EFFECT OF TIME SPENT IN ALL-YOU-CARE-TO-EAT UNIVERSITY DINING HALL ON WEEKDAY LUNCH NUTRITION QUALITY

by

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DEDICATION

This is dedicated to my daughters, Annika and Natalie.

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I would like to thank my husband, Craig Olson, my parents, Bill and Katie Slayton, and my in-laws, Larry and Diana Olson, whose invaluable support enabled pursuit of my studies. I would also like to thank Dr. Margaret Slavin for her role as chief advisor in this project, and her great patience and generosity of time and spirit. In addition, I would like to thank my committee members, Dr. Cara Frankenfeld, Dr. Lilian De Jonge, and Dr. Constance Gewa, for their advice and support, as well as Debby Kermer of George Mason University's Fenwick Library, for her guidance in Stata, and Sally Evans, of GMU's University Dissertation Services, for her time and support.

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LIST OF ABBREVIATIONS

Dietary Reference Intake ..... DRI
Equivalent ..... eq.
George Mason University ..... GMU
Healthier Campus Initiative ..... HCI
Healthy Eating Index ..... HEI
Mason Undergraduate Nutrition for Campus Health Research Project ..... MUNCH
Meal Nutrient Quality ..... MNQ
Ounce ..... oz.
Partnership for Healthier America ..... PHA
Theory of Planned Behavior ..... TPB

ABSTRACT

EFFECT OF TIME SPENT IN ALL-YOU-CARE-TO-EAT UNIVERSITY DINING HALL ON WEEKDAY LUNCH NUTRITION QUALITY

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George Mason University, 2019

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Background: College students' eating patterns have known nutritional shortfalls, particularly in consumption levels of fruit and vegetables, lean protein, low or nonfat dairy, and whole grains. In addition, excess calories and saturated fat are a concern, in light of their food environment and socioeconomic context. Research had indicated a possibility of meal-related timeframes impacting dietary choice. Students' lunchtime dining hall dietary choices may therefore be influenced by duration of lunchtime meals.

Objectives: To examine weekday lunchtime dietary choices in all-you-care-to-eat university dining halls, assess meal nutritional quality (MNQ), and explore differences in MNQ among students who report staying in the dining hall on this occasion for different durations of time.

Design: As part of the Mason Undergraduate for Campus Health (MUNCH) research study, surveys were used to collect information about undergraduate university dining hall food selections, basic demographic data, attitudes about diet, and the dining hall experience. To assess MNQ, food selection data was subjected to a 7 item rubric including both nutrient (calorie, saturated fat, sodium) and food group (whole grain, lean protein, low-fat dairy, and fruit/vegetable) standards, based on the Partnership for a Healthier America's Healthier Campus Initiative definition of a Wellness Meal and a custom-generated nutrient and food group database. Possible scores ranged as integers from 0-7, where a score of 7 indicated a student's meal having the best MNQ. Rubric outcome scores were used to then examine food intake patterns for students overall, and descriptive statistics were used to contextualize results. Linear and logistic regression analyses were then used to determine if time spent in the dining hall on this single eating occasion (<15 minutes, 15-60 minutes, or >60 minutes) was associated with different food patterns, energy intake, and overall rubric fulfillment.

Results: The nutritional quality of students' food selections, as measured by overall MNQ rubric fulfillment, showed several deficits in terms of food group, calorie, saturated fat, and sodium consumption (n=468). Out of a possible 7 points, no students' meals scored 6 or 7 points, and only 6 student meals received a score of 5. Meanwhile, 46 student meals were scored as a rubric value of zero. Of those with scores from 1-5, student meals were most successful in achieving the rubric component requiring less than 10% of calories from saturated fat, which was achieved by 60% of students.

Approximately one out of three students meeting criteria for lean protein, fruit and vegetable, calorie, and sodium intake. Fulfillment of low/nonfat dairy and whole grain rubric criteria was low, at 4% and 8%, respectively. Additionally, further breakdown of food choices reflected a possible lack of selection diversity across student choices made for foods containing whole grains or low or nonfat dairy. Linear and logistic regression analysis detected no major differences in MNQ of students spending different lengths of time at the dining hall on this single eating occasion, with one exception; students who stayed in the dining hall for less than 15 minutes had lower odds of meeting the lean protein rubric criteria than groups with longer time durations.

Discussion: The comparatively high level of rubric component fulfillment of saturated fat may be related to overall dining hall offerings being lower in saturated fat. Results from this study highlight areas for improvement in the nutritional quality of undergraduate students' lunch food choices in an all-you-care-to-eat university dining hall, regardless of the length of time they spend during that eating occasion.

CHAPTER ONE

The Nutritional State of Emerging Adults in the United States

Emerging adulthood is defined a the period from the late teens through the twenties, with a focus on ages 18-25.[1] This phase of life is commonly marked by a shift in lifestyle and food environment for this demographic - particularly for the 40.5 percent of 18- to 24-year-olds enrolled in college.[2]

Dietary Patterns for Emerging Adults Living on College Campuses: Dining Halls, Food Retailers, Dorms

Overall, college students' lives on college campuses are associated with better food patterns and body composition when compared with those of emerging adults in other living situations (i.e., at home with parents, college students living off-campus, and nonstudents living independently).[3,4] However, evidence suggests that food choices of emerging adults living on college campuses are still suboptimal in many respects. College students' stated determinants for food purchases on college campuses focused on taste, cost, and convenience.[5] Nelson and Story examined the nature of and sources of all available snacks and beverages in college students' dorm rooms, and revealed a pattern of calorie-dense, nutrient poor offerings, describing an average of 22,888 calories per dorm room in terms of total snack and drink calorie content.[6] Diversity of food intake is

another concern for college students; according to Haberman and Luffey, 76% of students reported eating the same foods day after day.[7] This repetitive dietary pattern, along with easy access to calorie rich, nutrient poor snacks in dorm rooms, could bear long term impact for students whose daily food patterns are high in calories and/or poor in nutrients.

Physiological Assessment of Emerging Adults

In a recent nationally representative longitudinal study, obesity in 13-20 year olds was at 10.2%; over five years, the prevalence for the same cohort at 19-26 years old had risen to 22.1%, indicating an enormous shift in body weight status in emerging adults as a population over the transition from adolescence to adulthood.[8]

For college students in particular, the risk of weight gain - more colloquially referred to as, "The Freshman Fifteen" – may be a large contributor to this population shift toward increased obesity rates. Research has repeatedly identified this first year undergraduate weight gain. Wengreen and Moncur reported that nearly one quarter of first year college students reported a significant weight gain - an average of 4.5 kg - during the first year's fall semester.[9] According to Hoffman et al, first year college students who had gained weight between the fall semester and February of the following semester averaged a weight gain of 3.1 kg ± 2.4.[10] The first undergraduate year's weight gain may signify the onset of a multi-year dietary intake/physical activity pattern that is inclined to weight gain. Morrell described weigh gain in the age range of 18-24 as outpacing weight gain at many other times of life. [11]

Notably, obesity rates do not plateau after emerging adulthood, but rather continue to increase later into adulthood. In 2010, the Centers for Disease Control (CDC) estimate that among adults aged 20+ with some college education, 38.4% of women and 36.2% of men were obese.[12] It seems likely that college students' freshman year weight gain and subsequent weight gain in the years that follow, then, may constitute a contributor to the population rise in obesity observed in emerging adults[8].

Risk Associated with Emerging Adults' Poor Dietary Choices and Physiological Assessments

College students' biomarkers associated with their diet and lifestyle may indicate potential for increased risk of cardiovascular disease, even at a relatively young age. Spencer et al. measured serum cholesterol, blood pressure, and self-reported health behavior in 226 college students aged 18-26 years, and found that while 10% of college students in the sample were already considered to have high cholesterol, a further 29% had undesirable total cholesterol levels, and 11% had high diastolic blood pressure readings.[13] Additionally, more than half of the students in the same study reported consuming a diet high in saturated fats, engaging in binge drinking, having a parental risk for high blood cholesterol or blood pressure, or experiencing elevated stress. Results from a multivariate regression analysis suggest that eating a diet high in saturated fat, along with smoking, binge drinking, and lack of cardiovascular exercise were predictive of undesirable cholesterol levels.[13] Morrell et al. concluded that that because of high rates of overweight/obesity, college-age adults are at risk for developing chronic diseases such as

diabetes mellitus and cardiovascular disease.[11] These combined findings of undesirable lipid markers and high rates of overweight/obesity and/or metabolic syndrome suggest an immediate risk of obesity-related disease, even in the near term, for emerging adults exhibiting these risk factors.

Dietary choices associated with weight gain may not burden only the middle aged and older when it comes to increased disease risk; emerging adults' dietary habits and associated weight gain in their younger years appear to increase their later-in-life risk of developing or dying from disease. In a 26 year followup study, Hubert et al. concluded that there is an increased risk of cardiovascular disease (CVD) in both sexes associated with weight gain in young adulthood, outside of initial weight and associated levels of risk factors[14]. The risks of obesity in emerging adults are also related to an increased risk of pancreatic cancer mortality later in life.[15]

Lower life expectancy appears to also be linked to young-age obesity. Greenberg's analysis focused on the concept of "hastened mortality", concluding that otherwise healthy nonsmokers, young- and middle-aged adults' obesity was associated with an average hastened mortality of 9.44 years.[16]

Taking into account emerging adults' biometrics and biomarkers pointing to short-term disease risk, and the long-term disease and mortality risks associated with dietary choices and overweight and/or obesity which occurred in emerging adulthood, research addressing undergraduates' dietary excesses and shortfalls is a first step in establishing nutritionally sound eating habits and associated reduction in risk factors, to improve both short and long term outcomes.

An Overview of Determinants Related to Overall Diet Quality for Emerging Adults in Campus Life

Food-related determinants may situationally differ in importance given contextual factors. Because of the context-drive aspect of determinants, replicating determinant impact may prove to be difficult. A systematic review of fruit and vegetable consumption concluded that while a great diversity of environmental determinants on fruit and vegetable consumption had been studied, the number of studies that replicated the associations with fruit and vegetable consumption for each environmental determinant was limited.[17]

Although determinant impact may be difficult to repeatedly assess for replication purposes, the influence of determinants of food choice and healthful behaviors are nevertheless keenly perceived by undergraduates. For example, students report that they encounter more *barriers* to successful weight management compared to *enablers* of successful weight management, indicating increased student awareness and perception of particular intrapersonal, interpersonal, and environmental determinants as impediments to successful weight management.[18] Commonly identified college student determinants of food choice include resource and personal preference determinants, including taste, price, and convenience.[5,19]

Students' dietary choices are associated with demographic differences, which be intrapersonal, interpersonal, or sociocultural. For example, gender has been independently associated with statistically significant differences in the foods rejected by

college students. Davy et al. identified women as being likelier to have tried different diets and as having a more developed awareness about nutrition in general compared to their male counterparts on campus.[20] According to a Mooney and Walbourn, male and female college students avoid different foods and have different reasons for doing so.[21] Race has also been associated with overall food choices.[22] Because of the rich complexity and strong influence of demographic determinants, demographic factors are often used as covariates studies examining dietary choices.

Health-Related Determinants and College Students' Dietary Choices

Students' dietary choices are influenced to varying degrees by a variety of health-related determinants. Studies involving nutrition labeling in student food environments such as canteens, student unions, or dining halls have drawn associations between nutrition labels and student behavior.[23–27]

Self-efficacy and attitudes about healthful eating are two of the most impactful determinants upon college students' ability to make health-oriented food choices. As emerging adults, college students are starting to build adult skillsets in self-efficacy about food choices and food-related behaviors, and the path toward consistently making health-oriented food choices – as powered by self-efficacy and attitudes – may possibly be a work in progress.

Some studies examine intersections of more than one type of determinant, such as health-related determinants in the context of gender. Conklin et al. examined the impact of nutrition information at point of selection and gender, college women reported using

calories displayed in point of selection nutrition information to make selections, while college men reported protein and overall nutrient content as important nutrition labeling determinants in the same point of selection system.[28] In these and other multi-determinant studies, the role of dietary approaches – particularly ones strongly associated with a given gender - arise as determinants, as well; for example, female college students are likelier than male college students to identify as consumers of vegetarian diets and identify their health concerns as a determinant of these choices.[29]

Non-Health Determinants

Determinants of food choice fall in many categories of influence; some determinants are straightforwardly resource-based, as in the case of time, money, and energy, while others, such as sociocultural determinants, are more subtle, yet still very impactful.

Sociocultural Determinants

Sociocultural determinants are major players in a college student's food choices, as well; one 2013 study of New Zealand college students highlighted the important role that close living arrangements play in students' choices, with students describing roommates and cohabiting romantic partners as among the biggest influencers of their food choices[30]; thus, choice of eating companions may constitute a very significant determinant in food choice for college students.

Cultural perceptions and misconceptions about fatness and related dietary choices infuse food-based contexts in campus life. In one college undergrad's case, roommates requested that she keep her food in her own bedroom instead of the communal kitchen, to avoid temptation to indulge in the undergrad's chosen foods perceived to be unhealthful or weight-gain-promoting.[31] The same sociocultural study noted that overweight or obese women may feel stigma associated with fatness in public dining areas on campus, and that this same population regularly anticipates judgment about dietary choices in these contexts.

Religious beliefs may also shape dietary choices – in specific proscriptive choices, such as keeping halal, or keeping kosher, or in less specific generalized religious terms concerning stewardship of resources and one's own body. However, Navarro-Prado et al. studied dietary differences and cardiovascular disease risk among Muslim and Christian students found that – regardless of professed religion – students were equally at risk for cardiovascular disease based on *different* dietary factors.[32] Therefore, food-related risk profiles may be uniquely caused by each respective set of sociocultural food choice determinants in terms of relationship to religious beliefs.

Personal Preference Determinants

College students have reported in research surveys that hunger and food cravings, appeal of food, time considerations, and convenience of food were the most influential factors in adolescent food choices.[19] However, as with humans at all life stages, college students' personal opinions about how a food tastes are an enormously influential

determinant.[33,34] While resource-based determinants such as time and convenience are cited by students as important, the study highlights that students recognize personal-preference-related determinants, too, to including food cravings, hunger, food quality, and basic appeal of the food. College students also report eating for a wide variety of personal preference reasons that are related to emotional status (homesickness, or treating oneself after an exam), boredom (late night snacking), and stimulation-seeking (coffees to get through the day).[35]

Environmental Determinants

Students' environment on campus is an important determinant of food choice. This is especially true in dining halls, where the design, ambience, and menu offerings may each exert influence upon food choice. Stroebele et al.'s found an association between environmental ambiance and dietary choices, describing different food selections and intake associated with different levels of the number of people present, food accessibility, eating locations, food color, ambient temperatures and lighting, and temperature of foods, smell of food, time of consumption, and ambient sounds.[36].

The broader on-campus food environment can have a tremendous impact on students' dietary choices. Despite the many ways the college food environment is now being thoroughly assessed in published literature, a campus can still offer nutritionally adequate menus, yet be geographically situated in a food desert, a situation whose impact is keenly felt by college students in their sense of available variety and selection.[37] This demonstrates that the campus food environment does not exist in a vacuum as students'

sole environmental determinant; their food choices may be impacted, too, by the food environment which surrounds the campus, too.

Money as a Resource Determinant

Food prices commands a great deal of influence as a resource-related determinant in student food choice. Tam et al. noted that among students surveyed about on-campus food purchasing habits, students selected cost as a top determinant, and also suggested cost-lowering as one of their top ideas for changing food buying habits among students on campus.[5] The authors conclude that price manipulation is an important lever for change. In a dining hall, students are quite likely to be on a meal plan, which may mean that the cost of any individual meal as a driver of food choices may be less of a determinant than if the student were buying the meal at retail, a la carte price.

Time as Resource Determinant

While time as a resource is recognized as a powerful influence on overall health, including time spent in health-promoting or health-deteriorating activities, the impact of how time is spent at mealtimes on dietary self-control, satiety, and other diet-related outcomes have been of particular interest in recent years by researchers.[38,39] Zick et al. described the difference in BMI for adult women and men (ages 25-64) with fewer minutes spent at mealtimes, noting that an 11-minute-smaller window in primary eating time for women corresponded to a 0.73 kg/m^2 higher BMI among women, while 23

fewer minutes per day of primary eating time was associated with a 1.7kg/m^2 higher BMI in men.[40]

Dining hall environment and the amount of time spent in the dining hall before actually eating (time-to-eating) seem to impact dietary choices. Staggering the availability of dining hall options by even a 15-minute window can significantly alter student meal choices; in a group of students faced with a healthful meal option but given the opportunity to wait 15 minutes to eat a less healthful meal, 94% decided to go ahead and eat the healthful meal. The reverse scenario, meanwhile, had zero students wait the 15 minutes out to eat a healthful meal. In a free choice scenario, with the third subgroup allowed to select either the healthful or the less healthful meals available simultaneously, about half chose the healthful meal.[41] This study of undergraduates highlights the influence of time-to-eating as a subtler but impactful variable in student dietary choice.

Relatedly, Hanks et al. described associated improved choices in terms of fruit and/or vegetable consumption or decreased selection of less-healthy foods, for students offered healthful choices in an "express" cafeteria format of preassembled ready-to-eat options.[42–44] That these express formats appear to nudge students toward more healthful dietary patterns may indicate time and effort as a barrier to student diners' selecting and/or assembling these options on their own.

