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Swap the Meat, Save the Planet: A Community-Based Participatory Approach to Promoting Healthy, Sustainable Food in a University Setting

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Swap the Meat, Save the Planet:
A Community-Based Participatory Approach to
Promoting Healthy, Sustainable Food in a University Setting

A dissertation submitted in partial satisfaction of the

requirements for the degree Doctor of Philosophy

in Community Health Sciences

by

Hannah Joy Malan

2020

ABSTRACT OF THE DISSERTATION

Swap the Meat, Save the Planet:

A Community-Based Participatory Approach to

Promoting Healthy, Sustainable Food in a University Setting

by

Hannah Joy Malan

Doctor of Philosophy in Community Health Sciences

University of California, Los Angeles, 2020

Professor Michael L. Prelip, Chair

Current dietary patterns threaten human and planetary health. In the United States, individuals must shift to dietary patterns higher in plant-based foods and lower in animal-based foods to reduce chronic disease risk and maintain stability of the Earth system. Despite high scientific agreement that we can simultaneously improve health and environmental sustainability through dietary shifts, interventions targeting these dual outcomes remain understudied. This dissertation employed a community-based participatory research approach to investigate how academics and non-academic foodservice leaders can collaborate to address gaps in the development, implementation, and evaluation of interventions to promote healthier, more

environmentally sustainable diets. Research was focused on the university setting and took place at the University of California, Los Angeles.

Guided by the diffusion of innovation framework, Study One qualitatively described and examined the process of developing and implementing the Impossible™ Foodprint Project—an intervention to reduce animal-based protein consumption in university dining. Intervention components included: 1) the addition of new menu items with Impossible™ plant-based meat, and 2) a complementary social marketing campaign framed around climate change. Findings from Study One highlight the value of the university's involvement in existing health and sustainability initiatives for intervention agenda-setting and collaboration among academics and non-academic partners. In addition, results suggest university foodservice leaders may be particularly open to strategies such as piloting new menu items and providing education—rather than taking existing menu options away. Furthermore, co-creation of intervention materials and feedback from multiple data sources enhanced capacity for foodservice leaders to expand efforts to promote low-carbon-footprint foods. Lack of coordination with restaurant operators emerged as a barrier to initial implementation of the social marketing campaign, while cost prevented scale-up of Impossible™ menu items beyond the pilot intervention restaurant.

Study Two utilized routinely collected sales and nutritional data from FoodPro, a widely used foodservice data management platform. A natural experiment with a pre-post non-equivalent comparison group design was used to evaluate 1) whether the Impossible™ Foodprint Project intervention met foodservice leaders' goal of reducing animal-based entrée sales, and 2) the impact of the intervention on the healthfulness and environmental sustainability of entrées sold. The analytic sample included 645,822 entrées sold at the three study sites during the Fall 2018 (pre) and Fall 2019 (post) academic quarters. During the post period, new menu items with

Impossible™ plant-based meat comprised over 11% of entrée sales at the intervention site. At the same time, the proportion of animal-based entrée sales decreased by 9% (raw change 7%, 83% to 76%), a significantly greater decrease than the two comparisons sites.

Healthfulness was operationalized as a decrease in the proportion of red meat entrées sold and improvement in the nutritional quality of entrées sold. While the proportion of red meat entrées sold significantly decreased by about 8% at the intervention site (raw change 4%, 45% to 41%), a similar decrease was observed at one of the comparison sites, resulting in an unclear intervention effect. Small but statistically significant nutritional changes were observed at the intervention site: On average, each entrée sold contained 21.3 fewer calories (kcal) and lower quantities of nutrients of concern: 0.2 fewer g saturated fat and 26.9 fewer mg sodium. Quantities of other nutrients also decreased: 0.7 fewer g protein, 0.1 fewer g fiber, and 1.5 fewer g unsaturated fat. However, nutritional outcomes varied when stratifying by entrée type (i.e., build-your-own vs. special), resulting in a conditional assessment of the intervention's nutritional impacts, described within.

Environmental sustainability was operationalized as reduction in climate impact level (low, medium, high) and carbon footprint of entrées sold. There were clear positive intervention effects on these outcomes. For example, the proportion of low-impact entrée sales increased by over 50% at the intervention site (raw change 7%, 14% to 21%), a significantly greater increase than the two comparison sites. This corresponded with an 8% decrease in the mean carbon footprint of each entrée sold at the intervention site, from 1,522 to 1,405 g CO_2-equivalent (117 g decrease). With 141,321 entrées sold at the intervention site in Fall 2019, this equates to approximately 16.4 metric tons of CO_2 saved—the equivalent of driving 42,000 miles.

In line with foodservice leaders' priorities, we also conducted a brief customer survey (n=215). Results suggest a diverse range of students was open to trying the new Impossible™ menu items, and customer satisfaction was high. In comparing one-time versus repeat consumers, we found significant differences across most behavioral and cognitive factors measured. In general, repeat consumers reported consuming less animal-based protein and were more likely to believe Impossible™ is delicious and a satisfying alternative to animal meat. We also found evidence that values and race/ethnicity may affect beliefs about the sensory experience of eating Impossible™, which in turn affects repeat consumption.

Finally, Study Three utilized a true experiment through Qualtrics to test whether environmental sustainability framing is more effective than health framing in "nudging" university consumers to choose a plant-based menu option. Participants were randomly assigned to one of three menu framing conditions—control (no framing), health framing, and environmental sustainability framing—and given the choice between chicken enchiladas and plant-based tacos. Of the 450 participants recruited for the study, 437 were maintained in the analytic sample, including 352 (79%) undergraduate students and 85 (21%) university staff. There were no statistically significant differences in choice across menu framing conditions. Approximately 39% of participants chose the plant-based tacos in the control condition, 36% in the health framing condition, and 40% in the environmental sustainability framing condition. In short, we found no main or conditional effects of environmental sustainability framing, compared to control. In contrast, we found some evidence that, compared to control, health framing may have negative effects among some subgroups, including university staff. Despite observed null effects of environmental sustainability framing, this approach may still be preferable to health framing given potentially counteractive health framing effects. In ancillary analyses described within, we found that, compared to health framing, environmental sustainability framing may improve anticipated enjoyment of a plant-based dish—even if it does not affect choice.

In sum, Study One sheds light on how and why interventions take shape, with an emphasis on collaboration between academic and non-academic foodservice partners. Study Two provides novel insight into the benefits and tradeoffs of promoting low-carbon-footprint foods and introducing new plant-based meat alternatives into institutional food environments. Experimental findings from Study Three suggest some nudges may be insufficient to affect choice of a plant-based menu item, while others may be counteractive. Taken together, results of this dissertation build capacity for academics and foodservice leaders to advance intervention action and research to improve human and planetary health through food.

The dissertation of Hannah Joy Malan is approved.

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2020

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Acknowledgements

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SELECT PUBLICATIONS & PRESENTATIONS

1. Westfall, M., **Malan, H.**, Leader, J., Slusser, W., Wang, M. (*Under review*). Teaching kitchen improves health professional students' nutrition knowledge, culinary skills, and confidence providing nutrition counseling.
2. **Malan, H.**, Watson, T. D., Slusser, W., Glik, D., Rowat, A. C., & Prelip, M. (2019). Challenges, opportunities, and motivators for developing and applying food literacy in a university setting: A qualitative study. *Journal of the Academy of Nutrition and Dietetics*, 120(1), 33-44.
3. Rowat, A., Soh, M., **Malan, H.**, Jensen, L., Schmidt, L., Slusser, W. (*2019*). Promoting an interdisciplinary food literacy framework to cultivate critical citizenship. *Journal of American College Health*, 1-4.
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6. Slusser, W., **Malan, H.**, Watson, T., Goldstein, M. S. (2018, March 12). Collective impact for health and wellbeing. *Stanford Social Innovation Review*. https://ssir.org/articles/entry/collective_impact_for_health_and_wellbeing
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INTRODUCTION

Recent research demonstrates an urgent need to shift dietary patterns to protect human and planetary health (Hedenus et al., 2014; Springmann et al., 2016; Willett et al., 2019). Specifically, Americans must reduce consumption of animal-based foods—such as red meat and dairy—and increase consumption of plant-based foods—such as fruit, vegetables, and legumes—to reduce chronic disease risk and maintain stability of the Earth system (IPCC, 2019; Willett et al., 2019). Climate change is a particularly concerning health issue, and studies suggest dietary shifts are crucial for mitigating greenhouse gas emissions within safe limits (Hedenus et al., 2014; Springmann et al., 2018). Interventions targeting food environments are considered upstream, cost-effective approaches for shifting diets at the population level (Larson & Story, 2009).

Food environment interventions within universities may be particularly effective due to 1) high levels of unilateral control; 2) power of procurement to influence markets; 3) limited outside marketing influence; and 4) college students' unique developmental period (Arnett, 2000; Nelson et al., 2008; Seymour et al., 2004). College is a critical period in the life course, and students may be more open to dietary behavior change than other populations (Nelson et al., 2008). Educational interventions suggest college students are especially motivated by social and environmental sustainability issues to improve their diets (Hekler et al., 2010; Jay et al., 2019). However, the use of environmental sustainability as a motivator to shift diets remains understudied. Specifically, it is not known whether university foodservice leaders should highlight health or environmental sustainability when promoting plant-based menu items.

Furthermore, gaps remain in understanding which food environment intervention strategies are most feasible and effective for achieving the dual goals of improving human and planetary health. While there is large overlap among foods that are both healthier and more environmentally sustainable, this is not always the case (Clark, Springmann, Hill, & Tilman, 2019; Hu, Otis, & McCarthy, 2019). For example, new plant-based meat alternatives, such as Beyond Meat™ and Impossible™ Foods, tend to be highly processed and high in sodium and saturated fat (Hu et al., 2019). At the same time, these products may deliver environmental, experiential, and sensory benefits desirable to both foodservice leaders and customers alike.

A large literature has documented the effectiveness of food environment interventions to improve either healthy eating (e.g., fruits and vegetables, nutrients) or sustainable eating (e.g., plant-based, low-carbon-footprint), but these outcomes are not typically assessed concurrently (Arno & Thomas, 2016; Bianchi et al., 2018; Lehner et al., 2016; Valdivia Espino et al., 2015). Given high scientific agreement that health and environmental sustainability can be improved simultaneously through dietary shifts, it is valuable to investigate the impacts of dietary interventions on both of these outcomes (IPCC, 2019). Furthermore, mixed evidence, short study periods, and inadequate implementation documentation have resulted in a lack of clarity regarding dietary intervention processes, effectiveness, and potential for scale-up (Roy et al., 2015; Szaszi et al., 2018; Valdivia Espino et al., 2015). In short, a gap remains between research and practice. For example: What might motivate a university to initiate and/or sustain an intervention, and why might some intervention strategies be preferable to others? Additional research is needed to support the development, implementation, and scale-up of university-based dietary interventions.

To address these gaps, this dissertation investigated how academics and non-academic foodservice leaders can collaborate to promote healthier, more environmentally sustainable diets in a university setting. Findings may also have relevance in other institutional settings, such as workplaces, hospitals, and K-12 schools. By employing a community-based participatory research (CBPR) approach, this applied scholarly endeavor involved learning, developing relationships, and building capacity among both the investigator and non-academic partner (Minkler & Wallerstein, 2003). Unlike traditional "outside expert" research, CBPR is driven by a non-academic partner and seeks to determine effective real-world approaches for achieving organizational, behavioral, and social change (Israel et al., 2005). As such, CBPR is ideal for enhancing intervention feasibility and building capacity for action (Chen, 2010; Israel et al., 2005; Minkler & Wallerstein, 2003).

Given this dissertation's focus on the university setting, all three studies were conducted at the University of California, Los Angeles (UCLA) over two academic years (2018-19 to 2019-20). Studies One and Two focused on the development, implementation, and evaluation of the Impossible™ Foodprint Project, a multi-component intervention to reduce animal-based protein consumption among university students. Using a CBPR approach, the Impossible™ Foodprint Project was collaboratively developed by university foodservice leaders and the investigator. Intervention components included: 1) the addition of new menu items with Impossible™ plant-based meat; and 2) a complementary social marketing campaign framed around climate change. The intervention was piloted at UCLA Dining's residential restaurant Rendezvous West in the Fall 2019 quarter.

