First Year Students' Meal Plans and Dining Hall Use: Differences by Food Insecurity, and Similarities among Roommates.

by

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ABSTRACT

Background: In the United States (US), first-year university students typically live on campus and purchase a meal plan. In general, meal plans allow the student a set number of meals per week or semester, or unlimited meals. Understanding how students' use their meal plan, and barriers and facilitators to meal plan use, may help decrease nutrition-related issues.

Methods: First-year students' meal plan and residence information was provided by a large, public, southwestern university for the 2015-2016 academic year. A subset of students (n=619) self-reported their food security status. Logistic generalized estimating equations (GEEs) were used to determine if meal plan purchase and use were associated with food insecurity. Linear GEEs were used to examine several potential reasons for lower meal plan use. Logistic and Linear GEEs were used to determine similarities in meal plan purchase and use for a total of 599 roommate pairs (n=1186 students), and 557 floormates.

Results: Students did not use all of the meals available to them; 7% of students did not use their meal plan for an entire month. After controlling for socioeconomic factors, compared to students on unlimited meal plans, students on the cheapest meal plan were more likely to report food insecurity (OR=2.2, 95% CI=1.2, 4.1). In Fall, 26% of students on unlimited meal plans reported food insecurity. Students on the 180 meals/semester meal plan who used fewer meals were more likely to report food insecurity (OR=0.9, 95% CI=0.8, 1.0); after gender stratification this was only evident for males. Students' meal plan use was lower if the student worked a job (β=-1.3, 95% CI=-2.3, -0.3) and higher when their roommate used their meal plan

frequently (β=0.09, 99% CI=0.04, 0.14). Roommates on the same meal plan (OR=1.56, 99% CI=1.28, 1.89) were more likely to use their meals together.

Discussion: This study suggests that determining why students are not using their meal plan may be key to minimizing the prevalence of food insecurity on college campuses, and that strategic roommate assignments may result in students' using their meal plan more frequently. Students' meal plan information provides objective insights into students' university transition.

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1. INTRODUCTION AND BACKGROUND

1.1. UNIVERSITY STUDENTS: ROOMMATES AND MEAL PLANS

In section 1.1, we report that student diets tend to not meet the dietary guidelines and discuss the disparities in dietary intake by gender and race/ethnicity. There is some concern that students meal plans and the food environment on university campuses may make it difficult for students to consume a healthful diet.[1,2] The potential association between student meal plans, dining hall use, dietary quality, and weight gain are discussed in this section.

In section 1.2, the high prevalence of food insecurity among university students, and associations between food insecurity, poor health, and academic success is discussed. While the current evidence is consistent in reporting that food insecurity is detrimental to health and negatively impacts academic performance, the reasons for the high prevalence of food insecurity among university students is unclear. Understanding if students who purchase certain meal plans are at heightened risk for food insecurity could indicate vulnerable student groups. Similarly, understanding the difference in meal plan utilization by food security status may provide a new way to identify food insecure students. This section also reviews the limited literature around food insecurity and food purchases.

The association of social networks and health behaviors and outcomes are reviewed in section 1.3. Social network studies have traditionally focused on friends and family members. Recent research suggests an influence effect also occurs among people randomly assigned to be in close proximity (e.g., some roommates). Recent findings suggest that randomly assigned roommates influence each other's BMI. This

dissertation examines one potential mechanism by which this could happen: meal plan use.

Given the focus on meal plan use behaviors; the personal factors of demographics, food insecurity, and meal plan; and the environmental factors of meal plan and roommates, the social cognitive theory is applied to this dissertation. Specific examples of how this theory fits into this dissertation are provided in section 1.4. The conceptual models used in this dissertation are presented in section 1.5

1.1.1. Meal Plans, Dining Halls, and Student Diets

In the U.S., many universities have meal plan options available; students can generally use their meal plan to enter and dine at the university dining hall(s).[3-9] Students may also use their meal plan to purchase food/beverages from on-campus restaurants, fast food outlets, and student unions.[4,6-11] As US first-year university students frequently live on-campus and purchase a meal plan, the dining hall meals are an important source of nutrition for these students. Different types of meal plans are available for purchase, such as all-you-can-eat,[3-6,9,11] a set number of meals per week,[3-5,9-11] or a set number of meals per semester.[3,5,6,8,9] While studies have compared the diet of students who have and do not have a meal plan, studies examining the different types of meal plans are missing from the literature. For instance it is currently unclear how student demographics are associated with the purchase, and use, or meal plans.

It is suggested that student diets may be influenced depending on whether the student lives on or off campus. Studies indicate that compared to students who live off campus, those who live on campus tend to consume more sweet baked products (e.g., cookies, cakes) and more ice-cream,[12] either a similar amount or more fruits

and vegetables,[12-14] and less sweets and alcohol.[12] Brevard et al. found that students who live off campus have higher triglyceride levels than students living on campus.[15] While Brevard et al suggest that the difference in triglyceride levels are due to 'lifestyle differences' between on- and off-campus students; differences in the nutrient and exercise levels among on- and off-campus students did not explain the differences in triglyceride levels. Of the students who do not live on campus, those who regularly purchase foods on campus appear to have a lower diet quality than the students who regularly bring food in from home; for instance the percentage of calories from fat among students who purchased food on campus was higher than for students who brought food from home.[16]

The disparity of student diet quality by living location may partially be due to students living on-campus having a meal plan. There are a limited number of studies that have examined student meal plans and dietary intake. Brown et al. indicated that more students meet the food group recommendations (e.g., fruits and vegetables) if they have a meal plan, as compared to not having a meal plan.[17] Brown's finding suggests that meal plans can help students consume a healthful diet. However, Heidal et al. reported no difference in fast food consumption by meal plan status.[18]

While students tend to perceive that the food offered on campus is not healthful,[19,20] the food offered at dining halls tends to be more healthful than the foods offered from other food outlets on campus. Horacek examined 15 institutions from the Northeast, Midwest, and Southeast of the US and found that 72% of the dining halls offered a healthful main dish (e.g., a main dish which met the current, 2005, US dietary guidelines for energy, total fat, and saturated fat), compared to 23% to 47% of the restaurants, fast food outlets, and student unions.[1] Horacek also determined

that nearly all (86%) of the dining halls offered a salad bar.[1] However, while dining halls tend to offer more healthful foods than other locations (i.e., fast food restaurants, sit down restaurants, and student unions), the majority (80%) of dining halls also provide a wide variety of foods, in an all-you-can-eat and a social environment, which may encourage overconsumption.[1,2] While healthful foods are available in the dining hall, one study reported that students found it difficult to select the healthful, options.[21] Interventions in the dining hall among university students have attempted to encourage students to make more healthful food choices. Studies have suggested that increasing awareness of the nutritional value of the foods, and highlighting the more healthful food options, are positively associated with the food selections students make.[22-24] For instance, when the nutritional information for a small and large serving of French fries was displayed, students chose a smaller serving for themselves.[23]

1.1.1. Food group consumption and university students

Few university students have diets that meet dietary guidelines.[17,21,25,26] Following a healthy diet is important as the dietary habits established prior to adulthood are thought to continue later into life.[27] Poor diet quality is associated with insufficient vitamin and mineral intake,[28] early mortality,[29-33] and chronic diseases such as hypertension,[34] hyperlipidemia,[35] type 2 diabetes,[33,36] cardiovascular disease,[29,33,37] cancer,[29,33] and obesity.[38]

Fruits and vegetables. Fruits and vegetables tend to be under-consumed by university students.[13,14,17,21,25,26,39-43] The average intake of fruits and vegetables for college students is generally reported as less than two servings (one cup) per day;[13,21,25,39,40] around 70% of students consume less than five servings of fruits and vegetables per day.[39,41-43] The low fruit and vegetable intake among college students

is of concern as low fruit and vegetable intake is associated with cardiovascular disease,[44-46] coronary heart disease,[47] diabetes,[48-52] some cancers,[47,53-56] and mortality,[55,57] among others.

Dairy and protein. There are conflicting reports around first-year college students' consumption of dairy and protein. Both inadequate and sufficient intakes for dairy[26,58] and protein[25,26,58] have been reported. Diary intake prior to adulthood has a significant impact on bone density later in life.[59,60] Inadequate dairy consumption for children and adolescents is concerning as it may also be linked to fractures and osteoporosis later in life.[59] Protein provides amino acids, which are used to build and repair body tissues.[61] Low levels of protein intake can result in the loss of muscle tissue, and other health issues.[61]

Fats and oils. The Dietary Guidelines For Americans 2015-2020 report states that the intake of oils in the United States (U.S.) is slightly *below* recommendations while the intake of saturated fats is *above* recommendations.[62] While the 2015-2020 dietary guidelines for Americans no longer specify the recommended percentage of energy intake from fat, the dietary guidelines previously recommended an intake between 20 and 35%.[63] The current recommendation is to limit the amount of saturated fat (intake <10% of calories) and trans fats (intake as low as possible), since heart disease is associated with the consumption of saturated and trans fats.[64-66] Consuming unsaturated fats instead of saturated fats is associated with a lower risk of cardiovascular disease.[62] College students tend to consume diets high in fat. For example, one study has indicated that students consume 31% of daily energy intake from fat.[67] Another study examining first-year students' diets determined that nearly 50% of the students' energy intake came from fat; approximately 13%, 10%, and 22% of the students energy came from saturated, polyunsaturated, and

monounsaturated fats respectively.[68] Fats and oils are calorie dense,[61] and may be associated with obesity.[69-71]

Grains. It is recommended that at least half of the grains consumed come from whole grains.[28] Whole grain consumption is associated with a lower BMI[72] and a reduced risk of type 2 diabetes[72,73] and coronary heart disease.[74] The amount of whole grains consumed by college students has been reported as inadequate.[21,75-77] However, a study has also reported that nearly half of college students consume more grains than the recommended amounts.[26] In 2007, Rose et al. reported that overweight and obese college students consumed less whole grains than non-overweight/obese students,[76] which provides further evidence of the beneficial effects of including whole grains as part of a healthful diet.

University students' diet over time. The diet quality of first-year students appears to deteriorate after the start of the first semester of university; decreases in the amount of fruit,[14] vegetables,[14,25] bread/pasta,[25] milk,[25] and meat[25] have been observed. However, decreases in the amount of fried foods consumed has also been observed between the start of the first, and end of the second, year of university.[43] As some students' meal plans need to be budgeted for the entire semester, some of these changes may be associated with students purchasing cheaper options as their meal plan credit decreases.[78] Studies examining how dietary quality is associated with the meal plan purchased, and meal plan use, are lacking from the literature. In particular, the pattern of meal purchases among students who need to budget a limited number of meals over a week or a semester is unknown.

Students consume fast food regularly, especially when they are with their friends.[79] Estimates range from students consuming around 2 fast food meals per week[40] to over 90% of students eating in fast-food restaurants at least six times a week.[80] The

range in estimates may partially be from the different food environments at universities. Fast food tends to be high in fat (including trans fat).[81,82] Perhaps unsurprisingly given the frequency of fast food consumption, another study indicated that over 20% of students consumed more than two servings of high fat foods the day prior.[41]

In the US, consuming three meals and at least one snack per day is common; however adolescents and young adults tend to consume less than three meals, and at least two snacks, per day.[62] Skipping breakfast is relatively common among university students;[40,42,80] with less than 60% of students regularly consuming breakfast.[80] However most students do consume lunch and dinner.[40,80] Snacking is also common among students. One study reported that over half of students consume an afternoon snack (54%) and 73% of students consume an evening/late night-snack.[80] Another study indicated students consume just under 2 snack meals per week.[40] These findings indicate that the dietary patterns of university students are likely to be different than those older than university students.

1.1.2. Weight Gain During University

There has been concern about the amount of weight university students gain, in particular during their first year. Over-consumption and opportunistic eating have been posited as a potential cause of the weight gain among first-year university students.[83,84] While first-year university students do tend to gain weight at higher rates than their non-university student counterparts, the amount gained is generally in the 1-2 kg range.[85,86] There are also indications that the weight gained during college is transitory, with first-year students weighing similar amounts at the start of their first and second year of university.[83] However, other studies have shown

continued weight gain during university with 2.5 kg or more gained between the start of the first, and end of the fourth, year of university.[87-89]

Surprisingly, given the multitude of dietary advice designed specifically to help first year students avoid gaining excess weight,[90] the association between dietary intake and weight gain among first-year students is not yet well understood. The majority of studies examining weight gain during the first year of university have not determined reasons for the weight gain. While some studies report an association between diet and weight gain, several other studies have failed to find an association. For instance one study reported that consumption of "junk" foods (i.e., high-fat cookies, cakes, chips, and ice-cream) were associated with weight gain among first-year university students.[84] However, several other studies did not find an association between university students' weight gain and dietary intake.[21,43,91,92] One study examined diet and weight gain among first-year students and found no difference among fruit and vegetable consumption, sugar sweetened beverages, junk food, fast food consumption, or total calorie intake between the students who gained ≥5% of their body weight and the students who did not gain ≥5% of their body weight.[92] Other studies have found no difference in BMI among university students by fried/fast food[21,43] or fruit and vegetable[43,91] consumption.

Detailed studies examining how dining hall frequency and other on-campus food purchases are associated with weight change are lacking from the literature. There is currently limited evidence that dining hall consumption is associated with weight gain. One study found that female students whose residence hall had an on-site dining hall gained significantly more weight than females whose residence hall did not have an on-site dining hall, however no difference was observed for males weight gain and having an on-site dining hall.[93] Another study found that the first-

year students who gained the most weight (>5% of body weight) tended to eat an average of 2.1 additional meals at on-campus dining facilities than those who gain less weight, however this was not statistically significant.[92] Given that dining halls are prevalent on US university campuses, and over 20 million students were enrolled in tertiary education in Fall 2017,[94] if dining hall use is associated with weight gain, changes to the foods provided in dining halls and the meal plan options offered could impact a large number of students. Additionally, if the current foods offered and the social all-you-can-eat environment of dining halls facilitates unhealthful eating patterns, these same patterns may track into older adulthood.[27]

1.1.3. Disparities in Dietary Intake by Gender and Race/Ethnicity

Disparities in dietary intake can partially explain why some populations experience worse health than others. Some of the disparities in dietary intake are to be expected; for instance the dietary guidelines recommend a higher caloric intake for males,[62] which is reflected in the higher actual caloric intake seen among males.[21] However, other systematic differences in dietary intake by gender and race/ethnicity indicate populations and dietary behaviors that may potentially benefit from change.

1.1.3.a. Disparities in Dietary Intake by Gender

It is unclear in the literature if males or females consume more fruits and vegetables. Since on average, males have a higher calorie need than females, the fruits and vegetables recommendations for males is higher than it is for females. However, the amount of fruits and vegetables males and females perceive they need is similar.[95] The difference between perceived and actual intake is greater for males than it is for females.[95] Some studies have shown that females are more likely to meet the USDA guidelines for fruits[17,21] and vegetables[21] than males. However another study showed that males consume more fruits and vegetables than

females.[96] Notably, vegetables are the most likely food type for male university students to avoid (compared to meat for females).[97] While it is currently unclear if males or females consume more fruits and vegetables, it is clear that the consumption of fruits and vegetables among university students is low.[13,14,21,25,26,39-41,61] The low consumption is of concern given the health benefits of fruits and vegetables.[44-57]

It is also unclear if males or females consume more fast food and high fat foods. Some studies have stated that females consume less fast food[21,96,98] and high fat foods[41] than males. These studies report that females consume fast food approximately once a week or less, compared to males who consumed fast food more than once a week. However, other research showed that more female first-year university students than male first-year university students consumed at least three fried foods (51% vs 29%), and at least three high fat foods (56% vs 35%) on a weekly basis.[43] Other research has indicated university students consume fast food and high fat foods on a regular basis,[40,41,79,80] which suggests it would be beneficial if the fast food and high fat intake of both male and females students was decreased.

Studies suggest that neither males, nor females, consume an adequate amount of fiber. It is recommended that relatively sedentary females aged 18 years consume 25.2g fiber/day, and that relatively sedentary males aged 18 years consume 30.8g fiber/day.[28] The recommendations increase to 28g/day and 33.6g/day for females and males aged 19-30.[28] Two studies have examined the difference in fiber intake among college students by gender, both studies reported that males consumed more fiber than females.[39,96] The fiber intake for both males and females was less than recommended amounts. Huang et al. examined college students in general and reported that males consumed around 19.9 g/day of fiber, while females consumed

around 16.1 g/day of fiber.[39] Li et al. examined first year students, and reported a fiber intake of 22.1 g/day for males and 15.9 g/day for females.[96] Among other benefits, fiber is associated with lower risks of cardiovascular disease,[99] diabetes,[99,100] coronary heart disease,[100] and hypertension.[100] As such, the low fiber intake for university-aged students of both sexes is of concern.

Studies suggest that males are more likely than females to consume the recommended amount of both dairy and protein. It is suggested that males perceive the recommended servings of dairy to be higher than the actual recommendations, while females aged less than 19 years are accurate in their perceived recommended intake.[95] Perhaps as a consequence of males' misperception of the recommended dairy intake, Brown et al. indicated that males are more likely than females to meet the recommended intake of dairy.[17] However, another study indicated that females consume more low-fat dairy than males (after adjusting for calorie intake).[21] Kolodinsky et al. suggested that more than half (56%) of females do not consume the recommended amounts of protein; significantly less than the percentage of males who do not meet the recommended amounts (22%).[26] Kolodinsky et al. also suggested that nearly 40% of males consumed more protein than recommended, compared to the less than 7% of females who consumed more protein than recommended.[26] Compared with females, males consume more red meat.[21] Studies have indicated that red meats appeal to a persona of strength and masculinity,[101-103] even among university-aged students,[104] which may explain the disparities in protein consumption by gender.

1.1.3.b. Disparities in Dietary Intake by Race/Ethnicity

There are disparities by race/ethnicity for dietary intake. For instance, it is suggested that the dietary quality of non-Hispanic Black populations are lower than the dietary

quality of the non-Hispanic White[105,106] and Hispanic populations.[105-107] There are indications that as the proportion of people who are Black increases in a neighborhood, the number of fast food restaurants per square mile also increases.[108] While availability of a food item doesn't necessarily result in that item being consumed, studies indicate that among adolescents the amount of fast food consumed is greatest among adolescents who are Black.[109,110] The disparity in fast food intake by race/ethnicity is of concern as among children and adolescents, consuming fast food is associated with an increase in total calorie intake, and lower diet quality (e.g., less fruits and vegetables consumed).[109,110]

As with fast food intake, studies indicate that people who are Black consume more sugar sweetened beverages than people who are Hispanic or non-Hispanic White.[111-113] West et al. estimated that among college students, the daily calorie intake from sugar sweetened beverages was slightly less than 800 kcal for students who were Black and slightly under 400 kcal for students who were White;[112] these estimates are much higher than the <300kcal/day of sugar sweetened beverages among young adults over 20 years of age found by Bleich et al.[111] There are also suggestions that the Hispanic population consumes more sugar sweetened beverages than the non-Hispanic White population.[113] Sugar sweetened beverage consumption has been associated with health outcomes such as weight gain[114] and diabetes.[115] As such, the health of university students is likely to increase if the amount of sugar sweetened beverages consumed among university students decreases.

1.1.4. Food intake and food purchases

Studies show that food intake is correlated with food purchases[116-119] and food environment.[120-122] While food purchases and food environment are a different measure than actual food intake, students' food purchases and food environment

provide an indication of dietary intake. For instance, university students with sugar sweetened beverages in their room have a higher intake of sugar sweetened beverages.[123] Studies have shown that supermarket receipt information is correlated with dietary intake, as measured by FFQ,[124] 24 hour recalls,[117] and food diaries.[118,119] Studies have previously obtained participant's supermarket receipts by manual collection[118,119,124-129] directly from supermarkets,[130,131] and via custom, participant-operated scanner technology at checkout.[132]

Currently, studies examining dietary change tend to use food frequency questionnaires (FFQ), food diaries, or 24-hour recalls. These methods to measure dietary intake are subject to many problems, such as under- and over-reporting,[133,134] daily diet variation,[135] reactivity,[133,135] and recall bias.[134,135] Interventions utilizing food purchase information are rare, but have several potential advantages. By examining food purchases, researchers may be able to obtain food purchase information over long periods of time in an unobtrusive manner; minimizing participant burden, reactivity, and recall bias.

1.2. FOOD INSECURITY

While studies suggest that the majority of students do not meet dietary guidelines, a large number of students are also experiencing food insecurity. Food insecurity is a lack of consistent access to enough food for an active, healthy life. The prevalence of food insecurity in the US was estimated to be 11.8% in 2017, corresponding to 15 million households.[136] The rates of food insecurity are higher among low-income households.[137-142] Among US university students the prevalence of food insecurity has been estimated at 33% (range 14% to 59%)[143] and at 51% (SD = 12).[144]

Food insecurity has been consistently linked to both poor health outcomes and poor nutrition (see section 1.2.1 and 1.2.2). While nutrition can be associated with weight status, there are mixed findings around food insecurity and weight status; many studies find no association (see section 1.2.3). It is currently unclear why the prevalence of food insecurity among university students is so high. Potentially the meal plans purchased, and the extent students use their meal plans, is associated with students' food insecurity. Few studies have examined the financial expenses of food insecure households. A summary of the existing literature is presented in section 1.2.4. The high prevalence of food insecurity among students is of concern given food insecurity is negatively associated with student outcomes (see section 1.2.5). While food insecurity is clearly associated with poorer health outcomes, nutrition, and academic performance, there has been concern around the validity of the survey measures food insecurity. In section 1.2.6 there is a discussion of the validity of the food insecurity measurement.

1.2.1. Food Insecurity and Health Outcomes

Adults who are food insecure are more likely to report that they are in poor health than people who are food secure.[145-148] Among adults, food insecurity has been associated with lower mental health,[145,146,149] higher rates of depression,[137,138,147,148] higher rates of stress[137] and anxiety.[137] Adults are also more likely to report insufficient sleep if they are food insecure.[149] Among children and adolescents food insecurity is associated with poor health,[150,151] hospitalizations,[151] suicidal attempts,[152] and depression.[152] Among university students, food insecurity has been associated with poor health,[153-155] and higher levels of stress,[156] and depression.[156-158] Notably, students who are severely food insecure report lower health than students who are moderately food insecure.[159]

The medical records for people who are food insecure reflect the higher levels of poor health reported. Food insecurity is associated with increased use of health care services,[139] increased number of visits to an emergency room,[160] and increased health care costs.[139] However, one study has indicated that while the incidence of food insecurity increased as medical expenses increased, after controlling for other variables food insecurity was not associated with increased health care costs.[161]

Food insecurity is associated with chronic diseases, such as hypertension,[138,162-165] diabetes,[138,163-165] and chronic obstructive pulmonary disease.[165] Food insecurity is also associated with chronic diseases being less well managed.[138,160] Importantly, among those with food insecurity, those with very low food security are more likely to have chronic diseases than those with low food security.[165] The limited amount of financial resources has a role in the poor health of those experiencing food insecurity. For instance, people experiencing food insecurity are more likely than their food secure counterparts to report not checking blood sugars due to the cost of the test, and to have had low blood sugars due to the cost of food.[160] People experiencing food insecurity are also more likely to report cost-related medication underuse (e.g. taking less medication than prescribed to save money)[160,166,167] which is associated with worse health outcomes.[168,169] Poor health among the food insecure may also partially be from the association between food insecurity and health insurance. In the U.S., food insecurity is associated with not having health insurance,[161] which is associated with not receiving medical care and worse overall health.[170] The health trajectory for those who do not have health insurance is worse than for those who have health insurance.[170]

1.2.2. Food Insecurity and Nutrition

While studies have shown that the total energy intake, and macronutrient composition is similar by food security status,[171] food insecurity is associated with lower dietary quality.[142,171-174] For instance adults with food insecurity are less likely to minimize their fat intake[175] and tend to consume less fruits[142,176,177] and vegetables.[142,171,176,177] Children tend to be shielded from the effects of food insecurity[178] and as such tend to consume a diet similar to their food secure counterparts.[174] However, studies have also shown children in food insecure households have a lower Health Eating Index (HEI),[173] consume less fruits[173,174] and vegetables,[173] less milk products,[173] and more energy-dense foods.[172] Children and adolescents in food insecure households are more likely to have iron deficiency anemia than their counterparts.[179,180] The lower diet quality among food insecure persons is a concern given the association between diet quality and health; lower diet quality is associated with greater risk of cardiovascular disease,[181] diabetes,[182,183] and early mortality.[184,185]

Food insecurity among university students is also associated with lower diet quality. Notably, in one study, nearly 30% of food insecure students reported that they had lost weight due to lack of financial resources to purchase food; only 3% of food secure students reported affirmatively to the same question.[154] Food insecure university students are less likely to agree that they have healthy eating habits off campus than their food secure counterparts.[156,157] Food insecure students also report poorer dietary patterns. Food insecure students are less likely to consume breakfast,[156,157] an evening meal,[156] home cooked meals,[157] at least two servings of fruit a day,[153] or at least four servings of vegetables per day,[153] than food secure students. Further, food insecurity among students is associated with an increase in takeaway food consumption.[154] It has been suggested that students are more likely

to be food insecure if they have low cooking self-efficacy or few cooking resources.[186] However, other studies have found no difference between food secure and insecure students' food preparation, cooking skills, and cooking resources.[154]

Students who purchase a meal plan theoretically have pre-paid for the majority of their meals and as such are less likely to experience food insecurity than other students. However, some studies indicate no difference in food security status by participation in a meal plan,[155,186,187] and some students who have purchased a university meal plan still report food insecurity.[158,188,189] Potentially, university dining hours may not be compatible with some students' schedules, resulting in these students finding it impossible to make use of their meal plan. To our knowledge no study has yet examined if some meal plans are more protective of food security than others, or if food insecure students fully utilize their meal plan.

1.2.3. Food Insecurity and Weight Status

Given the nutritional differences between food secure and insecure persons, a difference in weight status could be expected. Differences by age and sex could be anticipated due to younger children being shielded from household food insecurity and differences in gender roles. Most studies have found no association between food insecurity and body size among children.[173,190-193] Of the studies that have reported an association among children, both smaller body sizes[194] and larger body sizes have been reported.[195] There are potentially sex differences, with one study indicating that food insecure female children had a larger increase in weight that food secure female children, with no association observed for male children.[196] Similarly, studies have generally found no association between food insecurity and body size among adolescents[190,197] and university students.[156,157] Of the studies that report an association, food insecurity was associated with larger body sizes among

adolescents.[173,195,198] To our knowledge only two peer-reviewed articles have reported an association between BMI and food security among university students; Hughes et al. reports that nearly 30% of food insecure students, compared to 3% of food secure students, stated that they had lost weight due to not having enough money for food,[154] and Meza et al. describes a student losing weight due to their food insecurity.[199] However one conference abstract from 2014 stated that students with severe food insecurity were more likely to be overweight/obese than students with mild or moderate food insecurity.[200]

Among adults, food insecurity has been associated with a larger body size,[173,192,201] no difference in body size,[176,202] and a smaller body size.[201] Some of these differences may be due to which covariates are controlled for, with one study reporting an association between food insecurity and body size at the bivariate level, but not after controlling for covariates.[203] When sex differences are included an association with increasing body size is generally observed among females[204-207] but not among males.[205,207] Among the elderly food insecurity has been associated with a higher,[208] and a lower BMI.[173]

1.2.4. Food Insecurity and Financial Expenses

There is conflicting information on whether low-income earners have higher food costs. Nunnery et al. reported that at the per-person level, those with low income spend more on food,[209] while others report food expenditure decreases as income decreases.[210,211] It is argued that those with low income have higher food costs as they may be less able to access supermarkets (which have lower prices) as easily as those with higher income. However, it is also argued that those with low income have lower food costs as they tend to purchase lower quality foods,[210] and larger sizes.[210,211]

There is limited information on expense differences by food security status. One study among immigrant mothers from Liberia in the US determined that the amount spent on food was higher for those who were food insecure than for those who were food secure.[209] Among students, one study determined that the amount food secure and insecure students spend on housing and groceries was similar.[212] Similarly, no difference in transportation, eating out, entertainment, and shopping expenses were found by food security status.[212]

While there is limited information on expenditure by food security status, information has been obtained for those participating in Women, Infants, and Children (WIC) and the Supplemental Nutrition Assistance Program (SNAP). In the US the WIC program financially assists low-income pregnant and breastfeeding women, infants, and children at nutritional risk.[213] The WIC program is designed to improve participants nutrition and as such can only be used for specific foods, such as milk, eggs, legumes, and fruits and vegetables.[213] The SNAP program is less restrictive than WIC in the foods that can be purchased; nearly anything classified as a 'food item' can be purchased.[214]

The percentage of Women, Infants, and Children (WIC) and Supplemental Nutrition Assistance Program (SNAP) recipients is higher among those who are food insecure than those who are food secure; one study showed that 64% and 42% of food insecure low-income women participated in WIC and Food Stamps respectively, compared to 29% and 9% of their food secure counterparts.[137] While WIC/SNAP are designed for those with a limited income, not everyone with a low income uses these services; potentially mirroring that not everyone with a low income is food insecure.