In other school cafeteria settings, Zandian et al. observed that adolescent students in a dining hall setting ate their lunches very quickly when alone, but even more quickly when seated with peers.[45] The study authors went on to speculate, based on the results of the varying amount food intake observed under the different conditions, that when rushed

– as students were in this case, sharing social time and eating time in a short window meant that eating time was compressed in order to maximize social time. The authors concluded that the observed increased speed of eating may have detrimental effects for the students, such as loss of control of their food intake and/or over-eating. Time available at lunchtimes may impact fruit consumption specifically; Cohen et al. described the impact of cafeteria lunchtime timeframes on elementary in which students were less likely to choose a fruit during shorter (<20 minute) lunchtimes when compared with longer durations (>25 minutes), while other food group and entrée selections did not significantly differ between shorter and longer lunchtimes.[46]

In a review of the impact of time available upon dietary choices, however, a complicating factor is the subjectivity that arises from sociocultural interpretations of time spent in particular activities. An individual's perception of time and its passage is impacted by their sociocultural context.[47] Perception of time – often used in terms of self-reported timeframes spent on activities - and the cultural framework that impacts that perception are cited by the review author Barbara Fiese as possibly obscuring efforts to draw connections between time and nutritional outcomes.[48] The author concludes that the allocation of time and its association with diet is not straightforward as a result of these sociocultural differences in how passage of time is perceived; a person from one background may report the same timeframe as a participant from a different background, yet the actual time spent may in fact be longer or shorter for each, respectively. In addition, due to the requirement for direct observation to pursue higher accuracy in

student dining hall timelines, predictive associations are limited, since being observed may itself change the lunchtime timeline.

To accommodate students' varied schedules, some colleges and universities have moved from having distinct breakfast, lunch, and dinner hours, to more expanded hours, allowing students a broad window of time throughout the day in which to sit down for a meal. Because of these expanded hours, compared to students in dining halls with limited opening hours for each meal, students have the option to stay for longer timeframes, to eat, but also to socialize or to study. There has been no research on the population dietary choice impact – if any - of limited hours per meal versus expanded (16 hours) or unlimited (24 hours) hours in a university dining hall setting.

Determinants of Food Choices by Food Groups and Nutrients

Student eating patterns characterized through intake variables such as food groups, energy intake (calories or saturated fat), or micronutrient intake (such as sodium) may be more readily assessed for those respective variables' value-added. For example, assessing intake of servings of dairy can be used as a simplified marker for calcium intake, while percent of calories from saturated fat can be used as an indicator of disease risk.

Whole Grains

In one interventional whole grain study focusing on college students, after taking 3 days' worth of food log data, the baseline pre-intervention estimate of daily whole grain

consumption for college students came in at 0.37 oz. per day.[49] College students exhibit relative ignorance about what constitutes a whole grain food. An assessment of whole grain knowledge in college students determined that majority of students (63.9%) incorrectly identified wheat pasta as whole grain and that 72.2% failed to identify popcorn as whole grain.[50]

Aside from health-based reasons, students may choose whole grains simply for a matter of taste preference. One thesis explored determinants of whole grain consumption and concluded that the two primary reasons college students chose whole grains were for health reasons, and because they like the taste of whole grain foods.[51]

Low Fat and Nonfat Dairy

Dairy consumption in college students is woefully inadequate in many dimensions. As college students and their peers transition to young adulthood, mean daily over a 5 year transition from middle adolescence to young adulthood, calcium intakes of females and males are estimated to decrease by an average of 153 mg (1014 mg ± 17 to 860 mg ± 17) and 194 mg (1247 mg ± 22 to 1052 mg ± 22), respectively[52]. In terms of addressing calcium needs; Mahon and Haas found that students do not consume enough calcium in their daily diets and do not have knowledge about serving size or the importance of dairy consumption.[53] Demory-Luce et al. observed that in the transition from childhood (10 years old) to adulthood (19-28 years old), milk consumption decreased for both males and females, with a greater decrease among males.[54] Other studies have found decreases in milk consumption in young women during the transition

to young adulthood.[55,56] Therefore, existing research suggests not only that young adults typically consume calcium at levels far below recommended dietary allowances for their age, but these low intake numbers might be attributable at least in part to a combination of ignorance about calcium and dairy consumption and decreased consumption from childhood patterns.

Inadequate dairy consumption has repercussions for college students beyond calcium status. Research indicates that college students' body composition and bodyweight may also benefit from regular consumption of low-fat dairy products - a phenomenon some scientists are suggesting may have to do with calcium's role in weight management.[57,58] Based on their results, Poddar et al. wrote that low-fat dairy intake may be associated with better diet quality and weight management in college students, and that nutrition interventions should promote low-fat dairy intake as part of an overall healthful lifestyle.[57] Several determinants have been identified as impacting overall dairy/calcium intake in young adults, including: mealtime milk availability, health/nutrition attitudes, milk taste preference, healthful weight control behaviors, and healthful eating peer support.[52] In addition, taste is a major factor in students' preferences between dairy milk and plant-based milk alternatives – which are often calcium enriched.[59]

Protein

Protein inadequacy is rarely a problem in the emerging adult population. American adults aged 19-30 years old consumed an estimated 91 ± 22 g/day or roughly

double adequate protein dietary reference intake (DRI) recommendations at 46g/day for women and 56g/day for men in the 19-30 year old age range.[60]

However, there are certain groups of emerging adults for whom protein consumption may be of special concern; Robertson et al. found that of physically active (2.5+ hours per week) college males' perceptions of their own protein consumption, the vast majority of respondents believed their protein intake (which varied widely from 0.47g/kg - 4.37g/kg) was adequate for their needs.[61] Additionally, these male college students' perceptions of their protein choices as, "healthy" do not appear to align with USDA recommendations for consuming lean protein, given the college men's concurrently consumed amount of saturated fats (skin on chicken, full fat dairy) that accompanied these their protein choices. Therefore, consumption of excess grams of protein may be less of a concern than saturated fat – or other additions, like added sugars from sauces or fried breading – which are consumed with said protein by college students.

Fruits and Vegetables

High fruit and vegetable consumption is consistently associated with reduced all-cause mortality, according to a 2014 meta-analysis of 16 studies concerning fruit and vegetable consumption.[62] Among the biggest health outcomes whose incidence appears to be inversely associated with fruit and vegetable intake are cardiovascular disease and cancer. As discussed here, however, college students consume worryingly inadequate amounts of fruits and vegetables, instead opting for more calorie-rich, nutrient poor foods across on-campus dining environments.

For college students, constructs within the Theory of Planned Behavior (TPB) were found by researchers to be a key feature in student fruit and vegetable consumption. Students' baseline attitudes and perceived control of their own behavior predicted their intent to consume fruits and vegetables, which in turn predicted actual fruit and vegetable consumption.[63] Brug et al. found similar associations when examining the vegetable consumption determinants of Dutch adults.[64]

Saturated Fat

According to Morrel et al., college men ate 10.0% (mean 29.94 grams daily) of their calories from saturated fat, while college women ate 9.7% of calories from saturated fat (mean 20.08 grams daily).[11] Over half of a sample of college students were consuming a diet considered to be high in saturated fat, according to a 2002 study.[13] Nutritional knowledge is a determinant of saturated fat consumption in college students. Nutrition knowledge scores were negatively associated with saturated fat content in an assessed group of college students (mean age: 20 years old).[65]

Sodium

College students' daily mean sodium intake was 1941 mg, which falls under the recommended intake of 2300 mg or less per day.[66,67] For humans, sodium preferences are more impacted by diet most recently eaten, than by long term dietary patterns; reductions of sodium over the short term can enhance the appeal of reduced sodium foods to the human palate.[68] Therefore, college students' personal sodium preferences may be

associated with the relative sodium content of foods regularly consumed in their immediate campus environment. For college age adults, sodium may be believed to be less of a pressing issue with respect to blood pressure than dietary fat intake.[69] However, Krupp et al. observed higher blood pressures associated with sodium intake for young men only.[70]

Measures of Overall Nutritional Quality

In school aged children, DRIs, Adequate Intake (AI), and other USDA thresholds have been used to form rubrics for scoring micronutrient intake over the course of an entire school day (including meals not eaten at school) as inadequate or excessive.[71] Other broad measures, such as the Healthy Eating Index (HEI), similarly assess an entire day's macronutrient and micronutrient intakes. In one case, using National Health And Nutrition Examination Survey (NHANES) food consumption data for adults 20 and older, an HEI was used to score and assess nutritional intake across a single day of reported food consumption.[72]

Using metrics now increasingly applied in assessing other universities, multiple studies have been conducted by Erdman et. al[73] and Horacek et al[74,75] to evaluate campus food environments by scoring dining halls, student unions, campus snack and meal vendors, vending machines, and other food sources. The aspects examined for scoring rubrics include: availability of low-fat dairy, fresh fruits and vegetables, and whole grain breads, and/or nutrient density of offerings.

In the realm of school lunch assessment, many school lunch studies aim to analyze the quality of cafeteria offerings based upon national school lunch requirements, which often means examining menus over the course of a week or longer periods of time.[76] One method developed, the Healthy Meal Index, sought to analyze school canteen meals' nutritional quality on a per-meal basis. This index, which was developed in 2009, used three basic components: fruit and vegetable consumption, fat quantity and type, and whole grain and potato consumption.[77] However, the Healthy Meal Index does not take directly into account nutritionally relevant aspects such as calcium/dairy consumption, lean protein consumption, or sodium intake.

The Partnership for a Healthier America operates the Healthier Campus Initiative (HCI)[78,79], a campus-centered food service initiative which aims to set standards for the overall healthfulness of offerings at campus dining halls. Within the scope of these wellness standards are the dining halls' offering of what HCI calls a, "Wellness Meal." HCI has nutritional standards set for what constitutes a wellness meal offering during each of three meals of the day; while breakfast wellness meals must be less than 400 calories, and less than 460 mg of sodium, the lunch and dinner wellness meals require no more than 700 calories and 800 mg of sodium. HCI Wellness Meal food group requirements vary between meals, too; breakfast allows an either/or option for low/nonfat dairy and lean protein or lean protein equivalents, while lunch and dinner require certain amounts of both (1 cup and 2 ounces, respectively).

All HCI Wellness Meal standards require some fruits and/or vegetables (1 cup at breakfast and 1.75 cups at lunch and dinner, respectively), less than 10% of calories

coming from saturated fats, and no trans fats. The HCI rubric is a broad but relatively simple means of nutritional assessment, the HCI standards for wellness meals include minimums from certain food groups (low/nonfat dairy or dairy alt equivalents, lean protein or equivalents, whole grains, and fruits and vegetables), and maximums for calories, sodium, and calories from saturated fat. HCI continues to be assessed and validated as a meaningful contributor to campus wellness as a concrete policy support to overarching health and wellness initiatives.[80] While HCI's Wellness Meal standards are composed according to anticipated daily nutritional needs, with breakfast intake requirements set lower than lunch and dinner requirements, and the sum of all meals reflective of a day's total estimated nutritional needs. Thus, while the HCI Wellness Meal construct was not originally designed for single-meal use in research, it nevertheless represents a potential rubric-based means of assessing a meal's nutritional quality, particularly for studies collecting data for only one meal, with the rubric constructed in context of that meal contributing only part of the day's required nutrition. While HEI is harder to use as a nutritional quality tool examining just one meal out of the day, the HCI Wellness Meal offers a prospective framework that may be adapted for assessing the nutritional quality of a given meal.

The Need for Nutritional Assessment in Busy Undergraduate Lives

Because of the urgency of short-term and long-term risks associated with poor dietary patterns in emerging adulthood, assessing the food selection patterns of college students in their campus dining hall environment is an urgent priority. Students'

consumption of particular food groups, or calories, saturated fat, and sodium, can be measured, assessed for excesses or shortfalls, which can then serve as a basis for future university dining staff recommendations and interventions. While past research has shown dining hall meal timeframes to have some impact on student's eating speeds and intake levels, it remains to be seen whether there is a statistically significant difference in students' assessed dietary patterns, when comparing the meals of students in subgroups based upon duration of stay in dining halls during particular mealtimes.

CHAPTER TWO

Research Objectives

The overall aim of the study was to gain insight into weekday lunchtime dietary choices of students at George Mason University, within the context of its dining halls being open continuously throughout the day, as opposed to during defined mealtime hours. To achieve that aim, this study had two primary research objectives:

Objective 1: Assess the overall nutritional quality of meals chosen by undergraduate students during weekday lunches at two campus dining halls, according to the 'Wellness Meal' criteria of the Healthy Campus Initiative.

Anticipated outcome: As an observational objective, a hypothesis was not written. Based on prior research of diet quality in this age population, the expectation was that low proportions of students would report consuming a meal meeting the criteria of a "Wellness Meal" inspired rubric adapted for the purposes of this study.

Objective 2: Examine the relationship between the nutritional quality of meals chosen with respect to time spent in the dining hall, controlling for potential confounding factors including demographic, sociocultural, and lifestyle-related adjustment variables.

Hypothesis 2: The null hypothesis stated that there would be no meaningful meal nutrient quality difference found between groups categorized according to self-reported time spent in the dining hall. ($p > 0.05$) The alternative hypothesis stated that one or more differences would be detected in consumption levels of the 7 MNQ rubric components, particularly with regard to calorie and macronutrient intake being associated with increased time spent in the dining hall ($p < 0.05$).

Methods

This study used data from the Mason Undergraduate Nutrition for Campus Health (MUNCH) project. MUNCH was a cross-sectional study conducted during the 2015-2016 academic year to collect quantitative and qualitative data about the food choices of undergraduate students on George Mason University's Fairfax campus. This study used dietary data collected during 4 weeks in fall 2015 from a convenience sample of undergraduate students patronizing two on-campus dining halls.

Survey Data Collection

Surveys were collected electronically using the Surveymonkey.com platform and iPads. Student participants were recruited in-person by a researcher at the dining hall exits, who asked students to complete the survey during lunch hours (between 11a.m. – 3 p.m.) while exiting two of the three on-campus all-you-care-to-eat dining halls: Ike's is located in the typically lowerclassmen Presidents' Park neighborhood and Southside is located near center campus. Participants who completed the survey were eligible to enter

a drawing to win an iPad or gift cards to the campus bookstore. The survey protocol was approved by the George Mason University Institutional Review Board (789787-3), and subjects read a consent form and provided consent via a checkbox to begin the survey.

The survey included demographic questions, and questions about what they ate on this single eating occasion in the dining hall. The survey was pre-populated with menu items from lunch service that day, and students were asked to select the foods they ate and estimate the portion size they consumed, using dropdown number lists for the units provided (i.e., cups, tablespoons). An excerpt of one day's survey is available in the Appendix. Student researchers were available during surveys to assist, and measuring cups and spoons were available to help student participants estimate portion sizes. The survey generally took less than 10 minutes to complete, though time to complete the survey was not measured.

Study Population

Students were eligible to complete the survey if they self-reported as being an undergraduate student and were at least 18 years of age. This study collected data from 565 George Mason University undergraduate students. Student ages ranged from 18 to 39, with a mean age of 18.9 years ± 1.88 (463 out of 468 reporting for age). Meal plan status (on or off the meal plan) or campus living status (on or off campus) were not selection criteria. No students participated more than once.

Participant data was excluded from analysis in the following circumstances: less than three survey questions answered (n=6), observations reporting a BMI of less than

13.5 (n=4), observations whose time spent in the dining hall were missing (n=16), observations who had claimed to eat over 25 types of food *or* if they had claimed to eat equal to or more than 5 servings (the survey-listed maximum) for more than four foods (46 total deleted between the two outlier restrictions), and observations where calories eaten exceeded 3500 (26 observations). The study sample included 468 meals.

Generation of a Project-Specific Nutrient and Food Group Database

Student survey responses indicated consumption of 625 different dining hall foods during the weeks that surveys were administered. A database of nutrient and food group information was generated specifically for the foods included in this survey.[81] Nutrient information for most foods (calories, total fat, saturated fat, polyunsaturated fat, monounsaturated fat, trans fat, sodium, potassium, protein, vitamin A, vitamin C, calcium, and iron) was provided by the dining services contractor who managed the dining halls, Sodexo. For those foods where nutrient information was not available in the Sodexo database, information was retrieved directly from vendors (bakeries, lunch meat manufacturers), and at last resort, the best available match was identified in the USDA Food Composition Database, standard reference database, or Nutritionist Pro software (Axxya Systems, Redmond, WA).

Food group data was generated for each item and hand-coded, for each of the foods consumed. Sodexo recipes and amounts of individual ingredients were used in the majority of cases to determine the food group content of foods. Grain/whole grain, dairy/low-or-nonfat dairy, protein/lean protein, and fruit and vegetable group status were

determined using standards set by the Partnership for a Healthier America, whose 'Wellness Meal' standards were the basis for the Meal Nutrient Quality rubric used in this study. In addition, the USDA standard reference database and Nutritionist Pro software were used to determine food group content where unavailable through Sodexo, by using best-fit matches according to nutrient content.

Classification of Foods Offered as Single Food Group vs. Multiple Food Group

To support further analysis of the particular foods contributing to MNQ food group components of lunchtime dining hall foods selected by students, foods offered on data collection days were further classified according to whether they occurred as part of a single food MNQ rubric food group item or as part of a food containing multiple food groups – as an ingredient. This added layer of classification enabled identification of most-frequently chosen foods contributing to MNQ rubric fulfillment, but also a comparative assessment between MNQ food groups in the relative variety of foods chosen by students.

