Lamb, K.M. Flegal. **Prevalence of high body mass index in US children and adolescents, 2007–2008.** Journal of American Medical Association, 303 (3) (2011), pp. 242-249

Papas et al., 2007 M.A. Papas, A.J. Alberg, R. Ewing, K.J. Helzlsouer, T.L. Gary, A.C. Klassen. **The built environment and obesity.** Epidemiologic Reviews, 29 (1) (2007), pp. 129-143

Park et al., 2010 S. Park, W.M. Sappenfield, Y. Huang, B. Sherry, D.M. Bensyl. **The impact of the availability of school vending machines on eating behavior during lunch: the Youth Physical Activity and Nutrition Survey.** Journal of the American Dietetic Association, 110 (10) (2010), pp. 1532-1536, 10.1016/j.jada.2010.07.003

Philipson and Posner, 2003 T.J. Philipson, R.A. Posner. **The long-run growth in obesity as a function of technological change.** Perspectives in Biology and Medicine, 46 (3) (2003), p. S87

Philipson and Posner, 2008 T.J. Philipson, R.A. Posner. **Is the obesity epidemic a public health problem? A review of Zoltan J. Acs and Alan Lyles's obesity, business and public policy.** Journal of Economic Literature, 46 (2008), pp. 974-982

Plantinga and Bernell, 2007 A.J. Plantinga, S. Bernell. **The association between urban sprawl and obesity: is it a two-way street?** Journal of Regional Science, 47 (5) (2007), pp. 857-879

Rowland, 1990 M.L. Rowland. **Self-reported weight and height.** American Journal of Clinical Nutrition, 52 (6) (1990), pp. 1125-1133

Sallis et al., 1996 J.F. Sallis, J.M. Zakarian, M.F. Hovell, C.R. Hofstetter. **Ethnic, socioeconomic, and sex differences in physical activity among adolescents.** Journal of Clinical Epidemiology, 49 (2) (1996), pp. 125-134

Sallis et al., 1998 J.F. Sallis, A. Bauman, M. Pratt. **Environmental and policy interventions to promote physical activity.** American Journal of Preventive Medicine, 15 (4) (1998), pp. 379-397, 10.1016/S0749-3797(98)00076-2

Serdula et al., 1999 .K. Serdula, A.H. Mokdad, D.F. Williamson, D.A. Galuska, J.M.Mendlein, G.W. Heath. **Prevalence of attempting weight loss and strategies for controlling weight.** Journal of American Medical Association, 282 (14) (1999), pp. 1353-1358

Schochet, 2008 P.Z. Schochet . **Guidelines for Multiple Testings in Impact Evaluations of Educational Interventions.** (2008). NCEE-4018

Snijders and Bosker, 1993 T.A.B. Snijders, R.J. Bosker. **Standard errors and sample sizes for two-level research.** Journal of Educational Statistics, 18 (1993), pp. 237-259

Subramanian, 2004 S.V. Subramanian. **The relevance of multilevel statistical methods for identifying causal neighborhood effects.** Social Science & Medicine, 58 (10) (2004), pp. 1961-1967

Thaler and Sunstein, 2009 R.H. Thaler, C.R. Sunstein. **Nudge: Improving Decisions About Health, Wealth, and Happiness.** Penguin Group, New York (2009)

Trogdon et al., 2008 J.G. Trogdon, J. Nonnemaker, J. Pais. **Peer effects in adolescent overweight.** Journal of Health Economics, 27 (5) (2008), pp. 1388-1399

Welsh et al., 2005 J.A. Welsh, M.E. Cogswell, S. Rogers, H. Rockett, Z. Mei, L.M. Grummer-Strawn. **Overweight among low-income preschool children associated with the consumption of sweet drinks: Missouri, 1999–2002.** Pediatrics, 115 (2) (2005), pp. e223-e229

Whitaker et al., 1997 R.C. Whitaker, J.A. Wright, M.S. Pepe, K.D. Seidel, W.H. Dietz. **Predicting obesity in young adulthood from childhood and parental obesity.** New England Journal of Medicine, 337 (13) (1997), pp. 869-873

Yakusheva et al., 2011 O. Yakusheva, K. Kapinos, M. Weiss. **Peer effects and the freshman 15: evidence from a natural experiment.** Economics and Human Biology, 9 (2) (2011), pp. 119-132

Yakusheva et al., 2014 O. Yakusheva, K.A. Kapinos, D. Eisenberg. **Estimating heterogeneous and hierarchical peer effects on body weight using roommate assignment as a natural experiment.** Journal of Human Resources, 49 (1) (2014) (forthcoming)

Zhao and Kaestner, 2010 Z. Zhao, R. Kaestner. **Effects of urban sprawl on obesity.** Journal of Health Economics, 29 (6) (2010), pp. 779-787

[1] The data used in this study were initially collected and statistically powered to investigate the role of peers in mental health outcomes. A post hoc power analysis (Bosker et al., 2003, Snijders and Bosker, 1993) shows that our nested sample of 1064 females and 871 males living in 14 dormitories achieves 0.88 and 0.83 power for females and males, respectively, to detect large dormitory-level effect sizes (0.35 of R2); 0.72 and 0.68 power for females and males, respectively, to detect medium effect sizes (0.15 of R2); and 0.45 and 0.36 power for females and males to detect small effect sizes (0.02 of R2). Although our sample is underpowered for medium and small effect sizes, we believe that the results that we are able to detect are important and policy-relevant because they are not by self-selection which is a major methodological strength.

[2] Results not reported here but available upon request.

[3] In Table A4, we present unadjusted changes in weight/BMI across the weight change distribution by whether the dining hall was opened on the weekend or not.

[4] Results not reported here but available upon request.

[5] The coefficients on distance to gym are insignificant in these models and are not reported here, but are available upon request.

[6] Because multicollinearity may be an issue in such a model, we calculated the variance inflation factors, all of which were less than 3. We also estimated a ridge regression model to alleviate any potential multicollinearity bias; this did not significantly change our results.