Among students, food insecurity is more likely if the student has a loan that requires repayment,[187] works a part-time job,[187] receives financial aid[158,186,187,215] or food

assistance,[186] and less likely if the student receives financial assistance from family members.[186,187] It has been suggested that the financial aid provided to students is insufficient,[158,186] and that those who do not receive financial aid have sufficient resources to avoid being food insecure.[186] Long et al. reported that the value of the main US federal aid for low-income students (Pell Grants) has decreased over time.[216] Long et al. correctly stated that the maximum Pell Grant was worth less in 2005-2006 ($4,050), than it was in 1975-1976 ($1,400, equivalent to $5,064 in 2005).[216,217] However, the most recent data shows that in 2016-2017 the maximum Pell Grant was $5,820 and the average Pell Grant was $3,740; the maximum and average Pell Grant in 1976-1977 (converted into 2016 dollars) was $5,900 and $3,200 respectively. As such, the maximum Pell Grant in 2016-2017 was 99% of the maximum Pell Grant in 1976-1977, and the average Pell Grant in 2016-2017 was 17% *higher* than the average Pell Grant in 1976-1977.[217] As such, it is debatable if the value of the financial aid currently provided is lower than what it was previously. There is however clear evidence that there has been an increase in tuition costs in the U.S.,[218] which are also suggested as attributing to the high rates of food insecurity among students.[215]

1.2.5. Food Insecurity and Student Outcomes

Students who are food insecure are less likely to succeed academically. Among children, food insecurity is associated with absenteeism,[219,220] suspensions,[221] and lower academic performance.[193,196,219,221-223] Food insecurity remains negatively associated with academic outcomes among university students. It is estimated that 23% of food insecure students have suspended their studies, compared to only 7% of food secure students.[153] Food insecure students have a significantly lower Grade Point Average (GPA) than food secure students[155,187,215,224] and are more likely to fail

courses.[225] However, we note that not all studies have found an association between food insecurity and GPA.[158]

1.2.6. Misclassification of Food Insecurity

The USDA estimates 31.6% of low-income (income < 185% of poverty threshold) households are food insecure, compared to 5.6% of households with an income >185% of the poverty threshold.[178] Using data from 1995-1997, one study reported that nearly 20% of food insecure households had an income of at least 185% of the poverty threshold.[141] Another study reported that only ⅓ of low income households with very low food expenditure (in the lowest 5%) were food insecure; food assistance did not explain why the percentage of food insecure households among households with low-income with low food expenditure was not higher.[226]

The measurement of food insecurity has been examined given the lower-than-expected prevalence of food insecurity among households with low incomes, and the relatively high prevalence of food insecurity among households with incomes above the poverty line.[141,226] Studies suggest that food insecurity is underreported,[226] and that due to stigma and embarrassment people struggling with food insecurity do not use the resources available to help alleviate their food insecurity.[227,228] It has also been suggested that some people may intentionally misreport their food security status to appear less food secure than they actually are.[229] Nord examined why some high-income households reported being food insecure and determined that the majority of high-income households who reported food insecurity had indeed been food insecure.[141] Variability of income (i.e., experienced food security/insecurity when had high/low income but income level has since changed) and high economic needs, may partially explain the apparent mismatch between some households income and food security status.[141]

It has also been questioned how people who are food insecure can also be overweight or obese.[230] As discussed in section 1.2.3, the association between food insecurity and weight change is unclear. Notably, food insecurity and hunger are not the same thing.[231] The definition of food insecurity is a lack of consistent access to enough food for an active, healthy life. Hunger is a potential consequence of food insecurity.[232] As discussed in section 1.2.2, the diet of those who are food insecure tends to be less healthful than the diet of those who are food secure; unhealthful diets are associated with weight gain.[233]

While it is possible that the measure of food insecurity is not perfect, even those who criticize the measure concede that the food insecure measure appears to have internal (if not external) validity.[226] Potentially people with the same income but working longer hours are more likely to be food insecure due to lack of time to prepare foods,[234] and food obtained at no-cost (i.e. gifts, food banks) may explain the weak association between food expenditure and food security.[234]

It is of interest that the prevalence of food insecurity among college students is higher than among low-income adults, especially as some students are required to purchase a meal plan which theoretically limits students' food insecurity. Students who work for more than 20 hours per week may also be eligible for the Supplemental Nutrition Assistance Program (SNAP), one of the benefits provided to low-income individuals and families.[235] One potential reason for the discrepancy between food security rates among students and low-income adults is systematic differences in the interpretation and response of the food security questions. For instance, Hunt et al. reports college students have higher levels of worry than older adults (aged 64+).[236] One of the questions in the food security tool asks if "(I/We) worried whether (my/our) food would run out before (I/we) got money to buy more".[237] If college

students worry more in general than young adults, they may be more likely to report affirmatively to worrying about their food supply. Students may also be more willing to report difficulties with food given the perceived normalcy around student hunger.[238] On the other hand, adults may experience social desirability bias which results in them reporting food insecurity less frequently.

Even if the food security status of some households and people is misclassified, the current research indicates that being food insecure is detrimental to health.[145-148,239] The rate of food insecurity on university campuses is high,[143] and food insecurity appears to also be associated with worse academic outcomes.[155,215,221-224] If an association between type of meal plan and food insecurity exists, this information could be used to help indicate students who may need additional help during the semester. The ethics of offering any meal plan associated with high rates of food insecurity should also be examined.

1.3. SOCIAL NETWORKS AND HEALTH BEHAVIORS AND OUTCOMES

Research into dietary intake and food insecurity has tended to ignore that people are connected to each other. The study of social networks examines the connections between people, such as the connections with friendships, family members, and belonging to organizations. Social network analyses can also examine how people are connected is associated with health behaviors and outcomes. Understanding *who* people are connected to, and *how* being connected to others is associated with health behaviors could result in more effective interventions.[240-242]

Prior studies support the notion that social networks could be effectively utilized for behavior change. For instance there are indications that integrating social networks with behavior change interventions can result in the intervention being more

effective; diabetes interventions with a peer-support aspect appear to be more effective than diabetes interventions without a peer-support aspect.[243,244] The effectiveness of social network interventions may depend on the desired behavior change, and the connection between participants. A systematic review from 2010 indicated peer support resulted in behavior change for some behaviors (smoking cessation, condom use, physical activity); there was no evidence peer support was effective at behavior change for breastfeeding, women's cancer screening, and medical adherence.[245] Another systematic review showed the evidence for health benefits from online communities was lacking.[246]

Studies have shown that homophily, the tendency for people tend to associate with others like themselves, occurs among social networks. Social network analyses can determine *why* homophily occurs on health behaviors. The understanding of why homophily occurs on health behaviors can then be used to develop targeted interventions. For instance, if certain friends tend to influence each other towards a negative (or positive) health behavior, an intervention which incorporates the friendship network may be effective.

In 2007 Christakis and Fowler reported that obesity may be contagious. This widely publicized and controversial study is discussed in section 1.3.1. Homophily describes the tendency for friends to be similar to each other. In section 1.3.2 three potential reasons (selection, influence, and environmental effects) why homophily occurs with health behaviors occur are outlined. The evidence for selection, influence, and environmental effects for the homophily observed among friends and spouses BMI and health behaviors are discussed in section 1.3.3. While the similarities of health behaviors and outcomes of friends and family members could be somewhat anticipated, recent findings suggest that people in close proximity also tend to be

similar – even if they are not friends (see section 1.3.4). As this dissertation examines meal plan use among roommates, the purchasing patterns of friends, spouses, and roommates is discussed in section 1.3.5. Finally, in order to better understand the implications of these findings, section 1.3.6 discusses recent interventions which have a social network component.

1.3.1. Christakis and Fowler

In 2007, Christakis and Fowler reported that clusters of obesity occurred in social networks, and that a person was at greater risk for obesity if a friend, sibling, or spouse became obese.[247] Some studies have rebutted the claims made by Christakis and Fowler.[248-251] For instance in 2008, Cohen-Cole and Fletcher showed that the effects reported by Christakis and Fowler decreased, and were indistinguishable from zero, once controls for environmental factors and homophily were included.[249] In 2011, both Shalizi and Noel reported that latent homophily (becoming friends with others like you) in a network can result in spurious 'influence' effects appearing.[248,250] However, in the same year, van der Weele et al. confirmed that environmental factors and latent homophily could result in spurious 'influence' effects occurring, but concluded that the findings by Christakis and Fowler were reasonably robust to these effects.[251] Christakis and Fowler have also defended their position and criticized the rebuttals. For instance Christakis and Fowler show that while two of the five estimates provided by Cohen-Cole and Fletcher are indistinguishable from zero, all five of the estimates are also indistinguishable from the values proposed by Christakis and Fowler.[252] As such, the Cohen-Cole and Fletcher paper did not provide evidence against the estimates proposed by Christakis and Fowler.

1.3.2. Selection, Influence, and Environmental Effects

The main theories that explain why friends could be similar are selection, influence, or environmental effects. Selection effects occur when people preferentially become friends with other like them. Influence effects occurs when friends' behavior converges over time. Environment effects occur when the environment people are in results in people becoming similar. Given the complexity of friendship formation, it can be difficult to determine why friends are similar in their health behaviors and health outcomes; selection, influence, and environmental effects need to be examined concurrently.[248,250,251,253,254]

1.3.3. Similarities in Health Behaviors & Outcomes among Friends and Spouses

1.3.3.a. Body Mass Index

1.3.3.a.i. Friends

As expected, based on Christakis and Fowler's work, studies have shown that adolescents and young adults tend to have a similar BMI as their friends.[255-260] There is reasonably consistent evidence that adolescents are more likely to select a friend who has a similar BMI as themselves.[261-265] Other research has indicated people with a higher BMI are less likely to be nominated as a friend,[255,261-263,266,267] which may result in a perceived selection effect if people with a higher BMI are then likely to nominate each other as friends. At the other end of the BMI spectrum, there are recent suggestions that university students with a low BMI may also be less likely to be nominated as a friend.[267]

Influence effects also appear to increase the similarity in BMI among friends. A convergence of BMI over time between friends[264,265,267] has been reported. These

studies indicate that people's BMI changes over time to become more similar to their friends BMI. While one study did not find an influence effect of BMI among adolescents,[261] the co-efficient for influence effects from peers (1.08) was very similar to a similar study among college students (1.09) which found a significant effect.[267]

Environmental factors may also partially explain why friends have similar BMIs. For instance, friendships among university students tend to occur among those who live on the same residence floor[267,268] (and therefore within the same residence building). A natural experiment showed that female university students whose residence hall was further from the dining hall gained less weight.[93] As such, distance to dining halls may be a confounding environmental factor for university students and may partially explain the similarity of weight change among university students.

1.3.3.a.ii. Spouses

While spousal BMI is reported as being similar, the positive correlation among spouses BMI is small (the majority of studies reported a correlation <0.2).[269-279] The similarity of BMI among spouses has mainly been studied in wealthy countries and, contrarily, no association between spouses BMI was found when one study examined spouse anthropometrics among a forager community (the Hadza) in Tanzania.[280]

There is evidence that the similarity in BMI among spouses are due to selection, influence, and environmental effects. Selection on similar BMI have also been found among spouses.[276,277] For instance one study determined that someone who had a BMI above the 90th percentile as an adolescent was more likely to marry someone whose BMI was also above the 90th percentile as an adolescent.[276] Another study

found a (weak) positive correlation between engaged couples BMI, indicating spousal similarity *prior* to marriage.[277]

As spouses (in general) live together, separating influence and environmental effects is difficult. Consistent with the findings from Christakis and Fowler, the likelihood of becoming obese has been reported as being twice as likely if a spouse become obese.[271] The environment the spouses live in could plausibly result in weight change; for instance some neighborhoods encourage exercise and healthful dietary choices more than others.[281,282] One study found no increased similarity in spouses BMI over time[275] and another study found similarity *decreased* over time.[272] However, another study found a higher correlation of BMI among older (r=0.11), rather than younger (r=0.03), couples; the duration of marriage among the couples was not reported.[279] As these studies show it is unclear if a spousal influence effect for BMI exists. However, studies are consistent in reporting only a weakly positive correlation between spouses BMI. There is no indication that dramatic weight change, resulting in convergence of spouses BMI, occurs on a frequent basis.

1.3.3.b. Health Behaviors and Interpersonal Linkages

1.3.3.b.i. Friends

Similarities in levels of physical activity,[283] screen time,[283] fast food consumption,[283,284] alcohol intake,[285] cigarette smoking[286] weight control behaviors,[287-291] and depression[292] among friends have been reported. As with BMI, the reasons for these similarities are not yet clear. There is evidence for selection effects, with studies suggesting that adolescents are most likely to select friends who are similar to them in terms of physical activity,[264,265,293] alcohol consumption,[294] and smoking.[295-297] At the same time it has been reported that friends become more similar to each other in terms of their physical activity,[264,265,293] screen time,[265]

frequency of eating at a fast food restaurant,[284] alcohol use,[268,294,297,298] cigarette smoking,[286,295-297,299] and cannabis use.[294] As reported for BMI, the environment friends are exposed to may also contribute to similarities on health behaviors. It is currently unclear if the similarities among friends occur by selection, influence, and environmental effects. Potentially the mechanisms for similarities among friends vary depending on the health related behaviors and outcomes (i.e. similarities on physical activity may mainly be due to selection effects while similarities on alcohol consumption may mainly be due to influence effects).

1.3.3.b.ii. Spouses

Similarities of spouses health behaviors and outcomes are also observed, such as similarities for alcohol use,[300,301] cigarette smoking,[300,302] depression,[303,304] blood pressure,[275] and cholesterol levels.[275] As with friendships, it is currently unclear why spouses health behaviors and outcomes are similar. It is also not clear if the relative selection, influence, and environmental effects are constant across health behaviors and outcomes.

There is evidence for assortative mating at marriage (i.e. selection effects) for leisure interests[305] and cigarette smoking.[302] However, there are also reports of influence effects. For instance one study reported that when one spouse was engaged in a weight loss intervention, the other spouse also lost weight.[306] Similarly, when one spouse changed to have healthier behaviors (quitting smoking, increasing physical activity, and weight loss) the other spouse was also likely to do so.[307] Studies suggest that an adult is more likely to quit smoking if their spouse quits,[299,307] while wives are more likely to start smoking if their husband smokes.[302] However, another study reported no increased similarity of physical activity by duration of marriage.[308]

One study suggests there is no increased similarity among spouses for a variety of health measures (such as hypertension, cardiovascular disease, blood pressure, and triglycerides) by duration of marriage,[275] which suggest similarities among spouses occur prior to marriage. However other studies suggest influence or environmental effects may exist. There is consistent evidence that households with low income (which is associated with the environment one lives in)[309,310] are more likely to have poor health.[270,310] One study suggests that blood pressure levels of older married couples are more similar than younger couples.[279] The increased similarity in blood pressure among older couples could be due to selection (i.e. assortative mating on behaviors associated with high blood pressure) influence (i.e. influence to do blood pressure lowering exercises), or environmental effects (i.e. living in a high-stress area).

Similarly, another study determined that alcohol use among spouses converges over time[300] and that adults are more likely to drink heavily if their spouse drinks heavily.[285] While this appears to be a case of spouses influencing each other to consume similar quantities of alcohol, it may be selection or environmental effects. Potentially assortative mating occurs on behaviors related to alcohol consumption (i.e. using alcohol to cope with stress) which results in increased similarity in alcohol consumption later in marriage (when stress levels among couples may be more similar). The environment lived in may also result in spouses consuming more (or less) alcohol, resulting in more similar alcohol intake over time.

1.3.4. Similarities in Health Behaviors & Outcomes by Proximity Measures

As well as similarities in health behaviors and outcomes among friends and spouses, similarities among those in close proximity can also occur. While people living or working near to each other may not be friends, their close proximity may result in

behavior influences. For instance Christakis and Fowler reported that a person working in a small company was more likely to quit smoking if a co-worker also quit.[299] Other studies indicate that people working together tend to experience similar emotions,[311,312] which can be associated with health. For instance workplaces that are stressful have been associated with weight change.[313] The food environment at workplaces can also be similar for employees (i.e. office cake, vending machines, candy bowls). Studies have shown that food environments influence food purchases and consumption;[120,314,315] which in turn can influence health.

The similarities among people in close proximity may arise from selection effects. For instance, similar people may choose to work for the same employer, or in the same department. However, in some cases people are randomly assigned to a location with others. When a group of persons are randomly assigned to locations a unique quasi-experiment is formed; selection effects are minimized due to the randomization.

In the U.S., random assignment of cadets to squadrons in the Air Force Academy and soldiers to companies in the Army occurs. Studies have determined that an improvement in academic performance is observed when a cadet is assigned to a squadron of higher academic ability[316] and a decrease in fitness is found when a cadet is assigned to a squadron of low fitness.[317]

Another case of random assignment occurs for some university students. For many universities, first year students are required to live on-campus. After filling out a short lifestyle survey,[318-322] students are sometimes randomly assigned to a roommate who appears to match on lifestyle characteristics (e.g., smoking,[322-324] noise preferences[322,324] and time generally go to bed[320,322,324]). Some of the universities who randomly assign all first-year students a roommate are Colgate

University,[318] Duke University,[325] and Harvard University.[326] Some of the universities who randomly assign the first-year students who do not request a specific roommate are Arizona State University,[327] UC Berkeley,[320] Iowa State University,[323] the University of Arizona,[328] the University of Pennsylvania,[329] John Hopkins University,[319] and Northwestern University.[321] While some studies examining roommate selection and influence effects have been conducted; it is currently unknown to what extent university students' meal plan purchase and use is influenced by their roommate, or if roommates tends to use their meal plan at the same time and location as each other.

In general, first-year university students spend substantial amounts of time with their roommate, many students spend more time with their roommate than any other friend.[330] Of the students who choose their own roommates, selection effects are found. For instance roommates who choose to room together tend to be more racially/ethnically similar than roommates who are randomly assigned.[331] Some universities randomly assign first-year students their roommate(s) and then allow the students to select who they will room with in their second year. Chakravarti et al. found that mong students who shared a room with only one other person, race/ethnicity differences did not predict which roommates chose to continue living together; however, among students who shared a room with two other people there were indications roommates comprised of two White and one non-White student were less likely to continue living together in their second year.[332] Among the students who are randomly assigned a roommate, influence effects have been observed among academic outcomes,[330,333-336] BMI,[337] weight,[338] alcohol intake,[339] speech pronunciation,[340] personality,[341] racial attitudes,[331,335] stigma towards mental illness,[342] and vulnerability to depression.[343] The mechanisms by which roommates influence each other are not yet clearly understood. For instance, while one study

has shown that roommates influence each others' BMI,[337] to our knowledge no study has determined why roommate influence on BMI occurs. There are suggestions that roommates influence each others' alcohol intake;[268] convergence of dietary patterns could plausibly explain the convergence of BMI among roommates.

1.3.5. Purchasing Patterns among Friends, Spouses, and Roommates

Peers appear to influence purchases for all age groups; those who shop with their peers tend to spend more money than those who shop alone.[344-349] A purchase has been reported as being more likely to occur if a peer had already made, or appeared to make, the same purchase. For instance an iPhone purchase is more likely if a peer has already purchased an iPhone,[350] and the purchase of a cellphone ringtone is more likely if a friend had already done so.[351] One study provided a random sample of online music website subscribers a free upgrade to a 'premium' service, after providing this upgrade the friends of those who were randomly selected were more likely to purchase the same premium service.[352] Studies have also shown that parents and roommates influence what university students purchase (such as the brand of shampoo), but that parental influence appears to decrease over time while roommate influence increases.[353,354]

A purchase by a peer may also decrease the attractiveness of an item. While people in general are more likely to purchase items similar to those their friends have purchased, there are indications the most popular people will not purchase what their friends are purchasing; potentially to ensure they stay differentiated from their friends.[355] Similarly there are suggestions that some individuals may be less likely to purchase an item if their peers have already done so, and more likely to purchase an item if their peers have not yet done so.[356]

There are indications that for "important" purchases the majority of spouses state that purchase decisions are made jointly;[357] the definition of what comprised "important" purchases was not provided. A study conducted in Singapore supermarkets concluded that for general household purchases (i.e., cleaning products, food items) wives were more likely to make the purchases than their husbands; however the purchases often reflected the husbands preferences.[358] Another study examined clothing purchases and found that women frequently make purchases for their husband without the husband present.[359]

The influence to purchase an item may occur from within a social network. Yaacoub et al. determined that the clothing purchased; shopping malls, restaurants, and pubs frequented; movies watched; and vacation/trip choices were all influenced by Facebook friends.[360] Other studies found parental influence for teenagers purchases[361] and that more socially connected first-year students were more likely to consume food in the dining hall.[362] There is limited information regarding how social networks are associated with dietary purchases and dietary intake. For instance it is unknown if university roommates tend to purchase the same meal plan, or if roommates dining hall patterns converge. Potentially, effective and innovative strategies to prompt healthier eating habits among university students could be determined after understanding how the social network and food choices were associated.

1.3.6. Interventions Using Social Networks

While this dissertation will not test interventions, a review of social network interventions are examined to allow us to better understand the implications of the study findings. Social network analyses for health behaviors and outcomes is an emerging field. Many of the social network studies have determined if similarities of

health behaviors and outcomes in social networks occur, and the evidence for selection, influence, and environmental effects. Few studies have tested health interventions which utilize social networks. While there are few intervention studies using social networks for health behaviors and outcomes, interventions for other behaviors and outcomes have been conducted.

How the composition of social networks relates to the success of an intervention has been examined. Kim et al. suggested that the success of a behavioral intervention is associated with the specific people initially given the intervention.[240] The study by Kim et al. examined if multivitamin and water chlorination were more likely to be adopted among villagers in Honduras depending on who was initially trained; randomly selected villagers, friends of randomly selected villagers, and villagers with the highest in-degree were provided training.[240] The study determined that training friends of randomly selected villagers resulted in higher multivitamin use.[240] Centola suggested that the uptake of desired health behaviors among an online group could be increased by manipulating the level of homophily, and without changing other network characteristics (i.e., not changing the distribution of participants health or how connected participants were to each other).[363] The study by Centola found that the online groups that had a higher level of homophily also had more participants that started the desired health behavior (a diet diary).[363]

The manipulation of human behavior by changes in the social network raises ethical considerations. For instance Bhattacharya suggests that when randomly assigned roommates have similar academic ability the highest-performing roommates obtain a higher GPA, and the lowest-performing roommates obtain a lower GPA, than would be expected by chance.[364] The Bhattacharya study suggests that pairing roommates with different academic abilities would result in a more equal GPA distribution. While

to our knowledge no study has deliberately paired roommates to try and increase overall GPA, the ethics of increasing the GPA of those with low academic ability at the expense of decreasing the GPA of those with highest GPA is debatable.

A similar study by Murphy examined how the US Army soldiers company was associated with continuing education: the US Army randomizes soldiers to companies and provides subsidized continuing education to its soldiers.[365] New soldiers joining a company were more likely to enroll in continuing education credits when more soldiers in the company were taking continuing education credits.[366] This suggests the likelihood of a new soldier enrolling in continuing education credits could be manipulated by the company they were assigned to. Again, to our knowledge no study has deliberately assigned soldiers to different companies to try and increase (or decrease) the number of continuing education credits soldiers enrolled in.

Another study indicates the complexity of social network interventions. Similar to the Bhattacharya and Murphy studies, the US Air Force Academy determined that the academic ability of students was associated with their peer (squadron) group.[316] The US Air Force Academy conducted an intervention on the basis of the finding that assigning students with the lowest ability to the same squadron as students with the highest ability increased the GPA of the lowest ability students.[316] The intervention assigned some of the students with the highest and lowest abilities to the same squadrons to try and increase the GPA of those with the lowest ability.[367] The experiment was not a success. A *decrease* in GPA occurred among the lowest ability students who were intentionally assigned into a squadron with the highest ability students. The authors suggest that the squadrons where students of the lowest and highest abilities were mixed resulted in changed socialization patterns. In particular the authors suggest the peer influence they had hoped to create did not occur as

students socialized with others of similar ability, creating two distinct social groups. This study demonstrates how little is known about social networks interventions, and the potential unexpected consequences of social network interventions.

An ethically questionable social network study was conducted in 2012 by Kramer et al; the amount of positive and negative posts on the newsfeed for over half a million Facebook users was manipulated.[368] The results indicated that the posts of Facebook users were more positive if some of the negative newsfeed posts were removed, and that Facebook users posts were more negative if some of the positive newsfeed posts were removed. Kramer et al. concluded that emotional contagion from friends' Facebook posts may be occurring. Several main stream news outlets published articles on this Facebook study, with researchers stating that they thought the study breached ethical guidelines.[369-371] An Editorial Expression of Concern was later published addressing the decision to publish given the ethical concerns of participants not receiving informed consent and not having an ability to opt-out of the study, and Facebook reportedly created an internal review board in 2016.[372] Regardless of whether this study breached ethical guidelines or not, this study indicates the possibility of manipulating emotions by changes in social networks.

Other studies indicate that *perceived* actions and beliefs of friends can impact students' decision making. For instance studies indicate that while vaccinations are associated with peers vaccine *perceptions*,[373] they are also associated with the *perception* of peers vaccinations.[374] This suggests that by using a social network approach, likely vaccine non-compliers may be able to be identified. Connecting likely vaccine non-compliers with vaccine compliers, and providing normative information around vaccine compliance, could potentially result in higher vaccine compliance.

Studies using normative education have previously been successful. Among adolescents and university students, the perceived alcohol (and drug) use of their peers is higher than their peers' actual use.[375-380] The *perceived* alcohol intake of adolescents and university students friends influences *actual* alcohol intake.[379,381] Several studies have provided university students with information on the actual levels of alcohol use among students and observed a decrease in alcohol use.[382-384]

Interventions which use a social network approach to change health behaviors and outcomes may be more effective than more traditional approaches. First-year university students experience a large lifestyle change (e.g. living away from home for the first time), and are typically exposed to a new social network. First-year university students weight change appears to be associated with their friends,[267] and roommates,[337] weight. It is currently unclear why this convergence in weight occurs; dining hall use and food purchases may partially explain the convergence. Similarities in dining hall use and food purchases may also help explain other health behaviors and outcomes (i.e. food insecurity) within the first-year students' social network.

1.4. SOCIAL COGNITIVE THEORY

The first year of university can be a period of change and of new experiences. For instance, first-year students are often living away from home for the first time, and living in a completely new environment. One of the changes first-year students' experience is the purchase of a meal plan - which is intended to provide the majority of the students' meals. Another change many students will experience is sharing a room with another student. Some of the experiences students' encounter during their first year may be partially explained by the students' prior experiences, the students' demographics, and the students' living environment. For instance, students

experiencing food insecurity at the end of the semester may be more likely to have experienced food insecurity at the start of the semester, to come from a low-income family, and to have a roommate who doesn't share their food. Similarly, some student behaviors may also be partially explained by the students' prior experiences, the students' demographics, and the students' living environment. For instance, students may use more meals over the semester if they are male, and if their roommate often uses the dining hall.

In 1961 Albert Bandura developed the Social Cognitive Theory, which states that behavior, personal factors, and environmental factors are interdependent.[385,386] This means a person's past behavior, the environment the person is in, and the persons' belief in their ability to change their behavior all shape the persons' current and future behaviors.

This dissertation examines the behaviors of on-campus food purchases made by first-year students at this university. The main personal factors examined in this dissertation are sex, race/ethnicity, wealth (Pell grant status), and food security status. The environmental factors examined are campus, residence hall, roommate, time of day, day of week, and week of semester. The constructs of the Social Cognitive Theory, as described by Glanz, are summarized below.[386]

This dissertation examines how changes in personal factors affect purchasing patterns. The following constructs can be applied.

Outcome expectations are the belief that behaviors are likely to have consequences. It is anticipated that people will try to minimize the costs of their behaviors, and maximize the benefits. With an outcome expectation framework, students would be expected to use all of their pre-paid meal plans (maximize

benefits) and to ration their meals so that they never ran out (minimize costs). If some students do not anticipate any negative outcomes from running out of meals, or not using their meals, they may be more likely to do so.

Self-Efficacy indicates how confident a person feels that they will be able to perform a behavior. The self-efficacy of a student may be influenced by the self-efficacy of a roommate. For instance, if a student's roommate is confident that they will be able to make their own breakfast, the student may feel more confident that they will also be able to do the same.

Observational Learning is the learning of how to perform new behaviors by exposure to interpersonal or media displays of them. Similar to the personal factor of Self-Efficacy, Observational Learning can result in behavior change. Students from different backgrounds may have been exposed to different foods and dining patterns, which could be reflected in the students' initial food behaviors at university; The differences between students dining hall frequency and food purchases may reflect the observational learning they have obtained. Students may also adapt their own behaviors to mirror what they observe in their roommates and peers behavior. For instance, if one roommate chooses healthful options at the dining hall, the other roommate may start to also purchase healthful dining hall options. Similarly, if one student starts to make their own breakfast, that student's roommate may observe the behavior and mimic it.

Incentive Motivation, the use and misuse of rewards and punishments to modify behavior, may change students purchasing patterns so that they do not run out of meal plan credit. Students who run out of meal plan credits may be forced to miss meals, or consume sub-optimal meals, until their meal plan renews itself. In

contrast, students who manage their meal plan well are more likely to have credit available for spontaneous purchases throughout the year.