Whole-grain-containing foods were separated into two groups: single-food-group whole grain foods (such as brown rice, quinoa pasta, whole grain bread, etc.) and multiple-food-group containing foods (such as a soup that contains barley along with vegetables and lean meat). Similarly, lowfat and nonfat dairy containing foods were separated into single-food-group low/nonfat dairy foods (such as skim milk or low/nonfat yogurt, but also including dairy alternative equivalents such as soy milk) and multiple-food-group containing low/nonfat dairy foods (such as a macaroni and cheese recipe

made with skim milk). Lean-protein-containing foods were separated into single-food-group lean protein foods (such as dishes with unbreaded chicken breast, deli turkey, etc.) and multiple-food-group containing foods (such as a soup that vegetables and lean meat, or a pizza with chicken breast as a topping). Fruit-and-vegetable-containing foods were divided into categories of fruit-and/or-vegetable-only foods (such as fresh fruit, mixed vegetables, cooked vegetables, salsas and relishes, etc.) and multiple-food-group containing foods (such as a soup that contains vegetables, but also lean meats and grains or dairy, or a sandwich with vegetable toppings).

Additionally, to identify patterns or clusters of similar foods, some menu items were further classified according to general menu type (pizzas, pastas, sandwiches, rice dishes, egg dishes, etc.) to better summarize and highlight popular choices. For example, pizzas are a common Sodexo offering, but the toppings and other ingredients may vary slightly from one day to the next, this menu type subclassification enabled broader generalization when identifying consumption patterns.

Adaptation and Implementation of a Meal Nutritional Quality (MNQ) Rubric

The Partnership for a Healthier America's Healthier Campus Initiative includes an 8-point Wellness Meal guideline for selection of high nutritional quality meals at lunchtime[78]. The standards for meal nutritional quality (MNQ) set forth by this initiative are shown in Table 1. Because Sodexo at George Mason University does not serve foods with trans fats, this study adapted a 7 point rubric based upon the same parameters, while dropping the trans fat component, in order to avoid creating inflated rubric scores that

would have otherwise resulted from all student diners meeting the trans fat requirement. Food group content, calories, saturated fat, and sodium were calculated according to portion sizes consumed, using the project-specific nutrient database.

Using the parameters set forth by the 7 point Meal Nutrient Quality (MNQ) rubric for this study, respondents were assigned a component score for each of the 7 components. Component scores were binary, where 0 indicated having not met and 1 indicated having met the requirement for each respective component. For example, if a student's meal was less than 700 calories, they were assigned a component score of 1 to indicate that they had successfully met that component. In the theoretical case of a student's meal meeting all 7 rubric component requirements, the maximum MNQ score possible, therefore, would be a score of 7, while the minimum possible score (no rubric requirements met) would be 0.

Table 1: Partnership for Healthier America meal nutritional quality standards for lunchtime meals, and factors included in the adapted MNQ rubric

Nutritional Aspect	Rubric Parameter	Partnership for a Healthier America Healthier Campus Initiative lunchtime Wellness Meal guidelines	Modified lunchtime meal nutritional quality (MNQ) rubric
1. Whole Grains	≥ 2 ounce equivalents consumed in one meal	✓	✓
2. Low or Nonfat Dairy	≥ 1 cup equivalent consumed in one meal	✓	✓
3. Fruits and Vegetables	≥ 1.75 cups consumed in one meal	✓	✓
4. Lean Protein	≥ 2 ounce equivalents consumed in one meal	✓	✓
5. Calories	≤ 700	✓	✓
6. Saturated Fat	≤ 10% of total meal calories from saturated fat	✓	✓
7. Sodium	≤ 800 milligrams in one meal	✓	✓
8. Trans Fat	0 grams consumed	✓	

Time Spent at the Dining Hall

Time spent at the dining hall on this single eating occasion was assessed by one question on the survey: "Please estimate how much time you spent at the dining hall during this visit." Answer options were categorical: < 15 minutes, 15-30 minutes, 30-60 minutes, 60-120 minutes, and >2 hours.

Figure 1: Excerpt from original survey text as administered.

For the purpose of analysis, student responses were categorized together as follows: students who spent a very short time (<15 minutes), a moderate amount of time (15-60 minutes, the reference group), or a longer time (>60 minutes) in the dining hall during this visit. While this categorization may be broad and lose some precision, it likely provides a reasonable approximation given students' potential difficulty in estimating time.

Descriptive Statistics and Statistical Analysis

Foods were divided into categories and subcategories including all MNQ categories (whole grains, low/nonfat dairy, lean protein, fruits and vegetables, calories, saturated fat as a percentage of calories, and sodium), but also assessments of foods as containing predominantly one or multiple food groups, according to MNQ food group categories, as well as total grains, total dairy, and total protein intakes. Additional

subcategories were created to summarize food selections, describing certain foods as pizzas, pastas, breads, desserts, soups, rice dishes, etc., in order to give a broader understanding of which types of foods were most commonly selected by the students in the subsample.

Statistical analyses were conducted to examine whether there was an overall difference in nutritional quality – or a difference across particular meal nutrient quality rubric components. Linear regression analysis was conducted for intake of nutrients and food groups, respectively, as well as total rubric score, across dining hall time groups. In addition, logistic regression analysis was conducted for rubric component sufficiency – to evaluate significant differences between groups – based on time reported spent in the dining hall – for fulfilling the requirements of each of the MNQ rubric's 7 points. MNQ rubric scores (linear regression) and meeting recommendation based on score (logistic regression) represented dependent variable outcomes, while time spent in the dining hall was the independent variable. Covariates identified in this study included variables associated with physiological impact upon energy intake: age, gender, and BMI. Race was also included as an adjustment variable, to account for potentially associated dietary selection differences. Student lifestyle factors collected in survey demographic data which were expected to impact either time spent in the dining hall or overall food intake factors were included as covariates, including meal plan status (on or off the meal plan), campus living status (on or off campus), self-reported degrees of food insecurity, and the option (or lack thereof) of dormitory kitchen access. Statistical analysis was performed using Stata, version 14.2 (College Station, TX).

Results

Demographic Overview

The MUNCH survey assessed race and/or ethnicity through a single question, which can be seen as shown in the survey excerpt below:

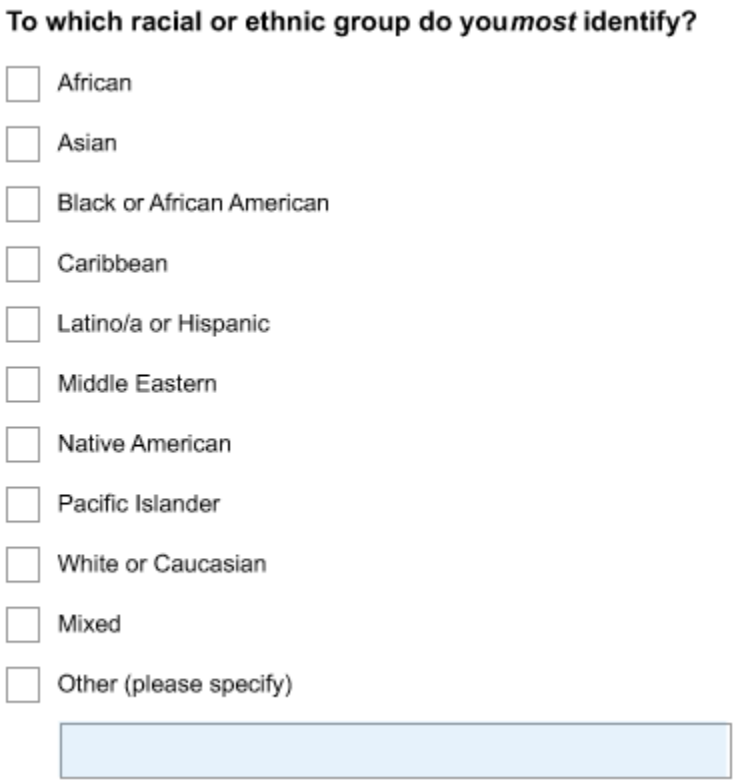

Figure 2: Assessment of race/ethnicity identification of responding students in MUNCH survey.

Survey respondents were diverse, reflecting the diversity of George Mason University's population at large[82,83]. Just over half of respondents described themselves as white or Caucasian, 15.6% described themselves as African American, 8.76% self-reported as Asian, 9.19% self-reported as mixed race and the remaining 12.82% came from a variety of other origins, including Middle Eastern and Latino/a or Hispanic. Self-reported race and ethnicity numbers and percentages can be seen in Figure 2 on the next page.

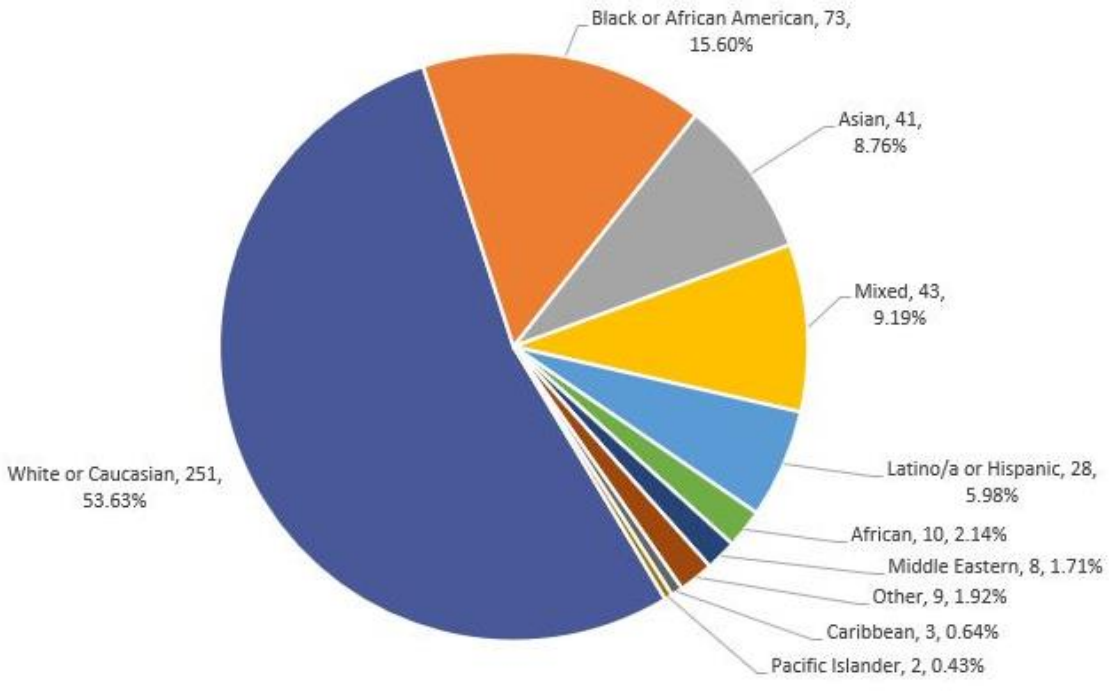

Figure 3: Summary of race/ethnicity by MUNCH survey respondents (n=468)

Additional demographics, including gender, meal plan status, kitchen access status, and self-reported food insecurity status, can be seen in Table 2. When categorizing respondents according to the period of time they reported spending in the dining hall on the day of the survey, demographic proportions differ slightly. For example, while percentages of men and women were within 6 percentage points of each other for the <15 minute group and the 15-60 minute group, of those reporting the longest stays at >60 minutes, 57% (n = 16) were men and 43% were women (n = 12). One student who lived off campus was in the group 45 students who spent <15 minutes in the dining hall, while four out of 28 students in the >60 minute group were off-campus residents.

Table 2: Demographic and lifestyle proportions across time groups

	<15 min	15-60 min	>60 min
Characteristics	n (%)	n (%)	n (%)
Gender			
Male	22 (48.89%)	186 (47.09%)	16 (57.14%)
Female	23 (51.11%)	207 (52.41%)	12 (42.86%)
Not reported	0	2 (0.51%)	0
Residence			
On-Campus	42 (97.67%)	362 (92.35%)	23 (85.19%)
Off-Campus	1 (2.33%)	30 (7.65%)	4 (14.81%)
Not reported	2 (4.44%)	3 (0.76%)	1 (3.57%)
Meal Plan Status			
On a meal plan	44 (97.78%)	379 (95.95%)	27 (96.43%)
No meal plan	1 (2.22%)	16 (4.05%)	1 (3.57%)
Food insecurity			
Agree/Strongly Agree	6 (14%)	34 (9%)	2 (7%)
Somewhat Agree/Somewhat Disagree	19 (43%)	146 (38%)	11 (39%)
Disagree/Strongly Disagree	19 (43%)	205 (53%)	15 (54%)
Race			
White or Caucasian	21 (47%)	218 (55%)	12 (43%)
African American	7 (16%)	62 (16%)	4 (14%)
Asian	6 (13%)	32 (8%)	3 (11%)
Caribbean	1 (2%)	2 (1%)	0 (0%)
Mixed	2 (4%)	38 (10%)	3 (11%)
Other	8 (18%)	43 (11%)	6 (21%)

Nutritional Quality of Lunchtime Meals Selected by GMU Undergraduates

The MNQ rubric was used to assess nutritional quality of undergraduate meals. Table 3 illustrates mean consumption for respective rubric components. It also includes totals calculated for non-rubric components: total grains (refined and/or whole, ounce equivalents), total dairy (all fat contents inclusive, cup equivalents), and total protein (lean and/or otherwise, ounce equivalents) consumed. MNQ rubric categories where means did not fulfill requirements included whole grains (0.35 oz. equivalents ±0.95), low or nonfat dairy (0.12 cup equivalents ±0.43), calories (1037.33 ±671.72), and sodium (1614.24 ±1364.95). Whole grain and for low or nonfat dairy categories had medians of zero, indicating most students' total failure to consume any of these food groups.

Table 3: Fulfillment of components of the Meal Nutritional Quality (MNQ) rubric during undergraduates' lunchtime dining hall visits (n=468).

Nutritional Aspect	Meal Nutritional Quality Rubric Parameter	Average Amount Consumed		Standard Deviation	Median
Total Grains	*N/A*	2.97	oz. eq.	±2.67	2.39 oz. equiv.
Whole Grains	≥ 2 oz. equivalent	**0.35**	**oz. eq.**	±0.95	0 oz. eaten
Total Dairy	*N/A*	1.14	cup eq.	±1.43	0.72 cups eaten
Low or Nonfat Dairy	≥ 1 cup equivalent	**0.12**	**cup eq.**	±0.43	0 cups eaten
Total Protein	*N/A*	3.92	oz. eq.	±4.52	2.78 oz. equiv.
Lean Protein	≥ 2 oz. equivalent	2.63	oz. eq.	±3.94	1.25 oz. equiv.
Total Fruits and Vegetables	≥ 1.75 cup equivalent	2.52	Cups	±3.47	1.10 cups
Calories	≤ 700 calories	**1037.33**	**calories**	±671.72	898 calories
Saturated Fat	≤ 10% total cal. from sat. fat	9.14	% of cal.	±5.37	8.89%
Sodium	< 800 mg	**1614.24**	**Mg**	±1364.95	1280.95 mg

Nutritional components whose average consumption levels do not meet rubric fulfillment are bolded. Greyed rows indicate food group data not included in scoring for the MNQ rubric.

Individual Rubric Component Scores

As can be seen in Figure 4, nearly two thirds (60%) of student-reported meals met the <10% of calories as saturated fat criteria, which represented the most commonly reached rubric criterion. About one third met the requirement set for less than 700 calories and less than 800 milligrams of sodium (37% and 28%, respectively). For the MNQ requirement of at least 2 ounces of lean protein per meal, 45% of student meals met the criterion, while the 1.75 cups of fruit and vegetable content were met by 40% of student reported meals. Also, the least commonly achieved rubric criteria were consumption of 1 cup or more of low/non-fat dairy and 2 ounces of whole grains, which only 4% and 8% of participating students achieved, respectively.

Total Rubric Scores and Categories by Score

Figure 5 illustrates the grouping of student meals by MNQ scores and the frequency of achieving each rubric criterion within each rubric score. Forty-six students attained a score of zero. Scores of 3 were the most commonly attained score, with 140 student meals being rated at this score. MNQ scores of 5 – the greatest meal score awarded out of the MNQ's possible 7 points – were achieved by 6 students. No student meals received a score of 6 or 7. Rates of attainment of a rubric component increased with rubric score for all food groups, with the exception of lean protein attainment between scores of 2 and 3, after which lean protein rubric attainment again rose with each subsequent rubric score.