To address gaps around how and why interventions take shape, Study One employed case study methodology to:

Aim 1: Investigate the process of developing and implementing an intervention to reduce animal-based protein consumption in university dining, with a particular focus on collaboration between academic and non-academic partners.

Using a quasi-experimental pre-post non-equivalent comparison group design, Study Two conducted an evaluation to:

Aim 2: Assess the effectiveness of a university dining intervention developed through community-based participatory research (CBPR) on the dual outcomes of healthfulness and environmental sustainability.

Finally, to inform future interventions and research, Study Three used a true experiment in an online simulated choice context to:

Aim 3: Determine whether environmental sustainability framing is more effective than health framing in "nudging" consumers to choose a plant-based menu item.

For **Aim 1**, I used qualitative methods to conduct a case study of the *process* of developing and implementing the intervention. This involved conducting key informant interviews with stakeholders including high-level decision-makers and foodservice operators at UCLA. I also extracted relevant information from archival records, documentation, and observation memos. The data were integrated and deductively analyzed according to Rogers' (2003) five-stage model of innovation development and implementation in organizations

(Rogers, 2003). As a final step, I inductively identified barriers and facilitators for progressing through the five stages of the model, with a focus on triangulation, or the convergence of findings from multiple data sources, to support validity.

For **Aim 2**, I used administrative sales records and nutritional data routinely collected by UCLA Dining through the foodservice management platform FoodPro. Using these data, I was able to compare entrée sales at the intervention site during the intervention pilot period, Fall 2019, to 1) entrée sales at the intervention site during the same period one year prior, Fall 2018 (pre-post analysis); and 2) pre-post changes in entrée sales at two comparison sites (difference-in-difference analysis). Over 645,000 entrée sales were included in the study. To assess outcomes of interest, I utilized FoodPro data and applied coding schemes to classify entrées according to entrée base (beef, pork, poultry, shrimp, fish, cheese-based, plant-based, Impossible™) and corresponding climate impact level (low, medium, high). Climate impact level classifications were based on published lifecycle analyses (LCAs) and carbon footprint percent daily value methodology developed by Leach et al. (2016). In response to foodservice leaders' evaluation priorities, we also conducted a customer survey of approximately 200 students to assess relationships between student-reported Impossible™ plant-based meat consumption and individual-level factors, such as demographics, meat consumption, beliefs, and experience with Impossible™.

For **Aim 3**, I conducted an original online experiment through Qualtrics. This involved recruiting 450 UCLA undergraduate students and staff through the Anderson Behavioral Lab's Sona participant pool. Participants were randomly assigned to one of three menu framing conditions—control (no framing), health framing, or environmental sustainability framing—and asked to make a choice between the same two menu items: 1) chicken enchiladas, and 2) roasted cauliflower and lentil tacos (i.e., plant-based tacos). The key outcome of interest was whether participants chose the plant-based tacos. Following their choice, participants completed a questionnaire about their values, attitudes, current dietary behavior, and sociodemographics. Data from the questionnaire were used to test for conditional effects of menu framing condition.

Chapter One provides a review of the literature on A) the links between diet, health, and environmental sustainability, B) why we eat what we eat, C) strategies for shifting diets, and D) shifting diets in a university setting. Chapter Two describes the theories informing the research questions and intervention strategies and introduces the conceptual models. Chapter Three outlines the research aims, questions, and hypotheses. Chapter Four describes the methodology and data sources for each study. Chapters Five, Six, and Seven present the results for Studies One, Two, and Three, respectively. Chapter Eight provides an integrated discussion of the implications of the findings, limitations, and recommendations for future research.

CHAPTER ONE: BACKGROUND AND SIGNIFICANCE

Part A. Understanding the links between diet, health, and environmental sustainability

The global burden of diet-related disease

Despite progress to increase food production and reduce hunger, current dietary patterns threaten public health on a global scale. In fact, due to their role in chronic disease, poor dietary patterns account for the largest burden of disease worldwide—more than tobacco, unsafe sex, drug use, and alcohol use combined (Willett et al., 2019). Diet-related chronic diseases such as cardiovascular diseases, type 2 diabetes, and some cancers have become leading causes of mortality and morbidity (WHO, 2010). Cardiovascular diseases account for approximately 31% of all global deaths, and 422 million adults have diabetes (WHO, 2018a, 2019). Diet has also been linked to many cancers, including cancers of the colon, kidney, breast, and esophagus (WHO, 2017). Diet-related conditions of overweight and obesity now affect almost two billion adults and 381 million children (WHO, 2018b). Overweight and obesity can reduce quality of life in numerous ways, including increasing risk of mental illness, poor physical functioning, high blood pressure, type 2 diabetes, and cardiovascular diseases (CDC, 2019a).

These outcomes warrant attention because diet-related chronic diseases are both preventable—and on the rise. Between 1975 and 2016, the global prevalence of obesity nearly tripled, with 13% of the world's adult population now obese (WHO, 2018b). At the same time, global prevalence of diabetes almost doubled (WHO, 2019). While obesity and related diseases were formerly considered a condition of high-income countries such as the United States (U.S.), low- and middle-income countries increasingly face a dual burden of undernourishment and obesity (Popkin et al., 2012). In every region of the world except sub-Saharan Africa and Asia, more people are affected by obesity than low body weight (WHO, 2018b).

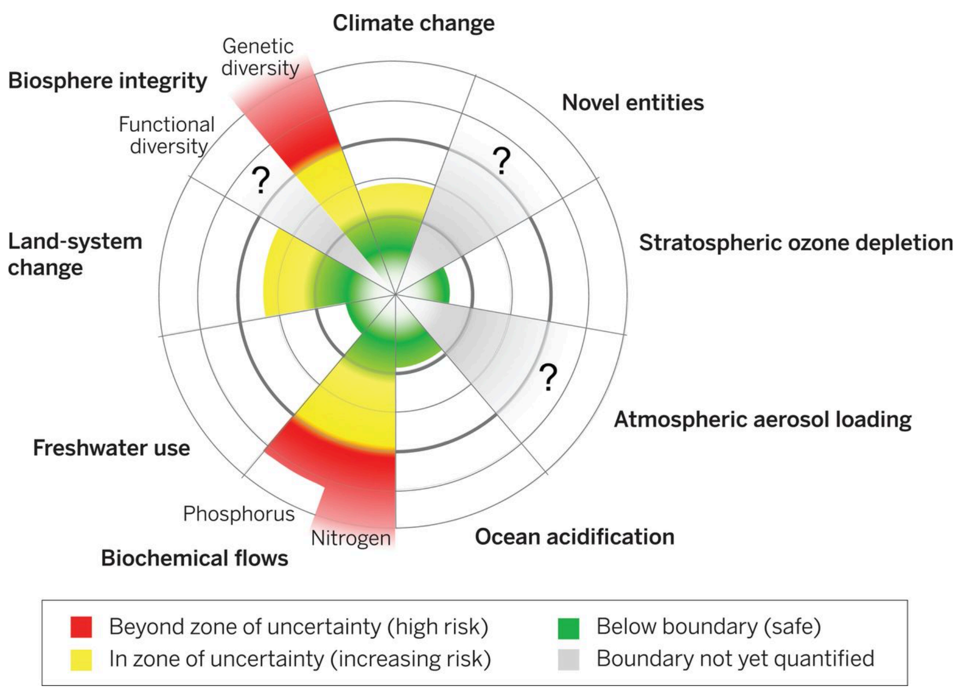
Nutrition, demographic, and epidemiological transitions

Popkin (1998) developed the "nutrition transition" framework to explain the rise in global obesity and diet-related chronic diseases. The nutrition transition refers to the Westernization of dietary patterns, characterized by higher consumption of calories, sugar, fat, animal products, and processed foods, and lower consumption of fiber, grains, and legumes (Guyomard et al., 2012; Popkin, 1998). The nutrition transition is proposed to occur alongside two other transitions associated with technological development, industrialization, urbanization, and economic growth: the demographic transition and the epidemiological transition (Popkin, 1998). The demographic transition refers to the shift from high to low fertility and mortality rates, indicating fewer births and longer life expectancy (Kirk, 1996). The demographic transition parallels the epidemiological transition, which refers to the shift from infectious to chronic disease burden and cause of death (Omran, 2005). As regions develop and incomes rise, dietary patterns shift away from traditional diets to obesity- and chronic disease-promoting Western diets (Popkin & Gordon-Larsen, 2004). Dietary changes are often exacerbated by decreases in physical activity due to changes in occupation, transportation, and leisure activities (Popkin & Gordon-Larsen, 2004). Together, these transitions have produced a growing global population characterized by longer lives—and more chronic disease over the life course. Given the role of diet in chronic disease, public health efforts are increasingly focused on improving dietary patterns.

Global diets and the boundaries of our planet

As the global population grows and human activity expands, so do impacts on our planet. These impacts are often considered using Rockström et al.'s (2009) planetary boundaries framework, which defines a safe operating space for humanity within the Earth's systems. The planetary boundaries framework covers nine systems, including: 1) climate change, 2) ocean acidification, 3) stratospheric ozone depletion, 4) nitrogen and phosphorus cycling, 5) novel entities, 6) freshwater use, 7) land-system change, 8) biodiversity loss, and 9) atmospheric aerosol loading. Remaining below defined boundaries is considered "sustainable" human activity—activity that can be safely sustained by the planet for current and future generations (Rockström et al., 2009). As of 2015, human have already exceeded safe boundaries for four of the nine systems, illustrated in Figure 1: 1) climate change, 2) nitrogen and phosphorus cycling, 3) land-system changes, and 4) genetic diversity (i.e., biodiversity loss) (Steffen et al., 2015).

Figure 1. Status of planetary boundaries, Steffen et al. (2015)



Food production is a leading driver of change in five of the Earth's systems, including: 1) climate change, 2) nitrogen and phosphorus cycling, 3) freshwater use, 4) changes in land use, and 5) biodiversity loss (Willett et al., 2019). Figure 2 illustrates global greenhouse gas (GHG) emissions by economic sector using data from 2010. The food system is represented in the "Agriculture, Forestry, and Other Land Use" sector and is second—barely—to "Electricity and Heat Production." In 2019, the United Nations (UN) Intergovernmental Panel on Climate Change (IPCC) estimated the global food system now contributes 25-30% of total GHG emissions (IPCC, 2019). GHG emissions from the food system include carbon dioxide (CO_2) and non-CO_2 emissions generated throughout the life cycle of food products—the growing, harvesting, processing, distributing, retailing, and consumption of food around the world (IPCC, 2019). Clearing forests for agricultural land, raising livestock, and using fossil fuels for fertilizers and machinery contribute a large share of GHG emissions in the food system (IPCC, 2019).

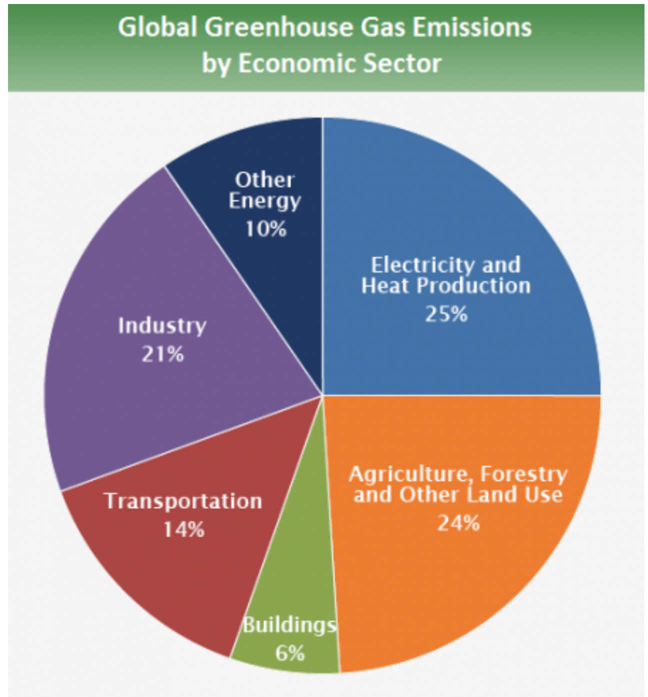


Figure 2. GHG emissions by economic sector, United States Environmental Protection Agency (2019)

Food systems also alter nitrogen and phosphorous flows through the excessive application of synthetic fertilizers and discharges from livestock waste and processing (Erisman et al., 2013; Xue & Landis, 2010). Altering these flows results in pollution of drinking water (nitrates), air quality (smog, particulate matter, ground-level ozone), freshwater (eutrophication), coastal ecosystems (dead zones), and other impacts such as climate change and ozone depletion

(Erisman et al., 2013). Furthermore, agriculture currently occupies 40% of global land and uses 75-84% of global consumptive freshwater (IPCC, 2019). Converting natural ecosystems—especially forests—to agricultural land not only contributes to climate change, but also poses the greatest threat to species extinction (EAT-Lancet Commission, 2019). Overfishing and irresponsible aquaculture practices threaten marine species and coastal habitats as well (EAT-Lancet Commission, 2019).