Facilitation is providing tools, resources, or environmental changes that make new behaviors easier to perform. For instance, if a student has a fridge or a microwave which they share with their roommate, this will facilitate storage of meals for the roommate.

Self-regulation states that people may intentionally experience some short-term negative outcomes in order to obtain a longer-term positive outcome. Self-monitoring, goal-setting, feedback, self-reward, self-instruction, and social support may be applied to self-regulation. Self-regulation can be understood basically as 'short-term pain for long-term gain'. Students who were food insecure and experienced hunger at the start of the academic year may self-monitor their meal plan more closely in the future, set spending goals/limits to ensure they have enough meals for future weeks, talk to other students about food spending patterns and obtain feedback on their own food spending patterns, reward themselves for meeting their goals by purchasing a treat or by avoiding food insecurity, self-instruct as they intentionally do not make an impulsive food purchase, and utilize social support to help ensure their food purchase are in line with their meal plan limits.

Moral Disengagement occurs when people disengage from the suffering of others. Moral disengagement can occur with euphemistic labeling, dehumanization, displacement of responsibility, and perceived moral justifications. Students who are food secure may disengage from those who are food insecure and going hungry, such as by blaming the student for their situation.

1.5. APPLICATION OF SOCIAL COGNITIVE THEORY

The behavior examined in this dissertation is the number of meals a student used on their meal plan and students' joint meal plan use with their roommate. The personal factors are students' food security status, the meal plan a student purchased, student demographics, and students' depressed mood, anxiety, working a job, and perception of their meal plan providing adequate food. The environmental factors examined are parents sending food, roommates and friends sharing food, the meal plan a students' roommate and floormate purchased, the number of meals students' roommate and floormates used, and time of day, day of week, month, and semester.

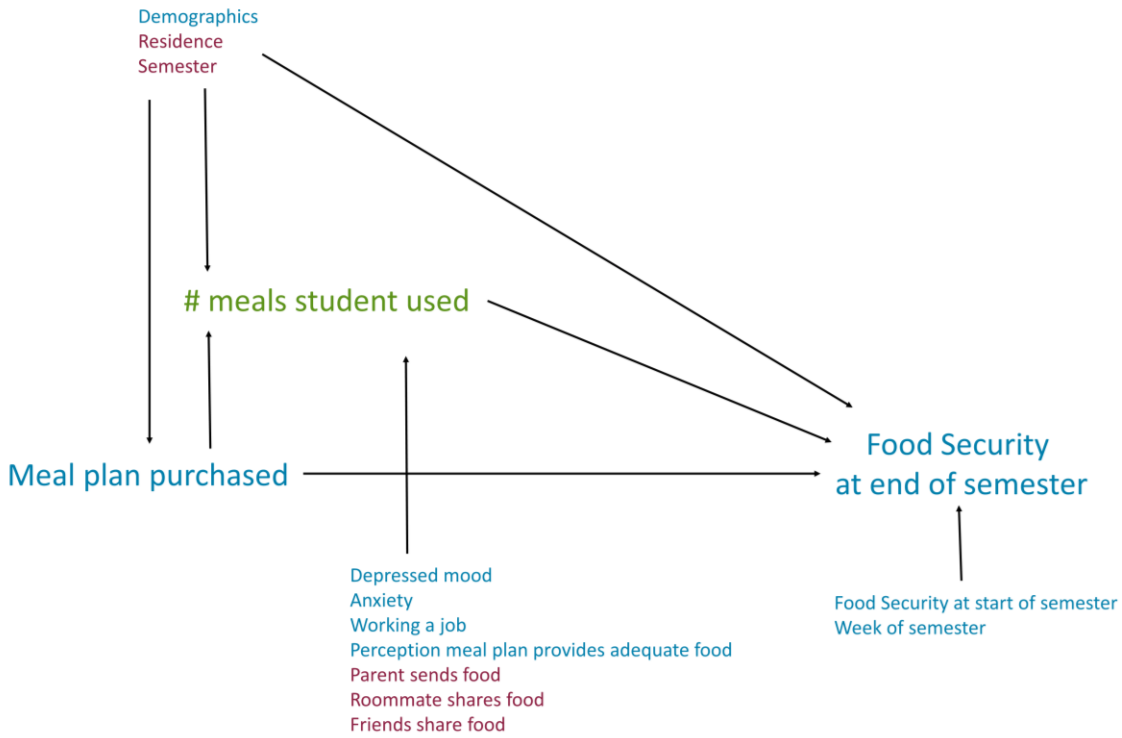
The association between food insecurity and meal plan purchase and meal plan use is examined in section 3. Figure 1-1 shows the conceptual model for how the variables used in section three are theoretically associated. As some meal plans provide more meals than others, we anticipated that students' who purchased meal plans that provided more meals would have higher meal plan use. We also anticipated that students demographics, residence, and semester would be associated with the number of meals student' used; in particular, males were anticipated to use more meals than females.

The students who reported food insecurity at the start of the semester, and who purchased cheaper meal plans, were anticipated to be more likely to be food insecure at the end of the semester than their counterparts. As students on the same meal plan theoretically have the same access to their meal plan meals, the extent students used their meal plan was thought to be a key predictor in which students reported food insecurity at the end of the semester. As food insecurity has been reported more frequently among students of color[158,189,215,387] and for students receiving financial aid,[156,158,215] we anticipated that demographic differences in food

security at the end of the semester may also be relevant. As the prevalence of food insecurity was previously found to be different between the campuses at this university,[156] and over time,[156] we anticipated that demographic, residence, and semester effects may also explain food insecurity at the end of the semester.

Several potential reasons for lower meal plan use (depressed mood, anxiety, perception meal plan provides adequate food, parents send food, roommate shared food with participant, friends share food with participant) were examined to determine if any of these factors are associated with students' meal plan use.

Figure 1-1: Conceptual Model For Meal Plan Purchased, Number Of Meals Students Used, And Food Security At The End Of The Semester



(Behavior = Green, Personal Factors = Blue, Environmental Factors = Maroon).

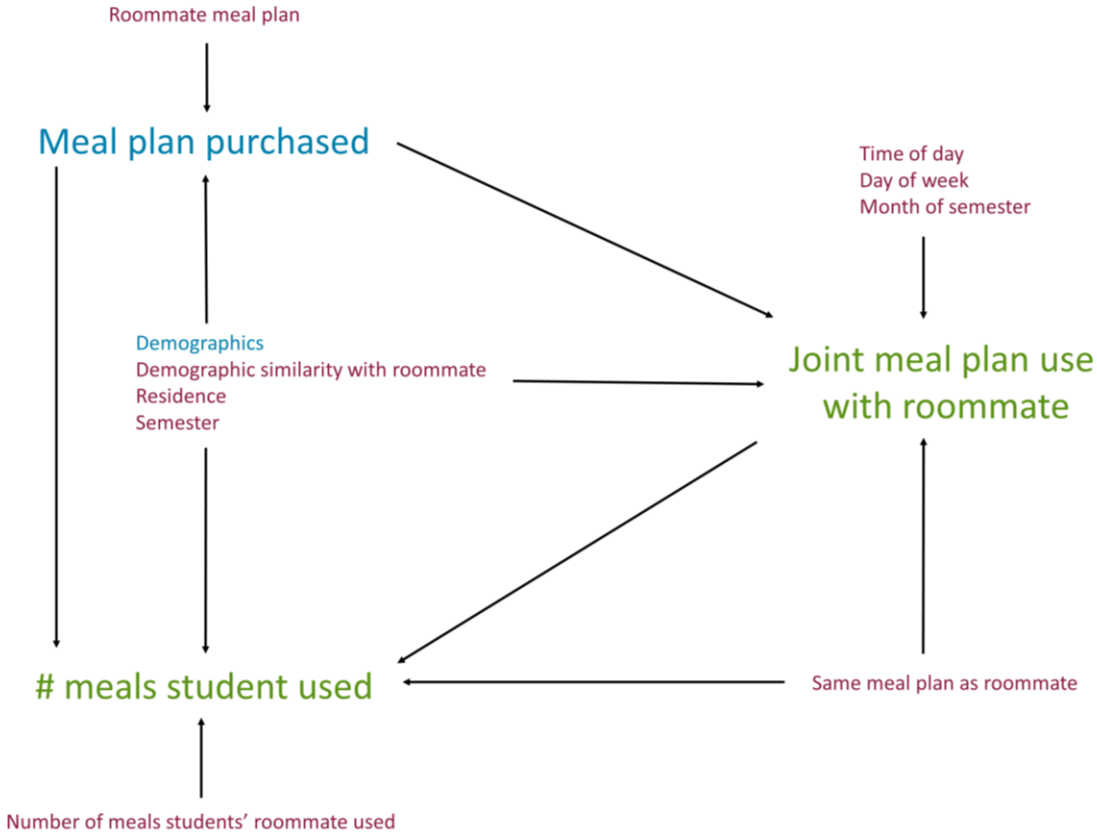
The association between student' meal plan purchases, similarities between the student and their roommate, the number of meals students' used, and joint meal plan use between students and their roommates is examined in section 4. Figure 1-2 shows the conceptual model for how the variables used in section four are theoretically associated.

Student demographics were anticipated to be associated with meal plan purchases, with males anticipated to purchase meal plans that provided more meals than the meal plans females purchased. As the number of food outlets is difference between campuses, the students' campus could potentially influence the meal plan students' purchased. The semester students' purchased a meal plan was also anticipated to be relevant (students' purchase a meal plan in both the Fall, and Spring, semesters). By the spring semester, students may better understand which meal plan will work best for them, resulting in different meal plan purchase decisions in the Spring semester.

The number of meals students used over the semester was anticipated to be associated with the meal plan a student purchased: students who purchased meal plans that provided more meals were anticipated to use the most meals. Similarly, males were anticipated to use more meals than females. Given the different dining options by campus, differences in the number of meals used by campus were considered. Students' who shared a room with a roommate who used a higher number of meals may be encouraged to use their meal plan more frequently (i.e. roommate influence for meal plan use). For instance, if students' prefer to use the dining hall with a friend, students whose roommate uses the dining hall frequently may perceive more opportunities to use the dining hall than a student whose roommate uses the dining hall less frequently.

The extent of joint meal plan use between students and roommates, which may result in higher meal plan use, was also examined. It was anticipated that roommates who were similar would have more joint meal plan use than students who were dissimilar. In particular, students who had the same meal plan as their roommate were anticipated to have higher joint meal plan use; their meal plans provided the same number of meals and the purchase of the same meal plan may indicate other underlying similarities. Given the tendency for friends to be racially/ethnically similar,[267,293] higher joint meal plan use among students who were the same race/ethnicity as their roommate was also considered. As the extent of joint meal plan use may change over time, time of day, day of week, and month of semester are included in the conceptual model.

Figure 1-2: Conceptual Model For The Meal Plan Purchased, Number Of Meals Students Used, And Joint Meal Plan Use With Roommate.



(Behavior = Green, Personal Factors = Blue, Environmental Factors = Maroon).

1.6. SUMMARY OF LITERATURE REVIEW

The diet quality of students has been reported as being of low quality.[17,21,25,26] This is of concern as diet quality is associated with health outcomes.[28-38] There has been limited research on university students meal plans, dining hall use and food purchases. Understanding which meal plan that students purchase, and how students use their meal plan, may help explain nutrition-related issues students experience during their first year of university. For instance, this information could potentially help researchers understand behaviors that may contribute to weight gain, and why there are high rates of food insecurity among university students. Many first-year students report being food insecure, which is associated with both

poor health[145,146,148,153-155] and poor academic outcomes.[193,196,219-225] It is currently unclear why the prevalence of food insecurity is so high among first-year students, or how students' meal plans and dining hall use are associated with food insecurity.

Current literature suggests a persons' friends BMI and health are associated with the persons' BMI[247,255-260,264,265,267] and health behaviors.[283-299] Recent findings suggest that university roommates – even when randomly assigned – are also associated with BMI change.[337] There is scant research on university roommates with the few existing studies often examining academic outcomes.[330,333-336] Few studies have examined health outcomes,[339,343] and to our knowledge no study has examined the extent university roommates dining patterns converge. Understanding the dynamics of roommates dining patterns may help to explain the current research findings which show a convergence of health behaviors and outcomes among friends and roommates.

In the U.S., first-year students are often required to purchase a meal plan. Surprisingly, given the large number of students in the U.S., there is scarce research into how the different types of meal plans (weekly, semester, unlimited) are associated with health outcomes and behaviors. There is also limited research into the association between student dining hall and food purchases, and health behaviors and outcomes. Understanding what meal plans students choose to purchase, students dining hall use patterns, and the foods/beverages students purchase will help guide future interventions. In particular, potential reasons for the high rates of food insecurity reported among students,[143] and for the association between roommates weight and weight gain,[337] may be determined. This information could then be used to guide effective and novel interventions to improve students' health behaviors and outcomes during their first year in college.

2. METHODS

2.1. STUDY DESIGN

This dissertation is a secondary data analysis which uses objective measures of food purchases among first year university students to 1) determine if meal plan purchases and meal plan use are different for food secure and insecure students, 2) determine if roommates use their meal plan to a similar extent and if their meal plan use converges over time, and 3) describe how student demographics are associated with meal plan purchases and meal plan use. Demographics, place of residence, and meal plan purchase and use was obtained from university records for first-year students attending Arizona State University during 2015-2016. A subset of students took part in the Social ImPact of PhysicAl and NutRition in College (SPARC) study during 2015-2016. As part of the SPARC study, students' food insecurity status was captured at the start and end of Fall 2015, and Spring 2016. At this University, all students are informed that information will be collected on them, and may be used for analyses.[388] The subset of students who provided information on their food security status also provided written consent and were informed that their survey information would be linked to information held by the university. All study protocols were approved by the Arizona State University Institutional Review Board (00004918 and 1309009596).

2.2. MEASURES

2.2.1. Meal plan purchased

The meal plan participants' purchased was obtained from University records. First-time first-year students are required to live in the residence halls and purchase a meal plan, unless they meet strict exemption criteria.[389,390] The meal plans can officially only be changed during the first week of each semester and cannot be

cancelled or refunded unless the student withdraws from the University.[390] The meal plans have a combination of Maroon and Gold Dollars (M&G) and Meals. The M&G is equivalent to cash and can be used to make purchases at all campus dining locations. The M&G decreases as you spend them, but can be increased for an additional fee.[390] Students can enter the dining halls by swiping their student card, which has their meal plan included; each meal plan swipe at the dining hall charges a student one of their meals.[390] All students are also allowed to use one of their meals per day to purchase a full on-the-go meal at seven locations other than the dining halls.[390]

Depending on the meal plan purchased, a set number of meals are provided per week, per semester, or on an unlimited basis. For weekly meal plans the meals become available at the start of the week and are forfeited if not used within the week; the week begins on Wednesday an ends on Tuesday.[389] For semester meal plans, any meals not used by the end of the semester are forfeited. Any remaining M&G money at the end of the summer (after the academic year is finished) from any meal plan is also forfeited.[389]

An honors college also exists within this institution. The food offered for honors students is of a higher quality and more diverse than the food offered to non-honors students,[391] which is reflected in the meal plan costs. Students who are not in the honors college cannot enter the honors dining hall unless they are a guest of an honors student. Meal plans are slightly different for non-honors and honors students. A summary of meal plans available to first year students at this institution is shown in Table 2-1.

Table 2-1: Meal Plan Options For First-Year Students At This Institution

	M&G	Meals	Cost/semester
Non-honors			
Gold	$150	8 /week	$1,410
Maroon[A]	$375	180 /semester	$2,085
Sparky's Favorite	$375	14 /week	$2,450
Unlimited	$250	Unlimited	$2,610
Honors			
Maroon[B]	$350	150 /semester	$2,005
Silver	$200	12 /week	$2,750
Platinum	$400	14 /week	$3,085
Unlimited	$100	Unlimited	$3,235

[A] 180 meals/semester equates to approximately 11 meals per week with consistent use.

[B] 150 meals/semester equates to approximately 9 meals/week with constant use.

2.2.2. Meal plan use

Arizona State University provides seven all-you-can-eat dining halls for students and another seven locations where an on-the-go meal can be purchased for a Meal swipe.[390] While information on the food consumed within the dining hall is unknown, the date, time, and location each first-year student who entered a dining hall by using their meal plan was provided by University services.

The dining halls have set times when students can access meal services during the weekdays and weekend. The dining halls on the main campus serve a limited number of options during transition periods (e.g., Late Breakfast and Late Lunch period) between meals; the dining halls at the other locations physically close for 30-minute transition between meals. The meal periods during the weekdays are: Breakfast (7:00 AM – 10:30 AM), Late Breakfast (10:30 AM – 11:00 AM), Lunch (11:00 AM – 2:00 PM), Late Lunch (2:00 PM – 4:30 PM), and Dinner (4:30 PM – 9:00 PM). The meal periods during the weekend are: Brunch (11:00 AM – 4:30 PM) and Dinner (4:30 PM – 8:00 PM). On Fridays the dining hall closes at 8:00 PM, rather than 9:00 PM. Based on the distribution of meal plan use, time of day was classified

as before 10:00 AM (morning), 10:00 AM – 1:00 PM (midday), and 1:00 PM – 4:00 PM (afternoon), and after 4:00 PM (evening).

2.2.3. Food insecurity.

As part of the SPARC study, food insecurity status at the start and end of the Fall 2015 and Spring 2016 semesters was obtained using the validated USDA six-item screener modified to reflect a one-month time frame.[392,393] All students responded to the following sequence of questions. A) Please indicate how often each statement was true for you in the last one month. "The food that I bought just didn't last, and I didn't have money to get more" and "I couldn't afford to eat balanced meals" The response options for these two questions were: often true; sometimes true; never true. B) In the past one month, did you ever cut the size of your meals or skip meals because there wasn't enough money for food?" The response options for this question were: no; yes, only 1-2 weeks; yes, some weeks but not every week; and yes, almost every week. C) Please indicate if each statement was true for you in the last one month "Did you ever eat less than you felt you should because there wasn't enough money for food?" and "Were you ever hungry but didn't eat because there wasn't enough money for food?" The response options for these two questions were yes, and no. Students who responded affirmatively to two or more of the questions were classified as food insecure.

2.2.4. Living location and Roommate.

At ASU, there are four campuses (Tempe, Downtown Phoenix, West, Polytechnic) and 15 residence halls for first-year students.[394,395] All of the rooms in the residence halls are designed for two people. University housing information was obtained for all first-year students to determine which residence hall, floor, and room they lived in. Students who resided in the same residence hall, floor, and room at the same time

were categorized as being roommates. Students can request a student who is enrolled in the same major, planning to live in the same residential hall, and of the same-sex (unless gender-neutral housing is requested) as a roommate.[327] If a student does not make a roommate request the university randomly assigns that student a roommate.

2.2.5. Demographics.

Participants' race/ethnicity, sex, year of study, and Pell grant status were obtained from University records. Race/ethnicity was recorded by the University administration as American Indian/Alaska Native, Asian, Black/African American, Hispanic/Latino, International, Native Hawaiian/Pacific Islander, Two or More Races, Unspecified, and White. Due to low counts American Indian/Alaska Native, Asian, and Native Hawaiian/Pacific Islander were combined to 'other' race/ethnicity for the paper with the larger sample size which examined roommate behaviors. For the paper with the smaller sample size which examined food security, International students, students of two or more races, and Black/African American students were also included in the ‘other’ race/ethnicity category. Participants' sex was recorded as Male vs Female. Pell grant was recorded as yes vs. no. The university provided a list of all first-year students for the 2015-2016 academic year.

2.3. STATISTICAL ANALYSES

Two different research questions, using two different samples, were examined.

2.3.1. Food insecurity and first-year college students' meal plan purchases and meal plan use

Study Sample:

A total of 534 first year students provided their food security status at the start and end of the Fall 2015 and/or the Spring 2016 semesters and were included in the analyses. The meal plan these students purchased and the extent students used their meal plan use was available. Compared to the cohort of 2015-2016 first-year students, this study has a higher proportion of female students (71% vs 45%; $p<0.001$), Black/African American students (11% vs 5%; $p<0.001$), Hispanic students (24% vs 19%; $p=0.003$), and Pell grant recipients (38% vs 30%; $p<0.001$), and a lower proportion of students classified as "other" race/ethnicity (18% vs 26%; $p<0.001$). No difference in the proportion of White students in the overall cohort of students, and students in this study was found (47% vs 50%; $p=0.175$).

Statistical Analyses:

Chi-square and ANOVA tests were used to examine the bivariate association between meal plan purchased and demographics. The average number of meals male and female students used in the 28 days prior to survey completion, and over each semester, was then determined for each meal plan. To determine if the meal plan purchased was a risk factor for food insecurity, a logistic generalized estimating equation (GEE) predicting students' food security status at the end of the semester by students' food security status at the start of the same semester and the students'

meal plan for the semester was run. Controls for sex, race/ethnicity, Pell grant status, first generation college student status, campus, week survey was completed, and semester were included in the model. As some students were included in the model in both the Fall and Spring semesters, a clustering effect for student was also included. A logistic GEE was used to determine if students who reported food insecurity at the end of the semester used less meals during the semester than the students who reported food security. To account for differences by meal plan, each meal plan was examined separately. Controls for food security at the start of the semester, sex, race/ethnicity, Pell grant status, first generation college student status, campus, week survey was completed, semester, and clustering of students, were included in the model. Given the sex differences in meal plan purchase and use, logistic GEEs stratified by sex were run to further examine if students who reported food insecurity at the end of the semester used less meals during the semester than the students who reported food security. Each meal plan was examined separately. Controls for food security at the start of the semester, race/ethnicity, Pell grant status, first generation college student status, campus, week survey was completed, semester, and clustering of students, were included in the model. A linear GEE was used to examine if students' meal plan use was predicted by any of seven different potential reasons for lower meal plan use (anxiety, depressed mood, working a job, perceived meal plan inadequacy, and alternative food supplies). Controls for sex, race/ethnicity, Pell grant status, first generation college student status, campus, semester, and clustering of students, were included in the model. Linear GEEs stratified by sex were then run to examine if the association between students' meal plan use and the seven different potential reasons for lower meal plan use was consistent when examining males and females separately. Controls for race/ethnicity, Pell grant status, first generation college student status, campus, semester, and clustering of students, were included in the model.

2.3.2. First-Year College Students: Roommates and Meal Plan Purchased and Meal Plan Use

Study Sample:

The official residences of all first-year students at this institution for the 2015-2016 academic year was provided by the institution. A total of 1745 students with only one official residence (i.e. the students who never changed room), complete demographic information, a known and standard meal plan, between 17 and 20 years of age, and with typical meal plan use were included in the analysis. Of these students, there were 593 pairs of roommates (i.e. two students who shared a room for the entire academic year), and 559 students whose roommate was not included in the study. Information on the meal plan students' purchased, and students' meal use was provided by the university.

Statistical Analyses:

ANOVA tests were run to determine if students meal plan use (low, typical, high) was associated with student demographics or the meal plan purchased. The bivariate associations between the meal plan purchased, student demographics, and key variables, for students with typical meal plan use were then examined using ANOVA and t-tests. Logistic GEEs, stratified by sex, were used to determine if roommates' tended to purchase the same meal plan as each other. The meal plan a student purchased was predicted by student demographics (race/ethnicity, Pell grant recipient, age), student residence, Semester, and the students' roommates meal plan. As students' purchased a meal plan in both the Fall and Spring semesters, a clustering effect by student was also included.

Linear GEEs, stratified by sex, were run to determine if the extent students' and roommates' used their meal plan was similar. The number of meals used by a student was predicted by the students' demographics (race/ethnicity, Pell grant recipient, age), student residence, Semester, the meal plan the student purchased, and the number of meals the students' roommate used during the semester. A clustering effect to account for students Fall and Spring meal plan use being modelled at the same time was included. The number of meals students use in the Fall 2015, and Spring 2016, semesters may be similar. As such, linear GEEs, stratified by sex, were run to determine if the extent students and roommates' used their meal plan was similar after taking into account students' prior meal plan use. The number of meals a student used during the Spring 2016 semester was predicted by the students' demographics (race/ethnicity, Pell grant recipient, age), student residence, the number of meals the student used during the Fall 2015 semester, the students Spring 2016 meal plan, and the number of meals the students' roommate used during the Spring 2016 semester.

Roommates pre-paid meal use may converge or diverge over time. Logistic GEEs, stratified by sex, were used to determine if certain students were more likely to use a meal at the same time and location as their roommate, and if using a meal at the same time and location as a roommate was more likely to occur at specific times. For each meal a student used, an indicator of if the students' roommate used a meal at the same time and location as the student was predicted by the students' demographics (race/ethnicity, Pell grant status, age), residence hall, and meal plan. To examine similarities among roommates, predictors of if both the student and the roommate were of the same race/ethnicity, Pell grant status, or had purchased the same meal plan was included. To examine changes over time, predictors of

semester, month, and time of day were also included. To account for the repeated measures, a clustering effect by students was included.

The same analyses but using the floormate sample were then run to examine environmental effects. Given that each student's pre-paid meal plan use was included in the models twice (once as the response variable and once as a predictor for the students' roommates' pre-paid meal use) pseudo-likelihood estimation was used.[396-398]

3. FOOD INSECURE COLLEGE STUDENTS AND OBJECTIVE MEASUREMENTS OF THEIR UNUSED MEAL PLANS

3.1. Abstract

Background Some researchers have proposed the prevalence of food insecurity among college students is high due to students' meal plans providing insufficient meals. The association between college students' food security status and their meal plans have not yet been examined.

Methods First year college students (N=534) self-reported their food security status in the Fall 2015 and/or Spring 2016 semester(s). Objective measures of students' meal plans were obtained from the university. Logistic Generalized Estimating Equations (GEEs) were used to determine if students' meal plan, and meal plan use, predicted food insecurity. Linear GEEs were used to examine several potential reasons for lower meal plan use.

Results Students did not use all of their available meals. Compared to students on the most expensive (unlimited) meal plan, students on the cheapest (8 meals/week) meal plan were the most likely to report food insecurity (OR=2.2, 95% CI=1.2, 4.1). However, in the Fall semester, 26% of students on unlimited meal plans also reported food insecurity. Food insecurity was associated with using fewer meals (OR=0.9, 95% CI=0.8, 1.0). Students who worked tended to use their meal plan less (β=-1.3, 95% CI=-2.3, -0.3).

Conclusion Students are reporting food insecurity while having meals left in their meal plan.

3.2. Introduction

Food security is defined as access at all times to enough food for an active, healthy life,[399] whereas food insecurity indicates inconsistent access to healthy food. Systematic reviews estimate the prevalence of food insecurity among United States (US) college students at 33%[143] and 51%[144], much higher than for US households (11.8%).[400] The high prevalence of food insecurity among college students is of concern because food insecurity is associated with lower dietary quality,[171-174] worse health outcomes,[137,149,165] and lower academic performance.[153,155,224,401,402] For instance, college students with food insecurity are more likely to report higher stress,[156,401] higher depression,[156-158,401] less sleep,[158] and a lower GPA[153,155,224,401,402] relative to their food secure peers.

Students who report food insecurity are also more likely to be financially independent from their family,[158,186,402] to have debt,[402] and to receive financial aid,[156,158,186] than their food secure counterparts. It is unclear if food insecure students tend to purchase less expensive meal plans than food secure students, and if food insecure students use their meal plan to a lesser (or greater) extent than their food secure counterparts. The extent food secure and insecure students use their meal plans is of interest as student meal plans are typically pre-paid at the start of the semester; students on the same meal plan have the same number of meals available to them.

In the US, many first-year college students are required to live on campus and to purchase a meal plan. The meal plans that universities offer typically consist of either a fixed number of dining hall meals per week or semester, or unlimited dining hall meals. Some meal plans also have cash-equivalence for food/beverage purchases at

other, non-dining hall outlets on campus. Students are expected to use their meal plan for the majority of their meals; students often do not have access to a full kitchen as they are not expected to cook for themselves. In general, if a student does not use all of the meals provided by their meal plan, the remaining meals are forfeited. There is currently limited information regarding the number of meals that students forfeit.

Some studies suggest that students experience food insecurity because their meal plans are insufficient, while other studies report no association between food insecurity and college students' meal plans. Studies describe a student on a 14-meals per week plan going hungry for a few days after using all of their meals early in the week,[403] and a student who ran out of meals on their meal plan.[188] Another study found that 43% of students who had a meal plan also reported food insecurity.[189] Researchers and university students and staff have suggested that changing the current structure of meal plans could help decrease the rate of food insecurity among students. For instance, Gallegos suggests providing students a way to pay for their meals through their taxes once they are employed[153] and university staff have suggested extending the dining hall hours[404] (dining halls typically open in the morning and close in the evening). University students and staff have also suggested more basic, affordable, meal plan options may be beneficial.[404] One of the studies that reported no association between food insecurity and meals plans found that first-year college students on a basic meal plan (8 meals/week) were no more likely to report food insecurity over the prior three months than first-year students on a meal plan that provided more meals per week.[157] Three other studies examined if having a meal plan (compared to not having a meal plan) was protective of food insecurity and found null results; two of the studies included students of all year levels[155,187] while the third study excluded first-year and graduate students.[186]

There are also indications that many students do not use all of their meal plan meals. Newspaper articles have suggested that food service providers price the meal plans with an expectation of 60-70% of the meals provided by each meal plan being used,[405] and that roughly the same proportion of meal plans are actually used.[406] It is clear that some students have unused meals left on their meal plan: the program Swipe Out Hunger redistributes students' unused meals to others and reports providing 1.5 million dining hall meals since it was established in 2010.[407] If students experiencing food insecurity also report unused meals, then understanding why this occurs could help explain why so many students report food insecurity.