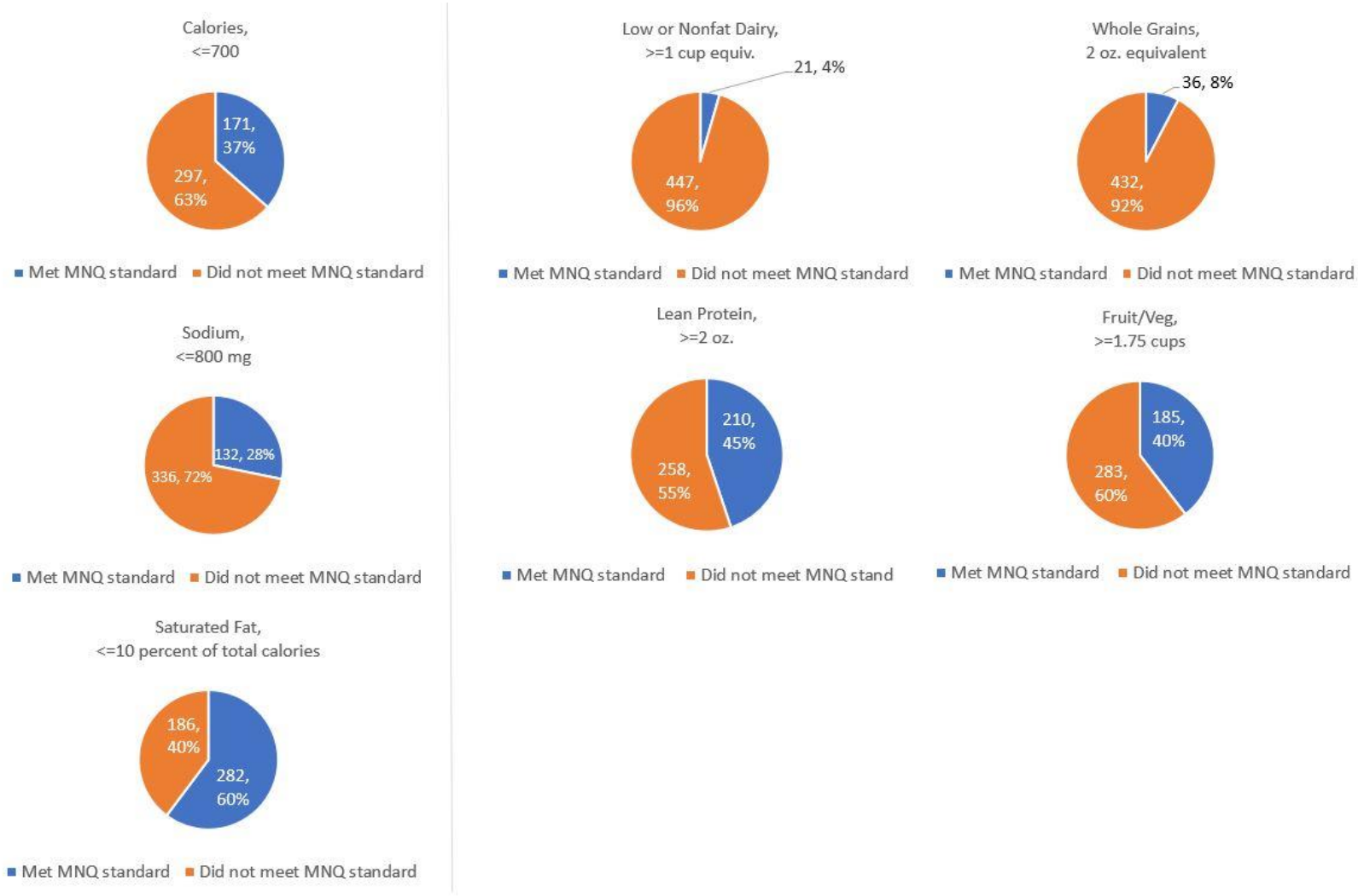

Figure 4: Meal Nutritional Quality (MNQ) rubric attainment. Proportions of students fulfilling each of the 7 rubric requirement categories are shown.

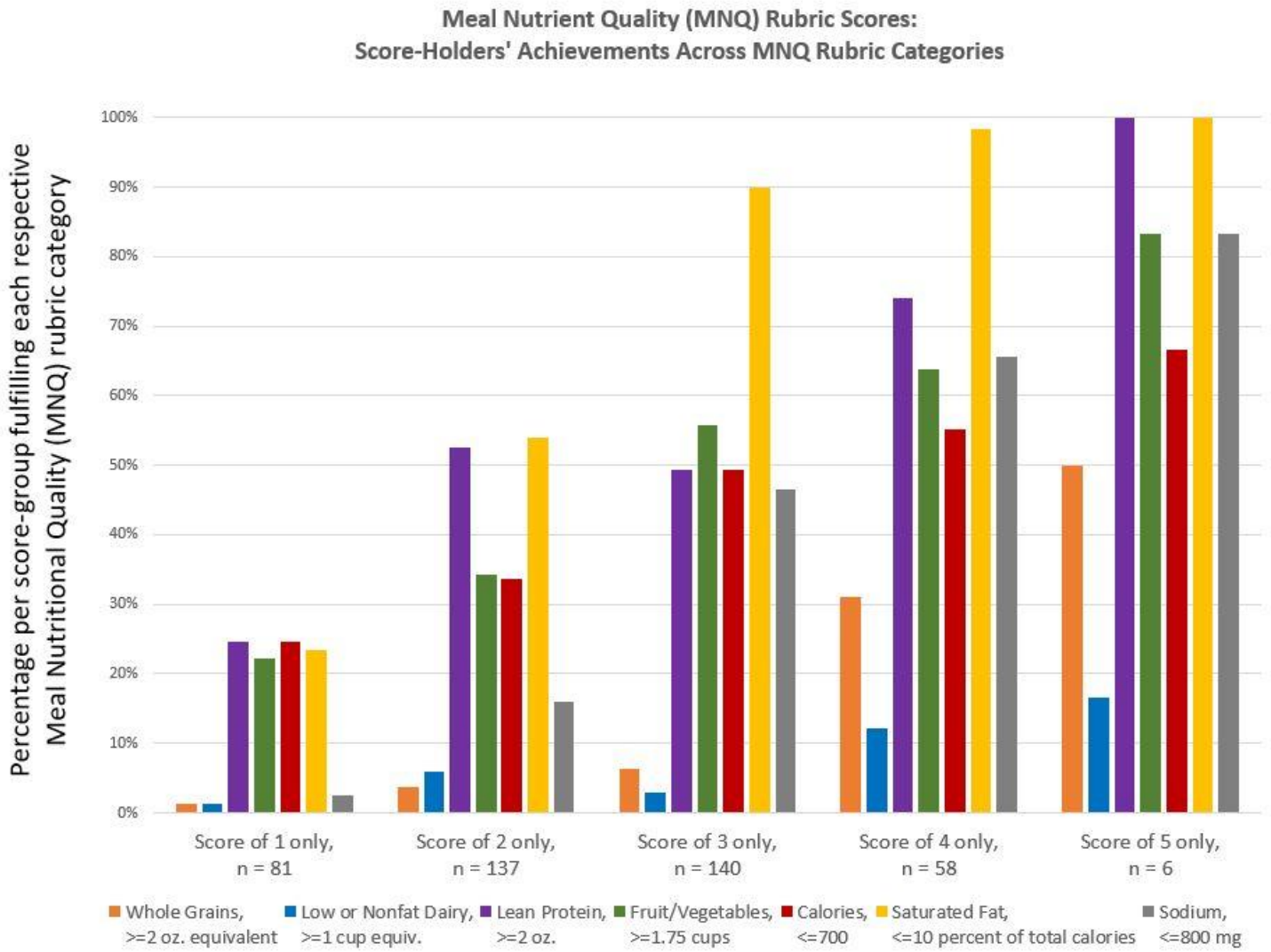

Figure 5: Percentages of each group of student meals, grouped by MNQ score, fulfilling each MNQ category

Mean Whole Grain Consumption Among Whole Grain-Containing Foods Selected

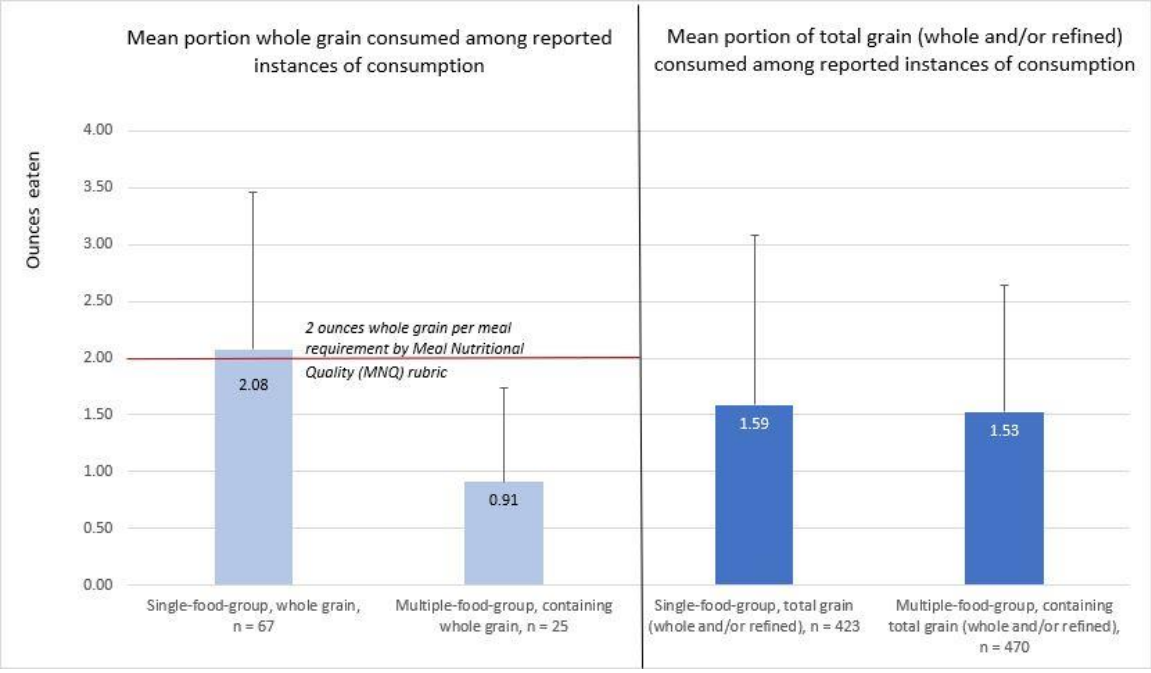

Figure 6: Mean ounces consumed of whole grains and total grains (whole and/or refined) consumed among reported instances of consumption

An analysis was conducted to examine the difference in amounts of grains consumed, between whole-grain-containing and total-grain-containing foods. These results can be seen in Figure 6. Note that while Table 3 shows average consumption of whole grains for *all meals* reported (n = 468), which includes meals that have no whole grains, Figure 6 details the mean whole grain consumption levels for *individual selections of given whole-grain-containing foods* – that is, detailing amounts of whole grain consumed only in cases of whole-grain-containing foods reported as consumed.

For whole-grain-containing foods, mean consumption of a single-food-group whole grain food (brown rice, whole grain bread, etc.) was 2.08 ounce equivalents (oz eq)

± a standard deviation of 1.39. Multiple-food-group foods containing whole grain (soups with barley, whole grain protein and vegetable wraps, etc.) were reported at mean consumption corresponding to 0.91 oz eq ± 0.83. For foods with any grain content (whole and/or refined), the mean consumption of grain content was 1.59 oz eq ± 1.49 for single-ingredient foods and 1.53 oz eq ± 1.12 for multiple-ingredient foods.

Overview: Types and Frequencies of Whole-Grain-Containing Foods Selected

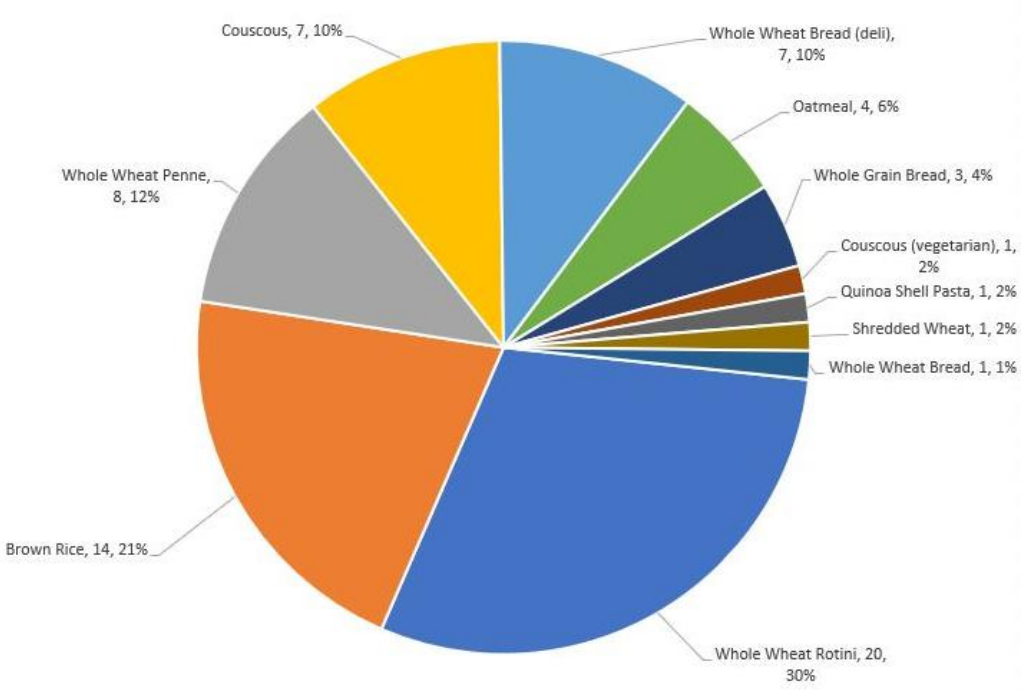

Figure 7: Frequency chosen, single-food-group items containing whole grains.
n = 67 total choices made for single-food-group whole grain foods.

Figures 7 (single-food-group whole grain items) and 8 (multiple-food-group whole grain items) illustrate breakdowns in terms of types of foods. As shown in Figure 7, whole wheat rotini, whole wheat penne, and brown rice collectively made up approximately 63% (42 choices) of all single-food-group whole grain items choices (out of 67 single-food-group whole grain food choices made). Other whole grain foods chosen included couscous (7 choices made), whole wheat and whole grain bread (11 choices total), oatmeal (4 choices), and one choice each for quinoa pasta and shredded wheat.

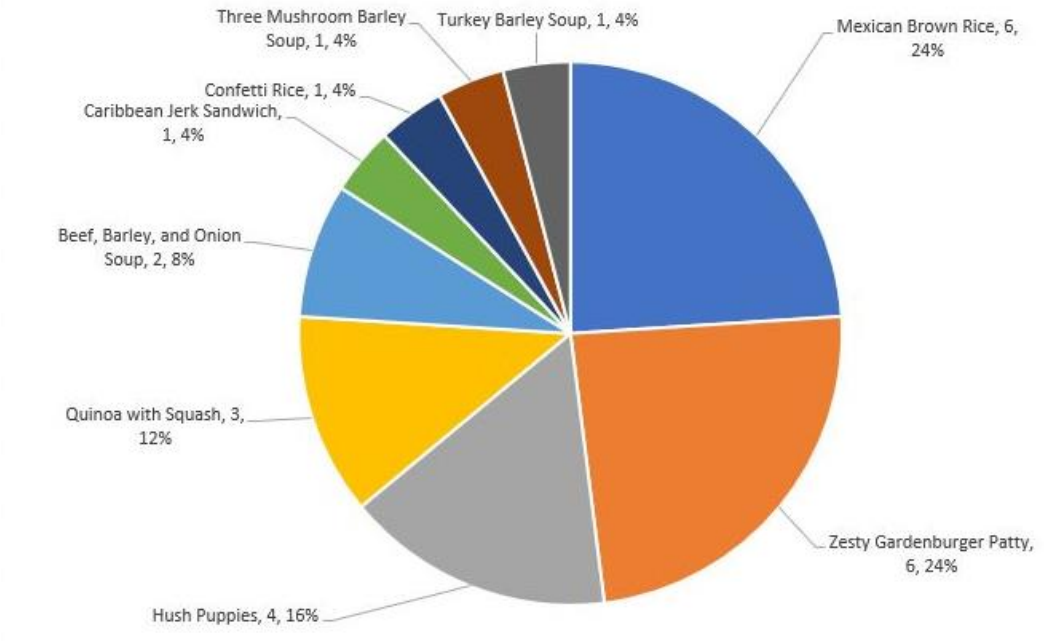

Figure 8: Frequency chosen, multiple-food-group items containing whole grains. n = 25 total choices made for multiple-food-group foods containing whole grain.

For multiple-food-group whole-grain-containing foods (n = 25 choices made total), nearly half of the choices (48% total) are attributable to a Mexican brown rice dish and the zesty Gardenburger patty, which contains oats as an ingredient. As shown in Figure 8, the remaining half correspond to a variety of choices, including hush puppies (which are made with corn meal), quinoa with squash, a beef barley soup, a turkey barley soup, a three mushroom barley soup, a Caribbean jerk sandwich, and a confetti rice dish which is made with pearl barley.