The challenge of feeding the world in 2050

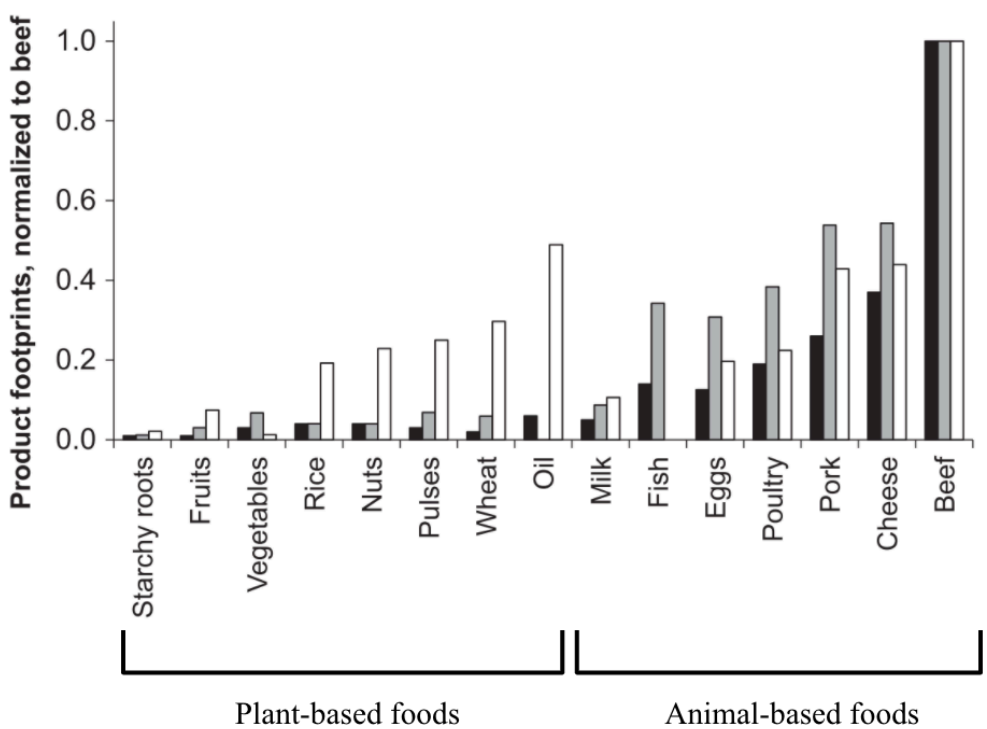
Of course, humans must eat, and anthropogenic impacts on the Earth's systems through food production are unavoidable. However, the demographic, epidemiological, and nutrition transitions previously discussed have created a global predicament of how to nutritiously and sustainably feed a growing population with rising incomes and longer lives, expected to reach ten billion by 2050 (EAT-Lancet Commission, 2019). Importantly, food systems—and thus human wellbeing—depend on the functioning of the Earth's systems (EAT-Lancet Commission, 2019; IPCC, 2019). It is now clear that current and projected food production patterns impose excessive burdens on the planet (Springmann et al., 2018). Beyond projected growth in global population by about a third, the proportion of animal-based foods in the diet is projected to increase alongside a projected tripling of global income (Springmann et al., 2018). Overall, environmental impacts from food production are projected to increase by 50-92%, with the greatest increases in impact occurring through GHG emissions (Springmann et al., 2018). Recent studies show that simply improving food production efficiency will not achieve safe and sufficient food to support active, healthy lives; demand-side solutions such as dietary shifts are needed to both mitigate and adapt to climate change to ensure food security (IPCC, 2019).

Understanding the environmental impacts of what we eat

Based on a substantial body of life cycle assessment (LCA) literature, we now know with high confidence that the environmental impacts of food products vary widely (M. A. Clark et al., 2019; Clune et al., 2017; Heller & Keoleian, 2014; Leach et al., 2016). LCAs are an internationally recognized method to account for the inputs, outputs, and impacts of production systems (Clune et al., 2017). LCA studies have found that, relative to plant-based foods, animal-based foods are generally less resource efficient and have larger environmental impacts per unit weight, per serving weight, per calorie, and per gram of protein (Willett et al., 2019). This can be understood through two key points: 1) growing and transporting food to feed animals requires more resources than eating food directly; and 2) livestock create additional impacts through methane and manure-related outputs. Meat and dairy from ruminant animals (e.g., cows, goats, sheep) are more impactful than other animal-based foods due to lower energy conversion efficiency and enteric fermentation, or methane produced when the animals pass gas (mostly through belching) (Shepon et al., 2016; Springmann et al., 2018). While organic and grass-fed production systems are often viewed as "environmentally-friendly" solutions, Clark and Tilman (2017) demonstrate that shifts to lower-impact foods and increases in agricultural efficiency would provide larger environmental benefits than switching to these alternative production systems. In fact, when comparing foods within product categories, the authors found that organic and grass-fed production systems produce similar or more greenhouse gases than conventional systems (Clark & Tilman, 2017).

The UN Food and Agriculture Organization (FAO) estimates the livestock sector alone uses 70% of all agricultural land, accounts for 10% of global human water use, and imposes the largest source of water pollution across all sectors (FAO, 2019). Furthermore, livestock contribute 14.5% of total GHG emissions, which is more than the entire transportation sector (FAO, 2019). Figure 3 below illustrates the carbon (black bars), nitrogen (gray bars), and water (white bars) footprints of food products by weight, relative to beef (Leach et al., 2016). Carbon footprints include total CO_2 and non-CO_2 (e.g., methane, nitrous oxide) GHG emissions converted to CO_2-equivalent (CO_2-eq) units (Leach et al., 2016). Nitrogen footprints represent total weight of reactive nitrogen released into the environment (Leach et al., 2016). Water footprints represent total amount of water used, including crop water use and irrigation (Leach et al., 2016). In sum, the evidence is clear that plant-based foods have the lowest environmental impacts; animal-based foods such as pork, poultry, fish, eggs, and dairy have intermediate impacts; and ruminant meats such as beef and lamb have the highest impacts.

Figure 3. Carbon footprints (black bars), nitrogen footprints (gray bars), and water footprints (white bars) of major food product categories relative to beef, adapted from Leach et al. (2016)



Climate change, food systems, and public health

While human populations depend on the safe operation of all nine Earth systems defined in the planetary boundaries framework, climate change is increasingly recognized as an urgent and serious existential threat. Moreover, we have come to understand the implications of climate change as both immediate and long-term. In 2019, the American Public Health Association joined over 70 health organizations to prioritize climate change as a health emergency (APHA, 2019). Climate-sensitive health implications include illness, injury, and death due to extreme weather events; food and water contamination due to microbial proliferation; changes in vector-pathogen-host relations; and changes in the distribution of allergens and infectious diseases (McMichael et al., 2006; Patz et al., 2005). To put these impacts into perspective, a recent study estimated the health-related costs of ten U.S. climate-sensitive events in 2012—including wildfires, extreme heat, West Nile and Lyme disease, extreme precipitation, allergenic pollen, air pollution, and a major hurricane—at about $10 billion (Limaye et al., 2019). While climate change imposes risks and costs on all people, the greatest burden will fall on the poor and vulnerable (IPCC, 2019; McMichael et al., 2006). As such, climate change is both a health issue and an equity issue, as it threatens to exacerbate health disparities across the globe.

The UN Intergovernmental Panel on Climate Change (IPCC) released a 2019 report documenting current and projected impacts of climate change on global food security, including higher food prices, productivity losses, and reduced nutritional quality due to increasing temperatures, changing precipitation patterns, changing distribution of diseases and pests, and increasing extreme weather events (IPCC, 2019). The report also concluded that fruit and vegetables—key components of healthy diets—are particularly susceptible to damage from climate change (IPCC, 2019). As mentioned above, vulnerable populations, including women and girls in poor regions, are most at risk of undernutrition, livelihood loss, and displacement caused by climate change—all of which can exacerbate poverty and adverse health (IPCC, 2019; McMichael et al., 2006). Recognizing the mutual relationship between climate change, food systems, and public health, the report called for large-scale changes to both food production and consumption practices around the world (IPCC, 2019). Specifically, the report calls for shifts away from high intake of animal-based foods towards diets rich in healthy plant-based foods.

Defining a diet for both human and planetary health

The state of the world described above has sparked an international movement to simultaneously address the dual challenge of how to nutritiously and sustainably feed the global population (EAT-Lancet Commission, 2019). In addition to the 2019 UN IPCC report discussed above, the EAT-Lancet Commission (2019) recently convened 19 Commissioners and 18 coauthors from 16 countries in the fields of health, agriculture, political science, and environmental sustainability to develop scientific targets for a global dietary pattern that promotes human health within safe boundaries of the planet. The recommended diet was developed with the goal of feeding a projected 10 billion people by 2050, while ensuring the possibility of meeting the UN Sustainable Development Goals (SDGs) and the Paris Climate Agreement (Willett et al., 2019). In short, the Commission calls for a transformation of the global food system to reduce the burden of diet-related chronic disease, environmental degradation, and other health risks (Willett et al., 2019). Importantly, the authors note that transforming the food system is essential for reaching the Paris Agreement of limiting warming well below 2 degrees Celsius, aiming for 1.5 degrees Celsius; this cannot be achieved by decarbonizing the energy system alone (Willett et al., 2019). Furthermore, studies modeling various food system climate mitigation strategies indicate that shifting consumption to include less meat and dairy—and much less beef—are crucial for limiting greenhouse gas emissions within safe limits (Hedenus et al., 2014; Springmann et al., 2018).

The Commission's "healthy reference diet" presented in Figure 4 outlines daily food group intake recommendations for healthy individuals ages two and above (Willett et al., 2019). The recommended dietary pattern is based on extensive evidence from controlled feeding studies, observational studies, and randomized trials—some of which will be reviewed here (Willett et al., 2019). Overall, the Commission concludes with high confidence that the following dietary pattern promotes low risk of chronic disease and promotes wellbeing: 1) protein sources mainly from plants, fish several times per week, and optional modest consumption of poultry and/or eggs; 2) fat mostly from unsaturated plant oils; 3) carbohydrates mostly from whole grains; 4) at least five servings of fruits and vegetables per day; and 5) optional moderate dairy consumption (Willett et al., 2019).

Figure 4. Healthy reference diet for human and planetary health, Willett et al. (2019)

	Macronutrient intake (possible range), g/day	Caloric intake, kcal/day
Whole grains*		
Rice, wheat, corn, and other†	232 (total gains 0–60% of energy)	811
Tubers or starchy vegetables		
Potatoes and cassava	50 (0–100)	39
Vegetables		
All vegetables	300 (200–600)	..
Dark green vegetables	100	23
Red and orange vegetables	100	30
Other vegetables	100	25
Fruits		
All fruit	200 (100–300)	126
Dairy foods		
Whole milk or derivative equivalents (eg, cheese)	250 (0–500)	153
Protein sources‡		
Beef and lamb	7 (0–14)	15
Pork	7 (0–14)	15
Chicken and other poultry	29 (0–58)	62
Eggs	13 (0–25)	19
Fish§	28 (0–100)	40
Legumes		
Dry beans, lentils, and peas*	50 (0–100)	172
Soy foods	25 (0–50)	112
Peanuts	25 (0–75)	142
Tree nuts	25	149
Added fats		
Palm oil	6·8 (0–6·8)	60
Unsaturated oils¶	40 (20–80)	354
Dairy fats (included in milk)	0	0
Lard or tallow‖	5 (0–5)	36
Added sugars		
All sweeteners	31 (0–31)	120

The 2,500-calorie allowance and inclusion of intake ranges allows for tailoring and application of the pattern to various populations and cultural food preferences, while remaining within environmental impact limits; individual calorie requirements depend on body size and level of physical activity (Willett et al., 2019). This dietary pattern aligns well with the Dietary Guidelines for Americans, which recommends the promotion of fruit, vegetables, whole grains, nuts and seeds, and seafood to prevent chronic disease risk (USDA & HHS, 2015). It also aligns well with the environmental impact hierarchy described above: high in low-impact plant-based foods, including vegetables, fruits, whole grains, legumes, nuts, and unsaturated oils; modest to low in seafood, poultry, and eggs; and low or without red meat.