The extent students use their meal plans may change by students' mental health, time commitments, and alternative food supplies; these same variables may also be associated with students' food security status. For instance, food insecurity is associated with anxiety and depression[156] which in turn can interfere with daily life.[408,409] Students experiencing anxiety and depression may withdraw from the dining hall environment, and as such have lower meal plan use. Prior studies have found that food insecure students are more likely to work a job than food secure students.[155,158,187,224] Working a job may make it difficult for a student to use their meal plan as they may be unable to access the dining halls during opening hours. Inconvenient hours have previously been reported as a reason why those with food insecurity do not use food pantries,[410,411] and students have also reported scheduling conflicts with classes which prevents them from using the dining halls.[403] It has been reported that students have a substantial number of food items in their residence hall room.[123] Students may find it more convenient to eat the food in their room rather than to eat at the campus food outlets.

This study examines college students' food security status and meal plans. First, the association between students' food security status and type of meal plan (i.e. weekly, semester, unlimited) purchased is examined. Then, objective data is used to determine if students who purchase meal plans that provide less meals, and students who use their meal plan less, are more likely to report food insecurity. Finally, several potential reasons that could result in lower meal plan use (anxiety, depressed mood, working a job, perceived meal plan inadequacy, and alternative food supplies) are examined. It was hypothesized that food insecure students, and students with anxiety or depressed mood, who worked a job, who perceived their meal plan provided inadequate food, and with alternative food supplies would have lower meal plan use. As students may be off-campus during the weekend, and as such unable to use their meal plan, or have no need to use their meal plan, the extent each student used their meal plan during the weekdays, and during the full week was differentiated. This information can help shape future interventions aimed at minimizing food insecurity on college campuses.

3.3. Methods

This is a secondary analysis from the larger, longitudinal Social impact of Physical Activity and nutRition in College (SPARC) study.[392] The SPARC survey included measures of the prior month's food security status, mental health, employment status, alternative food supplies, and meal plan adequacy. Students participating in the SPARC study also consented to the researchers accessing their university-collected data. The university provided information on the type of meal plan each student purchased, and their dining hall use. A total of 1435 students participated in the SPARC study during the 2015-2016 academic year. A total of 534 SPARC participants were first-year students living on one of the two targeted campuses (and not in the honors college) with useable information at the end of the Fall 2015

(n=470), or Spring 2016 (n=324) semesters; 260 students had useable information for both the Fall and Spring semesters. Participants were recruited primarily from floor meetings at residence halls at the start of the academic year. All participants provided written informed consent. Study protocols were approved by the Arizona State University Institutional Review Board.

3.3.1. Measurements

Food security status. The USDA six-item food security short form[393] was used to determine students' past month's food security status at the end of each semester. Participants were asked to indicate how often the following statements were true in the last one month: "The food that I bought just didn't last, and I didn't have money to get more", "I couldn't afford to eat balanced meals". The response options were "often true", "sometimes true", and "never true". Students were then asked "In the past 1 month, did you ever cut the size of your meals or skip meals because there wasn't enough money for food?". The response options were "No", "Yes, only 1 or 2 weeks", "Yes, some weeks but not every week", "Yes, almost every week". Finally, students were asked to indicate if the following statements were true for them in the last 1 month: "Did you ever eat less than you felt you should because there wasn't enough money for food?", "Were you ever hungry but didn't eat because there wasn't enough money for food?". The response options were "Yes" and "No". Any student who responded affirmatively to two or more questions was recorded as being food insecure.

Meal plan and dining hall use. The university provided the meal plan used, and date/time stamp for when each participant used their meal plan to enter a dining hall or to purchase a meal exchange. Other than a few days with zero recorded meal plan use, students' meal plan use was available for the entire semester. Zero recorded

meal plan use was observed for four days during the Fall 2015 semester (confirmation that the system down for three of these days was obtained), Thanksgiving day, and for four consecutive days during the Spring 2016 semester (one of which was Martin Luther King day).

It was unclear if the absence of meals recorded on the four days was due to a system failure during those days, subsequent data corruption, or another reason. At this university the four meal plans available to students are 8 dining hall meals/week, 14 dining hall meals/week, 180 dining hall meals/semester, and unlimited dining hall meals.[9] Each meal plan provided students with one "meal exchange" per day which allowed students to purchase one on-the-go meal (such as a sandwich, chips, and a drink) at a few of the on-campus food outlets.[390] While each of these meal plans also includes some cash-equivalence that can be used at on-campus food outlets, the dataset used for this analysis did not include students' cash-equivalence use. Students can officially only change their meal plan during the first week of a semester,[390] however some students appear to have changed their meal plan after this deadline - the meal plan some students used to access the dining hall changed after the first week. The reasons students changed their meal plan are unknown. Participants who changed their meal plan were classified as using the meal plan they used after the third week of the semester. Any student whose meal plan changed after the third week of the semester was excluded from the analyses for that semester (n=9). There were three students with no meal plan use in the 28 days prior to survey completion, but who used their meal plan after they completed the survey and prior to the semester ending. These three students were included in the analysis and recorded as having zero use during the 28 days prior to survey completion.

Mental health. Participants depressed mood was examined using the 2013 American College Health Association survey.[412] At the end of each semester participants reported how often in the past 1 month they had felt "things were hopeless", "overwhelmed by all they had to do", "very lonely", "very sad", "so depressed that it was difficult to function" and "overwhelming anxiety". The response options were "never", "rarely", "sometimes", "often" and coded to a 1 (never) - 4 (often) scale. Participants whose average response to these 6 items was above 2.0 were classified as having high levels of depressed mood. Participants anxiety was determined by asking "In the past 12 months, have you been told by a doctor or health care professional that you have anxiety?".[413] The response options were "No", "Yes, diagnosed and treated", and "Yes, diagnosed". Participants who reported a diagnosis of anxiety within the past 12 months were classified as having anxiety.

Working a job. At the end of each semester participants were asked "On average, how many hours a week do you work for pay?", a question also created specifically for the SPARC study. The response option was free flow text. Based on the distribution of responses, the responses were categorized as working for pay (any number of hours) and not working.

Meal plan adequacy. At the end of each semester participants were asked "Do you feel like your meal plan provides you with adequate food each week", a question created specifically for the SPARC study. The response options were "strongly disagree", "disagree", "agree", "strongly agree" and were further categorized as "strongly disagree/disagree" and "strongly agree/agree".

Alternative food supplies. Three questions were asked to determine participants' alternative food supplies. These items were created specifically for the SPARC study. At the end of each semester participants were asked, "How often do your

parents/guardians typically purchase or send food for you?". The response options were "never", "once per semester", "2-3 times per semester", "monthly", and "weekly" and were categorized as "less than twice a semester" and "twice a semester or more". Participants were also asked "When thinking about your meal plan, how often do your friends share their meal plan with you?" and "When thinking about your meal plan, how often does your roommate/suitemate(s) share their meal plan with you?". The response options for both questions were "never", "rarely", "sometimes" and "often" and were further classified as "never/rarely" and "sometimes/often".

Socio-demographics[1]. The university provided participants sex, race/ethnicity, date of birth, and family economic status. Students self-reported if they were a first-generation college student and which campus they resided on. The University administration recorded students' sex as male and female and students' race/ethnicity as "American Indian/Alaska Native", "Asian", "Black/African American", "Hispanic/Latino", "International", "Native Hawaiian/Pacific Islander", "Two or More Races", "Unspecified", and "White". Due to low counts for American Indian/Alaska Native, Asian, International, Native Hawaiian/Pacific Islander, Two or More Races, and Unspecified groups, these classifications were combined to "other" race/ethnicity. The race/ethnicities used in the current analyses are "White", "Hispanic/Latino", "Black/African American", and "other". Participants' age was determined based on their date of birth. Students family economic status was determined by whether the student was a Pell Grant recipient or not (a Pell Grant is federal aid provided to low-income students[414]). All students self-reported the

[1] Eight students reported being involved with an ASU varsity sports team in at least one semester. Due to the risk of identifying students, and the small sample size, no analyses on varsity sports teams is conducted.

highest degree or level of education that their parents/guardians completed. The response options were "Some high school (no degree)", "High school diploma (or equivalent)", "Some college (no degree)", "Associate"s degree/Trade/Technical/Vocational training", "Bachelor's degree", "Graduate or professional degree", and "Not applicable". If a student reported that neither parent/guardian had a bachelors, graduate, or professional degree, the student was classified as a first generation college student.

3.3.2. Statistical Analyses

Bivariate associations between the meal plan purchased and the key variables were examined for each semester using chi-square and ANOVA tests as appropriate. The Fall 2015 and Spring 2016 semesters were examined separately as students' decisions regarding their meal plans were anticipated to change as they became more familiar with the university and their dining options. The percentage of available meals used in the 28 days prior to survey completion, and across the semester, was determined for separately for males and females on each meal plan: the 180 meals/semester meal plan equates to approximately 11 meals per week with constant use, a conservative estimate of 16 weeks for the Fall 2015 semester and 17 weeks for the Spring 2016 semester was used.

A logistic generalized estimated equation (GEE) was used to examine if students' food security status at the end of the Fall and/or Spring semesters, was predicted by the meal plan a student purchased, after controlling for food security status at the start of the corresponding semester (i.e. food security at the end of Fall predicted by Fall meal plan and food security status at the start of Fall). To capture changes in meal plan use at the end of the semester, the week the survey was completed was included in the model. A clustering effect by student was included to account for the

same students responding in the Fall and Spring semesters. Controls for sex, race/ethnicity, Pell grant status, first generation status, campus, and semester were also included.

For each meal plan type, logistic GEEs were used to examine if food security status at the end of the Fall and/or Spring semester was predicted by the number of times a student used their meal plan in the 28 days prior to the students' survey completion. As the number of meals the student used for themselves, and not provided to guests, was of interest, meal plan use was determined as the number of meals the student used excluding guest passes. To aid in the interpretation of meal plan use, meal plan use in the prior 28 days (four weeks) was divided by four to obtain a weekly average. Controls for food security status at the start of the corresponding semester, sex, race/ethnicity, Pell grant status, first generation status, campus, semester, week survey was completed, and repeated measures by student were included in the models. Logistic GEEs stratified by sex were then run to determine if, when examining males and females separately, students' food security status at the end of the Fall and/or Spring semester was predicted by the number of times a student used their meal plan in the 28 days prior to the students' survey completion. Given the smaller sample size for these stratified models, only controls for food security status at the start of the corresponding semester, campus, semester, and a clustering effect were included in the model.

A linear GEE was used to determine if the number of meals a student used on average per week in the 28 days prior to completing the survey at the end of the Fall and/or Spring semester was predicted by students' self-reported mental health (depressed mood, anxiety), employment status, alternative food supplies (from parents, roommates, and friends), and perceived meal plan adequacy, as measured

at the end of the corresponding semester. Controls for sex, race/ethnicity, Pell grant status, first generation status, campus, semester, semester, and repeated measures by student, were included in the models. Linear GEEs, stratified by sex, were run to determine if the associations between number of meals used and students' self-reported mental health, employment status, alternative food supplies, and perceived meal plan adequacy, were consistent when examining males and females separately. Given the smaller sample size for the stratified models, only controls for campus, semester, and a clustering effect were included in the model.

3.4. Results

The prevalence of food insecurity was 36% at the end of the Fall 2015 semester, and 35% at the end of the Spring 2016 semester. No bivariate association with food insecurity and meal plan was found in the Fall semester; the prevalence of food insecurity at the end of the Fall semester ranged from 41% of students on the cheapest meal plan to 26% of students on the unlimited meal plan ($p=0.135$; Table 3-1). However, students' food security at the end of the Spring semester was associated with students' meal plan; the prevalence of food insecurity ranged from 47% of students on the cheapest meal plan to 11% of students on the most expensive meal plan ($p=0.001$).

At the bivariate level, the more expensive meal plans were consistently more likely to be purchased by males ($p<0.001$), and less likely to be purchased by Pell grant recipients ($p<0.001$ Fall, $p=0.019$ Spring), first-generation college students ($p<0.001$ Fall, $p=0.001$ Spring), and students whose parents sent them food at least twice a semester ($p<0.001$; Table 3-1). In the Fall semester, students on the cheapest meal plan were the most likely to be working (33% vs 20% - 25%, $p=0.041$), and the least likely to report that their meal plan provided adequate food each week (67% vs 81% - 87%, $p=0.002$), however these associations were not seen in the Spring semester (45% vs 34% - 45%, $p=0.645$ for working a job; 74% vs 76% - 83%, $p=0.679$ for meal plan adequacy).

Table 3-1: Demographics And Key Variables By The Meal Plan Purchased In The Fall 2015 (n=470), And Spring 2016 (n=324) Semesters

	Fall 2015					Spring 2016				
	8 meals/ week	180 meals/ semester[F]	14 meals/ week	Unlimited meals	p. value	8 meals/ week	180 meals/ semester[F]	14 meals/ week	Unlimited meals	p. value
N	138	95	155	82		114	84	91	35	
Food security status at start of semester, n (%)					0.073					0.124
Not FI	97 (70.3)	70 (73.7)	111 (71.6)	70 (85.4)		69 (60.5)	60 (71.4)	63 (69.2)	28 (80.0)	
FI	41 (29.7)	25 (26.3)	44 (28.4)	12 (14.6)		45 (39.5)	24 (28.6)	28 (30.8)	7 (20.0)	
Food security status at end of semester, n (%)					0.135					**0.001**
Not FI	81 (58.7)	60 (63.2)	99 (63.9)	61 (74.4)		61 (53.5)	58 (69.0)	61 (67.0)	31 (88.6)	
FI	57 (41.3)	35 (36.8)	56 (36.1)	21 (25.6)		53 (46.5)	26 (31.0)	30 (33.0)	4 (11.4)	
Age (mean (sd))	18.3 (0.4)	18.4 (0.4)	18.4 (0.4)	18.5 (0.6)	0.094	18.3 (0.4)	18.4 (0.5)	18.3 (0.4)	18.5 (0.5)	0.270
Sex, n (%)					**<0.001**					**<0.001**
Female	108 (78.3)	73 (76.8)	111 (71.6)	42 (51.2)		93 (81.6)	63 (75.0)	65 (71.4)	10 (28.6)	
Male	30 (21.7)	22 (23.2)	44 (28.4)	40 (48.8)		21 (18.4)	21 (25.0)	26 (28.6)	25 (71.4)	
Race/ethnicity, n (%)					0.352					0.695
White	64 (46.4)	52 (54.7)	69 (44.5)	42 (51.2)		45 (39.5)	33 (39.3)	41 (45.1)	18 (51.4)	
Black	13 (9.4)	7 (7.4)	21 (13.5)	7 (8.5)		11 (9.6)	10 (11.9)	14 (15.4)	4 (11.4)	
Hispanic	36 (26.1)	21 (22.1)	37 (23.9)	12 (14.6)		37 (32.5)	23 (27.4)	20 (22.0)	6 (17.1)	
Other	25 (18.1)	15 (15.8)	28 (18.1)	21 (25.6)		21 (18.4)	18 (21.4)	16 (17.6)	7 (20.0)	
Pell grant recipient, n (%)					**<0.001**					**0.019**
No	65 (47.1)	57 (60.0)	115 (74.2)	56 (68.3)		56 (49.1)	50 (59.5)	62 (68.1)	25 (71.4)	
Yes	73 (52.9)	38 (40.0)	40 (25.8)	26 (31.7)		58 (50.9)	34 (40.5)	29 (31.9)	10 (28.6)	
First generation college student, n (%)					**<0.001**					**0.001**
No	54 (39.1)	60 (63.2)	105 (67.7)	51 (62.2)		46 (40.4)	54 (64.3)	59 (64.8)	21 (60.0)	
Yes	84 (60.9)	35 (36.8)	50 (32.3)	31 (37.8)		68 (59.6)	30 (35.7)	32 (35.2)	14 (40.0)	
Campus, n (%)					0.815					0.342
A	67 (48.6)	43 (45.3)	67 (43.2)	39 (47.6)		47 (41.2)	27 (32.1)	34 (37.4)	17 (48.6)	
B	71 (51.4)	52 (54.7)	88 (56.8)	43 (52.4)		67 (58.8)	57 (67.9)	57 (62.6)	18 (51.4)	

Depressed mood, n (%)					0.748					0.379
Low	56 (40.6)	39 (41.1)	68 (43.9)	39 (47.6)		44 (38.6)	38 (45.2)	37 (40.7)	19 (54.3)	
High	82 (59.4)	56 (58.9)	87 (56.1)	43 (52.4)		70 (61.4)	46 (54.8)	54 (59.3)	16 (45.7)	
Anxiety, n (%)[A]					0.700					0.323
No	125 (90.6)	83 (87.4)	133 (86.4)	71 (86.6)		99 (86.8)	75 (89.3)	73 (80.2)	31 (88.6)	
Yes	13 (9.4)	12 (12.6)	21 (13.6)	11 (13.4)		15 (13.2)	9 (10.7)	18 (19.8)	4 (11.4)	
Works a job, n (%)[B]					**0.041**					0.645
No	92 (66.7)	70 (75.3)	124 (80.0)	64 (80.0)		62 (54.9)	46 (54.8)	54 (59.3)	23 (65.7)	
Yes	46 (33.3)	23 (24.7)	31 (20.0)	16 (20.0)		51 (45.1)	38 (45.2)	37 (40.7)	12 (34.3)	
Meal plan provides adequate food, n (%)					**0.002**					0.679
Strongly disagree/disagree	46 (33.3)	18 (18.9)	29 (18.7)	11 (13.4)		30 (26.3)	18 (21.4)	22 (24.2)	6 (17.1)	
Agree/strongly agree	92 (66.7)	77 (81.1)	126 (81.3)	71 (86.6)		84 (73.7)	66 (78.6)	69 (75.8)	29 (82.9)	
Parents send food, n (%)[C]					**<0.001**					**<0.001**
Less than twice a semester	38 (27.7)	45 (47.9)	68 (44.4)	46 (56.1)		39 (34.2)	42 (50.0)	56 (61.5)	23 (65.7)	
Twice a semester or more	99 (72.3)	49 (52.1)	85 (55.6)	36 (43.9)		75 (65.8)	42 (50.0)	35 (38.5)	12 (34.3)	
Roommate shares food with participant, n (%)[D]					0.990					0.154
Never/rarely	69 (51.1)	48 (51.1)	80 (52.6)	41 (50.6)		58 (51.3)	50 (60.2)	56 (61.5)	25 (71.4)	
Sometimes/often	66 (48.9)	46 (48.9)	72 (47.4)	40 (49.4)		55 (48.7)	33 (39.8)	35 (38.5)	10 (28.6)	
Friends share food with participant, n (%)[E]					0.819					0.865
Never/rarely	47 (34.8)	29 (30.9)	49 (32.5)	30 (37.0)		48 (42.5)	33 (39.8)	40 (44.9)	16 (47.1)	
Sometimes/often	88 (65.2)	65 (69.1)	102 (67.5)	51 (63.0)		65 (57.5)	50 (60.2)	49 (55.1)	18 (52.9)	

[A] n= 469 Fall, 324 Spring; [B] n= 466 Fall, 323 Spring; [C] n= 466 Fall, 324 Spring; [D] n= 462 Fall, 322 Spring; [E] n= 461 Fall, 319 Spring
[F] 180 meals/semester equates to approximately 11 meals per week with consistent use

Students did not fully use their meal plans. Students on more expensive meal plans used their meal plan more frequently ($p<0.001$; Table 3-2). Female students on the 8 meals/week meal plan used 71% and 64% of their available meals in the 28 days prior to survey completion in the Fall and Spring semesters respectively; for female students on the 14 meals/week meal plan these percentages drop to 60% (Fall) and 53% (Spring). In the 28 days prior to survey completion male students' on the 8 meals/week meal plan used 78% and 75% of their available meals in the Fall and Spring semesters respectively; male students on the 14 meals/week meal plan used 74% and 67% of their available meals in the Fall and Spring semesters respectively. On average, female (male) students on the 180-meals per semester meal plan used 62% (68%) of their meals in the Fall semester and 70% (74%) of their meals in the Spring semester.

Table 3-2: The Number Of Meals Students Used From Their Meal Plan In The 28 Days Prior To Survey, And Across The Semester (n=534; mean (sd))

	Fall 2015				Spring 2016			
	8 meals/ week	180 meals/ semester[A]	14 meals/ week	Unlimited meals	8 meals/ week	180 meals/ semester[A]	14 meals/ week	Unlimited meals
Females								
n	108	73	111	42	93	63	65	10
Number of meals in 28 days prior to survey								
Including guest passes	22.6 (9.3)	30.5 (14.5)	33.4 (12.1)	40.4 (18.9)	20.4 (8.4)	30.6 (12.0)	29.5 (11.4)	41.3 (23.7)
Excluding guest passes	20.1 (7.8)	30.4 (14.5)[B]	30.9 (10.0)	38.1 (17.3)	19.0 (7.2)	30.6 (12.0)[B]	27.8 (10.4)	36.1 (21.3)
Excluding guest passes and weekends	16.0 (6.4)	22.0 (9.9)	23.1 (7.5)	28.4 (12.1)	16.0 (5.9)	24.8 (9.2)	22.1 (8.0)	29.7 (16.7)
Number meals per semester								
Including guest passes	87.0 (31.0)	111.1 (43.2)	130.5 (42.5)	164.0 (58.6)	86.2 (31.0)	125.1 (41.9)	123.6 (39.2)	157.0 (77.6)
Excluding guest passes	79.0 (26.3)	111.0 (43.2)	123.3 (38.1)	155.9 (54.6)	78.7 (26.6)	125.0 (41.9)	117.2 (35.5)	141.0 (70.6)
Excluding guest passes and weekends	65.5 (20.7)	87.5 (32.5)	97.1 (28.4)	123.4 (40.5)	66.7 (22.4)	103.7 (33.4)	95.9 (26.6)	118.6 (57.8)
Percentage of meals used[C]								
28 days prior to survey	71%	68%	60%		64%	73%	53%	
Per semester[D]	68%	62%	58%		63%	70%	52%	
Males								
N	30	22	44	40	21	21	26	25
Number of meals in 28 days prior to survey								
Including guest passes	24.9 (7.2)	33.3 (13.0)	41.6 (13.3)	59.5 (23.9)	24.0 (7.3)	35.0 (11.6)	37.3 (11.8)	64.0 (25.9)
Excluding guest passes	23.0 (6.1)	33.3 (13.0)	36.6 (9.7)	57.2 (22.2)	22.0 (5.4)	35.0 (11.6)	34.2 (10.2)	61.6 (23.2)

Excluding guest passes and weekends	18.4 (4.7)	24.9 (9.5)	26.6 (7.6)	42.6 (15.7)	17.9 (4.8)	28.0 (9.5)	25.8 (6.9)	47.8 (17.4)
Number meals per semester								
Including guest passes	99.3 (30.3)	122.5 (45.6)	158.1 (42.1)	232.0 (86.2)	105.7 (22.5)	132.8 (40.9)	154.5 (48.2)	253.7 (94.9)
Excluding guest passes	89.4 (26.3)	122.5 (45.6)	146.4 (35.9)	224.3 (82.9)	94.0 (19.2)	132.4 (40.7)	142.6 (41.8)	246.0 (88.2)
Excluding guest passes and weekends	73.9 (20.4)	99.0 (36.0)	111.3 (27.5)	178.0 (62.6)	80.2 (14.3)	108.8 (34.3)	113.8 (30.5)	198.9 (70.2)
Percentage of meals used[C]								
28 days prior to survey	78%	74%	74%		75%	83%	67%	
Per semester[D]	78%	68%	71%		78%	74%	65%	

The number of meals males and females used in each semester were significantly different by meal plan ($p<0.001$)

[A] 180 meals/semester equates to approximately 11 meals per week with consistent use

[B] The 180-meals/semester meal plan does not allow guest meals. A few students (n=4 Fall, n=7 Spring) used a guest pass prior to changing onto the 180-meals/semester meal plan. A few students on the 180-meals/semester meal plan swiped their meal plan twice in the same minute, the second swipe was classified as a guest meal.

[C] The percentage of meals used was based on the number of meals used (including guest passes) out of the theoretical maximum number of meals a student on each meal plan could use. For students on an 8 (14) meals/week meal plan the theoretical maximum number of meals a student could have used was: 32 (56) meals in 28 days, 128 (224) meals in the Fall semester, and 136 (238) meals in the Spring semester. The percentage of meals used in the 28 days prior to the survey for students on the 180 meals/semester meal plan was based off a theoretical maximum of 45 meals for the Fall semester and 42 meals for the Spring semester.

[D] The semester length was calculated as 16 weeks for the Fall semester and 17 weeks for the Spring semester. This is less than the actual semester lengths (18 weeks) to account for less purchases made in the first and last weeks of semester, and four days of missing data during the Fall semester.

The adjusted odds ratio of food insecurity was significantly greater for students on the 8 meals/week (OR=2.2, 95% CI=1.2, 4.1) plan than students on the unlimited meal plan (Table 3-3).

Table 3-3: Results Of The Logistic GEE Examining Food Insecurity At The End Of The Semester By Socio-demographics And Meal Plan (n=534 participants, 794 data points)

	OR	95% CI	p. value
Meal plan			
Unlimited	(ref)		
8 meals/week	2.2	(1.2, 4.1)	**0.016**
180 meals/semester[A]	1.6	(0.8, 3.0)	0.176
14 meals/week	1.4	(0.8, 2.7)	0.247
Food security at start of semester			
Food secure	(ref)		
Food insecure	8.8	(6.0, 12.8)	**<0.001**
Sex			
Female	(ref)		
Male	0.9	(0.6, 1.3)	0.472
Race/ethnicity			
White	(ref)		
Black	1.7	(0.9, 3.1)	0.085
Hispanic	1.0	(0.6, 1.7)	0.881
Other race/ethnicity	0.6	(0.4, 1.0)	0.052
Pell grant recipient	1.0	(0.6, 1.5)	0.932
First generation college student	0.8	(0.6, 1.2)	0.373
Campus			
A	(ref)		
B	0.7	(0.5, 1.0)	**0.049**
Spring 2016 semester	0.6	(0.4, 0.9)	**0.012**
Week of semester	1.2	(1.0, 1.4)	**0.026**

[A] 180 meals/semester equates to approximately 11 meals per week with consistent use

When examining females and males together, students on the 180 meals/semester meal plan who used less meals per week were more likely to report food insecurity at the end of the semester; the odds of food insecurity decreased as students used more meals when weekends were included (OR=0.9, 95% CI=0.8, 1.0) and excluded (OR=0.8, 95% CI=0.7, 0.9; Table 3-4). However, when stratifying by gender the association between meal plan use and food insecurity was only seen among males on the 180 meals/semester meal plan (including weekends: OR=0.6; 95% CI=0.5, 0.8; excluding weekends: OR=0.6; 95% CI=0.4, 0.8; Table 3-5).

Table 3-4: Results Of The Logistic GEE Determining If Food Insecurity At The End Of The Semester Is Associated With Number Of Meals Used[A].

Meal plan	Number of students	Number of data points	Food insecure at end of the semester					
			Including weekends			Excluding weekends		
			OR	95% CI	p. value	OR	95% CI	p. value
8 meals/week	175	252	0.9	(0.8, 1.1)	0.476	0.9	(0.7, 1.1)	0.343
180 meals/semester[B]	145	179	0.9	(0.8, 1.0)	**0.011**	0.8	(0.7, 0.9)	**0.004**
14 meals/week	184	246	0.9	(0.8, 1.0)	0.150	0.9	(0.7, 1.0)	0.081
Unlimited meals	86	117	1.0	(0.9, 1.1)	0.895	1.0	(0.8, 1.1)	0.612

A control for food security status at start of semester, sex, race/ethnicity, Pell grant status, first generation status, campus, semester, week survey was completed, and a clustering effect by student were included in the models.
[A] number of meals used is determined by the number of meals used in the 28 days prior to survey completion at the end of the semester, and divided by four to obtain an average number of meals per week at the end of the semester.
[B] 180 meals/semester equates to approximately 11 meals per week with consistent use

Table 3-5: Results Of The Logistic GEE Determining If Food Insecurity At The End Of The Semester Is Associated With Number Of Meals Used[A] After Stratifying By Gender And Meal Plan.