Mean Lowfat and Nonfat Dairy Consumption Among Low/Nonfat-Dairy-Containing Foods Selected

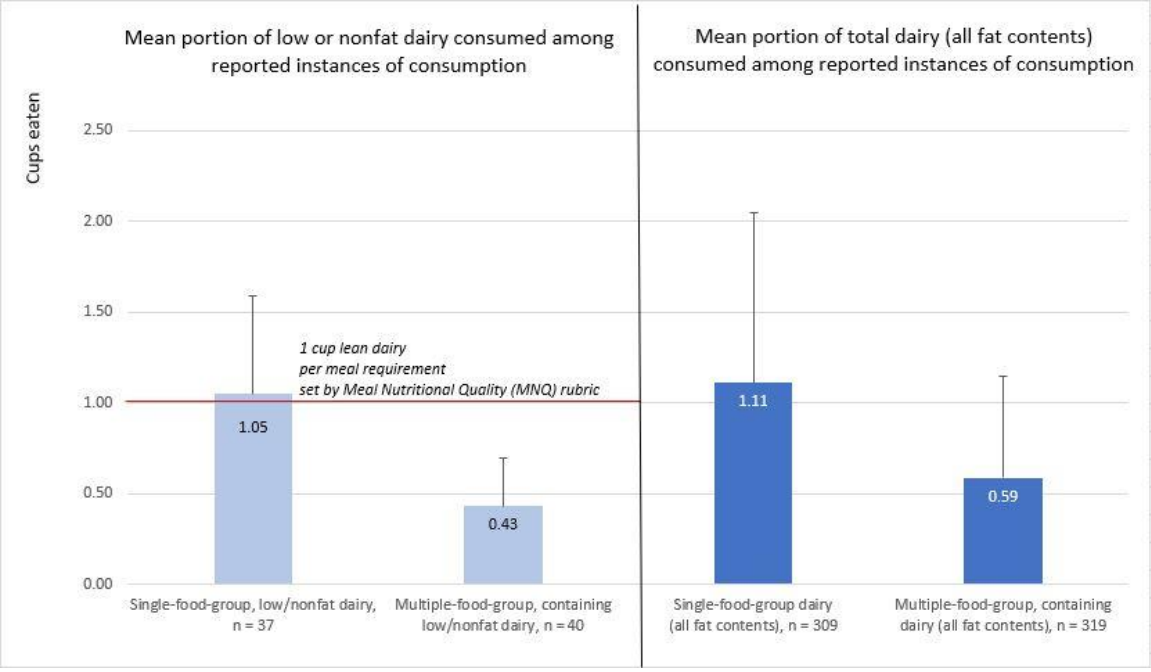

Figure 9: Mean cups/cup equivalents of low/nonfat dairy and total dairy (all fat contents) consumed among reported instances of consumption.
In both cases, selection of a multiple-food-group food resulted in less low/nonfat dairy (left, 0.43 c.) and less total dairy (right, 0.59 c.), compared with single-food-group low/nonfat and total dairy foods, respectively.

An analysis examined the difference in amounts of dairy consumed, across varying categories of low/nonfat-dairy-containing and total-dairy-containing foods. These results can be seen in Figure 9. Note that while Table 3 shows average consumption of whole grains for *all* meals reported (n = 468), which includes meals that have no dairy reported as consumed, Figure 9 details mean lowfat and nonfat dairy consumption levels for *individual selections of given low/nonfat-dairy-containing foods* – that is, detailing amounts of whole grain consumed only in cases where whole-grain-containing foods were reported to have been consumed.

For low/nonfat-dairy-containing foods, mean consumption of a single-food-group low/nonfat dairy food (lowfat strawberry yogurt, skim milk, etc.) was 1.05 ± 0.54 cup equivalents (c eq), while students consumed 0.43 c eq ± 0.27 of low/nonfat dairy from chosen multiple-food-group items containing low/nonfat dairy (such as macaroni and cheese or a fruit smoothie). For foods with any dairy content (all fat contents), the mean consumption of dairy content was 1.11 c eq ± 0.94. for single-ingredient foods and 0.59 c eq ± 0.56 for multiple-ingredient foods.

Overview: Types and Frequencies of Low/Nonfat-Dairy-Containing Foods Selected

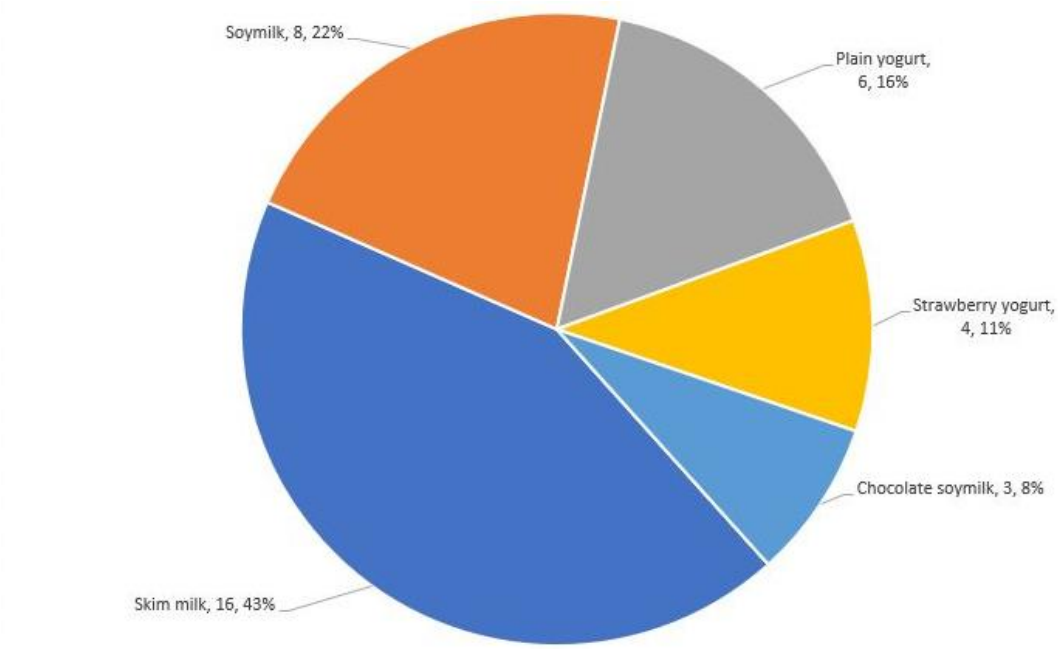

Figure 10: Frequency chosen, single-food-group items containing lowfat or nonfat dairy. n = 37 choices made.

As shown in Figure 10, 5 foods that qualified as single-food-group low/nonfat dairy were selected by students (n = 37 choices made for this category, total). Skim milk was the most-chosen item (16 choices), followed by soymilk (8 choices), plain lowfat yogurt (6 choices), strawberry yogurt (4 choices), and chocolate soymilk, 3 choices.

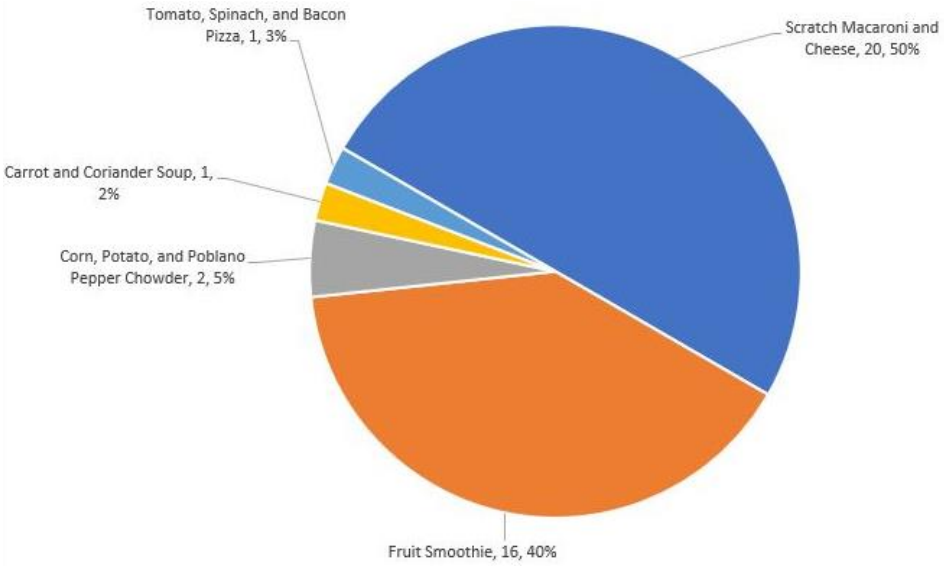

Figure 11: Frequency chosen, multiple-food-group items containing lowfat or nonfat dairy. n = 40 choices made.

As seen in Figure 11, for multiple-food-group low/nonfat-dairy-containing foods (n = 40 choices made total), half of the choices were for a macaroni and cheese dish, followed by 16 choices (40%) made to consume a fruit smoothie. Tomato, spinach, and bacon pizza, and carrot and coriander soup were both chosen each only once, and a corn and potato chowder was chosen twice.

Mean Lean Protein Consumption Among Lean-Protein-Containing Foods Selected

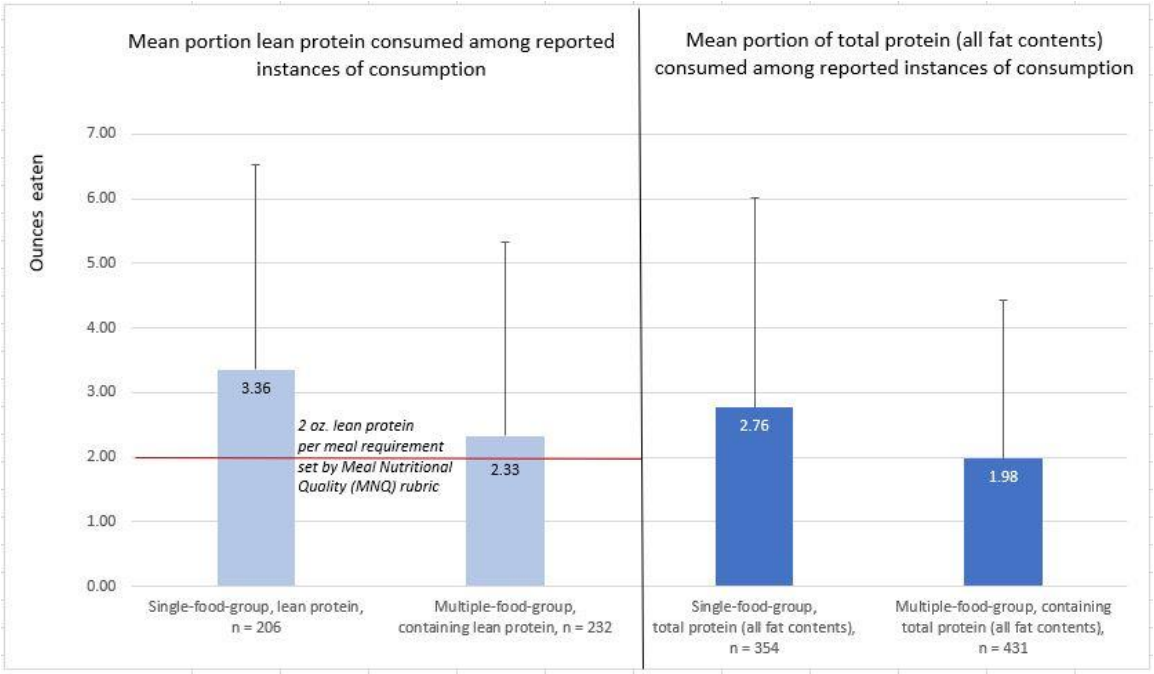

Figure 12: Mean ounces of protein consumed in reported instances of consumption.
On the left, single-food-group foods and multiple-food-group foods, and on the right, total protein (all fat contents) containing single-food-group and multiple-food-group foods.

An analysis was conducted to examine the difference in amounts consumed across varying categories of lean-protein-containing and total-protein-containing foods. These results can be seen in Figure 12. Note that while Table 3 shows average consumption of lean protein and total protein for *all* meals reported (n = 468), which includes meals that have no protein content, Figure 12 details the mean consumptions only in cases where lean or total protein containing foods were reported to have been consumed. For lean-protein-containing foods, mean consumption of a single-food-group lean protein food (chicken breast, boiled eggs, etc.) was 3.36 ounce equivalents (oz eq) ± 3.16, while mean consumption of multiple-food-group foods containing lean protein was

2.33 oz eq ± 3.01. For foods with any protein content, the mean consumption of protein was 2.76 oz eq ± 3.25 from single-food-group foods and 1.98 oz eq ± 2.45 from multiple-food-group foods.

Overview: Types and Frequencies of Lean-Protein-Containing Foods Selected

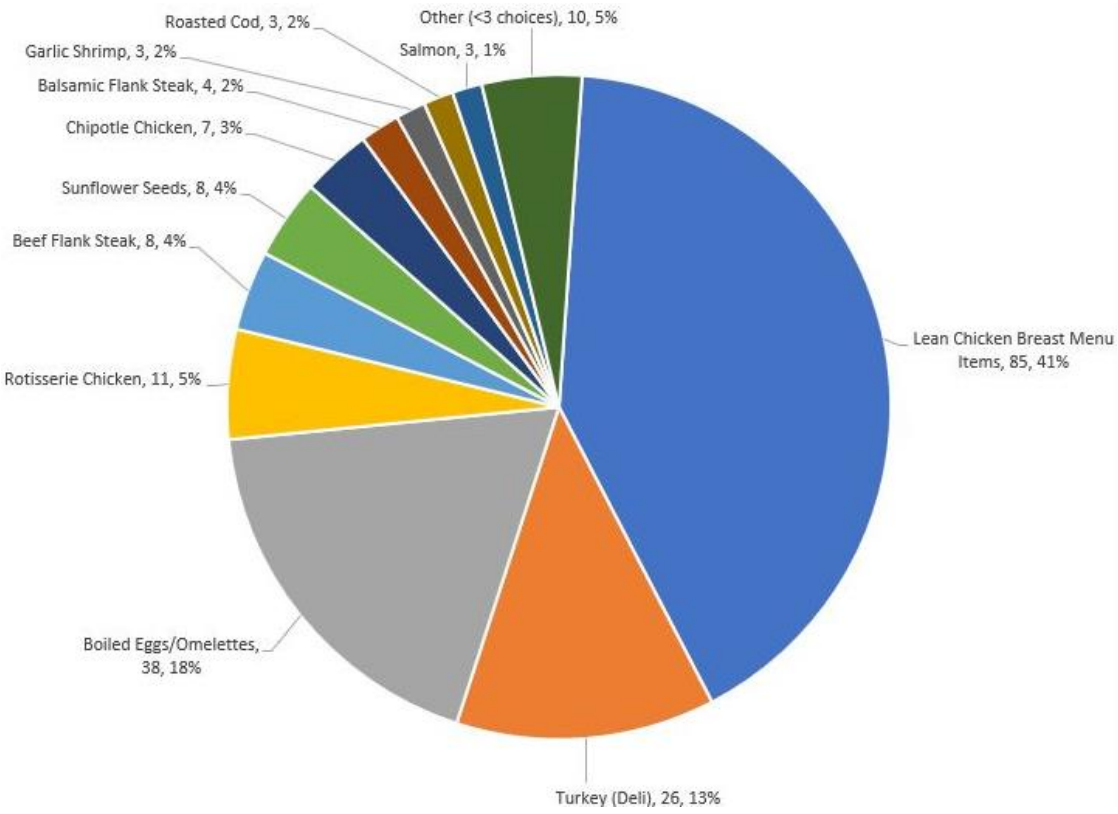

Figure 13: Frequency chosen, single-food-group items containing lean protein. n = 206 choices made.

As shown in Figure 13, lean chicken breast menu items make up the largest portion of single-food-group protein choices made (85 choices), out of 206 single-food-group protein food choices made. Other lean protein single-food-group items chosen included deli turkey (26 choices), and boiled eggs and omelettes (38 choices). A little over one quarter of the other choices made included rotisserie chicken, flank steak, sunflower seeds, chipotle chicken, flank steak, garlic shrimp, roasted cod, salmon, and a subcategory of other choices, in which foods chosen had <3 choices made per food, respectively.

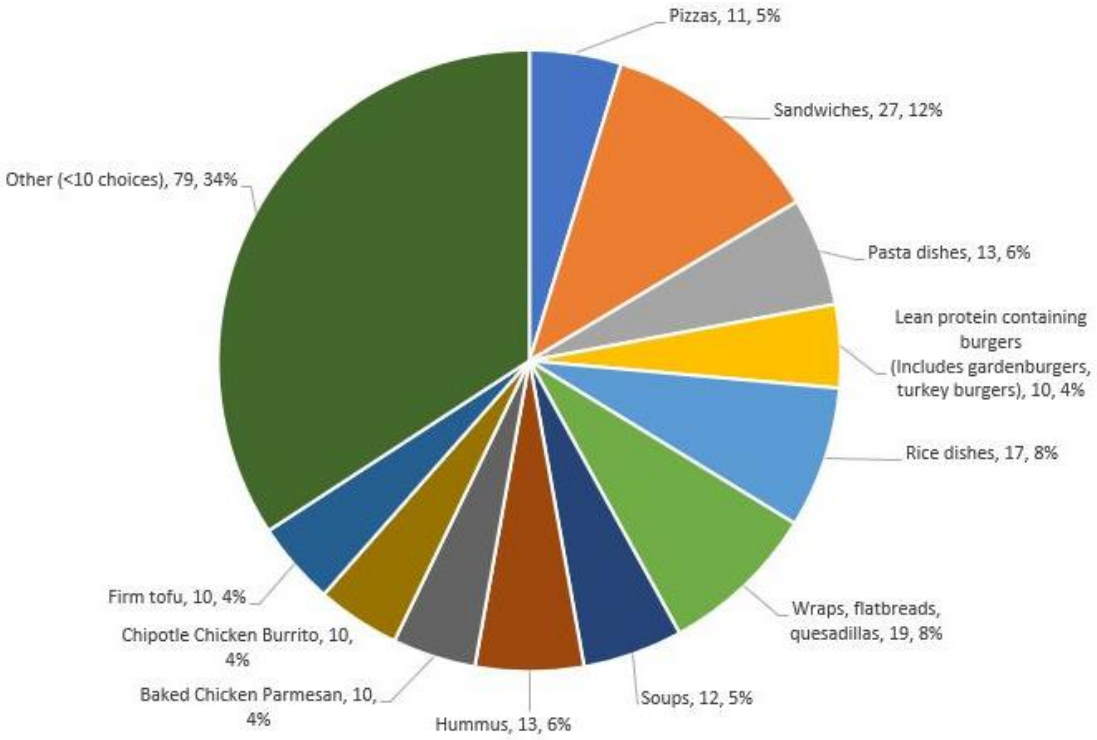

Figure 14: Frequency chosen, multiple-food-group items containing lean protein. n = 231 choices made.