The role of protein-rich foods and dairy foods

Although most foods contain some protein, it is worth discussing protein-rich foods in some detail due to their widely varying environmental impacts and role in chronic disease. Protein-rich foods include ruminant meat, such as beef and lamb; pork; poultry; eggs; fish and other seafood; legumes, such as beans and soy foods; and tree nuts. A large body of evidence supports recommendations for low or no red meat intake (Bouvard et al., 2015; Katz & Meller, 2014; National Research Council, 1989; WHO, 2003). In high-income countries, large prospective cohort studies and meta-analyses have demonstrated higher risk of mortality, cardiovascular disease, stroke, and type 2 diabetes among those with higher consumption of red meat (i.e., beef and pork) and processed meat (i.e., meat that has been salted, cured, or transformed in some way, usually to enhance flavor or preservation) (Bouvard et al., 2015; Pan et al., 2011; A. Pan et al., 2012). One meta-analysis found an increase of about one serving (100g) of unprocessed red meat and about half a serving (50g) of processed red meat per day increased the relative risk of diabetes by 19% and 51%, respectively (Pan et al., 2011). Due to strong evidence linking processed meat to colorectal cancer, the World Health Organization classified processed meat as carcinogenic; red meat was classified as probably carcinogenic (Bouvard et al., 2015). Studies have also found links between processed meat consumption and pancreatic cancer, prostate cancer, and weight gain in adults (Bouvard et al., 2015; Godfray et al., 2018; Vergnaud et al., 2010). Components of red and processed meat that may contribute to negative health effects include carcinogenic compounds created during processing or cooking, heme iron, saturated fatty acids, and sodium (specifically in processed meat) (Bouvard et al., 2015; Godfray et al., 2018).

In November 2019, a controversial article was published in the high-impact journal *Annals of Internal Medicine* providing new "guidelines" for red and processed meat consumption (Johnston et al., 2019). Led by a self-appointed panel, the guidelines challenged existing dietary guidance by recommending people continue consuming red and processed meat at current levels (Johnston et al., 2019). These recommendations were based on the panel's interpretation that 1) nutrition science has yielded weak evidence for health risks, 2) observed health risks are small, and 3) the public is unwilling to reduce meat consumption (Johnston et al., 2019). Unfortunately, this interpretation is inherently flawed and—as was later revealed—likely biased by the lead author's ties to the meat and food industry (Parker-Pope & O'Connor, 2019).

First, the panel's interpretation of weak evidence involved misuse of evaluation criteria designed for biomedical studies such as drug trails, rather than nutrition science (The Nutrition Source, 2019). Although nutritional epidemiology can be limited in its reliance on self-reported measures and observational study designs, this approach is valid and appropriate for studying complex lifestyle behaviors and exposures such as diet (Hu & Willett, 2018). Second, the panel's own meta-analyses actually corroborated previous findings that reducing meat consumption significantly reduces risks of major cardiovascular outcomes, type 2 diabetes, and cancer mortality (Bouvard et al., 2015; Johnston et al., 2019; Pan et al., 2011; A. Pan et al., 2012). However, when interpreting risks, the panel took an "individual decision making rather than a public health perspective," ultimately concluding that effect sizes of 1-18 fewer events per 1,000 is not sufficient to recommend reduction (Johnston et al., 2019). This is particularly problematic given the individual, social, and economic burden of these outcomes at the population level. Finally, the authors considered people's affinity for meat as part of their recommendation. This is simply inappropriate. While important, taste preferences should not be conflated with health risk assessment. In sum, it is worthwhile to note the threats of conflicts of interest in nutrition research. In the case of this article, findings appear to be subject to interpretation bias, quite likely due to influence from the food industry. Nutrition experts remain in support of the large body of evidence informing recommendations for reduced consumption of red and processed meat (The Nutrition Source, 2019).

Beyond red meat, negative health effects have not been found for consumption of white meat such as chicken (Godfray et al., 2018). Largely due to high omega-3 fatty acid content, fish consumption is associated with improved cardiovascular health and reduced risk of mortality from heart disease (Clark et al., 2019; Willett et al., 2019). Despite historical concerns about cholesterol in eggs, more recent evidence indicates consumption of dietary cholesterol is not linked to serum cholesterol (Dietary Guidelines Advisory Committee, 2015). In addition, a review of large prospective studies found that consumption of up to one egg per day is not associated with increased risk of heart disease in healthy populations (Dehghan et al., 2020). Although dairy consumption has been promoted in the U.S. to improve low calcium intake, calcium needs can be met through other foods sources such as leafy green vegetables, legumes, and plant-based milks (Dietary Guidelines Advisory Committee, 2015). Still, dairy products may confer other health benefits. For example, one systematic review and meta-analysis found that dairy intake is associated with reduced risk of type 2 diabetes (Aune et al., 2013). As such, the EAT-*Lancet* Commission concluded that a wide range of dairy intake is compatible with good health (Willett et al., 2019).

In general, higher consumption of nuts and legumes is linked with lower risk of chronic diseases (Afshin et al., 2014). Studies have demonstrated numerous health benefits of nut consumption, including improvements in blood lipid concentrations and cholesterol (Del Gobbo et al., 2015). Systematic reviews have found higher consumption of nuts is associated with reduced risk of cardiovascular disease, diabetes, and overall mortality (Afshin et al., 2014; Mayhew et al.). A controlled feed study found that legume consumption reduces LDL-cholesterol, and a systematic review found that higher consumption of legumes is associated with reduced risk of cardiovascular disease (Duane, 1997; Marventano et al.).

Researchers have also explored the health effects of substituting other protein-rich foods for red and processed meat. One study found lower risk of mortality, coronary heart disease, stroke, and type 2 diabetes when modeling replacement of red and processed meat with plant-based foods such as nuts, legumes, and whole grains (Godfray et al., 2018). The diabetes meta-analysis mentioned above found that replacing one daily serving of red meat with other animal-based foods such as low-fat dairy, poultry, and fish reduced relative risk of diabetes (Pan et al., 2011). Substituting poultry or fish for one daily serving of red meat was also found to reduce risk of coronary heart disease (A. Pan et al., 2012). Tilman and Clark (2014) demonstrated through modeling the health benefits of three alternative diets, all with low or no red meat and rich in plant-based foods—Mediterranean, pescatarian, and vegetarian. Compared to typical omnivorous diets, incidence of type 2 diabetes was reduced by 16-41%, incidence of cancer was reduced by

7-13%, and mortality from coronary heart disease was reduced by 20-26% (Tilman & Clark, 2014). Finally, the largest prospective study of vegetarian diets in the U.S. found that vegetarians (i.e., those who exclude meat and seafood) had a 12% lower overall mortality risk than omnivores, but pescatarians (i.e., those who eat seafood but exclude meat) had the lowest risk (Orlich et al., 2013).

The burden of American diets

Thus far, the discussion of food, health, and the environment has been global in scope. Unfortunately, the American diet is emblematic of the diet-related chronic disease risk and environmental degradation described above. In the U.S., diet-related conditions and diseases are common and costly. Approximately 40% of American adults, 20% of adolescents, and 18% of children are obese (CDC, 2019b, 2019c). Six in ten American adults have at least one chronic disease, and 30.3 million (9.4%) have type 2 diabetes (CDC, 2017b, 2019d). Ninety percent of the $3.3 trillion Americans spend on health care goes to chronic and mental conditions, with $147 billion spent on obesity and $237 billion on diabetes (CDC, 2018). Over the past 20 years, obesity prevalence has continued to rise, and diabetes diagnosis has more than tripled (CDC, 2017a). At the same time, calorie intake has increased alongside more food consumed away from home and larger portion sizes (Briefel & Johnson, 2004). Increasing consumption of food away from home has been identified as a risk factor for poor diet because away-from-home food promotes overconsumption and typically contains more calories, more saturated fat, and less fiber (Karen Glanz et al., 2005; Levitsky & Pacanowski, 2012). In short, Americans tend to follow a Western dietary pattern that threatens both human and planetary health: low in high-quality plant foods, and high in processed and animal-based foods (Dietary Guidelines Advisory

Committee, 2015). As illustrated in Figure 5 below, North Americans drastically exceed the Willett et al. (2019) healthy reference diet recommendations in the limited and optional food categories of beef, starchy vegetables, eggs, poultry, and dairy, and fall short of recommendations for all emphasized foods, including fish, vegetables, fruit, legumes, whole grains, and nuts.

Figure 5. The "diet gap" between current and recommended intake in North America, Willett et al. (2019)

In 2015, the U.S. Dietary Guidelines Advisory Committee linked health, dietary guidance, and environmental sustainability for the first time (Dietary Guidelines Advisory Committee, 2015). The Committee noted that American diets currently exceed the greenhouse gas emissions, land use, and water use required for healthy dietary patterns—including the Healthy US-Style Pattern, Healthy Mediterranean-Style Pattern, and Healthy Vegetarian Pattern. As such, the Committee concluded that American diets should be lower in animal-based foods and higher in plant-based foods such as vegetables, fruits, whole grains, legumes, nuts, and seeds (Dietary Guidelines Advisory Committee, 2015). Unfortunately, the Advisory Committee's recommendation was not included in the 2015 Dietary Guidelines for Americans, which was seen by many as evidence of industry interference (The Nutrition Source, 2015). Still the guidelines indicate that substantial shifts in American diets are necessary to improve population health.

Most Americans exceed recommendations for calories, added sugar, solid fats, sodium, and refined grains, and fall short of recommendations for fruits, vegetables, legumes, oils, and whole grains (USDA & HHS, 2015). Most Americans meet or exceed protein-rich food intake (especially men); however, consumption of seafood is low for all groups, and consumption of nuts, seeds, and soy products is low for both males and females ages 14-30 (USDA & HHS, 2015). With respect to fats, Americans exceed solid fat intake recommendations, while falling below recommendations for oil intake (USDA & HHS, 2015). The majority of solid fats in American diets come from animal-based foods, including meat and cheese in mixed dishes such as pizza, burgers, tacos, and sandwiches (USDA & HHS, 2015). Americans also exceed recommendations for added sugar and sodium, with the largest source of sugar (47%) coming from beverages, and the largest source of sodium coming from mixed dishes such as burgers and sandwiches (44%) (USDA & HHS, 2015).

A closer look at American meat consumption

As previously discussed, meat consumption typically increases alongside economic development, and U.S. Department of Agriculture (USDA) data demonstrates that U.S. meat consumption has almost doubled over the last century (Daniel et al., 2011). At 128 grams (~4.5 ounces) per day on average, American meat intake is estimated at three times the global average (Daniel et al., 2011; Macdiarmid et al., 2016). With respect to red meat, the US had the second highest beef and fifth highest pork consumption per capita in 2018 (OECD, 2019). Although red meat consumption has slightly decreased in recent years, increasing poultry intake has resulted in a continuous rise in total meat intake—including red meat, processed meat, and poultry (Daniel et al., 2011). Still, red meat continues to account for the greatest proportion (58%) of meat in the American diet (Daniel et al., 2011). In 2018, per capita beef consumption was estimated at about 77 grams (~2.7 ounces) per day in the U.S. (OECD, 2019). For context, USDA's MyPlate estimates one small lean hamburger at 56-85 grams (USDA, 2016). Beef consumption also contributes a disproportionate share of food-related greenhouse gas emissions. In the U.S., beef accounts for approximately 4% of food sold by weight but contributes 36% of food-related emissions, suggesting an opportunity to meaningfully reduce emissions by reducing beef consumption (Heller & Keoleian, 2014).