Meal plan	Number of students	Number of data points	Food insecure at end of the semester					
			Including weekends			Excluding weekends		
			OR	95% CI	p. value	OR	95% CI	p. value
Females								
8 meals/week	142	201	0.9	(0.8, 1.1)	0.414	0.9	(0.7, 1.1)	0.456
180 meals/semester[B]	109	136	0.9	(0.8, 1.1)	0.253	0.9	(0.7, 1.0)	0.136
14 meals/week	133	176	0.9	(0.8, 1.1)	0.467	0.9	(0.7, 1.1)	0.316
Unlimited meals	43	52	1.0	(0.9, 1.2)	0.763	1.0	(0.8, 1.3)	0.943
Males								
8 meals/week	33	51	1.1	(0.7, 1.6)	0.766	0.9	(0.6, 1.5)	0.774
180 meals/semester[B]	36	43	0.6	(0.5, 0.8)	**0.002**	0.6	(0.4, 0.8)	**0.002**
14 meals/week	51	70	0.8	(0.5, 1.1)	0.097	0.7	(0.4, 11)	0.084
Unlimited meals	43	65	0.9	(0.8, 1.1)	0.381	0.9	(0.7, 1.1)	0.221

A control for food security status at start of semester, campus, semester, and a clustering effect by student were included in the models. Due to the small sample sizes, sex, race/ethnicity, Pell grant status, first generation status, and week survey was completed were not included in the models.

[A] number of meals used is determined by the number of meals used in the 28 days prior to survey completion at the end of the semester, and divided by four to obtain an average number of meals per week at the end of the semester.

[B] 180 meals/semester equates to approximately 11 meals per week with consistent use

When females and males were examined together, no association between depressed mood, anxiety, perception that meal plan provided adequate food, parents sending food, roommate sharing food, or friends sharing food, was associated with the number of meals students on the 180 meals/semester meal plan used. However, students on the 180 meals/semester meal plan who reported working a job used less meals per week on average in the 28 days prior to survey completion when weekends were included in the models (ß=-1.3, 95% CI=-2.3, -0.3; Table 3-5), and when weekends were excluded (ß=-0.9, 95% CI=-1.7, -0.2).

When stratifying by gender, females on the 180 meals/semester meal plan who worked a job used less meals (β=-1.3, 95% CI=-2.5, -0.2; β=-0.9, 95% CI=-1.7, -0.1), this association was not examined among males on the 180 meals/semester meal plan due to low counts.

Table 3-6: Results Of The Linear GEE Testing What Factors Are Related To The Number Of Meals Students Used[A] On The 180 Meals/Semester[B] Meal Plan.

	Number of students	Number of data points	Number of meals used[A] Including weekends			Excluding weekends		
			B	95% CI	p. value	β	95% CI	p. value
Depressed mood	n=145	179	-0.5	(-1.4, 0.4)	0.295	-0.2	(-0.9, 0.4)	0.533
Anxiety	n=145	179	0.4	(-1.1, 1.9)	0.622	0.3	(-0.9, 1.4)	0.658
Works a job	n=143	177	-1.3	(-2.3, -0.3)	**0.012**	-0.9	(-1.7, -0.2)	**0.013**
Meal plan provides adequate food	n=145	179	0.0	(-1.2, 1.1)	0.988	0.0	(-0.8, 0.9)	0.984
Parents send food	n=144	178	0.2	(-0.8, 1.1)	0.734	0.2	(-0.5, 0.9)	0.593
Roommate shares food with participant	n=143	177	0.3	(-0.7, 1.3)	0.599	0.2	(-0.6, 0.9)	0.668
Friends share food with participant	n=143	177	0.5	(-0.5, 1.4)	0.320	0.5	(-0.2, 1.2)	0.200

A control sex, race/ethnicity, Pell grant status, first generation status, campus, semester, and a clustering effect by student were included in the models.

[A] number of meals used is determined by the number of meals used in the 28 days prior to survey completion at the end of the semester, and divided by four to obtain an average number of meals per week at the end of the semester.

[B] 180 meals/semester equates to approximately 11 meals per week with consistent use

Table 3-7: Results Of The Linear GEE Testing What Factors Are Related To The Number Of Meals Students UsedA On The 180 Meals/SemesterB Meal Plan After Stratifying By Gender.

	Number of students	Number of data points	Number of meals used[A] Including weekends			Excluding weekends		
			B	95% CI	p. value	β	95% CI	p. value
Female								
Depressed mood	109	136	-0.5	(-1.6, 0.5)	0.316	-0.3	(-1.0, 0.5)	0.516
Anxiety	109	136	0.2	(-1.4, 1.7)	0.829	0.1	(-1.0, 1.2)	0.836
Works a job	108	135	-1.3	(-2.5, -0.2)	**0.019**	-0.9	(-1.7, -0.1)	**0.034**
Meal plan provides adequate food	109	136	0.6	(-0.8, 1.9)	0.411	0.3	(-0.7, 1.3)	0.539
Parents send food	108	135	0.3	(-0.8, 1.4)	0.585	0.3	(-0.5, 1.1)	0.433
Roommate shares food with participant	108	135	0.0	(-1.2, 1.2)	0.974	-0.1	(-0.9, 0.8)	0.869
Friends share food with participant	108	135	0.2	(-0.9, 1.3)	0.683	0.3	(-0.5, 1.1)	0.436
Male								
Depressed mood	36	43	-0.8	(-2.5, 0.9)	0.348	-0.4	(-1.7, 0.9)	0.561
Anxiety[C]	36	43						
Works a job[C]	35	42						
Meal plan provides adequate food[C]	36	43						
Parents send food	36	43	-0.2	(2.3, 1.9)	0.845	-0.2	(-1.8, 1.5)	0.854
Roommate shares food with participant	35	42	1.2	(-0.5, 3.0)	0.161	0.9	(-0.5, 2.2)	0.223
Friends share food with participant	35	42	0.8	(-0.9, 2.6)	0.358	0.6	(-0.8, 2.0)	0.419

A control for campus, semester, and a clustering effect by student were included in the models. Due to the small sample sizes, sex, race/ethnicity, Pell grant status, first generation status, and week survey was completed were not included in the models.

[A] number of meals used is determined by the number of meals used in the 28 days prior to survey completion at the end of the semester, and divided by four to obtain an average number of meals per week at the end of the semester.

[B] 180 meals/semester equates to approximately 11 meals per week with consistent use

[C] Due to low counts in the number of males reporting low anxiety (n=0 in Fall 2015 and Spring 2016), working a job (n=2 in Fall 2015, n=6 in Spring 2016), and perceiving the meal plan did not provide adequate food (n=3 in Fall 2015, n=5 in Spring 2016), the analyses for anxiety, working a job, and perception that meal plan provides adequate food were not run for males.

3.5. Discussion

This study examined the association between meal plan use and food insecurity over time. We found that food insecurity was associated with the number of meals a students' meal plan provided, where students were the least likely to report food insecurity if they were on the most expensive (unlimited) meal plan. However, of the students on an unlimited meal plan in the Fall semester, 26% still reported food insecurity at the end of the semester. Surprisingly, students reported food insecurity while having meal plan meals available. There were indications that students who used their meal plan more frequently were less likely to be food insecure. This study indicates that students who work a job have lower meal plan use. From this study, it is unclear why students with unused meal plans, and students on unlimited meal plans in particular, reported food insecurity.

The extent food insecurity was reported by students on an unlimited meal plan, and the finding that the students in this study reporting food insecurity typically had meals available to them via their meal plan, was unexpected. Of concern is the possibility that the USDA food security tool is inappropriate for college student populations. If the USDA food security tool does not accurately assess students' food security status, analyses using the USDA food security tool to examine food insecurity among college students may be inaccurate. While the USDA food security tool has been validated for US households,[415] research is needed to ensure the tool generalizes to college students. Several of the food insecurity screener questions refer to not having enough money for food, and students may not think of their pre-paid meals as a 'money' source. Other questions in the food insecurity screener may not be applicable to students with a meal plan. For instance, cutting the size of a meal and eating less may not be applicable when eating at an all-you-can eat dining hall. Potentially, questions such as "In the past one month, could you have eaten

balanced meals every day (even if it meant changing your typical daily routine, such as getting up earlier)?" and "In the past one month, were you ever hungry but didn't eat because it wasn't possible to obtain food?". While some students may have misreported their food security status as lower than it actually was (potentially due to misinterpretation of the questions), another study has suggested that the USDA 18-item food security tool may under-report, not over-report, food insecurity.[226] It is unclear if the USDA 6-item food security tool used in this study also under-reports food insecurity. Even if the USDA food security tool is misclassifying some students, the systematic differences observed for college students health and academic outcomes by food security status[153,155,224] indicate that in general students who report food insecurity struggle more than students who report food security. Future research should estimate what proportion of false positives and false negatives occur among student populations when the USDA food security tool is used.

Students may report food insecurity while having meals available to them for many reasons. Potentially, some of the students who reported food insecurity *perceived* less access to food than their food secure counterparts. Food insecure students typically report higher levels of depression,[156,157] and one study found that students who report depression also report more *perceived* barriers to healthful eating.[416] However, there was no suggestion that depression was associated with lower meal plan use in this current study. Additionally, students reporting food insecurity may have eating patterns that do not fit well with the dining hall hours. Prior studies have shown that, in general, students reporting food insecurity obtain less hours of sleep,[158] and report higher levels of stress[156,401] – which has been associated with night eating.[417] While food insecure and secure students used their meal plan a similar extent, some students may have reported food insecurity due to difficulty in obtaining additional food at night (when most of the university food outlets are

closed). If students are truly food insecure, and have meals available to them, understanding why these apparently contradictory findings co-occur could help greatly reduce the prevalence of food insecurity being reported on college campuses. Future research should closely examine students' self-efficacy for food security, and include discussions with students to determine the situation(s) that led to food insecurity.

This study suggests that at the end of the semester, students with higher meal plan use are less likely to report food insecurity. Many of the students used, on average, one meal from their meal plan per day. It is unclear how many non-dining hall meals the students consumed in addition to this one meal. If a student typically has one large dining hall meal each day, failure to obtain this meal for just one day a week may result in the student reporting food insecurity. However, we note that at this university, there are several dining halls, each open for around 12 hours on weekdays (and around 8 hours on weekends). In addition to the dining hall locations, all students are able to use one meal exchange per day at select locations on campus: a location offering a meal exchange was open until 2AM each day. As such, this university provides students many dining options, however at evening/night some students would have to leave their residence hall and walk 5-10 minutes to use their meal plan. It was unclear how busy the locations that provided meals late at night were, and how long the wait time to obtain a meal at these locations typically were. If students are struggling to use their meal plan, this finding may indicate students' time management, rather than university dining options, is a key issue with student food insecurity. The typical frequency and duration of students' food insecurity should be examined, for instance future studies should determine if students' food insecurity tends to be chronic or acute, and how students experiences with food insecurity compares to adults' experiences with food insecurity.

Students on the 180 meals/semester meal plan who reported food insecurity used significantly less meals; however, when examining males and females separately this effect was only found among males. Potential reasons for lower meal plan use for students on the 180 meals/semester meal plan were examined. Students on the 180 meals/semester meal plan who reported working a job had lower meal plan use. Given the low number of males who reported working a job, no analysis for the male-specific association for working a job and meal plan use was conducted. For the female-specific analysis, working a job was associated with lower meal plan use.

While the location, days, and hours that students' worked was unclear from this study, this suggests that students' who work are unable to use their meal plan to the same extent as students who do not work. Broton et al. reports that students who are employed are significantly more likely than their non-working counterparts to state that they do not having enough time to eat.[188] As well as limited time to eat, students' are potentially working off campus, and as such unable to use their meal plan during their working hours. Students may also finish work after the main dining halls close, making it more difficult for these students to use their meal plan. Future studies should further examine the association between meal plan use, working a job, and gender. In particular, future studies should examine if students' meal plan use is associated with the shifts students work.

Females students who worked used around 1.3 less meals per week, which equates to roughly 0.93 less meals during the weekdays if the effect is constant across all days. The model suggests a constant effect as students who work were predicted to use 0.9 less meals over the weekdays. Peer-reviewed studies have reported that going home for weekends is common among first-year Hispanic[418] and first generation Appalachian students.[419] A New York Times article also reported many

students attending a North-Eastern college leave campus over the weekend.[420] From this study it was unclear if students who worked were off-campus and unable to use their meal plan, or on-campus but choosing to dine elsewhere, and if the reason students' who worked used less meals was the same for weekdays and weekends.

3.5.1. Strengths/Limitations

This study examines food insecurity from a new angle, and presents some surprising results. Strengths of this study include the objective information on meal plan purchase and use, and the large sample of first-year students. Another strength is the analysis of four different meal plans, which shows the odds of food insecurity increasing as the number of meals provided decreases. While it is a strength of this dissertation that the USDA food security tool was used to determine students' food security status, given our concern around what the USDA food security tool is capturing, we also count the use of this tool as a limitation. Other limitations of this study are that the findings are from a specific university, only for first-year students, and during only one academic year (2015-2016). The findings may be different at other universities, for students past their first year in college or with different demographics, and for other academic years. While students' food security status was determined using the validated USDA short form, food security status was determined via only one mode (questionnaire) and only asked once at the end of each semester. Low food secure and very low food secure students were grouped in the present analysis; differences may be more apparent when comparing students with very low food security to food secure students. The number of credits students were enrolled in, students' GPA, and students' class schedules, were not examined. Potentially students also had lower meal plan use if they had a heavier course load, spent more time studying, or had classes during meal times. Students were asked about parents/guardians purchasing and sending food to them, but were not asked

about how often they ate meals at their parents/guardians (or relatives) home, some students may have had lower meal plan use due to meals consumed with family members. While objective measures of meal plan use were used, it was not possible to verify the meal plan information from a secondary source. However, even if many of the meals students used went unreported, the majority of students would still have had meals available to them.

3.5.2. Implications

Students are reporting food insecurity while having pre-paid meals available to them. Better understanding why students are not fully using their meal plan could help develop interventions to reduce the prevalence of food insecurity among college students. Qualitative student interviews may provide necessary insight as to why these two apparent contradictory findings - food insecurity and unused meals – are occurring. Research is needed to understand how to encourage or enable students to use their meal plan more; doing so could reduce the extent of food insecurity on college campuses.

4. FIRST-YEAR COLLEGE STUDENTS: ROOMMATES AND MEAL PLAN BEHAVIORS

4.1. Abstract

Objective This study examined if first-year roommates' meal plan choices were similar, and the extent of meal plan joint use over time. This provides a starting point for interventions aiming to increase the extent students' use their pre-paid meal plan via roommate influence.

Methods Residence information for 1186 first-year students (N=593 roommate pairs), and 559 floormates was obtained for the 2015-2016 academic year. Logistic generalized estimating equations (GEEs) were used to determine if the meal plan students' purchased were the same as their roommates' meal plan. Linear GEEs were used to examine if students' meal plan use over the semester was higher with higher roommate meal plan use. A logistic GEE examined meal plan joint usage between students and roommates for each month of the semester. To determine if residence, rather than roommate, explained the results, a simulation was conducted by randomly assigning the floormates to a same-sex roommate.

Results Female students were likely to purchase the cheapest meal plan if their roommate also did so (OR=3.04, 99% CI=1.49, 6.21). Students' Spring meal plan use was higher if their roommate had higher Spring meal plan use, even after controlling for students' Fall meal plan use (Female: β=0.07, 99% CI=0.00, 0.13; Male: β=0.10, 99% CI=0.02, 0.18). Students were more likely to use a meal with their roommate if they were on the same meal plan (Female: OR=1.61, 99% CI=1.27, 2.04; Male: OR=1.57, 99% CI=1.09, 2.25), and less likely after the first month of being roommates (Female: OR=0.57-0.25; Male: OR=0.50-0.22;

$p<0.001$). The simulation analysis indicated these findings were not due to shared residence.

Discussion Students' meal plan choices were associated with their roommates' meal plan choices. Roommates' meal plan joint usage was highest at the start of the year. Strategic roommate pairings may result in students using their meal plan more. Further research should determine the extent of roommate influence on students' diet.

4.2. Introduction

First-year students in the United States (US) typically live in on-campus residence halls, share a room with at least one other student, and are required to purchase a university meal plan.[421,422] A meal plan generally provides the student with a set number of entries to a dining hall per week or semester, as well as additional cash-equivalence that can be used to purchase food items from on-campus food outlets. The extent students' use their meal plan may influence their health: the dining halls tend to have more healthful food options than other outlets such as fast food restaurants.[1] For students who are required to purchase a meal plan, using the pre-paid meals may be a cheaper alternative than purchasing additional foods. Surprisingly, prior research indicates that students typically use less than ¾ of their pre-paid meals, with many students using the dining hall around once a day.[423] As such, encouraging students to use the dining hall more may result in an improvement in student diet, and could potentially also save students money.

Studies have suggested that randomly assigned roommates influence the students' behaviors and outcomes. For instance first-year university students who were randomly assigned a heavier roommate were reported to gain more weight over the academic year,[337] and students were more likely to binge drink if they, and their roommate, had done so in high school.[339] Studies have also found that university students who were randomly assigned to a roommate with higher academic performance obtained a higher GPA,[333,334] and that students who were randomly assigned a student of a different race/ethnicity as their roommate tended to subsequently report less prejudice towards that race/ethnicity.[331] Different explanations for the perceived roommate influence have been suggested, such as certain behaviors being 'contagious',[339] and convergence on behaviors other than what was measured (e.g. convergence of physical activity resulting in a convergence

of BMI).[337] Zimmerman and Van Laar et al. both suggest that the close proximity of roommates may result in convergence among roommate behaviors.[331,333] Zimmerman discusses how roommates can compare each other through observation and discussions, the tendency towards group uniformity, and how 'abnormal' behavior from a student may result in a positive or negative interaction between roommates.[333] Van Laar et al. discusses how roommates equal status, common goals, required intergroup cooperation, and support of authorities (i.e. the four conditions for contact theory[424]) may result in lower levels of prejudice towards the race/ethnicity of the students' roommate.[331]

Given the suggestions that groups tend towards uniformity, the extent students are able to compare themselves to their roommates, and the prior findings suggesting roommate influence on health behaviors and outcomes, we examine the extent of roommate influence on students' meal plan. The roommate a student is paired with may influence which meal plan a student purchases. For instance, if a student has a fridge and microwave, this could facilitate storage of meals and meal preparation for both the student and the students' roommate. Further, upon observing the student, the students' roommate may learn how to store and prepare meals in their residence, and have higher self-efficacy around meal storage and preparation. Given the ability to store and prepare foods, both the student and the students' roommate may then opt to purchase foods they can prepare in their residence, and to purchase the cheapest meal plan. Similarly, if one student is worried that their meal plan may not be sufficient, the student may increase their roommates worry around meal plan sufficiency, such that both that student and the students' roommate purchase a more expensive meal plan.

Students may also influence the extent, and the times/location, their roommate uses their meal plan. Studies suggest that students spend more time with their roommate than any other friend,[330] and that students who are more socially connected use the dining hall more frequently.[362] Potentially, students may prefer to use the dining hall at the same time as a friend; those who are more socially connected may have a larger friend network to use the dining hall with (and therefore more opportunities to use the dining hall). If students prefer to use the dining hall with a friend, students may also be more likely to use the dining hall with their roommate, especially at the start of the academic year when the students' social network is small. Additionally, if one student has high (low) meal plan use, this may alter their roommates' perception of 'normal' meal plan use, such that the roommate mirrors the high (low) meal plan use of the student.

Roommates who are similar may have more joint meal plan use. Roommates who purchased the same meal plan may indicate the students (roommate pairs) with higher joint decision making; these students may be especially likely to use their meal plan at the same time and location as each other. Studies also suggest that friends tend to be racially/ethnically similar to each other.[267,293] Roommates who are demographically similar may be more likely to befriend each other (or to have been friends prior), and as such more likely to use their meal plans together. If similar roommates have more joint meal plan use than non-similar roommates, this could explain findings that similar students use their meal plan a similar extent.

One difficulty with roommate analyses is the confounding effect of environment. For instance, if students on the same residence floor (i.e. in the same environment; floormates) typically use their meal plan together, we could expect to see joint meal plan use among roommates *and* floormates. An analysis that examines both

roommates and floormates can help identify if environmental factors are likely responsible for findings among roommates, or not. To examine the extent of environmental factors, a simulation analysis, where students are randomly paired with a floormate can be conducted. If the similarities among roommates are also found among floormates, this suggests that the similarities among roommates are due to environmental factors. If no similarities among floormates are found, this suggests that similarities among roommates are due to roommates influencing each other, or the roommates being similar initially.

Students' meal plans are one of the main sources of dietary intake for students. If students' meal plan decisions are influenced by their roommate, novel ways to encourage dining hall use, and potentially higher dietary quality, may be more effective if targeted to roommates, rather than individuals. However, while deliberate student assignments may result in an increase in desirable behaviors, the limited number of studies examining social networks and roommates means the risk for unintended outcomes remains high. For instance, one study used deliberate student groupings to try and increase the GPA of students with low academic performance, however the GPA of the students decreased, rather than increased.[367]

The primary purpose of this study was to determine if roommates purchased the same meal plan, used a similar number of meals as each other, and used their meal plan at the same time and location as each other. We hypothesized that students would tend to purchase the same meal plan as their roommate. We hypothesized that students would have higher meal plan use over the semester if their roommate had higher meal plan use, especially if the student and roommate were on the same meal plan. Finally, we hypothesized that roommates' meal plan joint usage would be highest at the start of the academic year, and for students who were on the same

meal plan, or of similar demographics, as their roommate. We also sought to describe which meal plans students' purchased, and the extent students' used their meal plan in order to put the examination of roommates into context.

4.3. Materials and Methods

4.3.1. Study Sample

This manuscript is a secondary analysis of first-year students' meal plan decisions. Information on students' meal plan purchases, meal plan use, and roommate, for the 2015-2016 cohort of first-year students attending a large, southwestern university was obtained from university records. Inclusion criteria for students were: 1) complete demographic information available, 2) known and standard meal plan, 3) aged between 17 and 20 years old, 4) resided in the same residence hall, floor, and room, throughout the entire academic year, and 5) typical meal plan use (see description below). Students consented to their university records being used for research purposes as part of the universities' privacy statement.[388] This research was approved by the Arizona State University Institutional Review Board.

4.3.2. Measures

Roommates and Floormates. University records provided all of the residence halls, floors, and rooms that students had officially resided in during the academic year. At this university, the residence hall rooms for first year students have space for two people. A students' roommate was defined as someone who resided in the same residence hall, floor, and room, as the student for the entire academic year. If a student met the inclusion criteria, but did not have a roommate who met the inclusion criteria, the student was classified as a floormate. All floormates were then randomly assigned to a same-sex student from the roommate analysis who resided

in the same residence hall and the same or a nearby floor. As such, the roommate analyses include the students who had the same roommate for the entire academic year. The floormate analyses pairs the students who did not have the same roommate for the entire academic year with students from the roommate analyses.

Meal plan. The date, time, location, and meal plan type used, for each time a student used their meal plan was obtained from university records. There were four standard meal plan types (8 meals/week, 180 meals/semester, 14 meals/week, unlimited meals) available to students. For this study, student meal plan use was defined as the meals a student purchased for themselves (i.e. excluded meals purchased for a guest). The meal plan students purchased was determined as the meal plan that students used when they made a meal plan purchase. Some students changed their meal plan at the start of the semester; the meal plan the student used after the third week of semester was used. Students who changed their meal plan after the third week of semester, or who used non-standard meal plans (e.g. veteran meal plans) were excluded from the analysis. Students who did not use their meal plan at all during any of the first four months of either semester were classified as having atypical, low, meal plan use. Students who used their meal plan more than 289 times in either semester (289 meals = three standard deviations above the mean) were categorized as having atypical, high, meal plan use. Students with atypical (low or high) meal plan use were excluded from the analyses. The day students' used their meal plan was categorized as during a weekday, or on a weekend. Based on the distribution of responses, meal plan purchases were categorized as occurring in the morning (before 10 AM), at midday (10 AM to 1 PM), in the afternoon (1 PM to 4 PM), and in the evening (after 4 PM).

Converged meal plan use. If students used a meal within 1 minute and at the same location as their roommate using a meal, the students' meal plan use was classified as converging with the roommates' meal plan use for that meal.

Demographics. Students' date of birth, sex, race/ethnicity, and Pell grant status (federal aid to low income students) were provided by the university. Students' age was calculated as at the first day of class based on date of birth. Students' sex was reported as female/male. Students' race/ethnicity was classified as American Indian/Alaska Native; Asian; Black/African American; Hispanic/Latino; International; Native Hawaiian/Pacific Islander; Two or more races; Unspecified. Due to low counts, American Indian/Alaska Native, Asian and Native Hawaiian/Pacific Islander were classified as 'other' race/ethnicity. Pell grant status was reported as Pell grant recipient vs not.

4.3.3. Statistical Analysis

Descriptives

To better understand how students' meal plan use was associated with meal plan and demographics, the differences between students with low, typical, and high meal plan use was examined. As few students had high meal plan use, chi-square tests were only used to examine demographic differences between low and typical meal plan use. To better understand the distribution of meal plan use, a visualization showing meal plan use by sex and semester was also used.

Meal plan purchased

Chi-square and ANOVA tests, as appropriate, were conducted to determine if students' demographics were associated with the meal plan purchased in the Fall and Spring semesters. Logistic generalized estimating equations (GEEs) were used to

determine if the meal plan a student purchased was associated with the meal plan the students' roommate purchased in the same semester. Given the strong association between students' sex and the meal plan purchased, analyses were stratified by sex. The meal plans students purchased were predicted by the students' demographics (race/ethnicity, Pell grant status, age), residence hall, semester, and the students' roommates' meal plan for the same semester. To account for students' purchasing a meal plan in both the Fall and Spring semesters, a clustering effect by student was included in the model.

Extent meal plan used

A linear GEE was used to examine the extent students used their meal plan. Analyses were stratified by sex to account for males tending to purchase more expensive meal plans, and using their meal plan more. The students' meal plan was included in the model to determine the extent students on different meal plans used their meal plan. A term for roommates having the same meal plan was included in the model to test if roommates on the same meal plan had higher meal plan use. The number of meals the students' roommate used during the semester was included in the model to determine if students' had higher meal plan use if their roommate had higher meal plan use in the same semester. A term for roommates having the same race/ethnicity or Pell grant status was included in the model to determine if similar roommates had higher meal plan use than other roommates. Controls for student demographics (race/ethnicity, Pell grant status, age), residence hall, semester, and clustering by student were also included in the model.

To determine if students had higher meal plan use over the semester if their roommate had higher meal plan use, even after controlling for the students' prior meal plan use, an additional linear GEE was run. The students' meal plan use in the

Spring semester was predicted by the number of meals the students' roommate used in the Spring semester. Controls for the number of meals the student used in the Fall semester, student demographics (race/ethnicity, Pell grant status, age), roommates having the same race/ethnicity, Pell grant status, or meal plan, student residence hall, and student meal plan in the Spring semester were included in the model.

Meal plan joint usage

ANOVA tests were used to determine if the percentage of meals a student used each semester at the same time (within one minute) and location of their roommate using a meal was different by students' meal plan. To better understand the extent of meal plan joint usage over time, a visualization showing the proportion of meal plan joint usage for males and females for each month of the academic year was created. A logistic GEE was used to further examine the extent of meal plan joint usage, with separate analyses for females and males. As roommates on the same meal plan may have higher joint usage, a term for purchasing the same meal plan was included in the models. Similarly, a term for roommates being the same race/ethnicity, or having the same Pell grant status, was included in the models. Student demographics (race/ethnicity, Pell grant status, age), residence hall, and meal plan, were included in the model to determine if certain students were more likely to use a meal together. To determine the extent of joint meal plan usage over time, a term for month was included in the models. To determine if joint meal plan usage was higher at certain times of day, or days of the week, terms for day of week and time of day a student used their meal plan were included in the model. To account for repeated measures by students, a clustering effect by student was included in the model.

Floormate simulation analysis

The same analyses, but using floormates rather than roommates, was conducted to help determine if the results were due to a residence effect or a roommate effect. Given the number of different floormate combinations possible, analyses were conducted for 250 different floormate randomizations. The distribution of the model parameters of interest were used to determine the confidence interval and level of significance. Statistical significance was determined at $p<0.01$ due to the large sample size and number of tests. All analyses were conducted using the statistical software R (version 3.5.2).

4.4. Results

Descriptives

A total of 1942 students (71.5% of the students provided by the university) had complete demographic information, had a known and standard meal plan, and stayed in the same room for both semesters. Atypical first year students were excluded from the analyses: 26 students over 20 years old, and 5 students less than 17 years old, were excluded resulting in a sample size of 1911. An additional 37 students were excluded due to high meal plan use (>289 meals in either semester), and 129 students were excluded due to low meal plan use (zero meals used over one of the first four months of either semester). The remaining 1745 students resulted in an analytical sample of 559 students who did not have a roommate who met the inclusion criteria, and 1186 students who had a roommate who also met the inclusion criteria.

The demographics for the 1911 students with low, typical, and high meal plan use are shown in Table 4-1. Students with low meal plan use tended to purchase the cheapest meal plan (43% Fall, 57% Spring). Students with high meal plan use

tended to be male (95%) and to purchase the unlimited meal plan (97%, 100%; Fall, Spring). The total number of meals used in each semester for students with low, usual, and high meal plan use is shown in Figure 4-1. The average number of meals used per semester was 109 (sd = 60). Some students rarely used their meal plan, especially in the Spring semester: 2.2% of females and 1.2% of males used less than five meals over the entire Spring semester.