As can be seen in Figure 14, multiple-food-group lean-protein-containing foods (n = 231 choices made total), about one third of the choices (34% total) are a subcategory of "other" foods who each have less than 10 student choices made, respectively. The remainder of the choices are split between pizzas (11 choices, 5%), sandwiches (27 choices, 12%), pasta dishes (13 choices, 6%), burgers (10 choices, 4%), rice dishes (17 choices, 8%), wraps, flatbreads, and quesadillas, (19 choices, 8%), soups (12 choices, 5%), hummus (13 choices, 6%), baked chicken parmesan (10 choices, 4%), chipotle chicken burrito (10 choices, 4%), firm tofu (10 choices, 4%).

Mean Fruit and/or Vegetable Consumption Among Fruit-and/or-Vegetable-Containing Foods Selected

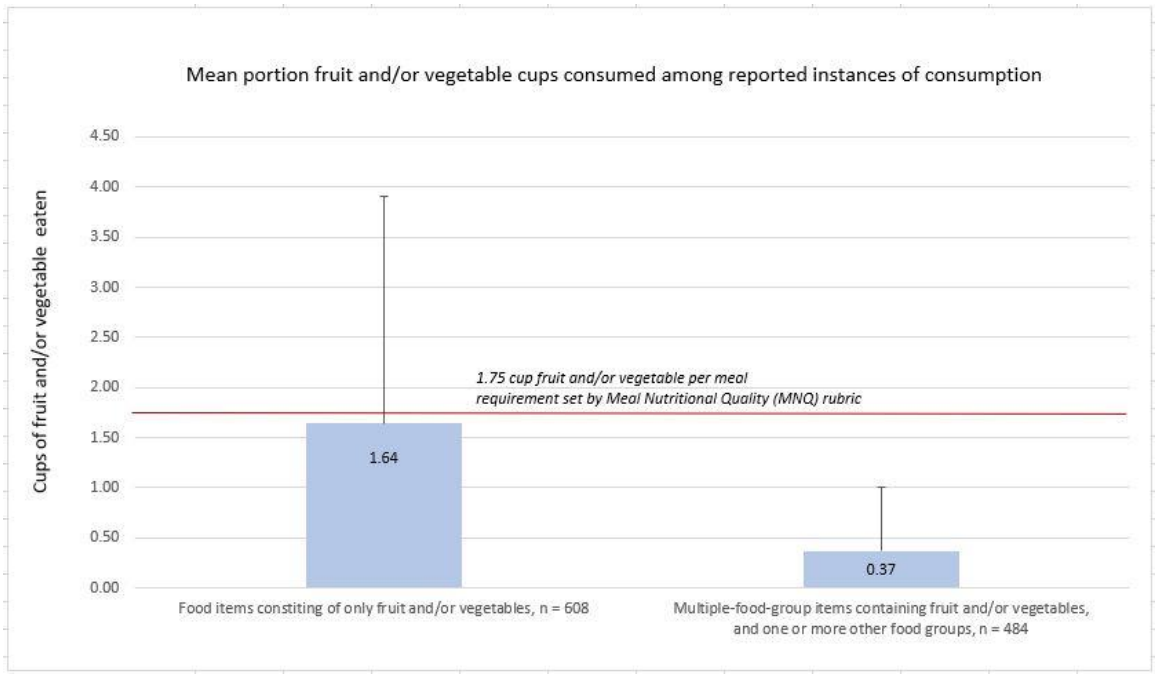

Figure 15: Average consumption of fruit and/or vegetables.
Food items containing only fruit and/or vegetables would be items such as fresh cut fruit, salad bar vegetables, vegetable stir fries, or combined fruit-vegetable items such as a mango salsa. Multiple-food-group items contain either fruit and/or vegetables, but also at least one other food group.

Figure 15 shows the results of an analysis of mean fruit and/or vegetables consumed from individual foods consisting of fruit and/or vegetables alone, versus mean fruit and/or vegetables consumed from foods consisting of fruit and/or vegetables and at least one other food group. Note that while Table 3 shows average consumption of fruits and vegetables for *all* meals reported (n = 468), which includes meals that have no fruit and/or vegetable content, Figure 15 details the mean consumption levels for each respective food only in cases of fruit-and/or-vegetable-containing foods reported as having been consumed. For fruit-and/or-vegetable-only foods, mean consumption was

1.64 cups (c) ± 2.27. For fruit-and/or-vegetable-containing foods that also have other food groups, mean consumption was 0.37 c ± 0.63.

Overview: Types and Frequencies of Fruit-and-Vegetable-Containing Foods Selected

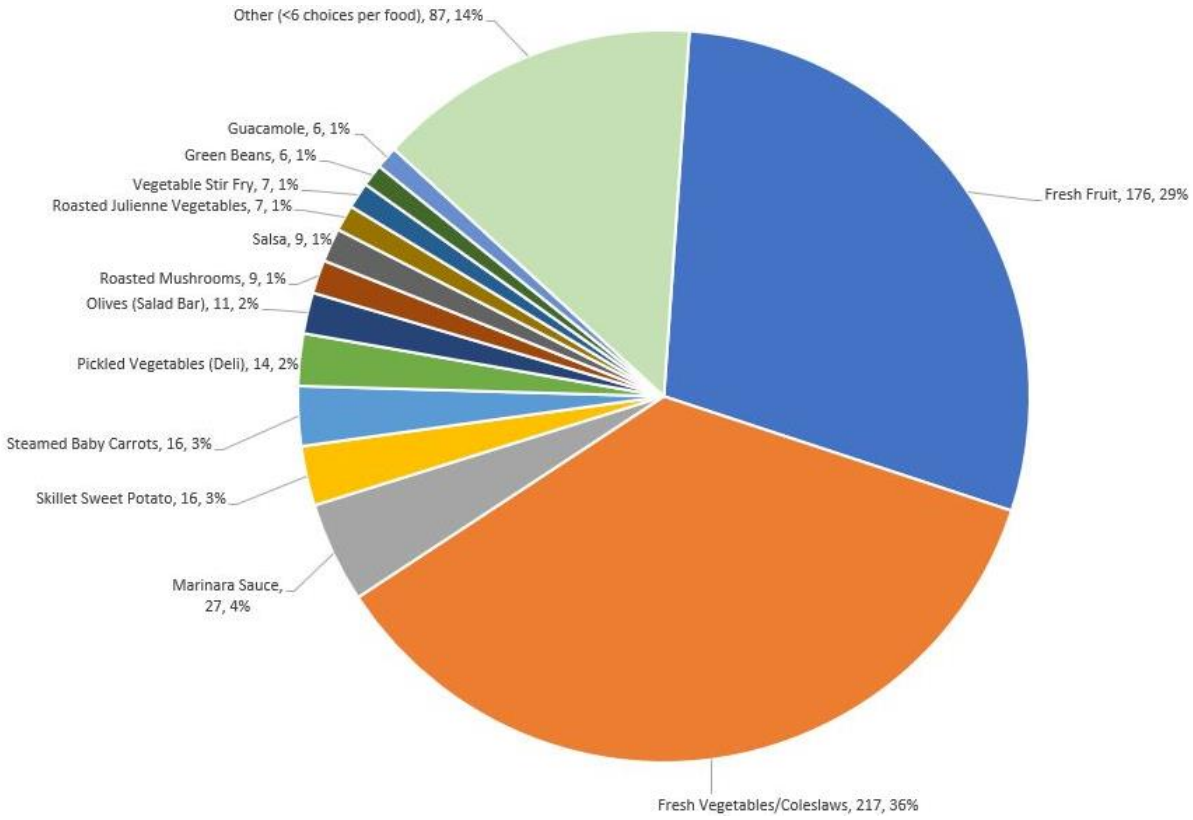

Figure 16: Frequency chosen, items containing only fruit and/or vegetables. n = 608 choices.

Fresh vegetables make up 36% of all fruit-and/or-vegetable-only choices. Fresh fruit is next, with 29% of fruit-and/or-vegetable-only choices made (n = 608 choices). A variety of other fruit-and/or-vegetable-only combination foods complete the remaining 21% of choices made in this category.

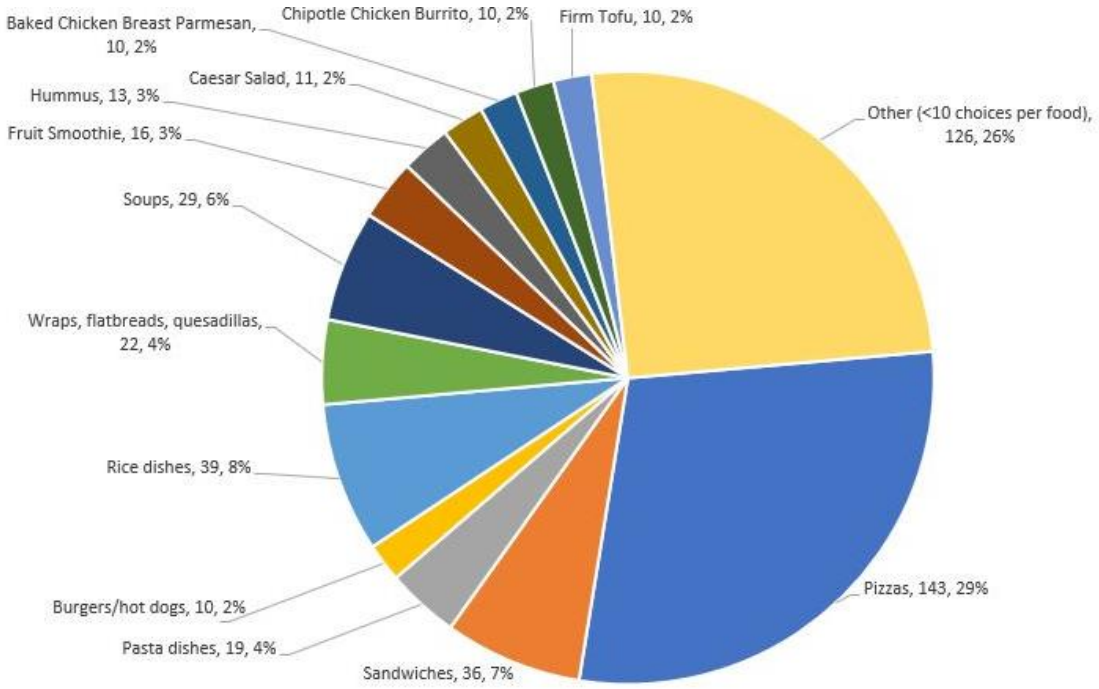

Figure 17: Frequency chosen, multiple-food-group items containing fruit and/or vegetables. n = 494 choices made.

As seen in Figure 17, out of 494 choices made for multiple-food-group items containing fruit and/or vegetables, pizzas were the largest subcategory, with 143 choices (29% of all choices made), due in large part to tomato sauce content. Sandwiches, pasta dishes, burgers, rice dishes, wraps flatbreads, and quesadillas, and soups made up a further 31% of choices made for multiple-food-group items containing fruit and/or vegetables and at least one additional food group.

Calorie Intake

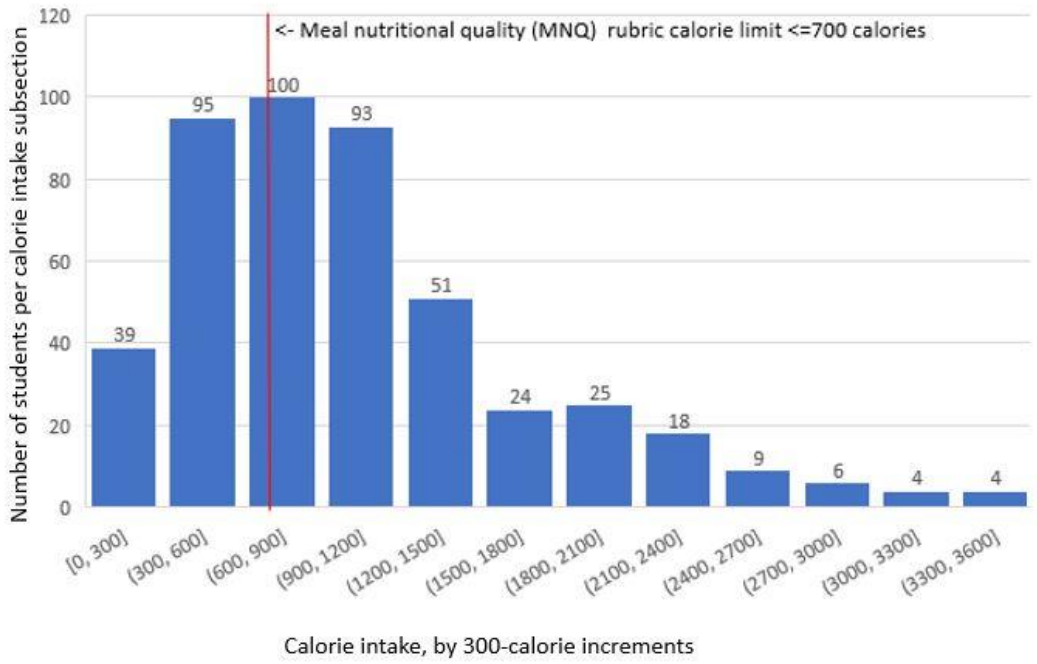

Figure 18: Frequency of student meal calorie intakes.

Figure 18 displays a frequency histogram for reported caloric intake in this study, after excluding outliers. The average reported caloric intake, 1037 calories, exceeds the MNQ rubric calorie limit of ≤700 calories per lunchtime meal (shown as a red line on the histogram).

Saturated Fat Intake as a Percentage of Calories

Mean saturated fat intake was at 9.14% of calories eaten ± 5.37%. This mean falls under the MNQ limit of ≤10% of calories from saturated fat. 60% of respondent meals met the MNQ saturated fat requirement.

Sodium Intake

Mean sodium intake was at 1614.24 mg ± 1364.95, with a median of 1280.95 mg consumed. Of respondent meals, just over one quarter (28%) fulfilled the MNQ rubric requirement that the lunchtime meal contain no more than 800.mg of sodium.

Analysis of Nutritional Quality of Meals According to Time Spent in Dining Halls

A linear regression analysis was conducted to determine if there were any associations between time spent in the dining hall and nutrient intake, as corresponded to the MNQ rubric (Table 4). Average calorie consumption variation between the longest duration and reference time groups trended toward significance ($p = 0.08$). In the case of students staying more than 60 minutes ($n = 28$), mean calorie intake was nearly 200 calories lower than the reference group, who stayed 15-60 minutes. There were no statistically significant differences in nutritional quality of students' meals.

A subsequent logistic regression analysis was conducted to determine if there were any associations between time spent in the dining hall and likelihood of meeting MNQ rubric requirements. As can be seen in Table 5, student meals during <15 minute dining hall visits are 64% less likely to meet the MNQ requirement for lean protein when

compared with student meals during moderate duration dining hall stays visits of 15-60 minutes (p = 0.01) No other differences of statistical significance were detected when conducting logistic regression analysis for MNQ attainment.

Table 4: Mean differences in MNQ rubric component intake and rubric scores, across time groups.

	<15 min (n=45)		**15-60 min (n=395)**		**>60 min (n=28)**	
	Mean (SD)	**p value**	**Mean (SD)**	**p value**	**Mean (SD)**	**p value**
Energy Intake						
Calories	897.35 (766.75)	0.42	1065.04 (665.47)	Ref	871.42 (557.97)	0.08
Food Groups						
Whole grain (oz.)	0.24 (0.74)	0.65	0.37 (0.99)	Ref	0.18 (0.56)	0.65
Low fat dairy (cups)	0.12 (0.36)	0.60	0.11 (0.43)	Ref	0.18 (0.50)	0.44
Fruit & vegetables (cups)	2.66 (3.94)	0.27	2.50 (3.42)	Ref	2.53 (3.60)	0.68
Lean protein (oz.)	1.53 (3.10)	0.19	2.68 (3.90)	Ref	3.76 (5.18)	0.24
Macronutrients						
Fat (g)	31.31 (26.17)	0.74	34.01 (25.49)	Ref	29.19 (23.18)	0.67
Sat Fat (g)	10.53 (9.82)	0.18	10.77 (9.09)	Ref	9.27 (9.46)	0.53
Sat fat as % of calories	9.40% (5.55%)	0.71	9.12% (5.40%)	Ref	9.19% (4.79%)	0.91
PUFA (g)	3.36 (5.41)	0.63	3.89 (4.72)	Ref	3.29 (3.32)	0.99
MUFA (g)	1.10 (2.44)	0.54	1.13 (3.10)	Ref	1.17 (2.08)	0.93
Carbohydrate (g)	121.44 (115.66)	0.83	150.59 (105.35)	Ref	115.95 (76.06)	0.66
Sugar(s) (g)	46.87 (55.00)	0.96	56.81 (51.85)	Ref	45.97 (42.94)	0.59
Fiber (g)	11.00 (16.18)	0.21	11.31 (12.24)	Ref	9.21 (11.53)	0.93
Protein (g)	35.61 (34.03)	0.74	43.29 (30.53)	Ref	40.18 (39.77)	0.84
Micronutrients						
Sodium (mg)	1534.84 (1907.69)	0.44	1637.52 (1308.54)	Ref	1413.37 (1116.73)	0.71
Meal Nutritional Quality (MNQ) rubric score						
Total scores (scale of 0-7)	2.18 (1.40)	0.93	2.20 (1.19)	Ref	2.50 (0.96)	0.49

Linear regression analysis, adjusted for age, gender, race, BMI, dorm kitchen access, on- or off-campus residence, meal plan status, and self-reported degrees of food insecurity.