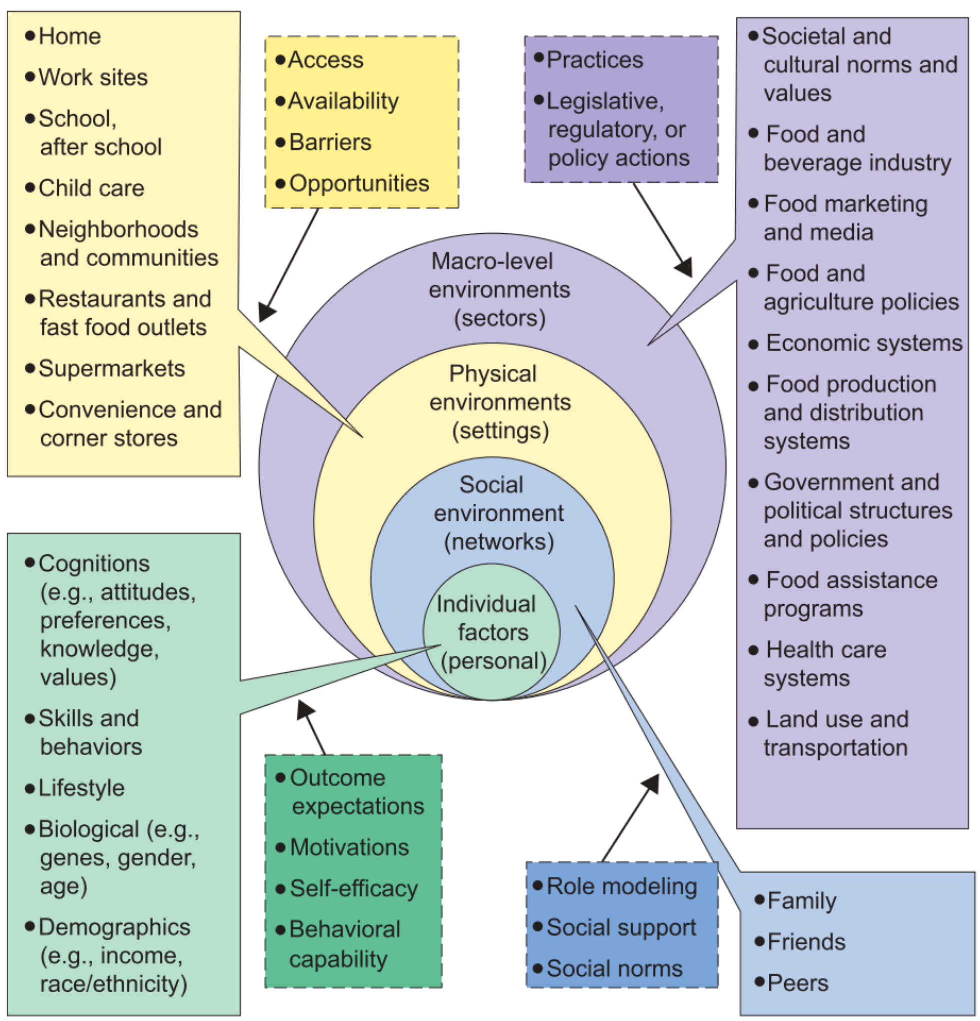
Part B. Exploring why we eat what we eat

Why do we eat what we eat?

In order to effectively shift dietary patterns, we must first grapple with a fundamental question: Why do we eat what we eat? The nutrition transition described above sheds light on global historical trends in human diets. However, a deeper exploration of our country-specific policies, practices, and human dynamics is needed. Various disciplines have explored dietary behavior over the past several decades—including nutritional sciences, psychology, philosophy, and consumer researcher—each with its own emphasis (Stok et al., 2017). Sobal and Bisogni (2009) argue that no single theory or paradigm can fully explain food choices, and that an integrated approach is needed to fully understand the complex food choice process.

In public health, an ecological perspective has been used to identify the range of dietary behavior determinants across multiple levels of influence (Sallis et al., 2008; Story et al., 2008). Individual influences comprise those within-person, such as cognitions and demographics. Environmental influences comprise everything beyond the individual and are often considered across three distinct levels: social, physical, and macro. Social environmental influences include those between people; physical environmental influences include specific settings; and macro-level environmental influences include policies and systems (Story et al., 2008). Importantly, ecological approaches recognize the complexity of dietary behavior due to interactions across multiple levels of influence (Bronfenbrenner, 1979). For example, while environmental factors such as food prices influence individuals across populations, specific impacts depend on an individual's income. Furthermore, the ecological concept of reciprocal determinism suggests that, just as environments shape individuals, individuals can shape their environments (Story et al., 2008). Story et al.'s (2008) widely used ecological framework for dietary behavior is presented in Figure 6.

Figure 6. **Ecological framework illustrating multiple, interacting levels of influence on dietary behavior, Story et al. (2008)**



The following sections will discuss a selection of macro, physical, social, and individual dietary determinants I consider germane to this dissertation.

Macro-level environment: A brief look at the Farm Bill and our food supply

The production and price of food in America is heavily influenced by the Farm Bill. While more than three-quarters of the $400+ billion Farm Bill budget is dedicated to nutrition programs, the remaining budget shapes agricultural output through subsidies in the form of crop insurance ($41.1 billion) and commodity payments ($23.6 billion) (Imhoff, 2019; Larson & Story, 2009; USDA ERS, 2019). Payments go mostly to large-scale monoculture, dairy, and livestock operations (Imhoff, 2019).

Originally written during the Great Depression and Dust Bowl era (1933), the Farm Bill was designed to support the millions of small farms that supplied the American food system (Imhoff, 2019). Since the 1950s, the number of farms has drastically decreased, while the size and industrialization of farms has increased (Imhoff, 2019). It is estimated that less than 4% of cropland is dedicated to growing fruits and vegetables, while 75% is used for just eight commodity crops, such as corn and soybeans (Wallinga, 2010). This is problematic as commodity crops do not necessarily support healthy diets.

Because food companies purchase commodities at artificially low prices, a variety of "transformed" food products containing sugar and fat are now widely available and relatively inexpensive (Wallinga, 2010). By ensuring the production of cheap livestock feed and providing extensive infrastructure payments to concentrated animal feeding operations (CAFOs), the Farm Bill directly influences the quantity and price of meat and dairy in the U.S. The rise of giant food corporations such as Nestlé and McDonald's has also significantly contributed to changes in the food supply (Guyomard et al., 2012). These companies ensure that processed and fast foods high in salt, sugar, fat, and animal products are now widely available in most countries and communities across the globe (Guyomard et al., 2012).

Physical environment: Country, communities, and micro-environments

Physical environments, or settings, are thought to affect food choices by determining what is available (supply, options); accessible (conveniently located, open, visible); affordable (price, value); and acceptable (meet personal standards for consumption) (Caspi et al., 2012; Story et al., 2008). As a whole, the modern American food environment has been described as obesogenic (i.e., obesity-causing) due to the pervasiveness of cheap, hyper-palatable, energy-dense foods and beverages designed to capitalize on innate human food preferences (Levitsky & Pacanowski, 2012; Wallinga, 2010). However, some community food environments are more obesogenic than others. Starting in the 1990s, scholars began exploring the concept of "food deserts," which generally refers to geographic areas void of supermarkets or other food outlets with affordable, healthy food (Walker et al., 2010). The effect of food deserts on diet has been demonstrated by researchers such as Moore et al. (2008) who found that, after controlling for age, sex, race/ethnicity, and socioeconomic status (SES), those living in areas with no supermarkets near their homes were 25-46% less likely to have healthy diets than those with the highest supermarket density. However, some quasi-experimental and longitudinal studies have found that opening a supermarket or improving neighborhood store offerings does necessarily not result in improved dietary intake among residents (Cummins & Macintyre, 2002; Ortega et al., 2016; Wrigley et al., 2003).

More recently, the term "food desert" has been debated and replaced with the perhaps more appropriate term, "food swamp" (Cooksey-Stowers et al., 2017). In a comparative study of food environment measurement, Stowers et al. (2017) found that assessing the relative distribution of low-quality to high-quality food outlets (i.e., food swamps) was a better predictor of obesity than the absence of supermarkets (i.e., food deserts). Thus, the authors argue that food environment interventions must both incentivize/increase healthier food venues while simultaneously reducing unhealthy venues (Cooksey-Stowers et al., 2017).

The composition of restaurants in communities has become increasingly important as Americans consume more and more food away from home. Food dollars spent on food prepared outside the home have doubled since the 1960s, now comprising about half of American food budgets (Cohen & Bhatia, 2012). The observed increase in caloric intake over the past decade has been largely attributed to frequency of eating out, which is associated with larger portion sizes and greater intake of fat and sodium (Guthrie, Lin, & Frazao, 2002). Higher intake of restaurant food and fast food has been linked to poor overall diet quality and increased risk of obesity and diet-related chronic disease (Ayala, Rogers, et al., 2008; Lachat et al., 2012; Todd et al., 2012).

Research has also explored factors within micro-environments such as restaurants, grocery stores, and institutions. Evidence suggests the availability, accessibility, affordability, and acceptability of foods within these contexts directly affects choice (Caspi et al., 2012; Larson & Story, 2009). For example, Cohen and Babey (2012) argue the presentation of choices in micro-environments largely shape our decisions. The authors suggest that, because people do not fully control their senses, we often respond to contextual cues automatically, without conscious thought (i.e., pull hand away when touching something hot) (Cohen & Babey, 2012). While automatic responses can be protective in some cases, they can also lead to choices that do not align with goals or preferences. In fact, research suggests external food cues can disinhibit eating and reduce rational decision-making (Zimmerman & Shimoga, 2014). Today, we are exposed to more and increasingly sophisticated food cues that promote consumption and encourage the selection of foods high in calories, salt, sugar, and fat (Cohen & Babey, 2012). Food cues are often designed by marketers and include a variety of formats including placement, signboards, framing, packaging, labels, and portion size (Buda & Zhang, 2013; Cohen & Babey, 2012). Studies show that exposure to food cues through advertising—both within and beyond food choices contexts—imposes strong effects on food choices (Karen Glanz et al., 2005; Zimmerman & Shimoga, 2014).

Social environment: Culture and interpersonal connections

The influence of the social environment on eating behavior is well established (Axelson, 1986; Cruwys, Bevelander, & Hermans, 2015; Larson & Story, 2009). While social influences such as cultural norms and values are often considered macro-level, they will be discussed here for the sake of clarity and continuity. Cultural values designate socially appropriate food activities or "foodways"—acceptable ways of obtaining, consuming, and disposing of food (Axelson, 1986). Societal values also influence food policy and the extent to which a society invests in nutrition programs, healthy communities, and environmental stewardship. Culture evolves over generations, and different subgroups and individuals experience culture differently (Axelson, 1986). Although regional diets have largely converged and become more Westernized since the 1960s, variation remains across cultures in terms of motivations, preferences, and meanings of food in everyday life (Guyomard et al., 2012; Hauser et al., 2011). For example, French food culture is cited as an explanation for why a large majority of French people eat both lunch and dinner at home, a practice associated with improved diet quality (Guyomard et al., 2012). Studies on acculturation—degree of immigrants' assimilation—have shed light on the unhealthy nature of American food culture (Almohanna et al., 2015; Ayala, Baquero, et al., 2008; Matias et al., 2013). For example, higher acculturation has been linked with lower consumption of fruits, vegetables, and fiber, and greater consumption of energy from fat among Mexican American women (Montez & Eschbach, 2008). A study of Asian students living in the U.S. also found increases in consumption of fat, sweets, dairy products, and American-style fast foods after immigration to the U.S. (Pan, Dixon, Himburg, & Huffman, 1999). In general, immigrants are thought to adopt more unhealthy eating behaviors the longer they live in the U.S. (Barcellos et al., 2012). Of course, it is difficult to disentangle the influence of physical food environments from culture, and interactions across these levels are acknowledged in ecological frameworks.

Social influences also operate on a more interpersonal level. Family, friends, colleagues, mentors, and other eating companions influence eating behavior through mechanisms such as modeling, reinforcement, social support, and information sharing (DiMaggio & Garip, 2012; Larson & Story, 2009; Umberson et al., 2011). Social modeling has been identified as a consistent and substantial determinant of food choice, operating through both unconscious mimicry and normative information (Cruwys et al., 2015; E. Robinson et al., 2014). Although people typically report they are not influenced by others, experimental studies demonstrate that individuals are more likely to reach for or consume food and beverages after seeing someone else do so (Cruwys et al., 2015). Normative information refers to gaining information about what and how much is appropriate to eat by observing others' behavior (Robinson et al., 2014). Is it thought that people engage in social modeling—both consciously and unconsciously—to bond with others or reduce uncertainty in action (Cruwys et al., 2015). Social networks can also promote healthy eating through support for healthy—or criticism of unhealthy—behaviors (Gruber, 2008). Within families, the household is a major determinant of diet due to both food availability and family food practices such as parents' eating behavior and family meals (Larson & Story, 2009).