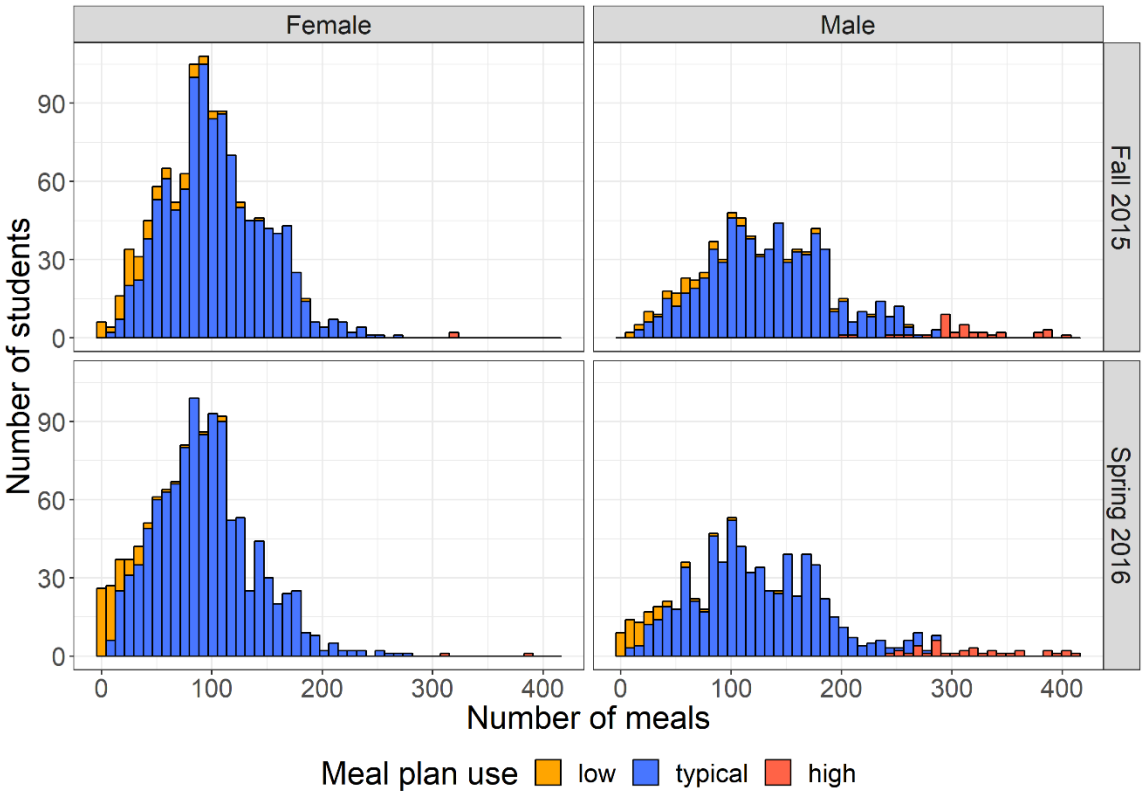
Roommates were significantly more likely than floormates to be the same race/ethnicity (45% vs 32%; $p<0.001$), to have the same Pell grant status (62% vs 57%; $p<0.001$), and to be on the same meal plan in Fall (37% vs 28%; $p<0.001$) and in Spring (37% vs 31%; $p<0.001$).

Table 4-1: Extent Students Aged 17-20 Years With Complete Demographics, Known And Standard Meal Plan, And One Residence (n=1911) Used Their Meal Plan By Key Demographics.

Meal plan use	Low[C]	Typical	High[D]
n	129	1745	37
Sex, n (%)			
Female	81 (62.8)	1090 (62.5)	2 (5.4)
Male	48 (37.2)	655 (37.5)	35 (94.6)
Race/Ethnicity, n (%)			
White	57 (44.2)	875 (50.1)	23 (62.2)
Black/African American	13 (10.1)	141 (8.1)	1 (2.7)
Hispanic/Latino	32 (24.8)	380 (21.8)	8 (21.6)
International	8 (6.2)	110 (6.3)	1 (2.7)
Two or more races	10 (7.8)	116 (6.6)	1 (2.7)
Other	9 (7.0)	123 (7.0)	3 (8.1)
Pell grant recipient, n (%)			
No	81 (62.8)	1186 (68.0)	26 (70.3)
Yes	48 (37.2)	559 (32.0)	11 (29.7)
Age (mean (sd))	18.4 (0.4)	18.4 (0.4)	18.5 (0.4)
Fall Meal plan, n (%)[A]			
8 meals/week	56 (43.4)	473 (27.1)	0 (0.0)
180 meals/semester[E]	23 (17.8)	345 (19.8)	0 (0.0)
14 meals/week	31 (24.0)	604 (34.6)	1 (2.7)
Unlimited meals	19 (14.7)	323 (18.5)	36 (97.3)
Spring Meal plan, n (%)[B]			
8 meals/week	73 (56.6)	658 (37.7)	0 (0.0)
180 meals/semester[E]	16 (12.4)	364 (20.9)	0 (0.0)
14 meals/week	26 (20.2)	503 (28.8)	0 (0.0)
Unlimited meals	14 (10.9)	220 (12.6)	37 (100.0)

[A] A significant difference between students with low and typical meal plan use by meal plan was found in Fall (p=0.001)
[B] A significant difference between students with low and typical meal plan use by meal plan was found in Spring (p<0.001)
[C] Students were classified as having low meal plan use if they did not use their meal plan for an entire month.
[D] Students were classified as having high meal plan use if they used their meal plan more than 289 (mean + 3 SD) times in either semester.
[E] 180 meals/semester equates to approximately 11 meals per week with consistent use

Figure 4-1: Number Of Meals Students Aged 17-20 Years With Complete Demographics, Known And Standard Meal Plan, And Only One Residence (n=1911) Used By Sex And Semester.



Students were classified as having low meal plan use if they did not use their meal plan for an entire month. Students were classified as having high meal plan use if they used their meal plan more than 289 (mean + 3 SD) meals in either semester

Meal plan purchased

Of the 1186 students with a roommate also included in the analyses, 63% were female, 51% were White, and 31% were Pell grant recipients (Table 4-2). Bivariate analyses indicated that the students who purchased the cheaper meal plans tended to be female, Hispanic/Latino or International, and Pell grant recipients. In the Fall semester, the majority of students (418/1186=35%) purchased the second most expensive, 14 meals/week, meal plan. In the Spring semester, the most commonly purchased meal plan was the cheapest, 8 meals/week, meal plan (438/1186=37%).

Table 4-2: Key Demographics For The 1186 Students (593 Roommates) By Meal Plan Type And Academic Semester.

		Fall 2015					Spring 2016				
meal plan	Total	8 meals/ week	180 meals/ semester[A]	14 meals/ week	Unlimited meals	p. value	8 meals/ week	180 meals/ semester[A]	14 meals/ week	Unlimited meals	p. value
	1186	318	227	418	223		438	245	351	152	
Sex (%)											
Female	752 (63.4)	232 (73.0)	167 (73.6)	259 (62.0)	94 (42.2)	**<0.001**	327 (74.7)	176 (71.8)	200 (57.0)	49 (32.2)	**<0.001**
Male	434 (36.6)	86 (27.0)	60 (26.4)	159 (38.0)	129 (57.8)		111 (25.3)	69 (28.2)	151 (43.0)	103 (67.8)	
Race/Ethnicity (%)											
White	603 (50.8)	124 (39.0)	116 (51.1)	243 (58.1)	120 (53.8)	**<0.001**	181 (41.3)	126 (51.4)	211 (60.1)	85 (55.9)	**<0.001**
Black/African American	92 (7.8)	22 (6.9)	15 (6.6)	39 (9.3)	16 (7.2)		28 (6.4)	20 (8.2)	35 (10.0)	9 (5.9)	
Hispanic/Latino	265 (22.3)	96 (30.2)	47 (20.7)	83 (19.9)	39 (17.5)		124 (28.3)	49 (20.0)	64 (18.2)	28 (18.4)	
International	69 (5.8)	34 (10.7)	14 (6.2)	11 (2.6)	10 (4.5)		47 (10.7)	10 (4.1)	7 (2.0)	5 (3.3)	
Two or more races	78 (6.6)	16 (5.0)	20 (8.8)	22 (5.3)	20 (9.0)		26 (5.9)	18 (7.3)	21 (6.0)	13 (8.6)	
Other	79 (6.7)	26 (8.2)	15 (6.6)	20 (4.8)	18 (8.1)		32 (7.3)	22 (9.0)	13 (3.7)	12 (7.9)	
Pell Grant recipient (%)											
No	819 (69.1)	195 (61.3)	159 (70.0)	304 (72.7)	161 (72.2)	**0.005**	280 (63.9)	168 (68.6)	254 (72.4)	117 (77.0)	0.009
Yes	367 (30.9)	123 (38.7)	68 (30.0)	114 (27.3)	62 (27.8)		158 (36.1)	77 (31.4)	97 (27.6)	35 (23.0)	
Age (mean (sd))	18.39 (0.40)	18.40 (0.43)	18.37 (0.39)	18.38 (0.39)	18.44 (0.41)	0.224	18.40 (0.42)	18.38 (0.37)	18.36 (0.40)	18.46 (0.42)	0.108
Dorm (%)											
A	494 (41.7)	134 (42.1)	102 (44.9)	179 (42.8)	79 (35.4)	**0.001**	185 (42.2)	107 (43.7)	144 (41.0)	58 (38.2)	**0.002**
B	62 (5.2)	14 (4.4)	10 (4.4)	18 (4.3)	20 (9.0)		24 (5.5)	10 (4.1)	17 (4.8)	11 (7.2)	
C	356 (30.0)	84 (26.4)	63 (27.8)	139 (33.3)	70 (31.4)		111 (25.3)	79 (32.2)	120 (34.2)	46 (30.3)	
D	52 (4.4)	27 (8.5)	8 (3.5)	13 (3.1)	4 (1.8)		33 (7.5)	4 (1.6)	11 (3.1)	4 (2.6)	
E	130 (11.0)	40 (12.6)	23 (10.1)	35 (8.4)	32 (14.3)		60 (13.7)	22 (9.0)	29 (8.3)	19 (12.5)	
F	92 (7.8)	19 (6.0)	21 (9.3)	34 (8.1)	18 (8.1)		25 (5.7)	23 (9.4)	30 (8.5)	14 (9.2)	
% meals at same time and location as roommate	0.18 (0.20)	0.24 (0.25)	0.21 (0.21)	0.20 (0.21)	0.18 (0.19)	0.028	0.16 (0.22)	0.13 (0.17)	0.13 (0.19)	0.11 (0.16)	0.095

[A] 180 meals/semester equates to approximately 11 meals per week with consistent use

Student demographics remained significant predictors of meal plan purchased in the adjusted models examining which meal plan a student purchased. For females, the demographic purchasing the cheapest (8 meals/week) meal plan were International (OR=3.46, p=0.002) students, and Pell grant recipients (OR=1.54, p=0.009; Table 4-3). For males, the demographics purchasing the cheapest meal plan were Hispanic/Latino (OR=2.57, p=0.004) and International (OR=6.06, p<0.001) students. Students were also more likely to purchase the cheapest (8 meals/week) meal plan in Spring than in Fall (Female: OR=1.60, 99% CI=1.35, 1.89; Male: OR=1.41, 99% CI=1.15, 1.74), and less likely to purchase the most expensive (unlimited) meal plan in Spring (Female: OR=0.53, 99% CI=0.39, 0.73; Male: OR=0.75, 99% CI=0.62, 0.90). For females, the meal plan a student purchased was associated with the meal plan their roommate purchased; no association was found between the meal a male student purchased and their roommates' purchase. If the (female) students' roommate purchased the cheapest meal plan, compared to the most expensive meal plan, the student was also likely on the cheapest meal plan (OR=3.04, 99% CI=1.49, 6.21), and unlikely to have purchased the most expensive meal plan (OR=0.31, 99% CI=0.13, 0.73).

Table 4-3: Results Of Logistic Generalized Estimating Equation (GEE) Examining The Meal Plan Students' Purchased (Females: n=752 students, 1504 data points; Males: 434=students, 868 data points).

	8 meals/week			180 meals/semester[A]			14 meals/week			Unlimited meals		
Female	OR	99% CI	p	OR	99% CI	p	OR	99% CI	p	OR	99% CI	p
Race/ethnicity												
White												
Black/African American	0.64	(0.29, 1.45)	0.162	1.12	(0.48, 2.60)	0.729	1.41	(0.66, 2.98)	0.242	0.94	(0.29, 3.05)	0.897
Hispanic/Latino	1.48	(0.92, 2.40)	0.035	0.82	(0.48, 1.41)	0.358	0.83	(0.50, 1.36)	0.328	0.81	(0.36, 1.80)	0.495
International	3.46	(1.23, 9.70)	**0.002**	1.02	(0.37, 2.85)	0.959	0.28	(0.06, 1.27)	0.030	0.39	(0.07, 2.16)	0.155
Two or more races	1.14	(0.50, 2.56)	0.688	1.20	(0.52, 2.79)	0.569	0.66	(0.28, 1.51)	0.194	1.38	(0.40, 4.80)	0.508
Other	1.70	(0.72, 4.03)	0.114	0.89	(0.36, 2.18)	0.735	0.50	(0.20, 1.24)	0.050	1.43	(0.44, 4.6)	0.433
Same race/ethnicity	1.05	(0.70, 1.59)	0.739	1.01	(0.65, 1.57)	0.937	0.97	(0.64, 1.46)	0.840	0.89	(0.47, 1.72)	0.657
Pell grant recipient												
No												
Yes	1.54	(1.00, 2.37)	**0.009**	0.81	(0.51, 1.30)	0.259	0.74	(0.47, 1.16)	0.084	1.04	(0.52, 2.05)	0.897
Same Pell grant recipient	0.85	(0.57, 1.28)	0.317	1.12	(0.72, 1.73)	0.511	1.10	(0.72, 1.67)	0.554	0.96	(0.51, 1.82)	0.873
Age	1.21	(0.72, 2.01)	0.345	0.94	(0.55, 1.61)	0.762	0.70	(0.41, 1.20)	0.089	1.58	(0.75, 3.32)	0.112
Residence Hall												
A												
B	0.73	(0.27, 1.99)	0.417	0.89	(0.28, 2.85)	0.801	0.82	(0.32, 2.14)	0.600	2.91	(1.00, 8.45)	**0.010**
C	0.81	(0.51, 1.29)	0.246	1.25	(0.79, 1.96)	0.213	1.12	(0.71, 1.77)	0.511	0.72	(0.33, 1.60)	0.295
D	1.57	(0.59, 4.19)	0.232	0.58	(0.19, 1.76)	0.210	0.72	(0.22, 2.30)	0.461	1.32	(0.23, 7.75)	0.683
E	1.01	(0.52, 1.99)	0.957	0.66	(0.30, 1.47)	0.184	0.87	(0.42, 1.83)	0.636	2.16	(0.81, 5.74)	0.042
F	0.53	(0.24, 1.16)	0.038	1.47	(0.66, 3.29)	0.216	1.13	(0.52, 2.46)	0.695	1.38	(0.44, 4.36)	0.466
Semester												
Fall 2015												
Spring 2016	1.60	(1.35, 1.89)	**<0.001**	1.09	(0.87, 1.38)	0.315	0.73	(0.61, 0.87)	**<0.001**	0.53	(0.39, 0.73)	**<0.001**
Roommate meal plan												
Unlimited												
8 meals/week	3.04	(1.49, 6.21)	**<0.001**	0.95	(0.43, 2.06)	0.854	0.60	(0.30, 1.18)	0.050	0.31	(0.13, 0.73)	**<0.001**

180 meals/semester	1.28	(0.62, 2.63)	0.387	1.60	(0.74, 3.43)	0.116	0.93	(0.47, 1.85)	0.798	0.41	(0.16, 1.05)	0.014
14 meals/week	1.21	(0.59, 2.47)	0.487	1.31	(0.62, 2.77)	0.354	1.05	(0.54, 2.05)	0.857	0.54	(0.23, 1.27)	0.062
	8 meals/week			180 meals/semester[A]			14 meals/week			Unlimited meals		
Male	OR	99% CI	p	OR	99% CI	p	OR	99% CI	p	OR	99% CI	p
Race/ethnicity												
White												
Black/African American	2.06	(0.66, 6.38)	0.100	0.91	(0.23, 3.61)	0.859	0.94	(0.36, 2.43)	0.859	0.64	(0.20, 2.04)	0.322
Hispanic/Latino	2.57	(1.09, 6.05)	**0.004**	1.22	(0.49, 3.02)	0.569	0.50	(0.23, 1.06)	0.018	0.89	(0.37, 2.11)	0.725
International	6.06	(2.13, 17.27)	**<0.001**	1.79	(0.45, 7.16)	0.282	0.21	(0.07, 0.64)	**<0.001**	0.49	(0.16, 1.48)	0.095
Two or more races	1.05	(0.26, 4.28)	0.936	1.44	(0.39, 5.40)	0.472	0.53	(0.16, 1.73)	0.167	1.60	(0.53, 4.78)	0.272
Other	2.02	(0.59, 6.87)	0.141	2.23	(0.77, 6.50)	0.053	0.34	(0.11, 1.07)	0.016	1.01	(0.32, 3.19)	0.988
Same race/ethnicity	0.80	(0.39, 1.64)	0.418	1.13	(0.56, 2.30)	0.653	0.92	(0.51, 1.65)	0.708	1.17	(0.62, 2.19)	0.530
Pell grant recipient												
No												
Yes	1.40	(0.67, 2.94)	0.237	1.53	(0.70, 3.35)	0.163	0.96	(0.5, 1.87)	0.889	0.58	(0.27, 1.23)	0.062
Same Pell grant recipient	1.10	(0.54, 2.23)	0.722	0.86	(0.40, 1.85)	0.622	1.17	(0.63, 2.15)	0.515	0.84	(0.43, 1.62)	0.487
Age	1.09	(0.50, 2.35)	0.777	1.03	(0.47, 2.28)	0.921	0.89	(0.46, 1.73)	0.645	1.04	(0.51, 2.13)	0.891
Residence Hall												
A												
B	1.45	(0.42, 5.03)	0.440	0.51	(0.11, 2.24)	0.239	0.98	(0.31, 3.13)	0.969	1.15	(0.36, 3.74)	0.756
C	0.96	(0.43, 2.15)	0.885	0.50	(0.22, 1.15)	0.032	1.34	(0.71, 2.52)	0.232	1.15	(0.59, 2.24)	0.594
D	3.31	(0.77, 14.28)	0.035	0.34	(0.05, 2.37)	0.154	1.23	(0.27, 5.69)	0.728	0.20	(0.01, 2.97)	0.124
E	1.54	(0.58, 4.04)	0.253	1.03	(0.38, 2.80)	0.946	0.74	(0.31, 1.73)	0.356	0.89	(0.35, 2.23)	0.743
F	1.07	(0.30, 3.86)	0.892	0.73	(0.20, 2.70)	0.539	1.28	(0.47, 3.52)	0.523	0.89	(0.28, 2.81)	0.798
Semester												
Fall 2015												
Spring 2016	1.41	(1.15, 1.74)	**<0.001**	1.20	(0.89, 1.61)	0.110	0.91	(0.77, 1.07)	0.130	0.75	(0.62, 0.90)	**<0.001**
Roommate meal plan												
Unlimited												
8 meals/week	1.54	(0.67, 3.51)	0.178	0.92	(0.31, 2.7)	0.836	1.08	(0.51, 2.27)	0.793	0.64	(0.29, 1.41)	0.146
180 meals/semester	0.88	(0.31, 2.53)	0.754	1.14	(0.45, 2.87)	0.721	1.65	(0.76, 3.59)	0.096	0.60	(0.27, 1.36)	0.108
14 meals/week	0.91	(0.42, 1.96)	0.752	1.58	(0.73, 3.42)	0.126	1.17	(0.62, 2.19)	0.525	0.69	(0.37, 1.30)	0.134

[A] 180 meals/semester equates to approximately 11 meals per week with consistent use

Extent meal plan used

Students on more expensive meal plans used more meals than students on cheaper meal plans. Students on the cheapest meal plan used around 75 less meals per semester than students on the most expensive meal plan (Female: β= -76.28, 99% CI=-88.94, -63.61; Male: β=-79.49, 99% CI=-93.07, -65.91; Table 4-4). For females, students whose roommate was on the same meal used an additional eight meals per semester on average (β=7.71, 99% CI=2.57, 12.86); no association was found for males having the same meal plan as their roommate and meal plan use (β=4.02, 99% CI=-5.29, 13.33). There was no association with meal plan use and roommates being the same race/ethnicity (Female: β=-2.32, 99% CI=-8.31, 3.67; Male: β=-5.90, 99% CI=-16.70, 4.90) or having the same Pell grant status (Female: β=0.74, 99% CI=-6.81, 5.33; Male: β=7.45, 99% CI=-3.82, 18.72). The number of meals students' roommate used was associated with the number of meals students used. For every meal a students' roommate used, the student was predicted to use around an additional 0.2 meals over one semester (Female: β=0.23, 99% CI=0.16, 0.31; Male: β=0.18, 99% CI=0.09, 0.28). This means that compared to students' whose roommates used 50 meals over the semester, students' whose roommates used 150 meals were anticipated to use around an additional 20 meals over the semester; more than one additional meal per week.

The number of meals the students used in the Spring semester remained significantly associated with the number of meals their roommate used in the Spring semester (Female: β=0.07, 99% CI=0.00, 0.13; Male: β=0.10, 99% CI=0.02, 0.18), even after accounting for the number of meals the student had used in the Fall semester (Table 4-5). As such, even after accounting for the number of meals students used in the Fall semester, students' whose roommates used 150 meals would be anticipated to use around an additional 9 meals

over the Spring semester than students' whose roommates used only 50 meals; approximately ½ an additional meal per week.

Table 4-4: Number Of Meals Used By First-Year Students, Adjusted For Roommate Meal Plan Use (Females: n=752 students, 1504 data points; Males: 434=students, 868 data points).

	Female			Male		
	B	99% CI	p. value	β	99% CI	p. value
Race/ethnicity						
White						
Black/African American	4.96	(-7.10, 17.03)	0.289	-16.03	(-34.09, 2.04)	0.022
Hispanic/Latino	-4.29	(-11.73, 3.15)	0.137	-8.10	(-21.82, 5.62)	0.129
International	15.40	(2.21, 28.58)	**0.003**	1.95	(-13.84, 17.73)	0.751
Two or more races	3.81	(-7.71, 15.34)	0.394	-6.16	(-31.94, 19.63)	0.539
Other	-4.63	(-18.18, 8.91)	0.378	4.17	(-9.83, 18.17)	0.443
Same race/ethnicity	-2.32	(-8.31, 3.67)	0.318	-5.90	(-16.70, 4.90)	0.160
Pell grant recipient						
No						
Yes	3.81	(-2.73, 10.35)	0.133	4.41	(-7.40, 16.22)	0.336
Same Pell grant status	-0.74	(-6.81, 5.33)	0.755	7.45	(-3.82, 18.72)	0.089
Age	-0.79	(-7.62, 6.04)	0.765	-6.12	(-17.72, 5.47)	0.174
Residence Hall						
A						
B	-13.87	(-28.78, 1.03)	0.017	2.52	(-18.34, 23.37)	0.756
C	-15.50	(-22.97, -8.04)	**<0.001**	-13.93	(-26.30, -1.57)	**0.004**
D	-20.25	(-31.82, -8.67)	**<0.001**	-24.11	(-41.56, -6.67)	**<0.001**
E	-18.80	(-29.72, -7.88)	**<0.001**	-14.32	(-29.75, 1.10)	0.017
F	-24.28	(-36.84, -11.72)	**<0.001**	-18.15	(-35.27, -1.04)	**0.006**
Semester						
Fall 2015						
Spring 2016	-0.89	(-3.66, 1.87)	0.405	-3.94	(-8.22, 0.34)	0.018
Student meal plan						
Unlimited meals						
8 meals/week	-76.28	(-88.94, -63.61)	**<0.001**	-79.49	(-93.07, -65.91)	**<0.001**
180 meals/semester[A]	-49.08	(-61.89, -36.28)	**<0.001**	-48.22	(-64.27, -32.17)	**<0.001**
14 meals/week	-41.05	(-54.03, -28.08)	**<0.001**	-35.93	(-50.06, -21.80)	**<0.001**
Same meal plan	7.71	(2.57, 12.86)	**<0.001**	4.02	(-5.29, 13.33)	0.266
Number meals roommate used	0.23	(0.16, 0.31)	**<0.001**	0.18	(0.09, 0.28)	**<0.001**

[A] 180 meals/semester equates to approximately 11 meals per week with consistent use

Table 4-5: Number Meals Used In The Spring Semester By First-Year Students, Adjusted For Fall Semester Use And Roommate Use In The Spring Semester (Females: n=752 students, 1504 data points; Males: 434=students, 868 data points).

	Female n=752			Male n=434		
	β	99% CI	p. value	β	99% CI	p. value
Race/ethnicity						
White	(ref)					
Black/African American	5.87	(-3.70, 15.44)	0.114	-1.87	(-18.35, 14.60)	0.770
Hispanic/Latino	-1.98	(-8.39, 4.42)	0.425	4.45	(-6.72, 15.62)	0.305
International	2.40	(-10.46, 15.26)	0.631	-18.11	(-34.43, -1.79)	**0.004**
Two or more races	5.19	(-6.57, 16.96)	0.256	-12.08	(-34.40, 10.24)	0.163
Other	1.67	(-8.38, 11.72)	0.669	-6.14	(-24.63, 12.36)	0.393
Same race/ethnicity	0.02	(-5.12, 5.16)	0.992	1.89	(-6.97, 10.76)	0.582
Pell grant recipient						
No	(ref)					
Yes	2.54	(-3.24, 8.32)	0.257	0.00	(-11.53, 11.53)	1.000
Same Pell grant status	2.20	(-3.02, 7.43)	0.278	2.64	(-7.08, 12.35)	0.484
Age	0.33	(-5.83, 6.49)	0.890	-3.25	(-12.72, 6.22)	0.376
Residence Hall						
A	(ref)					
B	-11.58	(-26.09, 2.93)	0.040	3.72	(-14.19, 21.64)	0.592
C	-5.96	(-11.90, -0.03)	**0.010**	-7.20	(-17.55, 3.16)	0.073
D	-11.21	(-21.26, -1.15)	**0.004**	-0.17	(-18.18, 17.84)	0.981
E	-2.83	(-12.27, 6.61)	0.440	6.10	(-6.89, 19.09)	0.227
F	-5.42	(-15.55, 4.71)	0.168	-4.28	(-25.19, 16.63)	0.598
Student meal plan (Spring)						
Unlimited meals	(ref)					
8 meals/week	-29.31	(-46.22, -12.41)	**<0.001**	-16.67	(-33.77, 0.43)	0.012
180 meals/semester[A]	-12.73	(-29.21, 3.76)	0.047	-9.84	(-27.43, 7.74)	0.149
14 meals/week	-17.42	(-33.76, -1.08)	**0.006**	-1.74	(-14.48, 11.00)	0.725
Same meal plan	4.62	(-0.45, 9.69)	0.019	2.50	(-6.06, 11.06)	0.453
Student Number meals used (Fall)	0.63	(0.55, 0.71)	**<0.001**	0.68	(0.55, 0.80)	**<0.001**
Roommate Number meals used (Spring)	0.07	(0.00, 0.13)	**0.006**	0.10	(0.02, 0.18)	**0.001**

[A] 180 meals/semester equates to approximately 11 meals per week with consistent use

Meal plan joint usage

The proportion of meals that a student used at the same time and location as their roommate was 21% in Fall and 14% in Spring (Table 4-2). Figure 4-2 shows the proportion of meals students used with their roommate for each month. Females used a higher proportion of their meals with their roommate, and the proportion of meals used with a roommate was higher at the start of the academic year. Logistic regression indicated students were more likely to use a meal at the same time and location as their roommate if both the student and the roommate were on the same meal plan (Female: OR=1.61, 99% CI=1.27, 2.04; Male: OR=1.57, 99% CI=1.09, 2.25; Table 4-6). Female students were more likely to have joint meal plan usage with their roommate if the student and the roommate were the same race/ethnicity (OR=1.76, 99% CI=1.33, 2.32), and less likely to use a meal at the same time and location as their roommate if the student was Black/African American (OR=0.44, 99% CI=0.28, 0.70). Students were most likely to use a meal with their roommate in August (the start of the academic year). Compared to August, students used less meals with their roommate in September (Female: OR=0.57, 99% CI=0.52, 0.63; Male: OR=0.50, 99% CI=0.44, 0.57); with the least number of meals used with a roommate occurring in in April (the end of the academic year; Female: OR=0.25, 99% CI=0.21, 0.31; Male: OR=0.22, 99% CI=0.17, 0.29). Students were more likely to use a meal with their roommate during weekends (Female: OR=1.17, 99% CI=1.08, 1.26; male: OR=1.28, 99% CI=1.16, 1.41), and during midday (Female: OR=1.33, 99% CI=1.15, 1.55; Male: OR=1.31, 99% CI=1.04, 1.64), afternoon (Female: OR=1.24, 99% CI = 1.06, 1.47; Male: OR=1.44, 99% CI=1.15, 1.81), and evening (Female: OR=1.53, 99% CI=1.32, 1.78; Male: OR=1.88, 99% CI=1.49, 2.37) time periods than during weekdays and during the morning.