Table 5: Odds of meal nutrient quality (MNQ) rubric category fulfillment, across time groups

	<15 min (n = 45)			15-60 min (n = 395)		>60 min (n = 28)		
	Odds ratio (Confidence interval)		p value	Odds ratio (Confidence interval)	p value	Odds ratio (Confidence interval)		p value
Energy Intake								
Sufficiently low calories (<700 cal)	1.62	(0.83, 3.17)	0.16	1 (Ref)	Ref	1.79	(0.76, 4.20)	0.18
Food Groups								
Sufficient whole grain (>=2 oz. eq)	1.15	(0.31, 4.29)	0.83	1 (Ref)	Ref	0.52	(0.06, 4.66)	0.56
Sufficient low/nonfat dairy (>= 1 cup eq)	1.19	(0.24, 5.87)	0.83	1 (Ref)	Ref	2.97	(0.56, 15.88)	0.20
Sufficient fruit & veg (>=1.75 cup eq)	1.03	(0.50, 2.12)	0.94	1 (Ref)	Ref	0.93	(0.37, 2.32)	0.87
Sufficient lean protein (>=2 oz. eq)	**0.36**	**(0.16, 0.81)**	**0.01**	1 (Ref)	Ref	1.82	(0.76, 4.32)	0.18
Macronutrients								
Sufficiently low saturated fat (<=10% of total cal)	0.87	(0.45, 1.70)	0.68	1 (Ref)	Ref	0.90	(0.38, 2.10)	0.81
Micronutrients								
Sufficiently low sodium (<= 800mg)	1.54	(0.58, ,4.11)	0.39	1 (Ref)	Ref	1.24	(0.40, 3.88)	0.71

Logistic regression analysis, adjusted for age, gender, race, BMI, dorm kitchen access, on- or off-campus residence, meal plan status, and self-reported degrees of food insecurity.

Discussion

The nutritional quality of student lunchtime meal choices was low, as assessed by the MNQ rubric. No students achieved scores of 6 or 7 out of 7 possible rubric points, and only 6 students out of 468 achieved a score of 5 out of 7. The significant majority of students (86%) received a score of 3 or less.

No difference in MNQ score was detected across groups who stayed in the dining hall for short (<15 minute), medium (15-60 minutes), or long duration (>60 minutes). The only significant difference in MNQ components was observed in that the group who reported spending the least time in the dining hall had significantly lower odds (p=0.01) of consuming the recommended 2 ounces of lean protein than the medium time duration reference group.

Food Groups

Whole Grains

Whole grain intake was very low. Average whole grain intake across all 468 reported meals was 0.34 oz ± 0.95, and only 36 students (8%) met the MNQ requirement of 2 ounces of whole grain per meal. Whole grains were the second-least fulfilled of all MNQ requirements, following lowfat and nonfat dairy.

When consuming a single-food-group whole grain food item, average student intake exceeded the rubric requirement, with 2.08 oz. ± 1.39. *Total* grain intake appears to be unaffected by whether total grain was the sole food group represented, or one or 2 or more food groups within a given food. The reasons for this cannot be deduced fully

from the current dataset, though the wide variety of pizzas, sandwiches, and pasta dishes containing large amounts of refined grains may help to explain the discrepancy between whole grain consumption and total grain consumption, particularly when comparing single-food-group averages with multiple-food-group averages. Since whole grain pizzas were not offered during the course of this study's data collection, and whole grain sandwiches or wraps were consumed far less frequently than refined grain versions, this could explain why average consumption levels for multiple-food-group items containing whole grain as an ingredient (0.91 oz. ± 0.83, which included items like soups with barley) were lower than average consumption levels for multiple-food-group items with grains of any kind (1.53 oz. ± 1.12). Intake of foods with whole grains as an ingredient – given the available foods on the menu in this study with whole grain as one of two or more food groups in a given food – may not be sufficient by itself to meet the MNQ requirement of 2 or more ounces of whole grains per lunchtime meal.

Although Ha et al. showed an increase in whole grain consumption through an interactive educational module[49], trying to address GMU undergraduates' shortfalls in whole grain consumption through educational intervention alone may not result in increased consumption. Williams and Mazier examined the role of whole grain education on whole grain consumption, and concluded that while nutrition education was associated with improved perceptions of whole grains' healthfulness, it was not associated with any increase overall whole grain consumption.[84]

The extremely low GMU undergraduate whole grain consumption aligns with findings by Gager, that 77% of students reported eating less than what they estimated to

be recommended daily servings for whole grains.[50] That is, students were asked to estimate whole grain servings, and then to report their own whole grain consumption – revealing a strong possibility that a large proportion of students already knowingly under-consume whole grains. In other words, taking Williams and Mazier's work on whole grain education into context with Gager's finding, whole grain shortfalls may not be adequately addressed by education as primary intervention, because students are already fairly aware of their whole grain consumption shortfalls, even as they continue to eat low amounts of whole grains.

Addressing GMU undergraduates' whole grain shortfalls may therefore require less traditional approaches, including increased efforts to seek out and integrate higher whole grain content in popular foods such as the crusts of pizzas, the pasta in pasta and noodle dishes, the rice in rice dishes, and the baguettes, wraps, and breads in ready-to-eat sandwiches.

Lowfat and Nonfat Dairy

Consumption of low and nonfat dairy was very low, with a mean consumption at 0.12 cups ± 0.43. Only 21 students (4%) met the MNQ requirement of 1 cup of lowfat or nonfat dairy, making this food group the least-fulfilled of all MNQ requirements.

For both nonfat and lowfat dairy and dairy with higher fat contents, it appears that a determinant of total average dairy consumption may be whether the student chooses items that contain dairy as the sole food group (i.e., plain milk or yogurt). For lowfat and nonfat dairy single-food-group items, the average consumed amount of these types of foods (yogurts, milk, soymilk, etc.) appears to be sufficient to meet the 1 cup of low or

nonfat dairy requirements set by the MNQ (See Figure 9). Otherwise, student selections in which low or nonfat dairy is only one of several food groups present (i.e. an ingredient, as in macaroni and cheese or a fruit smoothie) do not appear to meet the dairy rubric requirement.

If low or nonfat dairy intake (or intake of their equivalents such as soy milk) were assumed to be this low for all meals, there could be cause for alarm about student calcium intake levels. However, since Larson et al. found both male and female dairy and calcium intakes associated with eating breakfast, it could be that in emerging adults, dairy intake also is associated with eating breakfast, when milk or equivalents are used on cereal, in coffee and/or tea, or consumed as a beverage.[85] Therefore, while low lunchtime dairy consumption seen in this study may have implications for planning future nutritional interventions in the GMU dining halls, it is also possible that student dairy consumption outside of lunchtime meals, particularly breakfast, may compensate in part for the meager low/nonfat dairy consumption levels at lunchtime.

Notably, total dairy intake in this data set is much higher; the GMU lunchtime mean dairy intake was 1.14 cups (slightly over one USDA MyPlate serving equivalent). Since, by young adulthood, women are thought to be consuming a mean of 2.57 servings of dairy (all fat contents) per day, and young men 3.29 servings (all fat contents), it would appear that GMU undergraduate dairy intake for a single meal is roughly one third of what the literature suggests is current average dairy serving intake for a single day.[52,85]

Racey indicated several candidate determinants of adolescent dairy intake for interventional nutrition education – including taste, convenience and social context of

parents and peers as major factors in dairy intake.[86] If some of these determinants carry over to the emerging adult college environment – but particularly taste and convenience, which are under greatest control of GMU dining hall staff – it could be that a wider variety of low or nonfat dairy options could address both taste and convenience for undergraduates who are currently under-consuming this food group.

Protein

Student consumption of lean protein was much more promising, with 45% of student-reported meals meeting the requirement of 2 oz. of lean protein or equivalents set by the MNQ. When participants selected foods that consisted of lean protein as the sole food group, the average lean protein consumption for that food was 3.36 oz ± 3.16, compared with selections/consumption of foods with lean protein as an ingredient, in which average consumption 2.33 oz ± 3.01. This indicates that even in the case where students are selecting only foods with lean protein as an ingredient, the MNQ lean protein requirement may still be met in many cases. Figure 14 shows a breakdown of foods selected which contained lean protein as an ingredient, which is a notably wide variety of foods. The variety shown in these lean protein containing food selections is considerably greater than the variety of foods chosen containing low/nonfat dairy or whole grains, which may help to explain students' relative success in meeting MNQ requirements for lean protein, even through foods where lean protein is just one of multiple food groups represented, such as sandwiches, rice dishes, soups, etc. Since college men are consuming an estimated mean 117g of protein per day, and college women are

consuming and estimated mean 73.6 grams of protein per day, protein intake (all protein consumed, lean or otherwise) appears to be very much adequate in college populations since dietary reference intakes (DRI) for this group identify 46g/day for women and 56g/day for men as adequate.[11,87]

While there is a possibility for GMU undergraduate protein intake could be shifted to leaner sources, which would increase the number of student meals fulfilling the lean protein requirement of the MNQ rubric, inadequacy of protein as a macronutrient *per se* is not a concern. This is aligned with of college male athletes' perceptions of sufficient protein intake, even if the proteins reported as consumed are often not lean.[61] While little research on educating college students on making distinctions between lean and non-lean proteins has been done, it is recommended that any future GMU protein consumption intervention should not target absolute protein consumption – in grams, but instead that educators favor educating students on distinctions between lean and non-lean protein items, such as distinguishing between breaded and fried chicken tenders compared to grilled chicken breast, or chicken salad (with mayonnaise) from the deli, compared with deli turkey meat, or egg salad (with mayonnaise) compared to boiled eggs.

Fruits and Vegetables

Fruit and vegetable intake fared decently as a food group fared somewhat better. Across all student meals (Table 3), of which some meals may have included more than one fruit and/or vegetable containing item, average intake was 2.52 cups. For individual

choices of food items consisting of only fruit and or vegetables, average intake per item was 1.64 cups. In other words, when choosing a single food consisting of fruit and/or vegetables, average consumption levels nearly brought students to the 1.75 cup MNQ requirement. The overall meal mean fruit and vegetable consumption (Table 3) at 2.52 cups indicates the consumption of more than one fruit/vegetable containing item (and therefore meeting of the 1.75 cup requirement) as a common occurrence. However, with a median intake of 1.10 cups and a standard deviation of 3.47 cups, it may be that fruit and vegetable consumption skews higher for a subset of more healthful, eager fruit and vegetable eaters, which would explain how the mean consumption exceeds the MNQ requirement (Table 3), while only 40% of student meals met the fruit and vegetable intake requirement. Demory-Luce et al. assessed average young adulthood consumption of vegetables at 163.0 grams/day ±166.8, and fruit consumption at 90.6 grams/day ±200.1.[54] Demory-Luce's comparatively large standard deviations for both fruit intake and vegetable intake – which resemble GMU undergraduates' comparatively large standard deviations for combined fruit and vegetable intake - may indicate a similar consumption-skewing phenomenon of more healthful, eager fruit and vegetable eaters in the population of emerging adults at large.

Because of potential skewing from heavier fruit and vegetable eaters, there is still room for improvement, inasmuch as 60% of GMU undergraduate meals did not meet the MNQ fruit and vegetable requirement. Nutritional interventions on focusing on fruit and vegetable intake, which have shown success in increasing consumption of fruit and

vegetables, are recommended as a potential tool to address fruit and vegetable consumption shortfalls.[88]

Calories, Saturated Fat, and Sodium

Calories

Calorie intake averaged over 300 calories higher than the MNQ rubric's 700 calorie limit. The relative popularity of calorie dense foods, such as pizza, may account for some of the surplus. Additionally, 60% of student meals do not meet MNQ requirements for fruit and vegetable consumption, indicating that students are not eating enough of the high volume, low calorie options which would otherwise assist in moderating student calorie intake.

In this study, the mean calorie intake for men was 1120, while the mean calorie intake for women was 947. Comparing these numbers to a 2012 study, which calculated college student daily calorie intakes at 2695 for men and 1863 for women, it is possible that GMU undergraduate women could be consuming close to half of their daily calorie intake at the lunchtime meal, and that GMU undergraduate men could be consuming about 42% of their calories at the lunchtime meal.[11] In order to gain a better understanding of whether these lunchtime calorie intakes are excessively high, greater context would be required about daily calorie intake patterns. Data would need to be collected in future studies to understand the GMU undergraduates' daily calorie distributions across meals and snacks, particularly in light of new GMU college food environment introductions, including the 2019 GMU campus advent of Starship

Technologies' food delivery robots, which enable students to more easily consume breakfast, and popular calorie dense foods, such as doughnuts and pizza, in general.[89]

Saturated Fat

Of the 7 rubric criteria, the highest proportions of student meals met rubric requirements for saturated fat as a percent of calories eaten (60% of student meals meeting the 10% or less requirement). The mean intake of 9.14% calories from saturated fat (Table 3) is consistent with data in a 2012 study of college student metabolic syndrome risk factors, which determined that college men surveyed at 10.0% of their calories from saturated fat, while college women ate 9.7% of calories from saturated fat.[11]

However, this MNQ requirement achievement may not be quite as remarkable as it seems; overall student calorie intake calculated for reported meals averaged 1038 calories, which is more than 300 calories higher than the MNQ rubric requirement for 700 calories as a lunchtime energy intake limit. Since the MNQ limit for saturated fat intake as a percent of calories is ≤10%, the implied upper boundary for calorie intake in saturated fat calories is 70 calories (7.78 grams of saturated fat). Mean absolute saturated fat consumption was 10.66 grams ± 9.17, which indicates that while 60% of student consumption of saturated fat technically meets the MNQ lunchtime requirement, absolute saturated fat consumption still exceeds the absolute saturated fat intake level implied by the MNQ's design, by approximately 37%. Since college men's mean daily saturated fat consumption has been calculated at 29.94 grams (or, assuming a distribution of three meals, roughly 9.98 grams per meal), and mean college women's daily saturated fat

intake has been calculated at 20.08 grams (assuming three meals, 6.69 grams per meal), these absolute saturated fat results are somewhat similar, but difficult to compare exactly given the daily vs. one lunchtime intake; the daily numbers include saturated fat intake from snacks, as well, so dividing by three from a daily intake number may not be sufficiently accurate for a true comparison.[11]

Sodium

Reported mean sodium intake averaged over double the 800mg limit set by the MNQ rubric, with only 28% of students staying under the MNQ rubric's sodium limit. Frequent selection of sodium-rich foods such as pizzas, pasta sauces, deli meats may contribute greatly to these numbers. As with other MNQ rubric elements, additional context about daily sodium intake across all meals and snacks would help to identify whether lunchtime sodium intake is simply inordinately high, or whether it is consistently high as part of food patterns all day long. Even if lunchtime is exceptionally high in sodium, however, the mean of 1614 mg for just one meal is approximately two thirds of the recommended 2300 upper limit of sodium intake level for American adults.[67] Since research suggests that the palate adjusts to sodium content of recent dietary intake, GMU may be able to reduce overall undergraduate sodium intake through measured interventional approaches, including a gradual reduction of the sodium added in many commonly served Sodexo recipes.[68]

Time Spent in Dining Halls over Lunchtime Meal

The MNQ was the primary tool in assessing potential differences between groups of students based on duration of stay in the dining hall over lunchtime meals. Linear regression analysis of the category data for each MNQ rubric category revealed no major differences between groups based on duration of stay in the dining hall. However, a logistic regression analysis based upon MNQ rubric subcategory binary fulfillment did detect one statistically significant change, in terms of adequate lean protein consumption: students reporting the shortest dining hall stays (<15 minutes) were significantly less likely to consume adequate amounts ($p = 0.01$, ≥2 oz. of lean protein or equivalents) of lean protein in their lunchtime meal.