Individual: Biology, psychology, and demographics

At the individual level, biological, psychological, and demographic factors have been well documented. Research suggests humans are predisposed to prefer sweet and salty tastes, reject new tastes, and learn preferences by associating foods with contexts and consequences (i.e., conditioning) (Birch, 1999). Sensory experiences of satiety and regulation of hormones leptin and ghrelin also affect appetite and subsequent food intake (Guyomard et al., 2012). While fat has been found to generally improve sensory perceptions of food palatability and quality, individual preferences for fat may depend on body weight, past eating experience, or some genetic component (Drewnowski, 1997).

Physical and psychological motivators are also important in food choice—including hunger, stress, mood, conformity, need for ego recognition, knowledge, beliefs, and values that define "good" and "bad" consequences of behaviors (Baranowski et al., 1999; Brug, 2008; Finch et al., 2019; Guillaumie et al., 2010; Worsley, 2002). In general, greater knowledge, self-efficacy, skills, and positive attitudes about healthy eating predict better diet quality (Brug, 2008). In the U.S., salient food values typically include taste, convenience, cost, health, managing relationships, and morals/ethics (Sobal & Bisogni, 2009). Sobal and Bisogni (2009) describe the cognitive process of weighing values as a "personal system" that mediates the influence of the environment on individual food choice. However, psychological explanations typically acknowledge both conscious/rational and subconscious/automatic aspects of the food choice process (Furst et al., 1996). Of note, food choices involve managing multiple competing values, which can result in reliance on habits and heuristic strategies such as elimination, limitation, substitution, or routinization (Sobal & Bisogni, 2009). Shot-term expectations of pleasure/disgust can also outweigh long-term goals and expectations of healthfulness (Kringelbach, 2015). In fact, food preferences derived from sensory-affective responses to aspects of food such as taste, smell, and appearance appear to be some of the strongest predictors of food choices (Birch, 1999; Eertmans et al., 2001; Furst et al., 1996).

Furthermore, individual demographics including age, gender, socioeconomic status (i.e., occupation, education, and income), race/ethnicity, and religion also play a role in diet. In the U.S., diet quality tends to follow a socioeconomic gradient (Darmon & Drewnowski, 2008; Kirkpatrick et al., 2012). SES disparities are thought to exist due to multiple factors such as cost, access, knowledge, attitudes, and preferences (McGill et al., 2015). Importantly, financial resources explicitly constrain dietary behavior, and low-SES individuals are more likely to be exposed to low-quality food environments (Darmon & Drewnowski, 2008; McGill et al., 2015). In in the U.S., children and older adults tend to have higher quality diets than younger and middle-aged adults; women higher than men; and Hispanics and whites higher than African Americans (Hiza et al., 2013). Religion is also understood to influence diet through religion-related abstinence as well as distinctive dietary patterns (e.g., vegetarian) (Sabaté, 2004).

A closer look at meat-eating in America

The environmental influences described above play a large role in explaining why Americans eat so much meat: It is widely available, affordable, culturally acceptable, and hyperpalatable (for most). At the individual level, demographics, values, and beliefs are thought to be strong determinants of meat consumption and vegetarianism (Gossard & York, 2003). In general, American men consume more total meat and beef than women; African Americans and Asians consume more total meat than Whites; and Hispanics consume more beef than non-Hispanics (Gossard & York, 2003). Gossard and York (2003) also found an interaction between gender and race, suggesting effects of differential socialization for men and women in different racial groups. When examining meat consumption by region, meat consumption is highest among Midwesterners and non-urban residents (Gossard & York, 2003).

In addition, multiple U.S. studies demonstrate an upper bound to the observed positive income-meat intake relationship: Meat consumption—particularly red and processed meat consumption—plateaus or declines at the highest levels of socioeconomic status in the U.S. (Fang Zhang et al., 2018; Guenther et al., 2005). One explanation is greater awareness of the health implications of high red meat intake (Fang Zhang et al., 2018). In addition, low income is associated with a higher likelihood of consuming processed pork products, such as sausages, potentially reflecting an effect of affordability (Guenther et al., 2005). In a nationally representative survey of American adults, two-thirds reported reducing meat consumption over the last three years; cost and health were the most commonly reported reasons for doing so (Neff et al., 2018). Twenty-one percent of respondents reported eating no red meat, while the largest proportion (42%) reported eating red meat 2-4 times per week (Neff et al., 2018). The predominant reason among those who were not reducing meat consumption was the belief that a healthy diet includes meat (Neff et al., 2018). In the U.S., men are especially likely to consider meals incomplete without meat (Ruby & Heine, 2011).

Women tend to follow healthier dietary patterns, which include higher intake of fruits and vegetables, lower intake of total meat, and a preference for lean meat over red and processed meats (de Boer et al., 2016; Gossard & York, 2003; Guenther et al., 2005; Vergnaud et al., 2010). Women are also more likely to be vegetarian (Ruby & Heine, 2011). It is theorized that men "perform" eating behaviors aligned with the concept of masculinity defined by their culture (Newcombe et al., 2012). Predominant masculinity often promotes expectations around risk-seeking behavior, immunity to disease, denial of weakness, and reluctance to seek help (Newcombe et al., 2012). This can result in men being less likely than women to demonstrate concern for health and healthy eating. It also explains why men tend to favor symbolically masculine foods—such as bloody, protein-rich red meat—and avoid foods considered more feminine, such as fruits and sweet food (Newcombe et al., 2012).

Ruby and Heine (2011) found that people following both omnivorous and vegetarian diets rated vegetarians as more virtuous, but also as weaker and less masculine. In Western cultures, people typically become vegetarian due to moral concern for animals, the environment, and/or health (Ruby & Heine, 2011). Compared to omnivores, vegetarians also tend to display greater empathy for human- or animal-related suffering and are less likely to support social hierarchies (Ruby & Heine, 2011). Studies have also found a negative association between universal values (e.g., climate change) and meat consumption (Cordts et al., 2014; de Boer et al., 2016). However, consumers concerned with the negative social and environmental consequences of meat production tend to prefer humane production and reduced consumption over elimination (de Boer et al., 2016).

Part C: Strategies for shifting diets

Shifting diets: Supply and demand in micro-environments

Mitigating the human and planetary health risks associated with American diets requires intervention. More specifically, interventions are needed to shift dietary patterns to be lower in animal-based foods and higher in high-quality plant-based foods such as vegetables, fruits, whole grains, legumes, nuts, and seeds (Dietary Guidelines Advisory Committee, 2015; Willett et al., 2019). Dietary intervention is challenging due to the complex and interacting determinants of diet previously discussed. In general, interventions that target more upstream determinants—including policy, food environments, and social factors—are considered most cost-effective and sustainable for population health (Story et al., 2008). For example, many scholars argue that an overhaul of agricultural policy is needed to prioritize production quality rather than quantity, and incentives are needed to encourage private sector commitment to nutrition and environmental sustainability (Haddad et al., 2016). Still, there remains debate about how best to restructure policy to achieve desired outcomes given the complexity of the global food system (Guyomard et al., 2012). Current evidence suggests simply changing agricultural subsidies will not result in meaningful changes to food production, prices, and consumption; rather, incremental changes over decades are needed to incentivize desired changes (Mozaffarian et al., 2012).

In the near-term, some interventions have been successful by addressing food supply and/or demand in more micro-environmental settings, such as grocery stores, restaurants, and institutions (Afshin et al., 2015; Mozaffarian et al., 2012; Seymour et al., 2004). These interventions typically target availability, accessibility, incentives, pricing, or information within a specific setting (Seymour et al., 2004). A brief overview of supply- and demand-side strategies employed in interventions is provided below.

Supply-side strategies aim to affect consumption by altering the policies and practices that determine food availability (Guyomard et al., 2012). To a large extent, research suggests consumers eat what is available (Roy et al., 2015). For example, institutional procurement policies (i.e., purchasing guidelines, bans) are effective for a variety of dietary outcomes, including both increasing healthy food intake and decreasing unhealthy intake (Afshin et al., 2015). Studies also suggest increasing the ratio of healthy to unhealthy options can increase healthy choices (Cohen & Babey, 2012). Decreasing portion size has also been effective in reducing consumption of unhealthy foods (Roy et al., 2015). Such interventions, which focus on altering available options, are thought to affect consumption through mechanisms such as visual cues and increased acceptability/preference for available items—or through a direct effect of availability (Jago et al., 2007). Still, constraining or restricting the availability of food options could result in blowback or unintended consequences.

For example, the Dining Director at UCLA reported that students increased consumption of beef on Fridays following the introduction of the university's "Beefless Thursday" intervention that excludes beef from all dining hall menus on Thursdays. In psychology, this is referred to a "reactance," where consumers intentionally choose a restricted option because they do not want to be controlled (Brehm & Brehm, 2013). Given the mixed effectiveness of food environment interventions overall, it can be argued that supply-side interventions have not dedicated ample attention to building consumer demand (Ortega et al., 2016; Roy et al., 2015)

Demand-side food environment interventions focus on influencing consumption through strategies such as information provision, labeling, and social marketing (Cordts et al., 2014; Guyomard et al., 2012). Economic instruments such as subsidies and taxes can also affect demand by altering price—and thus affordability—of food options (Cordts et al., 2014).

Information provision can be appropriate when there is evidence of low consumer knowledge and awareness (Worsley, 2002). Similarly, nutrition labels are designed to address the market failure of information asymmetry and provide information consumers want and need to make informed choices (Verbeke, 2005). These strategies are often appealing to leaders and policymakers because they preserve individual choice; however, the effectiveness of labels and other informational strategies depends largely on consumers' willingness and ability to process the information provided (Guthrie, Mancino, & Lin, 2015; Shangguan et al., 2019). In other words, effects of labels are likely modified by individual-level factors such as gender, socioeconomic status, and motivation (Guthrie et al., 2015). Indeed, studies suggest nutrition information is most commonly used by the "nutrition elite" who tend to be older, high-SES women (Guthrie et al., 2015). Campaigns providing general education and nutrition information have been effective at raising awareness but typically fail to translate into behavior change (Brambila-Macias et al., 2011).

Social marketing aims to address both individual behaviors and broader social norms by altering behavioral outcome expectations (Verbeke, 2005). Social marketing goes beyond information provision and emphasizes the exchange of positive outcomes for behavior (Lee & Kotler, 2016). For example, an informational strategy might provide calorie and disease risk information, while a social marketing strategy might promote eating nuts for sustained energy (benefit). By aligning desired behaviors with existing values, social marketing can both improve individual attitudes and normalize behavior (Kraak et al., 2017; Lee & Kotler, 2016). Because values differ widely across populations, social marketers must understand the unique beliefs and values of the behavioral targets (Lee & Kotler, 2016).

Shifting diets: Contributions from behavioral economics

In the past decade, insights from behavioral economics have been used to improve and/or complement traditional supply and demand strategies (Kraak et al., 2017). The field of behavioral economics centers on the principle of bounded rationality and integrates concepts from economics, psychology, and marketing to explain and influence decision-making (Just & Gabrielyan, 2016; Thaler & Sunstein, 2009). For public health interventions, the field of behavioral economics has highlighted 1) humans' pervasive use of heuristics (i.e., mental shortcuts), and 2) the importance of the choice context on behavior (Arno & Thomas, 2016; Bergeron et al., 2019). These insights support the use of "nudges"—or choice architecture—to present choices in ways that facilitate desired behavior without restricting options or substantially changing economic incentives (Thaler & Sunstein, 2009). In short, nudges are intended to guide and enable desired behavior by altering the physical or mental accessibility of the desired choice. For example, traffic light labels were found to be successful at nudging hospital cafeteria patrons to choose healthier food items (Thorndike et al., 2012). By employing an intuitive labeling scheme to identify the healthiest (green), moderate (yellow), and less healthy (red) food options, these labels capitalize on existing associations and remove the barrier of cognitive effort required by traditional nutrition labels (Thorndike; Wilson et al, 2016).