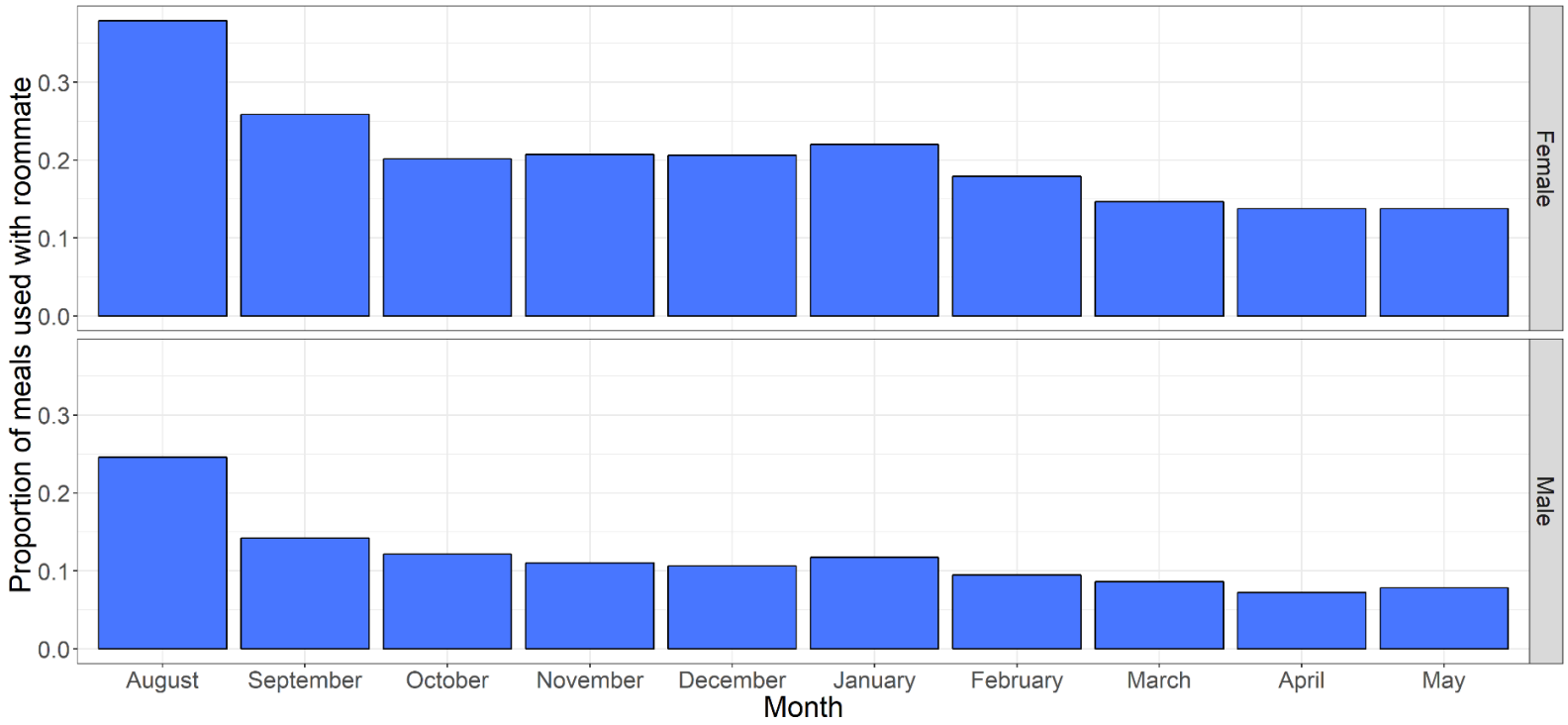
Table 4-6: Logistic Regression Predicting Which Meals Students Would Use Within One Minute And At The Same Location As Their Roommate (Females: n=752 students, 153,370 data points; Males: 434=students, 112,873 data points).

	Female			Male		
	OR	99% CI	p. value	OR	99% CI	p. value
Race/ethnicity						
White	(ref)					
Black/African American	0.44	(0.28, 0.70)	<**0.001**	0.83	(0.48, 1.46)	0.408
Hispanic/Latino	0.76	(0.54, 1.09)	0.051	1.27	(0.75, 2.13)	0.239
International	0.78	(0.46, 1.32)	0.228	0.66	(0.33, 1.31)	0.121
Two or more races	1.13	(0.66, 1.92)	0.564	0.92	(0.39, 2.19)	0.806
Other	1.27	(0.75, 2.16)	0.243	1.46	(0.65, 3.29)	0.225
Same race/ethnicity	1.76	(1.33, 2.32)	<**0.001**	1.41	(0.96, 2.06)	0.020
Pell grant recipient						
No	(ref)					
Yes	0.96	(0.72, 1.28)	0.722	0.96	(0.62, 1.47)	0.799
Same Pell grant status	1.08	(0.82, 1.42)	0.496	1.14	(0.77, 1.67)	0.398
Age	0.89	(0.65, 1.22)	0.339	1.15	(0.72, 1.81)	0.446
Residence Hall						
A	(ref)					
B	1.11	(0.59, 2.11)	0.663	1.51	(0.83, 2.73)	0.075
C	1.02	(0.77, 1.36)	0.824	1.16	(0.78, 1.74)	0.333
D	1.06	(0.59, 1.90)	0.807	2.13	(0.76, 5.97)	0.058
E	0.99	(0.61, 1.61)	0.965	1.41	(0.79, 2.54)	0.126
F	0.69	(0.40, 1.18)	0.073	0.54	(0.24, 1.19)	0.045
Student meal plan						
Unlimited meals	(ref)					
8 meals/week	0.90	(0.60, 1.35)	0.494	1.64	(0.96, 2.80)	0.018
180 meals/semester[A]	0.87	(0.58, 1.31)	0.394	1.12	(0.62, 2.03)	0.615
14 meals/week	0.87	(0.60, 1.28)	0.366	0.96	(0.65, 1.41)	0.775
Same meal plan	1.61	(1.27, 2.04)	<**0.001**	1.57	(1.09, 2.25)	**0.001**
Month						
August	(ref)					
September	0.57	(0.52, 0.63)	<**0.001**	0.50	(0.44, 0.57)	<**0.001**
October	0.41	(0.36, 0.46)	<**0.001**	0.41	(0.35, 0.49)	<**0.001**
November	0.42	(0.37, 0.48)	<**0.001**	0.36	(0.30, 0.43)	<**0.001**

December	0.43	(0.37, 0.5)	**<0.001**	0.35	(0.28, 0.44)	**<0.001**
January	0.46	(0.39, 0.53)	**<0.001**	0.38	(0.31, 0.47)	**<0.001**
February	0.36	(0.30, 0.42)	**<0.001**	0.30	(0.24, 0.38)	**<0.001**
March	0.28	(0.23, 0.33)	**<0.001**	0.27	(0.22, 0.34)	**<0.001**
April	0.25	(0.21, 0.31)	**<0.001**	0.22	(0.17, 0.29)	**<0.001**
May	0.26	(0.20, 0.33)	**<0.001**	0.25	(0.18, 0.35)	**<0.001**
Day of week						
Weekday	(ref)					
Weekend	1.17	(1.08, 1.26)	**<0.001**	1.28	(1.16, 1.41)	**<0.001**
Time of Day						
Morning (before 10 AM)	(ref)					
Midday (10 AM to 1 PM)	1.33	(1.15, 1.55)	**<0.001**	1.31	(1.04, 1.64)	**0.003**
Afternoon (1 PM to 4 PM)	1.24	(1.06, 1.47)	**0.001**	1.44	(1.15, 1.81)	**<0.001**
Evening (after 4 PM)	1.53	(1.32, 1.78)	**<0.001**	1.88	(1.49, 2.37)	**<0.001**

[A] 180 meals/semester equates to approximately 11 meals per week with consistent use

Figure 4-2: Proportion Of Meals Used At Same Time (Within One Minute) And Location As Roommate, By Sex And Month (n=1186 students; 266,243 data points)



Floormate simulation analysis

When floormates, rather than roommates were examined in simulation models, there was no association between the students' meal plan and their residence mates meal plan (Table 4-7). For both males and females, international students remained likely to purchase the cheapest meal plan ($p<0.001$) and the cheapest meal plan was more likely to be purchased in the Spring semester than the Fall semester ($p<0.001$).

There was no association between the number of meals a student used and the number of meals their floormate used (Female: $\beta=0.01$, 99% CI=-0.08, 0.10; Male: $\beta=0.01$, 99% CI=-0.09, 0.10; Table 4-8). Consistent with the roommate analyses examining meal plan use, female international students used more meals than White female students did ($\beta=9.18$, 99% CI=2.28, 16.08), and students with cheaper meal plans used less meals than students on the unlimited meal plan ($p<0.001$).

The proportion of meals that a student used at the same time and location as their floormate mate was 1.22% in Fall and 0.93% in Spring. Logistic regression indicated that floormates on the same meal plan, and floormates of the same race/ethnicity or with the same Pell grant status were no more likely to have joint meal plan usage than other floormates (Table 4-9). Similarly, no association with student demographics, or student meal plan and joint meal plan use was found. The extent of joint meal plan use among floormates did not significantly change after the first month of being floormates, or by day of week. However, for males, floormates were more likely to have joint meal plan use at midday (OR=1.75, 99% CI=1.05, 2.92) and in the evening (OR=1.89, 99% CI=1.15, 3.11) than in the morning.

Table 4-7: Results Of Logistic Generalized Estimating Equation (GEE) Examining The Meal Plan Students' And Their Floormates Purchased (Females: n=676 students, 1352 data points; Males: 442=students, 884 data points).

	8 meals/week			180 meals/semester[A]			14 meals/week			Unlimited meals		
Female	OR	99% CI	p	OR	99% CI	p	OR	99%	p	OR	99%	p
Race/ethnicity												
White												
Black/African American	0.79	(0.54, 1.16)	0.118	1.02	(0.65, 1.59)	0.921	0.98	(0.66, 1.45)	0.875	1.85	(1.04, 3.28)	0.006
Hispanic/Latino	1.26	(0.95, 1.67)	0.032	0.80	(0.59, 1.08)	0.057	0.89	(0.68, 1.16)	0.244	1.12	(0.74, 1.72)	0.475
International	3.26	(1.91, 5.57)	<**0.001**	1.15	(0.74, 1.81)	0.415	0.22	(0.09, 0.55)	<**0.001**	0.37	(0.13, 1.07)	0.016
Two or more races	1.17	(0.80, 1.72)	0.295	1.25	(0.81, 1.95)	0.187	0.64	(0.39, 1.03)	0.017	1.14	(0.54, 2.43)	0.652
Other	2.22	(1.55, 3.18)	<**0.001**	0.59	(0.4, 0.87)	<**0.001**	0.58	(0.40, 0.84)	<**0.001**	1.01	(0.48, 2.12)	0.984
Same race/ethnicity	0.92	(0.59, 1.42)	0.609	1.09	(0.68, 1.75)	0.638	0.99	(0.66, 1.50)	0.974	1.05	(0.54, 2.06)	0.854
Pell grant recipient												
No												
Yes	1.31	(1.02, 1.67)	**0.005**	1.24	(0.94, 1.63)	0.047	0.74	(0.58, 0.95)	**0.002**	0.63	(0.43, 0.92)	**0.001**
Same Pell grant recipient	1.01	(0.68, 1.52)	0.938	1.04	(0.65, 1.65)	0.834	0.99	(0.64, 1.54)	0.976	0.92	(0.47, 1.80)	0.754
Age	0.93	(0.73, 1.19)	0.446	1.07	(0.82, 1.39)	0.521	0.82	(0.64, 1.07)	0.055	1.67	(1.12, 2.51)	**0.001**
Residence Hall												
A												
B	1.33	(0.98, 1.82)	0.017	0.47	(0.31, 0.72)	<**0.001**	0.99	(0.71, 1.37)	0.930	1.93	(1.09, 3.40)	**0.003**
C	1.16	(0.90, 1.49)	0.144	0.91	(0.69, 1.19)	0.359	0.95	(0.74, 1.22)	0.611	0.96	(0.61, 1.51)	0.821
D	3.00	(1.89, 4.79)	<**0.001**	0.41	(0.25, 0.70)	<**0.001**	0.56	(0.33, 0.95)	0.005	0.66	(0.20, 2.15)	0.363
E	1.05	(0.82, 1.34)	0.600	0.60	(0.47, 0.76)	<**0.001**	0.94	(0.75, 1.20)	0.536	2.61	(1.71, 3.99)	<**0.001**
F	1.18	(0.85, 1.65)	0.191	0.97	(0.66, 1.44)	0.853	0.64	(0.40, 1.03)	0.015	1.76	(0.96, 3.25)	0.016
Semester												
Fall 2015												
Spring 2016	1.82	(1.61, 2.06)	<**0.001**	1.06	(0.93, 1.20)	0.269	0.68	(0.61, 0.77)	<**0.001**	0.43	(0.35, 0.52)	<**0.001**
Roommate meal plan												
Unlimited												
8 meals/week	0.94	(0.42, 2.14)	0.857	1.06	(0.52, 2.17)	0.837	0.94	(0.45, 1.97)	0.839	1.59	(0.00, 543.43)	0.837
180 meals/semester	1.02	(0.48, 2.16)	0.948	1.03	(0.45, 2.34)	0.920	0.89	(0.43, 1.86)	0.690	1.51	(0.00, 536.64)	0.856
14 meals/week	1.00	(0.50, 2.00)	0.987	1.00	(0.48, 2.08)	0.995	0.90	(0.40, 2.02)	0.740	1.67	(0.01, 558.2)	0.819

	8 meals/week			180 meals/semester[A]			14 meals/week			Unlimited meals		
Male	OR	99% CI	p	OR	99% CI	p	OR	99%	p	OR	99%	p
Race/ethnicity												
White												
Black/African American	2.22	(1.29, 3.82)	**<0.001**	0.81	(0.43, 1.51)	0.372	1.11	(0.67, 1.83)	0.594	0.53	(0.29, 0.97)	**0.007**
Hispanic/Latino	3.59	(2.49, 5.16)	**<0.001**	1.12	(0.79, 1.60)	0.396	0.55	(0.39, 0.77)	**<0.001**	0.60	(0.39, 0.9)	**0.001**
International	10.35	(6.93, 15.46)	**<0.001**	1.04	(0.68, 1.59)	0.795	0.22	(0.14, 0.34)	**<0.001**	0.27	(0.16, 0.45)	**<0.001**
Two or more races	1.29	(0.70, 2.39)	0.288	0.42	(0.20, 0.88)	0.002	0.92	(0.53, 1.58)	0.677	1.39	(0.83, 2.33)	0.103
Other	2.54	(1.48, 4.37)	**<0.001**	2.48	(1.59, 3.87)	**<0.001**	0.32	(0.18, 0.58)	**<0.001**	0.66	(0.37, 1.18)	0.063
Same race/ethnicity	1.18	(0.61, 2.29)	0.518	1.06	(0.54, 2.07)	0.828	0.86	(0.44, 1.70)	0.569	0.97	(0.53, 1.78)	0.903
Pell grant recipient												
No												
Yes	1.07	(0.72, 1.59)	0.652	1.18	(0.82, 1.71)	0.236	1.01	(0.69, 1.48)	0.971	0.82	(0.54, 1.24)	0.208
Same Pell grant recipient	0.95	(0.53, 1.72)	0.832	1.04	(0.55, 1.95)	0.882	0.97	(0.54, 1.73)	0.898	1.05	(0.54, 2.01)	0.861
Age	1.10	(0.85, 1.42)	0.335	0.73	(0.57, 0.95)	0.002	0.93	(0.72, 1.20)	0.464	1.27	(0.97, 1.66)	0.020
Residence Hall												
A												
B	1.43	(0.92, 2.23)	0.036	0.98	(0.75, 1.29)	0.865	1.08	(0.79, 1.49)	0.515	0.70	(0.46, 1.07)	0.029
C	1.04	(0.72, 1.51)	0.772	0.73	(0.53, 1.00)	**0.010**	1.52	(1.10, 2.08)	**0.001**	0.78	(0.55, 1.09)	0.056
D	1.66	(0.94, 2.95)	0.023	1.31	(0.94, 1.82)	0.038	1.34	(0.83, 2.16)	0.120	0.27	(0.15, 0.46)	**<0.001**
E	1.82	(1.22, 2.70)	**<0.001**	0.62	(0.36, 1.06)	0.021	1.15	(0.77, 1.72)	0.380	0.69	(0.45, 1.05)	0.023
F	1.33	(0.84, 2.11)	0.107	0.90	(0.57, 1.43)	0.555	1.06	(0.66, 1.70)	0.761	0.80	(0.49, 1.31)	0.244
Semester												
Fall 2015												
Spring 2016	1.72	(1.53, 1.94)	**<0.001**	1.08	(0.97, 1.22)	0.071	0.87	(0.80, 0.95)	**<0.001**	0.69	(0.63, 0.76)	**<0.001**
Roommate meal plan												
Unlimited												
8 meals/week	0.88	(0.33, 2.32)	0.738	1.05	(0.46, 2.41)	0.876	0.94	(0.47, 1.85)	0.799	1.13	(0.47, 2.73)	0.713
180 meals/semester	0.99	(0.45, 2.21)	0.986	0.81	(0.25, 2.68)	0.656	1.12	(0.51, 2.46)	0.708	1.00	(0.36, 2.79)	0.998
14 meals/week	0.85	(0.40, 1.81)	0.582	1.09	(0.47, 2.50)	0.798	1.12	(0.47, 2.64)	0.736	0.95	(0.37, 2.44)	0.889

[A] 180 meals/semester equates to approximately 11 meals per week with consistent use

Table 4-8: Number Of Meals Used By First-Year Students, Adjusted For Floormate Meal Plan Use (Females: n=676 students, 1352 data points; Males: 442=students, 884 data points).

	Female			Male		
	β	99% CI	p. value	β	99% CI	p. value
Race/ethnicity						
White						
Black/African American	8.64	(3.06, 14.22)	<**0.001**	-5.90	(-14.70, 2.90)	0.084
Hispanic/Latino	-7.95	(-12.43, -3.46)	<**0.001**	-5.65	(-12.16, 0.87)	0.026
International	9.18	(2.28, 16.08)	**0.001**	-4.02	(-10.35, 2.32)	0.102
Two or more races	-2.53	(-9.19, 4.12)	0.327	-3.49	(-14.61, 7.62)	0.418
Other	-2.29	(-8.11, 3.54)	0.312	12.18	(5.99, 18.37)	<**0.001**
Same race/ethnicity	0.01	(-7.5, 7.51)	0.999	4.61	(-5.99, 15.21)	0.262
Pell grant recipient						
No						
Yes	1.92	(-1.95, 5.79)	0.202	-5.30	(-11.6, 1.01)	0.030
Same Pell grant status	1.09	(-5.23, 7.41)	0.658	-3.21	(-12.76, 6.34)	0.387
Age	3.60	(-0.09, 7.28)	0.012	-1.70	(-6.08, 2.68)	0.316
Residence Hall						
A						
B	-13.26	(-18.79, -7.72)	<**0.001**	1.26	(-5.93, 8.44)	0.653
C	-22.94	(-27.91, -17.97)	<**0.001**	-19.54	(-25.86, -13.22)	<**0.001**
D	-31.89	(-38.5, -25.27)	<**0.001**	-31.62	(-39.36, -23.87)	<**0.001**
E	-23.94	(-28.53, -19.35)	<**0.001**	-18.42	(-25.47, -11.37)	<**0.001**
F	-28.44	(-35.76, -21.13)	<**0.001**	-16.55	(-24.39, -8.71)	<**0.001**
Semester						
Fall 2015						
Spring 2016	-2.61	(-4.26, -0.97)	<**0.001**	-6.88	(-9.03, -4.72)	<**0.001**
Student meal plan						
Unlimited meals						
8 meals/week	-72.91	(-80.1, -65.72)	<**0.001**	-80.15	(-86.11, -74.19)	<**0.001**
180 meals/semester[A]	-44.54	(-52.09, -36.99)	<**0.001**	-47.93	(-54.27, -41.6)	<**0.001**
14 meals/week	-38.19	(-45.56, -30.82)	<**0.001**	-34.88	(-40.96, -28.81)	<**0.001**
Same meal plan	0.35	(-5.81, 6.50)	0.885	-0.59	(-10.86, 9.68)	0.883
Number meals floormate used	0.01	(-0.08, 0.10)	0.726	0.01	(-0.09, 0.10)	0.880

[A] 180 meals/semester equates to approximately 11 meals per week with consistent use

Table 4-9: Logistic Regression Predicting Which Meals Students Would Use Within One Minute And At The Same Location As Their Floormate (Females: n=676 students[A]; Males: 442=students[A]).

	Female			Male		
	OR	99% CI	p. value	OR	99% CI	p. value
Race/ethnicity						
White						
Black/African American	0.81	(0.22, 3.02)	0.686	1.39	(0.43, 4.48)	0.471
Hispanic/Latino	0.86	(0.29, 2.53)	0.719	1.25	(0.50, 3.12)	0.535
International	0.60	(0.15, 2.34)	0.336	2.28	(0.36, 14.49)	0.252
Two or more races	1.09	(0.28, 4.30)	0.869	1.53	(0.37, 6.27)	0.437
Other	1.48	(0.29, 7.61)	0.534	1.01	(0.27, 3.75)	0.988
Same race/ethnicity	1.67	(0.51, 5.45)	0.265	1.84	(0.62, 5.50)	0.150
Pell grant recipient						
No						
Yes	0.93	(0.44, 1.98)	0.816	0.92	(0.52, 1.62)	0.698
Same Pell grant status	0.98	(0.35, 2.79)	0.964	1.16	(0.47, 2.89)	0.666
Age	0.94	(0.41, 2.19)	0.856	0.93	(0.42, 2.06)	0.811
Residence Hall						
A						
B	2.44	(0.46, 13.02)	0.169	1.70	(0.49, 5.94)	0.276
C	1.07	(0.29, 3.99)	0.895	0.80	(0.20, 3.21)	0.684
D	1.20	(0.13, 10.87)	0.831	0.75	(0.08, 7.24)	0.742
E	1.34	(0.24, 7.51)	0.661	0.62	(0.10, 3.83)	0.497
F	0.61	(0.05, 7.16)	0.605	0.57	(0.05, 5.95)	0.539
Student meal plan						
Unlimited meals						
8 meals/week	0.90	(0.25, 3.32)	0.843	0.81	(0.28, 2.37)	0.620
180 meals/semester[B]	1.16	(0.34, 3.96)	0.758	0.84	(0.25, 2.83)	0.716
14 meals/week	1.00	(0.31, 3.24)	0.993	1.13	(0.42, 3.02)	0.745
Same meal plan	1.20	(0.39, 3.65)	0.677	1.43	(0.49, 4.17)	0.386
Month						
August						
September	0.75	(0.45, 1.26)	0.155	0.94	(0.58, 1.52)	0.733
October	0.65	(0.36, 1.17)	0.060	0.74	(0.39, 1.41)	0.233
November	0.74	(0.39, 1.38)	0.212	0.76	(0.40, 1.44)	0.264
December	0.55	(0.24, 1.26)	0.063	0.67	(0.29, 1.54)	0.219
January	0.74	(0.34, 1.63)	0.324	0.74	(0.37, 1.46)	0.249

February	0.69	(0.33, 1.44)	0.191	0.74	(0.38, 1.44)	0.242
March	0.50	(0.21, 1.19)	0.039	0.49	(0.22, 1.11)	0.025
April	0.45	(0.19, 1.06)	0.016	0.48	(0.21, 1.06)	0.017
May	0.34	(0.00, 205.42)	0.666	0.39	(0.10, 1.57)	0.083
Day of week						
Weekday						
Weekend	0.92	(0.62, 1.37)	0.585	1.04	(0.76, 1.42)	0.768
Time of Day						
Morning (before 10 AM)						
Midday (10 AM to 1 PM)	1.37	(0.68, 2.77)	0.250	1.75	(1.05, 2.92)	**0.005**
Afternoon (1 PM to 4 PM	0.93	(0.41, 2.07)	0.806	1.48	(0.87, 2.50)	0.055
Evening (after 4 PM)	1.37	(0.67, 2.79)	0.251	1.89	(1.15, 3.11)	**0.001**

[A] The number of data points varied for each of the 250 iterations, depending on the floormate pairings. The average number of data points per iteration for females was 130,268 (SD=986) the average number of data points per iteration for males was 111,503 (SD=841)
[B] 180 meals/semester equates to approximately 11 meals per week with consistent use

4.5. Discussion

This study examined if students purchased similar meal plans, and had similar meal plan use, as their roommates. Understanding this roommate similarity is required before interventions designed to alter meal plan choices via roommate influence are tested. Students' meal plan purchases were associated with the students' demographics, and their roommates' meal plan purchase. Of surprise was the nearly 7% of students who rarely used their meal plan. Students tended to purchase less expensive meal plans in the Spring semester. This study indicates that roommates influence each other's meal plan use, particular at the start of the academic year and for certain roommate pairings. Interventions based on first-year college roommates may be most effective if implemented as early in the year as possible.

Students were more likely to purchase the cheapest, and less likely to purchase the most expensive, meal plan in the Spring semester. This finding may suggest that students used the dining hall less than they (or their parents) had anticipated in the Fall semester. The default meal plan at this university provides 14 meals/week (the second most expensive meal plan), and the university states that this meal plan is "super popular" and the "most selected plan for first year residents".[9] A combination of default settings, advertising, and intentions to ensure a smooth transition to university may all contribute to the misalignment between the number of meals provided by the students' meal plan and the students' meal plan use. Given the popularity of the cheapest meal plan (8 meals/week) in the Spring semester, we question if a meal plan that provides 8 meals per week is actually sufficient for student's dining hall needs. However, it is unclear from where students obtained the rest of their meals. University students' tend to have diets that do not meet dietary guidelines,[17,26] and healthful options are typically more readily available in dining halls than other food outlets available to students in the campus food environment.[1]

Understanding why students are not using the dining hall(s) may suggest changes that not only increase the use of dining halls, but may also potentially improve students' dietary intake. The reasons for students opting to purchase lesser meal plans in the Spring semester should be researched further.

Weight gain is common for first-year students, and is potentially associated with meal plan use. Kapinos et al. found that female students whose residence was connected to a dining hall gained more weight than the female students whose residence was in a different building than their dining hall; Kapinos et al. did not find an association between location of residence and dining hall and weight gain for male students.[93] It is of interest that in the current study, students tended to purchase a meal plan that provided less meals in the Spring than in the Fall. While systematic reviews suggest that first-year students gain weight during their entire first year of college,[85,86] some studies suggest that more weight is gained in Fall than in Spring.[337,425] How students' higher meal plan use in Fall is associated with students weight gain in Fall is unknown. Further research should examine if dining hall use is associated with weight gain, and if students are choosing meal plans that provide less dining hall meals in Spring due to weight concerns.

Students were more likely to use a meal with their roommate if they were the same race/ethnicity. It is unclear from this study if roommates of different race/ethnicities were less likely to use a meal together due to the friendship between these roommates being less developed than the friendship between roommates of the same race/ethnicity, or for other reasons. One study has indicated that White students reported more satisfaction and involvement with their roommate when assigned a roommate that is the same race.[335] The findings from this study may further suggest that friendships among roommates of different race/ethnicity are less

developed than friendships between roommates of the same race/ethnicity. Another study showed that roommates who requested to room with friends were more racially/ethnically homogenous than roommates who were randomly assigned.[331] As the pre-existing relationship between roommates in this study was unknown, the association between meal plan use and race/ethnicity may be confounded with pre-existing friendship: roommates who were friends prior to starting university may be more likely to be the same race/ethnicity and to use their meal plan together. While the relationship status between the roommates in this study was unclear, a prior study using a subset of the students used in this study suggested that around 80% of roommates were randomly assigned.[337] Factors other than students' race/ethnicity (such as pre-existing friendship) may explain why students' of the same race/ethnicity were more likely to use a meal together. Further research should examine the underlying causes of the association between roommates' relationship and race/ethnicity before any conclusion is made.

Students used their meal plan with their roommate less on weekdays, in the morning, and after the first month. The difference in the extent students used a meal with their roommate may indicate that roommates spend more time together later in the day, and during weekends rather than weekdays, as they may have varying class schedules, work schedules, and other commitments. The lower number of meals used with a roommate later in the year may also indicate that first-year roommates become more independent of each other as the year progresses. Studies have indicated that in the first year of college, students spend more time with their roommate than any other student, but that less than 40% of students list their roommate as a 'best friend'.[330] After the first month, students may be forging different friendship groups, and be less co-dependent on their roommates. As such,

interventions targeted to first-year roommates living in residence halls may be more effective at the very start of the academic year.