On the whole, relative to other MNQ requirements, undergraduate meals reported did better in meeting lean protein requirements, which coincides with college student population studies indicating adequate protein intake in general.[11,87] In this study, the difference in consuming adequate lean protein for lunchtime dining hall diners who stay less than 15 minutes may be related to one or more aspects about the lunchtime dining experience that make consumption of adequate amounts of lean protein more difficult to manage. This could be because of certain time-related logistical constrains for some lean-protein-containing foods (for example, a lean protein containing turkey barley soup requiring time to cool and consume by the spoonful), or because of the fact that other fast foods which do not contain lean protein – such as pizza – are simply easier to grab and consume in a short window. Future analyses may be able to detect a difference in particular foods more or less commonly chosen between students with a short dining hall

stay and students with longer dining hall stays – information which could assist GMU dining hall staff in balancing the meals of students in a rush with lean protein options that are strategically designed with a short lunchtime in mind. Notably, grams of protein intake did not differ between time groups, as assessed by linear regression; intake of protein was numerically 7 grams lower in the short time (<15 minutes) group, but the difference did not rise to statistical significance. Also, the short time group consumed 35.6 grams of protein on average, which provides over half the daily DRI requirements for most young men and women from this single eating occasion.

MNQ Rubric as an Assessment Tool

The Healthier Campus Initiative's Wellness Meal model was originally conceived as the Partnership for a Healthier America's promotional guideline of healthful meals. Example meals that meet the Wellness Meal criteria are presented as options in university dining hall settings—with the intent of encouraging diners to select these healthy options—and was not initially designed as an evaluative rubric *per se.* However, the simplicity of its design and its ability to capture nutritional quality of a single meal served well in the adapted MNQ rubric framework for this project to provide insight into the nutritional quality of meals in the dining halls.

While the single numeric score of the MNQ rubric does not provide detail on food groups or nutrients consumed for any individual student, observations of trends of achievement of food group/nutrient criteria in combination with the totals scores are insightful. Upon review of Figure 5, it is evident that any individual student scoring a 1 or

2 was more likely to be achieving any rubric point(s) on the basis of calories, saturated fat as a percentage of calories, fruits and vegetables and lean protein – and less likely to have scored a 1 or 2 related to rubric fulfillment for sodium, whole grains, or low/nonfat dairy and alternative equivalents.

Additionally, the MNQ rubric score is useful in providing context to compare any individual student meal quality in relationship to the quality of all assessed student meals. A student meal with a rubric score or 4 or 5, in the context of GMU's fall campus lunchtime menu during this study, was among the healthiest meals being selected within that student population. Overall rubric scoring patterns – in which neither a 6 nor a 7 out of 7 were achieved – indicate that persistent deficits in particular rubric criteria, such as consumption of whole grains and lowfat or nonfat dairy, which may require greater conscious intention and effort on behalf of the individual student to fulfill. Even so, since the highest scoring meals show similar categorical deficits (whole grains, low/nonfat dairy) as the lowest-scoring meals, individual student intention and effort may only go so far, and chances for success in improving rubric fulfillment in these areas may increase from complimentary long term interventional support on the part of GMU's dining hall staff in partnership with Sodexo. Joint GMU/Sodexo interventions could be planned using the relative variety of undergraduate selections of foods containing lean protein and/or fruits and vegetables as a framework to adapt for low/nonfat dairy and whole grain intake, strategically expanding the varieties of foods available containing lowfat and nonfat dairy, and/or whole grains, to incentivize increased consumption. Strategies could

include offering a greater variety of yogurt flavors, or updating the rotating Sodexo menu recipes to contain brand new whole-grain dominant dishes with different flavor profiles.

The MNQ rubric addresses a wide diversity of human physiological needs in 7 categories – for example, sufficient fiber and micronutrients through fruits and vegetables, sufficient lean protein, sufficient calcium through low/nonfat dairy requirements, moderate calorie intake, etc. Compared to the Healthy Meals Index for canteens, the MNQ covers more nutrient variables with its rubric. For example, a meal high in sodium, low in dairy/calcium, and lacking in lean protein, but high in fruits and vegetables, potatoes, whole grains, and low in fat could score reasonably well on the Healthy Meals Index, whose three scoring components are fruit and vegetable consumption, fat quantity and type, and whole grain and/or potato consumption, but would score no more than a 4 out of 7 using the MNQ rubric.[77] In the same way that the Healthy Meal Index has fewer components scored than the MNQ rubric (3 compared to 7), the MNQ rubric does not leave the same allowance for nuance as the widely used Healthy Eating Index (HEI) as a numeric indicator of nutritional quality, because the HEI rubric scores across 13 components.[90] Although the interactive version of HEI has been used successfully to assess college students' diets, HEI is calculated on the basis of a full day's intake of food and thus could not be used for this meal assessment study.[91]

The HEI's most recent 2015 iteration includes minimums for refined grains and added sugars – and *allows* dairy of all fat contents to fulfill its dairy requirements, while maintaining an overall saturated fat intake minimum at ≤8% of energy intake.[92] Further, scores in each of the 13 HEI components are sliding, with a minimum and maximum

score assigned according to consumption criteria. As a result, the composite total HEI score is a continuous variable, ranging from 0 to 100, in comparison to the ordinal ranked values achievable through the MNQ here.

Because of HEI's more nuanced scoring, a student could consume a meal with a whole grain turkey wrap, fruit salad, and stir fried vegetables, with a glass of whole milk – a meal with many essential nutrients – and still have that meal contribute toward a reasonably high HEI score if it were embedded in the context of similar food intake patterns for breakfast and dinner. In the MNQ rubric, whole fat dairy is *de facto* disqualified as a contributor toward low/nonfat dairy intake, and in fact poses some risk toward also not qualifying for sufficiently low saturated fat content – meaning that a student's meal containing a glass of whole milk is at risk of scoring zero in more than one category – for the MNQ low/nonfat dairy requirement *and* possibly the saturated fat as a percentage of calories requirement. However, in the HEI's more nuanced 2015 scoring system, the whole milk, by itself, may not necessarily deflate the score, though other high-dairy-fat items such ice cream or pizza are likelier to, because of HEI minimums for saturated fats, added sugars, and refined grains. Therefore, HEI's more nuanced take – in addition to its scoring over the course of an entire day's worth of food - may allow more flexibility in achieving a score reflecting high nutritional quality, as compared to the MNQ.

Several recent studies have associated dairy fat intake with positive outcomes such as better weight management, reduced inflammation, and inverse associations with metabolic syndrome.[58,93,94] Additionally, a 2016 analysis found no association between

saturated fat from dairy consumption and insulin resistance or type 2 diabetes mellitus.[95] Thus, compared with HEI, the MNQ rubric may not be sufficiently nuanced to account for the possible health benefits associated with whole food instances of higher fat dairy intake, in particular.

The MNQ's deliberate design to score a single meal, using just 7 food group and nutrient intake categories, will necessarily contain less nuance and information than another snapshot nutritional quality scoring system – the HEI – which covers an entire day's worth of food intake, and takes into account 13 separate food group and nutrient intake categories. Students with overall very healthful eating patterns would score highly on both, and students with overall poorer eating patterns would score lower, respectively. However, certain students may score comparatively better, in relative terms, on HEI, because of the context and nuance afforded to their meals' analyses using HEI scoring. However, HEI's higher data requirements (for both an entire day's worth of food, and for 13 food group and nutrient variables) may well make it less suited toward future analyses involving machine learning, and therefore the simpler MNQ rubric may serve a particularly useful role making future discoveries about food patterns in more controlled settings for particular populations, such as undergraduate dining hall patrons eating a weekday meal.

A future MNQ rubric redesign could theoretically integrate certain aspects of HEI to improve nuance. For example, at the time of data collection in fall of 2015, added sugars were not required to be shown on nutrition labels, and therefore added sugar data would have been incomplete, at best, for this dataset. However, now that nutrition

labeling is increasingly including added sugar content in compliance with federal mandates which occurred after the data collection, a future study replication involving data collection may be able to use a rubric that included added sugars as a category. As an example of how this might change scoring of a single meal, a low/nonfat dairy item or alternative equivalent that contained sugar – such as lowfat strawberry yogurt or chocolate soymilk – would then affect MNQ rubric scoring in 2 categories – low/nonfat dairy and added sugars, respectively.

Even with the reduced nuance attributable to its simplicity, the MNQ rubric performed well in this study, in terms of giving an overarching and categorical assessment of student meal nutritional quality. Student reported meal scores could be compared and contrasted with reasonable effectiveness, and persistent deficits – as in the case of low/nonfat dairy and whole grains – were easily identifiable as remaining underfulfilled across students eating a multitude of food patterns. Therefore, although the MNQ has origins in PHA CHI's promotion of prestructured dining hall Wellness Meals, its adaptation as an assessment tool was reasonably effective, in the absence of richer nutrient data for foods served in the dining hall (such as added sugars), for gauging the nutritional quality of a single lunchtime meal.

Limitations

This study was designed to collect data from students at GMU dining halls during weekday lunchtime meals over a few weeks in the fall of 2015. Selection bias may have impacted the respondents willing to give time to filling out the study data collection

survey. Particularly in the case of the group of students claiming to have stayed less than <15 minutes, those opting to stay to fill out surveys may not have in fact been as rushed as those who stayed <15 minutes and refused to fill out surveys on account of needing to be somewhere else immediately. Additionally, students' accuracy in dining hall duration estimation is another limitation, which can be impacted by sociocultural factors influencing perceptions of time.[38,47]

This study also has some limitations related to data collection. While care was taken by data collectors to offer context and examples to respondent students in estimating portion size, students' assessments may be limited as both a function of estimation accuracy and memory of how much of a given food was actualy consumed. Additionally, perhaps due to the incentive of an offered entry drawing to win a prize, some student responses appeared to be improbable due to patterns indicating questionable data quality. To address this phenomenon, this study uses exclusion criteria that centered around improbable occurrences (for example, excluding students who reported eating the maximum – 5 servings – of 5 or more foods, or more than 3500 calories consumed for a single lunchtime meal). However, these criteria, which excluded a sizeable number of respondents, may have inadvertently excluded respondents with earnest responses.

In addition, while Sodexo and GMU dining staff supplied all possible nutritional and recipe information for foods, certain foods' data were missing or incomplete, which was addressed through, "next best match" of foods through USDA listed reference foods and foods listed in Nutritionist Pro software. However, especially for more complicated

multi-ingredient foods for which information was missing or incomplete, these matches still may be limited in accuracy.

The results of this study may not be generalizable because of limitations, as well. This study is cross-sectional, and as such, student responses may not reflect any given student respondent's typical food choices. In addition, because these choices were made in a limited environment of two dining halls with a monthly rotating menu, without taking into account other campus eating environments and opportunities, such as the student food court and GMU's new food delivery robots, this study's conclusions may not be generalizable to students' overall consumption patterns – only to undergraduates' weekday lunchtime dining hall consumption patterns. Because GMU's menus, dining hall hours, and all-you-care-to-eat trayless dining hall model will differ from other campus dining hall models, generalizing results with other universities in mind may also not be possible.

Finally, as discussed in the *MNQ as an Assessment Tool* section, the adapted MNQ rubric itself trades some nuance in its analysis for the simplicity of its seven rubric items which enable efficient and reasonably effective analysis of student meals' nutritional quality. Future MNQ rubric adaptations that address this are possible.

Conclusion

This study used a simple but balanced nutritional rubric, with minimums for desirable components (food group consumption) and maximums to prevent undesirable excesses of calories, sodium, and saturated fat, and summarized and illustrated the

shortfalls in George Mason University undergraduate students' lunchtime meal choices. The summary of rubric scores demonstrated that the overall food patterns of students were suboptimal and in line with what has been reported in literature for student intake of calories, saturated fat, sodium, whole grains, low or nonfat dairy, fruits and vegetables, and lean protein, respectively. A stark impression of undergraduates' nutritional meal quality was evident, where dairy consumption and whole grain consumption were exceptionally low.

Closer examination of individual food groups showed that total dairy and low or nonfat dairy choices were far from ideal; in the total dairy choices scope, the chosen foods were frequently high in calories, saturated fat, sugar, and refined starches, while in the low or nonfat dairy scope, the choices were either very low in frequency or were foods that contained only fractions of a serving of low or nonfat dairy. Whole grain consumption was similarly lacking.

The deficits in consuming both whole grains and low or nonfat dairy may be addressed in the future by targeted interventions in the campus dining hall setting. When looking at total and non/low-fat dairy (4% rubric fulfillment) and whole grain rubric deficits (8% rubric fulfillment), and comparing them to the relative success of 60% of students staying under the saturated fat percent limit, the question arises: to what extent has the composition of the available foods influenced these dietary intake results? It may follow that students' frequent achievement is attributable to the overall saturated fat content of the foods available in the GMU/Sodexo dining halls. This is suspected in the current study, but definitive conclusions are beyond the scope of this analysis.

Follow-up research could examine the saturated fat content of the Sodexo menu and relate it to the low or nonfat dairy options and whole grain options. The same research could examine the diversity and range of availability of better-performing MNQ food groups, such as lean protein and fruits and vegetables, and compare it to the menu diversity and range of availability of low/nonfat dairy and whole grains, in order to determine whether associations with menu variety and frequency and food group consumption levels exist.

One 2016 qualitative study on adolescent whole grain consumption concluded that potential facilitators for whole grain consumption included improved sensory appeal and increased availability and choice, and tailoring the foods available for young people.[96] Similar issues were reported for adolescents in dairy intake[86], and while emerging adults' factors may vary slightly, these echo the literature review for emerging adults' factors behind eating whole grains and low or nonfat dairy: availability, choice, taste, and convenience are all common threads, which GMU/Sodexo together influence tremendously. Nonetheless, if relative rubric successes for intake of lean protein, saturated fat, and fruits and vegetables are indeed associated with the overall variety and macronutrient composition of GMU/Sodexo dining hall menus themselves, then perhaps altering the range and diversity of offerings of low or nonfat dairy and whole grains in the dining halls may lead to similarly improved food group outcomes.

Interventions may have some success in addressing GMU undergraduate consumption shortfalls; however, using previous research as indicators, interventional successes may vary between food groups. In particular, whole grain consumption may

not be adequately challenged through educational intervention alone, and therefore sustained, targeted menu changes through GMU dining hall offerings may compliment any nutritional interventions planned. In addition, since MNQ fulfillment of lean protein was less likely for students staying in the dining hall for less than 15 minutes, any future GMU dining hall menu changes should include a focused evaluation of which lean protein options can be consumed by students in a rush, and whether other such options might be added to the menu. GMU dining hall staff and Sodexo should ideally work to determine if sourcing of commonly consumed items – such as preprepared pizza crusts and sandwich breads and wraps – can be altered to include more of desired food groups, such as whole grains, in order to transform the most commonly chosen foods into improved contributors to MNQ rubric fulfillment.

To target food group shortfalls and excesses in calories, saturated fat, and sodium, it is recommended that GMU dining hall staff use a combination of strategic menu re-evaluation and redesign with respect to each rubric component, healthier sourcing of commonly consumed preprepared items, and dynamic, interactive nutritional education intervention approaches, in order to shift undergraduates' current dietary choices in dining halls toward higher overall nutritional quality.

APPENDIX

Select pages from the original 28 page PDF of MUNCH Surveys Administered Fall 2015: Time categorization (page 6) and food security indicators (page 8), and an excerpt of the food selection survey pages (page 11).

Questions about this visit to the dining hall

Please estimate how much time you spent at the dining hall during this visit.

- ◯ < 15 minutes
- ◯ 15-30 minutes
- ◯ 30-60 minutes
- ◯ 60 minutes - 2 hours
- ◯ 2+ hours

Would you consider this to be a meal, snack, or other eating occasion?

- ☐ Meal
- ☐ Snack
- ☐ Other (please specify)

On a scale of 1 (most amount of time spent) to 8 (least amount of time spent), rank the following activities based on how you divided your time at the dining hall today.

	Selecting what to eat	☐ N/A
	Trying to find a table	☐ N/A
	Eating	☐ N/A
	Using my phone/tablet for leisure. (Texting, playing games)	☐ N/A
	Doing homework or other work	☐ N/A
	Talking with friends/companions	☐ N/A
	Reading	☐ N/A
	Other	☐ N/A

6

In the dining hall, how easy is it to*determine if the food served is healthy*?

- ◯ Very difficult
- ◯ Difficult
- ◯ Neither difficult nor easy
- ◯ Easy
- ◯ Very easy

To what extent do you agree with the following statement?

"I have a lot of knowledge about how to choose a nutritious diet."

- ◯ Strongly disagree
- ◯ Disagree
- ◯ Neither agree nor disagree
- ◯ Agree
- ◯ Strongly agree

To what extent do you agree with the following statement?

"I worry about having enough food to eat."

- ◯ Strongly disagree
- ◯ Disagree
- ◯ Somewhat disagree
- ◯ Somewhat agree
- ◯ Agree
- ◯ Strongly agree

8

Monday, Oct. 5 - Ike's

Hot foods

	Please select amount you ate
Cuban Mojo Roasted Pork Loin (# of pieces)	
Cuban Roasted Vegetable Mojo (# of cups)	
Roasted Corn (# of cups)	
Citrus Rice (# of cups)	
Cantonese Stir-Fry with Zucchini (# of cups)	
Asian Chicken Wings (# of wings)	
Chipotle Patty Melt with the bun (# of melts)	
Chipotle Patty Melt without the bun (# of melts)	
Curly French Fries (# of cups)	
Onion Rings (# of onion rings)	
Roasted Red onions (# of tablespoons)	
Roasted Portobello (# of tablespoons)	
Roasted Garlic Dijon (# of tablespoons)	
Fire Roasted Tomato Sauce (# of tablespoons)	
Cilantro Lime Basmati Rice (# of cups)	

11

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