Shifting diets in micro-environments: What works

Numerous scholars argue the use of different nomenclatures has challenged the integration and assessment of nudge interventions (Arno & Thomas, 2016; Szaszi et al., 2018; Wilson-Barlow et al., 2014). In addition, there remains a lack of clarity regarding what constitutes a nudge (Arno & Thomas, 2016; Wilson et al., 2016). At the same time, decades of marketing research and numerous reviews indicate the effectiveness of altering the presentation of choices in micro-environments (Arno & Thomas, 2016; Brambila-Macias et al., 2011; Kraak et al., 2017; Wilson-Barlow et al., 2014). A systematic review of cafeteria interventions found that interventions employing nudge strategies were more effective than those which relied on more cognitively demanding processing (Gordon et al., 2018). In a systematic review and meta-analysis, Arno and Thomas (2016) found that nudges resulted in an average 15.3% increase in healthier choices. A review by Lehner et al. (2016) found strong evidence of effectiveness for 1) providing simplified information and visual signifiers; 2) altering the availability, accessibility, and visibility of options; 3) reducing portions sizes; and 4) highlighting social norms and ideal-type behavior.

Another review by Wilson et al. (2016) categorized food and beverage nudge interventions into two categories: priming and salience. Priming nudges refer to altering subconscious food cues, such as visibility and accessibility. Salience nudges refer to altering the personal relevance or vividness of options. Overall, the results were mixed, but the authors found all interventions that combined priming and salience nudges positively affected healthy choices (Wilson et al., 2016). The strongest results came from Thorndike et al.'s (2012) study of an intervention at a hospital cafeteria. The two-phase study design demonstrated that adding a priming component (visibility and accessibility of healthy options) enhanced effects of the salience component (traffic light labels) (Thorndike et al., 2012).

Other research indicates the effectiveness of combining nudges with increased availability of healthier options. Espino et al. (2015) conducted a systematic review based on the six categories of restaurant interventions: 1) point-of-purchase information highlighting healthy choices; 2) promotion with advertising strategies to promote healthy choices; 3) availability through modifying menu items or increasing healthy options available; 4) pricing reductions or economic incentives for healthy choices; 5) required healthy options through catering; and 6) accessibility by making healthy options more easily identifiable. Only interventions which combined point-of-purchase information plus availability yielded sufficient evidence of effectiveness (Valdivia Espino et al., 2015). More recently, Vadiveloo et al. (2017) demonstrated that redesigning a worksite grill menu to increase the availability of healthful menu items improved the quality of nutrients purchased and increased sales. However, a survey conducted in conjunction with the intervention revealed mixed satisfaction among customers, with reported frustrations around loss of variety, novelty, and value (Vadiveloo et al., 2017).

As connections between food and environmental sustainability have become clearer, studies have begun assessing the impact of interventions designed to specifically reduce meat consumption and/or the carbon footprint of food choices. In a systematic review, Bianchi et al. (2018) found that three of four interventions providing meat alternatives along with educational materials were effective at reducing meat consumption, while only two of four interventions making meat less prominent found significant effects. In addition, the authors found that all three interventions reducing portion size were effective, while only one of five interventions altering the description of meat or meat alternatives at point-of-purchase yielded significant effects (Bianchi et al., 2018). One intervention in a university restaurant found that making a vegetarian dish more salient by placing it first on the menu increased sales by six percentage points (40% increase), and the effect increased or persisted over time (Kurz, 2018). However, a nudge intervention using a “Dish of the Day” strategy found no effect on adolescents’ or older adults’ likelihood of ordering a vegetarian meal (dos Santos et al., 2018). Another study of a “Dish of the Day” intervention included older consumers in four European countries (Zhou et al., 2019).

The authors found no significant intervention effect but found that female gender, country of origin, and personal values were strong predictors of selecting the plant-based dish (Zhou et al., 2019).

Furthermore, studies have highlighted the value of eco-labeling strategies to reduce the attitude-behavior gap for consumers with pro-sustainability values (Guyader et al., 2017). Similar to health nudges, eco nudges can increase the salience of sustainable choices by providing relevant point-of-purchase information, describing norms around sustainable consumption, and using green colors or other labels (Demarque et al., 2015; Guyader et al., 2017). In a series of studies, Camilleri et al. (2019) found that consumers significantly underestimate the carbon emissions of foods but shift purchases when presented with an intuitive carbon label. In an experiment, participants were given the choice between purchasing beef or vegetable soup and assigned to one of two conditions: carbon label or control (Camilleri et al., 2019). Participants in the carbon label group purchased significantly fewer cans of beef soup than those in the control, and a mediation analysis revealed an indirect effect of carbon emissions awareness (Camilleri et al., 2019). Thøgersen and Nielsen (2016) also found traffic light carbon labels to be effective in experiments but noted the effect is significantly stronger among more environmentally concerned consumers. A series of experiments found consumers perceive foods described with eco-framing words—such as organic, local, and seasonal—as tastier and higher quality (Sörqvist et al., 2015). However, it is unclear if this effect holds for words such as sustainable or low-carbon-footprint. Furthermore, it is not known whether eco-labeling is more effective than health-labeling to encourage the choice foods that are both healthy and sustainable.

Shifting diets in micro-environments: Gaps and opportunities

Much work has been done to study and apply strategies for shifting diets in micro-environments such as schools, workplaces, and restaurants. Common intervention outcomes include 1) increasing consumption of fruits, vegetables, and meals that meet specific nutrition criteria, and 2) reducing consumption of calories and specific nutrients such as sugar, sodium, and saturated fat (Lehner et al., 2016; Valdivia Espino et al., 2015). More recently, researchers have begun focusing on planetary health-oriented outcomes such as reducing meat consumption and increasing consumption of meals that meet carbon footprint or other sustainability criteria (Bianchi et al., 2018; Thøgersen & Nielsen, 2016). While there is a large degree of overlap across outcomes beneficial to both health and environmental sustainability, these two distinct goals are not typically assessed concurrently in intervention research.

Recent studies have highlighted the dual benefits of shifting to dietary patterns higher in fruits, vegetables, and other plant-based foods; however, it is not yet clear whether interventions targeting nutrition necessarily improve environmental sustainability outcomes, and vice versa. Of note, recent developments in plant-based meat alternatives promise potential to dramatically reduce environmental impacts, but the nutritional and long-term health implications of such products are not well understood (Hu et al., 2019). Indeed, some of the most popular plant-based meat alternatives, such as Beyond Meat™ and Impossible™, are highly processed and contain high amounts of sodium and saturated fat from coconut oil (Hu et al., 2019). Additional research is needed to understand the nutritional impacts of introducing these products into food environments.

Furthermore, it is not year clear whether dietary interventions with dual goals of improving health and environmental sustainability should appeal to values of personal health, environmental sustainability, or both. To my knowledge, only one study has compared the impacts of providing consumers with carbon- and health-related traffic light labels (Osman & Thornton, 2019). Compared to the control condition, both carbon- and health-related labels positively shifted choices, but there was no significant difference between labels in the magnitude of change (Osman & Thornton, 2019). Because the researchers used a within-subjects repeated choice experiment to compare label effects, these results are likely confounded. Surprisingly, the authors also found that attitudes towards health and sustainability did not predict meal choices (Osman & Thornton, 2019). These results are in conflict with expectancy value theories, as well as results from Thøgersen & Nielsen (2016) described above. Given these gaps and limitations, additional research is needed to determine the relative effects and boundaries of health versus environmental sustainability menu framing.

Finally, as demonstrated in the discussion above, the overall effectiveness of interventions in micro-environments has been mixed. It appears, however, that addressing both supply and demand is a promising approach (Bianchi et al., 2018; Lehner et al., 2016; Valdivia Espino et al., 2015; Wilson et al., 2016). Based on their reviews, Lehner et al. (2016) and Seymour et al. (2004) suggest the best results are likely in institutions with limited outside marketing influence and high levels of unilateral control over food environments. In the next section, I will discuss why universities are particularly promising settings to implement and study dietary interventions to improve human and planetary health.

Part D: Shifting diets in a university setting

Shifting diets: Why intervene in university settings?

In a review of micro-environmental dietary interventions, Seymour et al. (2004) found that those based within institutions such as workplaces and universities had the greatest effect on food choices (Seymour et al., 2004). One reason is due to "limited access," where institutions hold more control over the consumer choice context (Seymour et al., 2004). Institutional food purchases also create markets to which suppliers respond (Story et al., 2008). In addition to these benefits, universities may be particularly well suited for dietary interventions due to students' unique developmental period in the life course. Emerging adulthood (ages 18-25) has been recognized as a critical period for developing dietary habits when many individuals gain new autonomy over food choices (Arnett, 2000; Nelson et al., 2008). Furthermore, researchers have noted emerging adulthood as an overlooked time for behavioral intervention because it is a natural transition period when individuals may be more open to behavior change (Nelson et al., 2008).

In 2018, approximately 20 million Americans enrolled in colleges and universities (National Center for Education Statistics, 2018). These environments are often thought to challenge healthy eating due to all-you-care-to-eat dining formats, lack of peer and institutional support, financial constraints, and stress (Deliens et al., 2014; Nelson et al., 2008). On the other hand, universities present a unique opportunity for intervention, and many institutions already promote healthy eating through academic, programmatic, and environmental strategies (Deliens et al., 2016; Roy et al., 2015). My previous qualitative research with students at UCLA supports intervening in universities for numerous reasons: 1) students view college as an appropriate time to develop food knowledge and skills; 2) students view the university as a trusted source of information; 3) students appreciate signage to increase transparency in university dining facilities; and 4) students describe trying new foods in dining halls as an opportunity for experiential learning (Malan et al., 2019). Furthermore, UCLA students describe their food-related behaviors as being motivated by both health and social responsibility—including issues of social justice, ethical treatment of animals, and environmental sustainability (Malan et al., 2019).

Dietary behaviors among college students

Diet quality often declines in late adolescence and emerging adulthood (Larson, Perry, Story, & Neumark-Sztainer, 2006). Studies have found that, compared to childhood, emerging adulthood is associated with greater consumption of sugar-sweetened beverages, salty snacks, poultry, seafood, and beef, and lower consumption of fruits and vegetables (Demory-Luce et al., 2004; Lien et al., 2001). Compared to the general public, college students report lower fruit and vegetable intake and higher intake of high-fat and high-calorie foods (Deshpande et al., 2009). Previous qualitative research found that college students see taste, time, convenience, and cost as the major barriers to healthy eating (Deliens et al., 2014). Students also report frequent snacking, meal skipping, and consumption of fast food and pre-prepared food (Allman-Farinelli et al., 2016; Colatruglio & Slater, 2016) National data indicate young adult males in particular exceed recommendations for animal-based protein food intake such as meat, poultry, and eggs (Dietary Guidelines Advisory Committee, 2015).

A 2015-16 survey of over 1,000 residential undergraduates at UCLA found high consumption of protein foods compared to other food groups (Table 1) (unpublished data). Based on a 34-item food frequency questionnaire (FFQ), students reported consuming protein foods 5.8

times per day, on average, compared to fruit 1.2 times and vegetables 2.6 times per day. Within the protein foods category, students reported consuming meat, poultry, and eggs 3.1 times per day, on average, compared to plant protein 1.7 times and seafood 1 time per day. Within the category of meat, poultry, and eggs, students reported consuming red meat 0.9 times per day, on average, with males consuming red meat significantly more frequently than females (1.2 times versus 0.7 times per day). Although not perfect measures of dietary intake, these estimates indicate the relative frequency of food group intake across food group categories and genders.

Table 1. Weighted mean (SD) daily food group and subgroup intake frequency by gender, residential undergraduate students at UCLA, 2015-16 (n=1,156)

Gender	Fruit	Veg	Meat Poultry & Eggs[a]	Red Meat	Plant Protein	Seafood	Total Protein Foods[b]	Total Grains	Dairy
Total	1.2 (1.1)	2.6 (2.3)	3.1 (2.3)	0.9 (1.0)	1.7 (2.1)	1.0 (1.4)	5.8 (4.3)	3.3 (2.5)	1.6 (1.7)
	***		***	***		***	***		***
Male (n=357)	1.1 (0.9)	2.5 (2.0)	3.8 (2.1)	1.2 (1.0)	1.8 (2.0)	1.2 (1.4)	6.7 (4.1)	3.4 (2.1)	1.9 (1.6)
Female (n=799)	1.4 (1.2)	2.7 (2.6)	2.6 (2.2)	0.7 (0.9)	1.7 (2.1)	0.9 (1.4)	5.2 (4.1)	3.2 (2.7)	1.4 (1.8)

Non-parametric Wilcoxon Mann-Whitney and Kruskal Wallace tests used to asses significance of differences between group means. Significant gender differences indicated by * p<.05, **p<.01, and ***p<.001. [a]Meat, Poultry & Eggs category includes Red Meat. [b]Total Protein Foods includes Meat, Poultry, & Eggs; Red Meat; Plant Protein; and Seafood.