The lack of meal plan similarities between students and their same-sex floormates suggest the similarities among roommates is not due to environmental factors. The two likely mechanisms resulting in students purchasing similar meal plans as their roommate, having higher meal plan use when their roommate did so, and using their meal plan at the same time as their roommate, are roommate influence and selection of a similar student as a roommate initially. Additional research showing how students' friendship groups form, and who students eat with over time – even after their first year, may suggest at-risk student populations to target for interventions later in the year and throughout students' time in college. For example, students' whose meal plan use decreases over time, and who appear to become more isolated from their peers over time, may be at heightened risk of several health problems, such as food insecurity and depression.

4.5.1. Strengths and Limitations

The strengths of this study include the large sample size, objective measures of meal plan use for an entire academic year, the university-derived information for student demographics and living location, and the simulation analysis which allow potential environment effects to be examined. Limitations need to be considered to place these findings into context. It was unclear which roommates were randomly assigned to each other, and which students had requested to be roommates. This issue makes it difficult to distinguish roommate selection from roommate influence. Roommates may have *influenced* the extent students used their meal plan, however the association may also be due to *selection* effects. Students may have *selected* roommates with similar characteristics as themselves, and subsequently had similar

meal plan use. Other limitations include that only students' official residence was known – students may have unofficially resided elsewhere; while students' meal plan use was recorded, students' dietary intake was unknown; and the similarities in course work and study habits between roommates was unknown. Potentially, roommates taking courses at similar times, and with similar study habits, were more likely to use a meal together than roommates with dissimilar schedules and study habits. Finally, while higher meal plan use was observed for students' whose roommate had higher meal plan use, it is unclear if students without a roommate would have had even higher meal plan use. These findings are from a specific cohort of students at one university. Findings may be different in other years, and at other institutions.

4.5.2. Conclusion

A students' roommate was associated with the meal plan a student purchased, the extent the meal plan was used, and when and where a meal was used. The simulation analyses using residence mates, rather than roommates, found no association between students and residence mates' meal plan purchased, or meal plan use. As such, while it is unclear if the similarities between roommates were due to selection or influence effects, the findings are unlikely to be due to environmental effects. Future research should examine if roommates dietary intakes are similar and the psychosocial implications of the findings from this paper. If similarities in dietary intake among roommates occur, the extent of roommate influence, roommate selection, and environmental effects should be examined.

5. DISCUSSION

This dissertation examined predictors and factors related to first-year students' meal plan purchases and meal plan use. Food insecurity and meal plans were examined as many students' are reporting food insecurity, which is associated with poorer health and worse academic outcomes. Understanding the underlying reasons why students are reporting food insecurity can help researchers to minimize the prevalence of food insecurity among students. The association between roommates' and students' meal plan purchases and use were also examined. Understanding the extent of roommate influence on students' meal plan purchases and meal plan use can help researchers to determine if roommate influence is a viable approach to interventions aimed at changing meal plan behaviors. This study is the first to assess objective meal plan purchases and use and how it is related to social and behavioral health factors. Findings provide university insights on meal plan use for first-year students and set the stage for future research examining how meal plan usage over time is related to health outcomes such as dietary intake and weight gain. Findings raise questions about students' reported food insecurity, and how roommates and other friends can help support health among college students.

This dissertation found that students with lower meal plan use were more likely to report food insecurity, and that students' roommates' meal plan use was associated with students' meal plan use. In the US, first year students' are typically required to live on campus and to purchase a meal plan.[3,5,6,11,319,322,327,329,426-428] As the students' meal plan is expected to provide the majority of the students' meals, understanding how students use their meal plan provides insight into a significant portion of students' dietary intake. The extent students' use their meal plan is of particular interest as the foods offered in the dining halls have been shown to be more

healthful than foods offered from other on-campus food outlets.[1] This study determined that, on average, first-year students do not maximize their meal plan use. Based on these findings, universities may wish to examine if students' schedules enable them to fully use their meal plans, where students are obtaining their other meals from, and other reasons why students are not using all of their pre-paid meals. Future research may suggest novel ways of increasing meal plan use, which may then improve students' dietary quality, overall health, and academic performance.

The meal plans provided to students typically provide a set number of dining hall meals per week or semester, or unlimited dining hall meals. Similar to other universities, students in this study were able to use one of their meals to purchase foods from other on-campus food outlets each day, and were also provided some cash-equivalence that could be used to purchase items from other on-campus food outlets.[4,6,11] The meal plan students' purchase at the start of the semester is expected to provide students a significant proportion of their meal requirements for the semester. Meal plans are pre-paid and non-refundable, as such meal plans are designed to ensure that all students, regardless of background or wealth, have meals available to them: students on the same meal plan can theoretically use the same number of meals, there is no financial incentive to not use the meals available.

As anticipated, the meal plan students' purchased was associated with the number of meals students' used; students who purchased more expensive meal plans (that provided more meals) tended to use more meals than students' who purchased cheaper meal plans. Student demographics were also associated with the meal plan purchased: females, Hispanic/Latino and International students, Pell grant recipients, first generation college students, and students whose parents regularly sent food,

tended to purchase the cheapest meal plans. The students who purchase the cheapest meal plan may do so due to an expectation that they will not need more meals, or due to financial constraints. From this study it is unclear why these demographic differences occurred. Future research should examine where the students on the cheapest meal plan in particular are obtaining the rest of their meals from, and why students purchased the meal plan they did.

Students tended to purchase the cheapest meal plan, and were less likely to purchase the more expensive meal plans, in the Spring semester. The default meal plan at this university provides 14 meals per week and is advertised as being "super popular" and the "most selected plan for first year residents".[9] While most students did purchase the 14 meals per week meal plan in the Fall semester, by the Spring semester most students opted to purchase the cheapest (8 meals per week) meal plan. Clarity around the meal plan students have purchased previously may help ensure new students purchase meal plans that work for them. Additional research should examine why students tended to purchase a cheaper meal plan in the Spring semester, and what type of meal plan structure students' think would work well for them.

The association between meal plan purchases, meal plan use, and food security was of interest due to prior studies suggesting that students were experiencing food insecurity due to their meal plan being insufficient.[189,403] Students' reported food insecurity while having meals available to them, which raises the question of what the USDA food security tool is measuring in this student population. The six-item USDA food security tool asks students if they ran out of food and didn't have money to get more, couldn't afford to eat balanced meals, ate less due to not having money for food, or were hungry but didn't eat due to not having money for food. If students

do not view their pre-paid meals and cash-equivalence as a 'money' source, then the USDA food security tool may be misclassifying students. Future research should determine how well the USDA food security tool classifies students' who use a meal plan, who eat in a dining hall with an all-you-can-eat buffet of meals available to them, and who have cash-equivalence available for meals.

For one of the four meal plans, students with lower meal plan use were significantly more likely to report food insecurity. The lower meal plan use suggests that students on this meal plan experiencing food insecurity had even more meals available to them than students on the same meal plan who were food secure. Organizations, such as Swipe Out Hunger, provide food insecure students meals to help alleviate their food insecurity.[407] This study suggests that providing students who already have a meal plan additional meals may be an ineffective strategy at countering food insecurity. Determining the barriers to meal plan use for students with a meal plan may be a more effective strategy to combat food insecurity for this population.

The findings from this dissertation suggest one potential barrier to meal plan use is working a job. Students who worked a job had lower meal plan use. As students who are food insecure are more likely to work a job,[155] it may be that these students are not using all of their available meals due to barriers with meal plan use (e.g. working off campus). While students at this university were provided with one meal exchange per day, which allowed students to use their meal plan to purchase an on-the-go meal, these were only available at select locations. The meal exchange locations were roughly a 10-minute walk from some of the main residence halls, and were not always open before 10 AM on weekends or in the evenings. Additionally, some of the dining halls were not open before 10 AM on weekends, and all dining halls were closed by 9 PM. Students who work may be using less meals due to the amount of

time required to walk to and from a meal exchange location, and due to the meal exchange locations and dining halls open hours not matching to the students' schedules. Future research should seek to further understand how working a job is a potential barrier to meal plan use. If students are leaving to work prior to being able to use their meal plan, or arriving back to their residence after the main dining locations have closed, changes to the dining hours and flexibility of where meals can be used may increase meal plan use. While information around how the dining hall and food outlet hours were set was not available, the hours each location is open is presumably based on the number of customers received each hour, and the cost of being open each hour. The dining hall and food outlets hours may work well for most students, but the hours may negatively impact a small proportion of students. It may be that a specific population of students – students who work - find the dining hall hours incompatible with their job hours and are less able to use their meal plan than other students.

As this dissertation shows, food insecurity is a complex issue. Until the root causes of food insecurity on campus are found and addressed, food insecurity is likely to remain an issue among students. Prior studies have fairly consistently shown that college students who report food insecurity tend to have poorer health and worse academic performance.[154,155,224] Future research should seek to determine what exact situations resulted in students' reporting food insecurity, and determine ways to minimize the extent food insecurity occurs. As friends tend to be similar to one another, one area of interest is how students' social networks are associated with food insecurity. Future studies should examine if students food security status can be determined by the students' social network. If friends tend to have a similar food security status this could suggest clusters of at risk students who are food insecure for the same underlying reasons. Some students may be food insecure due to low

food security self-efficacy. If this is the case, research should determine if pairing food insecure and food secure students together results in a decrease in food insecurity. Future research should also examine if students experiencing food insecurity have better health and academic outcomes if their friends are food secure, or food insecure.

This dissertation determined that students' meal plan use was higher when their roommates' meal plan use was higher. Students' meal plan use was also higher if their roommate was on the same meal plan as the student. While diversity is typically encouraged at universities, the higher meal plan use by roommates on the same meal plan suggests that some uniformity among roommates may be beneficial. There is no suggestion that pairing students by wealth or race/ethnicity will increase the number of meals a student uses. Qualitative data from first-year university students indicate that students are less likely to visit the dining halls alone.[429] Interventions to increase meal plan usage might consider encouraging friend groups to use their meal plans together, ensuring students' feel comfortable using the dining hall alone, encouraging students to socialize with people dining alone, and building stronger connections among roommates.

Students were more likely to use a meal at the same time and location as their roommate than a same-sex floormate, especially at the start of the academic year. Students were more likely to use a meal with their roommate if their roommate was the same race/ethnicity, or on the same meal plan, as the student. This may indicate that students' meal plan use is influenced by their roommates' meal plan use, especially if the roommates have the same meal plan or are the same race/ethnicity. It is unclear from this study which combination of race/ethnicity pairings among roommates resulted in the lowest, and highest, percentage of shared meals. If lower

shared meal plan use typically occurs for roommates of two particular race/ethnicities (e.g. White and International students) this may indicate that these particular roommate pairings may have lower levels of friendship and social support.

Students were classified as using a meal with their roommate if they used their meal plan within one minute of each other at the same location. This very narrow definition of shared meal plan only captures if roommates' entered the same dining hall (or purchased a meal exchange) at the same time. It does not capture if the roommates chose similar meals, or dined together. It also does not capture the extent roommates were similar in their other behaviors, or the level of friendship among the roommates. Of note, the decrease in the number of roommates using their meal plan at the same time and location as each other as the semester progressed does not necessarily indicate that students dined with their roommate less as the semester progressed. Roommates may have been less likely to swipe in together, but may have still dined in the dining hall together.

From this study it appears that roommates' influence which meal plan a student purchases, the extent a student uses their meal plan, and when/where a student uses their meal plan. This apparent roommate influence could potentially be exploited to increase students' meal plan use, and potentially also improve nutrition related factors (e.g. increase dietary quality). Future studies should examine who students' use their meal plan with later in the semester. Understanding who students use their meal plan with may suggest friendship groups that can also influence meal plan use.

5.1. Research implications.

Many students purchased a meal plan that provided 8 meals per week, and did not use all of their available meals. Future studies should determine where students are obtaining the rest of their meals from, and why students are not fully using their meal plan. Longitudinal studies should examine if the location other meals are obtained from, and reasons for not using a meal plan, change over time. The dining halls typically provide an all-you-can-eat environment with a wide variety of food choices. Some universities allow students to take a single item, (e.g. fruit, a cookie, yoghurt, or a beverage) out of the dining hall,[7,427,430] while other have a no-food-outside-the-dining-hall rule,[390,431] or allow students to purchase a reusable to-go box that students' can fill in lieu of dining in the dining hall.[432-436] Future research should examine if these differences in dining hall regulations have an impact on students' food security.

The students' dietary quality was not examined in this dissertation. It is unclear how students' dietary choices change over their first year. One study indicates that students consume more calories at the start of the year than at the end of the year,[437] and this current study shows that students' use more meals in the Fall semester than in the Spring semester. These two studies suggest that changes in students' dietary decisions and dietary quality occurs during the first year of college. Future research should determine if differences in dietary patterns and dietary quality occur for students' on different meal plans, and if students' dietary quality is higher when students use a greater proportion of their available meals.

As well as using traditional approaches to examining diet (e.g. food frequency questionnaires, food diaries, 24-hour recalls), future studies should examine some of the more modern approaches to determining dietary intake. For instance, students

are required to purchase cash-equivalence that can only be used at on-campus food outlets. Determining students' foods and beverages purchases over time (e.g, using receipt information) could provide a detailed, longitudinal, understanding of the dietary items students' obtain. Unlike the traditional approaches, using a receipt approach uses objective information, would likely have minimal reactivity, and no recall bias. While food purchase information does not equate to dietary intake, other studies have indicated that food purchases are correlated to dietary intake.[116-119] Other approaches to determining dietary intake are observing students in the dining hall, potentially using pre and post plate images to more accurately estimate students' diets. To fully determine students' dietary intake a combination of their dining hall use, cash-equivalence purchases, and meals/snacks obtained elsewhere will need to be examined in combination. Understanding patterns in students' meal plan use could indicate periods of time when students' dietary intake is low, or less healthful. Future studies should examine if the food/beverage items students' purchase with their meal plan cash-equivalence is different by food security status, and similar by roommates.

The association between working a job, using less meals, and food insecurity is of concern as it indicates a subset of students who may be struggling with university. Studies indicate that nursing students who work a job have lower academic achievement,[438] and that food insecurity is associated with lower academic performance.[155,215,224] Future studies should examine if meal plan use and dietary quality partially explain the association between working a job, food insecurity, and academic performance. Studies should also determine if students' overall health improves with higher meal plan use and reasons other than working a job that result in lower meal plan use.

Understanding the role friends and roommates play in students' dietary choices may help better promote healthful diets among the college population. Similarities in dietary intake among friends and roommates should be further examined, and the extent of selection, influence, and environmental effects determined. It is currently unclear to what extent friendships help (or hinder) food insecure students. Studies suggest that some friends provide emotional support and can be a source of food.[439] However food insecure students' also report the financial cost of socializing (e.g., eating together), and that they avoiding social events due to the cost.[439] Food insecure students are also more likely to work a job[187] which may give them less opportunities to socialize with their peers; one food insecure student describes how their food insecurity resulted in being more isolated from their friends.[199] The social positioning of food insecure students in their social network over time should be examined to determine if food insecure students tend to have less friends, and lower quality friendships, than food secure students.

Studies have already shown roommate influence on BMI,[337] alcohol intake,[339] and depression.[343] This dissertation shows potential roommate influence on meal plan use, which suggests research into roommate influence on dietary quality should be examined. The extent of roommate influence on other diet-related health outcomes, such as diabetes risk and heart disease, should also be determined. Prior studies have shown that students are more likely to become friends with other students who live on the same floor, than students from different floors.[267] While similarities in meal plan use were not found among floormates, future research should examine if joint usage among floormates occurs for the additional meals students obtain.

Similarly, studies have shown that friendship influence and selection on many health behaviors and outcomes, such as BMI,[261-263,265,267] physical activity,[264,265,293] alcohol

intake,[294,297] and smoking.[295-297] Additional studies should examine if friends influence the extent students' use their meal plan, and which meal plan students' purchase. Determining students' social network can be difficult. As roommates were more likely to use a meal plan together than floormates, students' dining patterns may indicate who their roommate is, or friends are. Future studies should determine the extent students' friends can be determined by similarities in meal plan use, and from other events which result in a precise electronic time stamp associated with the student, such as students swiping their student ID card to access residence buildings and to enter the recreation center. Future studies should also determine the extent friends' influence each other's meal plan use, as friends could be a potential way to increase number of meals eaten in the dining hall.

This dissertation suggests systematic differences by campus and by residence hall: the extent food insecurity was reported was different by campus, and the extent students used their meal plan, and the extent roommates used their meals together, was different by residence hall. At this university some residence halls cost more than others and students are limited to which residence hall they can apply to by the major they intend on taking.[394] Additionally, only some residence halls have attached dining halls.[440] Future studies should examine if systematic difference by campus and residence hall do occur, such that students in some residence halls are at higher risk for poor health behaviors and outcomes than students in other residence halls. If systematic differences do occur by residence or campus, understanding the drivers of these differences could help improve students' health.

Research should also examine if strategic roommate pairings, or efforts to increase friendships among roommates, can result in increases in meal plan use and integration into the university social network. If particular roommate pairings result

in higher meal plan use, deliberate roommate pairings may help lower the prevalence of food insecurity. At the same time, pairing certain students' together may help students integrate into the university environment and encourage them to succeed. Universities often collect information on students such as whether they smoke,[322-324] noise preferences[322,324] and typical bed time[320,322,324] to help pair compatible students together. Potentially, pairing students on other characteristics, such as whether they work a job and which meal plan they purchased, may increase the amount students' use their meal plan, and their dietary quality. However, pairing students on characteristics such as working a job and meal plan may inadvertently result in students of similar wealth and background being paired together, limiting the extent of diversity among students and increasing segregation.

5.2. Practice implications

The findings from this dissertation suggests that students purchase the cheapest (8 meals/week) meal plan after their first semester. While the higher cost meal plan may seem like the most value for money, purchasing a cheaper meal plan in the Fall semester may be more compatible with students' meal plan needs. It is difficult for students to opt-out of a meal plan if they live on campus. It is unclear how many students who purchased the cheapest meal plans would have preferred to not purchase a meal plan at all. Universities, in particular those which have a number of food outlets near students' residences, should examine the impact in students' health and academic performance if they are allowed the option of not purchasing a meal plan.

The ethics of requiring students who live on campus to purchase a meal plan is debatable. Meal plans attempt to ensure that all students have meals available to them throughout the entire semester. In theory, meals plans are a convenient option

that allow students to focus on their coursework and the transition to university. However, being required to purchase unwanted meals could be adding financial stressors to students. It is ironic that a meal plan, marketed as something to assist students through their time in college, may be hindering the very students it is designed to help. If students purchase their meal plan, then need to work a job to meet financial obligations, they may then have a time schedule incompatible with dining hall hours which results in lower meal plan use. As such, the meal plan a student purchases may result in a higher risk of food insecurity, rather than ensure food security. Exploring more flexibility with the meals plans may help to alleviate student food insecurity.

The dining halls, where students are expected to obtain the majority of their meals, are presumably open during typical student dining periods. Providing dining hall meals to students outside of the typical operating hours (e.g. before 11 AM on weekends and after 9 PM on weekdays for the dining halls at this institution) may be financially costly to the company running the dining hall. Expecting food companies to voluntarily remain open during periods with low use, and to run at a loss during these periods, is unreasonable. However, it is reasonable to expect universities to provide a healthful and safe environment for their students. In particular, it is reasonable to expect the university to do their utmost to ensure the health and safety of the students they require to live on their campuses. If students are reporting food insecurity due to the dining hall operating hours being insufficient, the university could have an ethical responsibility to ensure the company running the dining halls provides meal options to students during the time periods that work for students.

This dissertation indicates that first-year students with a meal plan experience food insecurity for reasons other than a lack of meals on their meal plan. Determining why students are reporting food insecurity while having meals available to them may help develop effective interventions aimed at decreasing the prevalence of food insecurity. If students are reporting food insecurity while having meals available to them due to the measure used to determine food insecurity not working as intended on this college population, then alternative ways to measure food insecurity among college students should be examined. What the current USDA food security tool is measuring among college students with a meal plan should also be determined. If students' schedules result in them being unable to use their meal plan, ensuring students can use their meal plan at a convenient and safe location outside of typical dining hours may help counter the prevalence of food insecurity among students.

As students were more likely to use a meal with their roommate than a floormate, targeted advertising to encourage roommates to dine in different locations, at different times, and more frequently, may be effective. If food service providers do price the meal plans with the expectation that students will only use 60-70% of the meals available to them,[405] increasing the number of meals students use could also increase the cost of the meal plans. However, if students' start using more of their meals, and feel that the costs of their meal plan are justified, the level of theft from meal outlets – which some students apparently feel entitled to do given the cost of the meal plans and the number of their unused meals[441-443] – could potentially decrease resulting in slightly lower overheads.

5.3. Strengths and Limitations

The strengths of this dissertation include the large sample size, the longitudinal design, and the objective measurements of meal plan purchase, meal plan use,

demographics, and residence location. In particular, 384,260 meal plan transactions over an entire academic year, and 1745 students were included in the paper examining meal plan use among roommates. The main limitation of this dissertation is that meal plan use, not dietary intake, was captured. The quantity and quality of foods/beverages consumed from each meal plan use was unknown. Given the all-you-can eat buffet in the dining halls these variables cannot be estimated from the data provided. The lack of information regarding pre-existing friendships among roommates limits the inferences that can be made. The similarities in meal plan purchases and meal plan use among roommates may be due to the roommates with pre-existing friendships having similar preferences. As such, it is difficult to differentiate the potential influence, and potential selection, effects. Finally, this dissertation is based on first year students from one academic year (2015-2016) and at a specific university, findings may differ for students past their first year, for other academic years, and at other universities.

5.4. Conclusions

By requiring first year students living on campus to purchase a meal plan, universities are theoretically ensuring that students have meals available to them. This dissertation shows that having a meal plan does not necessarily result in food security, and that students do not fully use their meal plan. The association between demographics and the meal plan students purchased was examined. Females, Hispanic/Latino and International students, and Pell grant recipients tended to purchase the cheapest (8 meals/week) meal plan. Students also tended to purchase the cheapest meal plan in the Spring semester, and if their roommate purchased the cheapest meal plan. The number of students purchasing the cheapest meal plan in the Spring semester suggests that students do not want (or need) a meal plan that

provides all of their meals. Future studies should determine where students are obtaining the rest of their meals from.

Several potential barriers and facilitators to meal plan use were examined. As anticipated, students who purchased an unlimited meal plan had the highest meal plan use, and students who purchased the cheapest meal plan had the lowest meal plan use. Students' meal plan use tended to be higher when the students' roommate was on the same meal plan as the student, and when the students' roommate had higher meal plan use. Certain roommate pairings, such as by pairing roommates who have purchased the same meal plan, may result in higher meal plan use. For one of the meal plans, the association between meal plan use and students' mental health, employment, perception of their meal plan, and alternative food supplies was examined. Students' meal plan use was lower if the student worked a job. Future studies should examine if students who work a job have scheduling conflicts that prohibits them from using their meal plan.

Students on the cheapest meal plan, and students with lower meal plan use, were the most likely to report food insecurity. Surprisingly, students typically did not use all of their available meals. On average less than 75% of available meals were used and 7% of students did not use their meal plan for an entire month. In Fall 2015, 26% of students on the unlimited meal plan reported food insecurity at the end of the semester. This means that students reported food insecurity while having meals available to them. The USDA food security tools asks about having money for food, and eating less. Of concern is the possibility that the USDA food security tool questions are not applicable for college students with a pre-paid meal plan and access to an all-you-can-eat dining hall. Future studies should examine what the USDA food security tool is measuring when applied to a college student population

with a meal plan. Future studies should also determine why students are not using all of their available meals.

Roommates were more likely to use meals at the same time and location if they both had the same meal plan. Future studies should examine if pairing students' by meal plan increases meal plan use. An increase in meal plan use may help reduce the prevalence of food insecurity on college campuses, and may also improve students' dietary quality. The extent roommates used their meal plan together decreased over the academic year. Future studies should determine how the social network of students, and who students use their meal plan with, changes over the academic year.

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APPENDIX

APPENDIX A. IRB approval: continuation, 08/14/2018 - 07/26/2019

ASU Knowledge Enterprise Development

APPROVAL:CONTINUATION

Meredith Bruening
Nutrition
602/827-2266
Meg.Bruening@asu.edu

Dear Meredith Bruening:

On 8/14/2018 the ASU IRB reviewed the following protocol:

Type of Review:	Continuing Review
Title:	The Role of Friendship Networks on BMI and Behaviors among College Freshmen
Investigator:	Meredith Bruening
IRB ID:	1309009596
Category of review:	(4) Noninvasive procedures, (7)(a) Behavioral research
Funding:	Name: HHS: National Institutes of Health (NIH), Funding Source ID: HHS-NIH-National Institutes of Health
Grant Title:	None
Grant ID:	None
Documents Reviewed:	• Script explaining the app (goes with the AppdescriptionPDF), Category: Participant materials (specific directions for them); • ReminderFlyers.pdf, Category: Recruitment materials/advertisements /verbal scripts/phone scripts; • TangoCardAnnouncementEmail.pdf, Category: Participant materials (specific directions for them); • UpdatedProtocol_MergedWithdevilWASTE_Modification_06252018.doc, Category: IRB Protocol; • Microbiome pilot consent form, Category: Consent Form; • devilWASTE Male Participant Data Collection Sheet 2015.pdf, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • RefusalResponseSheet.pdf, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions);

	• Refer-A-Friend Program_100715.pdf, Category: Recruitment materials/advertisements /verbal scripts/phone scripts; • GetInvolvedinScienceRecruitFlyer.pdf, Category: Recruitment Materials; • Changes in app survey questions, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • ExtraMoneyRecruit.pdf, Category: Recruitment Materials; • Microbiome pilot flyer, Category: Recruitment Materials; • devilWASTE Study Enroll Form 2015.pdf, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • WelcomeBackSpringEmail, Category: Participant materials (specific directions for them); • DidYouMissUs_RecruitmentFlyer.pdf, Category: Recruitment materials/advertisements /verbal scripts/phone scripts; • Updated longitudinal survey plan, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • devilSPARC_2015ConsentForm_082115.pdf, Category: Consent Form; • devilWASTE Female Participant Data Collection Sheet 2015.pdf, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • BoostInEMAIncentives_100715.pdf, Category: Participant materials (specific directions for them); • waist_hip_circumference_form.pdf, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • height_weight_form.pdf, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • RecruitQuestionFlyer.pdf, Category: Recruitment Materials; • script just devilSPARC, Category: Consent Form; • TangoCongratulations.pdf, Category: Participant materials (specific directions for them); • devilWASTE Screening Form 2015.pdf, Category: Screening forms; • NewSpringTeamMembers, Category: Other (to reflect anything not captured above); • ExtraIncentivesEmail100715.pdf, Category: Participant materials (specific directions for them); • devilSPARC messages_072115.pdf, Category: Recruitment materials/advertisements /verbal scripts/phone scripts; • Tentative devilSPARC data collection schedule.pdf, Category: Other (to reflect anything not captured above); • devilWASTE script, Category: Consent Form; • App_Description.pdf, Category: Participant materials (specific directions for them); • Flyers for Extra Participants.pdf, Category: Recruitment materials/advertisements /verbal scripts/phone scripts; • Participant ID card and reminders, Category: Participant materials (specific directions for them);

The IRB approved the protocol from 8/14/2018 to 7/26/2019 inclusive. Three weeks before 7/26/2019 you are to submit a completed Continuing Review application and required attachments to request continuing approval or closure.

If continuing review approval is not granted before the expiration date of 7/26/2019 approval of this protocol expires on that date. When consent is appropriate, you must use final, watermarked versions available under the "Documents" tab in ERA-IRB.

In conducting this protocol you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).

Sincerely,

IRB Administrator

APPENDIX B. IRB approval: continuation, 09/12/2018 - 09/17/2019

ASU Knowledge Enterprise Development

APPROVAL:CONTINUATION

Meredith Bruening
Nutrition
602/827-2266
Meg.Bruening@asu.edu

Dear Meredith Bruening:

On 9/12/2018 the ASU IRB reviewed the following protocol:

Type of Review:	Continuing Review
Title:	Eating and Physical Activity Behaviors of College Students as Reported by Student Card Data
Investigator:	Meredith Bruening
IRB ID:	STUDY00004918
Category of review:	(5) Data, documents, records, or specimens
Funding:	Name: HHS: National Institutes of Health (NIH), Grant Office ID: NTS0035, Funding Source ID: 1DP5OD017910-01
Grant Title:	None
Grant ID:	None
Documents Reviewed:	

The IRB approved the protocol from 9/12/2018 to 9/17/2019 inclusive. Three weeks before 9/17/2019 you are to submit a completed Continuing Review application and required attachments to request continuing approval or closure.

If continuing review approval is not granted before the expiration date of 9/17/2019 approval of this protocol expires on that date. When consent is appropriate, you must use final, watermarked versions available under the "Documents" tab in ERA-IRB.

In conducting this protocol you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).

Sincerely,

IRB Administrator

cc: Stephanie Brennhofer
Michael Todd
Irene van Woerden
Stephanie Brennhofer