In a study conducted at UCLA on the impact of environmental education on dietary behavior, freshman students in the comparison group increased beef consumption over the course of the academic year, potentially indicating an effect of unlimited beef availability (Jay et al., 2019). Another study found that demand for unhealthy foods increased as the semester progressed, suggesting a need for interventions to diminish these trends (Wansink et al., 2013). In comparing lower- and upper-level college students, one study found few differences in typical eating habits, indicating habits established early in college may track to later years (Driskell et al., 2005).

Qualitative research with young adults suggests food choices are an important way to construct a desired image, judge others, and signal conformity with peers (Stead et al., 2011). Concerns around topics such as social justice and environmental sustainability may be especially relevant for college students (Hekler et al., 2010; Jay et al., 2019; Malan et al., 2019). For example, Hekler et al. (2010) found that students who took a course on food and society significantly improved their healthy eating more than students in health-focused food courses (e.g., community health, obesity). Jay et al. (2019) found that students enrolled in a course on food systems and the environment significantly decreased beef consumption and significantly increased vegetable consumption over the course of two quarters. Although these findings are promising, classroom-based educational approaches are inherently limited in reach.

A survey of over 2,500 young people ages 15-23 found that those who valued at least two alternative food production practices (e.g., local, organic, non-GMO, nonprocessed) were more likely than their peers to meet Healthy People dietary targets (Robinson-O'Brien et al., 2009). Those who valued alternative food production practices were also more likely than their peers to be non-white and lower socioeconomic status (Robinson-O'Brien et al., 2009). Another survey of over 1,000 diverse students at two-year and four-year colleges found that awareness of the carbon footprint of foods is low, but about half of respondents (48%) placed moderate to high importance on local, organic, and sustainable foods (Pelletier et al., 2013). In addition, students who held these values consumed more fruits and vegetables, more fiber, fewer added sugars, and less fat than those who did not (Pelletier et al., 2013). The authors concluded that messaging around social and environmental implications of food choices may be effective for this age group, and that additional research is needed to understand the promises of such an approach. Furthermore, additional research is needed to assess potential gender differences in the effectiveness of social and environmental food messages, as female college students are more likely to make food decisions—particularly rejecting meat—based on values of health and ethics (Mooney & Walbourn, 2001).

University-based interventions: What works

Compared to other micro-environmental settings, university-based invention research is quite limited. Roy et al. (2015) conducted the only systematic review of university-based food environment interventions. Fifteen studies conducted between 1998 and 2014 were eligible for inclusion, and 13 showed improvements in outcomes of interest, including nutrition knowledge, food consumption, and sales. However, the authors concluded additional research on long-term effectiveness and multi-component interventions is needed (Roy et al., 2015). Interventions providing labels with macronutrient information (n=4) were found to significantly influence behavior, but outcomes were not always clinically relevant (Roy et al., 2015). Two of three interventions providing benefit-based promotional messages (i.e., energy, taste) were found to be effective; however, both studies used pre-post designs and short study periods (less than five weeks) (Buscher et al., 2001; Peterson et al., 2010).

One study using interpretive star labels to indicate healthfulness did not result in significant improvements in food choice or nutrient intake; the authors concluded such approaches may be more effective when combined with changes in availability (Hoefkens, Lachat, Kolsteren, Van Camp, & Verbeke, 2011). Studies on availability-focused interventions (n=3) found that reducing portion sizes or providing free produce improved dietary intake (Roy et al., 2015). Two multi-component interventions were found to be effective. Michels et al. (2008) found that providing a 20% subsidy along with educational materials led to a 6% increase in healthy and 2% decrease in unhealthy food consumption; these results were sustained even after the subsidy was removed (Michels et al., 2008). Shive et al. (2006) found that a two-month social marketing campaign combined with increased availability of fruit resulted in a small but significant increase in fruit consumption; 70% of survey respondents reported seeing the campaign materials, and typical daily fruit consumption increased by approximately half a serving (Shive & Morris, 2006).

Following the Roy et al. (2015) review, Seward et al. (2016) published the first study of a traffic light label intervention in a university cafeteria setting. The full intervention included traffic light labels, choice architecture (i.e., healthy items conveniently located), and Harvard Healthy Eating Plate stickers on trays. The evaluation included a rigorous quasi-experimental time series design, where the full intervention was implemented for seven weeks at two cafeterias and compared to two cafeterias with choice architecture only (partial intervention) and two cafeterias with no intervention (controls). In contrast to demonstrated effectiveness of this intervention in other settings, the authors found no significant changes in red (least healthy) or green (healthiest items) menu items served, compared to controls (Seward et al., 2016). The authors found that, although students reported using the labels and wanted the intervention to continue, there were no clear dietary improvements (Seward et al., 2016). The authors attributed the lack of effectiveness to students' low knowledge of the health consequences and label fatigue; they also noted that high variation in meals served between sites made it difficult to find significant differences between intervention and control sites (Seward et al., 2016).

University-based interventions: Gaps and capacity to intervene

This review of the evidence for university-based food environment interventions indicates mixed results and other limitations such as short intervention and study duration as well as weak study designs. Espino et al. (2015) also point out that intervention effectiveness depends largely on specific materials, dosage, and delivery, which may not be captured in the literature (Valdivia Espino et al., 2015). Researchers have noted that a lack of procedural-level description of interventions in the literature has resulted in limited ability to 1) replicate results, 2) disentangle effects of complex intervention components, and 3) summarize the evidence of effectiveness (Szaszi et al., 2018).

Indeed, settings-based interventions depend on context, and demonstrated effectiveness in one setting does not guarantee effectiveness—or viability—in another (Chen & Garbe, 2011). Furthermore, while nudge interventions are generally considered low-resource demand and broadly applicable, it remains unclear which strategies are most acceptable to university foodservice leaders (Szaszi et al., 2018). In other words: What might facilitate or prevent intervention implementation and scale-up? For example, an exploratory study of managerial perceptions found that foodservice managers are skeptical to implement changes (i.e., interventions) due to concerns about customer demand and operational complexities (Filimonau & Krivcova, 2017). Although institutions such as universities hold enhanced unilateral control over operations, ensuring buy-in from diverse foodservice stakeholders remains essential to intervention success (Filimonau & Krivcova, 2017; Seymour et al., 2004). Additional intervention development and implementation research conducted in collaboration with foodservice leaders is needed to inform university-based interventions.

Conclusion

Despite incredible progress to increase food production, global dietary patterns threaten human and planetary health. The Westernization of diets—characterized by high consumption of calories, sugar, fat, and animal products—has contributed to rising rates of chronic disease and dangerous environmental degradation, including climate change. In high-income countries such as the US, shifting to dietary patterns higher in healthy plant-based foods and lower in animal-based foods can simultaneously improve health and environmental sustainability. However, shifting diets remains a challenge: Dietary behavior is a complex phenomenon subject to multiple levels of influence. Micro-environmental interventions (e.g., restaurants, institutions) are considered cost effective and impactful, yet intervention feasibility remains understudied, and intervention effectiveness is mixed. In general, combining strategies to address both supply and demand is a promising approach, such as increasing the availability and attractiveness of plant-based food options.

Moreover, university settings offer several advantages for intervention. For example, universities often control institutional dining operations, and college students may be more open to dietary intervention than other populations. Still, additional research is needed to inform interventions to promote healthier, more environmentally sustainable food in university settings. Of note, while many foods are both healthier and more environmentally sustainable, this is not always the case. In addition, gaps remain in understanding the extent to which interventions are acceptable and scalable for foodservice leaders, and how interventions can leverage students' interest in environmental issues to influence their food choices. Collaborating with university foodservice leaders to investigate these gaps can advance intervention research and practice.

CHAPTER TWO: THEORY

Overview of Theory

This dissertation aimed to better understand how researchers can collaborate with university foodservice leaders to promote healthier, more environmentally sustainable diets. While recent research has demonstrated the dual benefits of shifting to diets that are lower in animal-based foods and higher in plant-based foods, it remains unknown what interventions are 1) acceptable and scalable for university foodservice, and 2) effective for improving both health and environmental sustainability.

It has been suggested that dietary interventions connected to larger social movements, such as climate change, may be more attractive and impactful than those focused on health-related outcomes (Hekler et al., 2010; T. N. Robinson, 2010b). This notion—often referred to as "stealth intervention" or the theory of process motivation—served as a core perspective for the research (T. N. Robinson, 2010b). Specifically, the research was interested in environmental sustainability as a motivator for dietary shifts. This hypothesis was explored in all three studies.

Life course theory informed the decision to intervene in a college setting and the emphasis on climate change as a salient issue in the current historical time and place. The development and hypothesized effectiveness of the intervention was informed by an ecological perspective and theories of social marketing and behavioral economics (i.e., nudge). An ecological perspective suggests targeting both environmental- and individual-level factors to shift diets (Story et al., 2008). The expectancy-value model suggests interventions could be effective by improving students' awareness of and attitudes towards plant-based foods (Ajzen, 1991). At the same time, behavioral economics informed the recognition of bounded rationality and use of heuristics in food decision-making (Tversky & Shafir, 1992). As such, intervention strategies such as increasing the physical and mental availability (i.e., salience) of certain foods could have a direct effect on behavior without altering attitudes. Aim 3 employed a reason-based choice framework to test whether environmental sustainability framing is more powerful than health framing in nudging consumers to choose a plant-based menu item (Shafir et al., 1993).

Finally, to systematically examine the process of collaborating with university foodservice to develop and implement an intervention (Aim 1), I employed a five-stage model from the diffusion of innovations theory (Rogers, 2003). The following chapter discusses in detail each of the theories, frameworks, and perspectives used to inform the research. It concludes with descriptions of the integrated conceptual models that guided my approach.

Theory of process motivation

I begin with a discussion of process motivation because it provides the rationale for my exploration of environmental sustainability as a motivator for dietary behavior change. Often referred to as the "stealth intervention" approach, Robinson's (2010) theory of process motivation focuses on intrinsically rewarding or motivating factors to effect sustainable behavioral change. The theory posits that health-beneficial interventions may be more effective by focusing on other rewarding aspects of a behavior—such as enjoyment, pride, or social interaction—rather than health outcomes (T. N. Robinson, 2010a). In short, interventions must consider motivations for *participating in the process* of achieving better health outcomes.

This theoretical approach is rooted in theories of motivation and behavior such as social cognitive theory (Bandura, 1986). In social cognitive theory, behavior change is thought to depend on self-efficacy, or confidence in one's ability to perform certain actions to achieve desired outcomes (Bandura, 1986). Robinson (2010) suggests focusing on health outcomes may undermine self-efficacy when these outcomes are delayed, invisible, and/or unattained. In contrast, process motivators are rewarding in and of themselves; simply participating in the intervention provides individuals with satisfaction and thus sustained interest and action. Process motivation is aligned with Robinson and Sirad's (2005) solution-oriented research approach, which prioritizes studying the causes of health as opposed to causes of disease. Rather than identifying problems or convincing people to value health outcomes, these approaches proactively identify, test, and disseminate health-promoting factors that may not explicitly focus on improving health.

Research demonstrates that process motivation and "stealth interventions" have been effective for health-related behavior change, especially physical activity and diet. In such interventions, health outcomes may be considered "side effects" (T. N. Robinson, 2010a). For example, a dance class intervention that focused on positive aspects such as having fun, performing for family, and belonging to a group was successful at increasing physical activity and reducing weight gain among African American adolescent girls (Robinson et al., 2003). In addition, an alternative transportation worksite plan aimed at reducing car usage significantly increased physical activity among worksite commuters (Brockman & Fox, 2011).

In the college setting, two studies—one at Stanford and one at UCLA—found that students improved their healthy eating behaviors after completing courses about connections between food, society, and the environment (Hekler et al., 2010; Jay et al., 2019). At Stanford, researchers found students were even more motivated by social issues than health to improve their diet quality (Hekler et al., 2010). At UCLA, students in a course on food systems and the environment significantly increased vegetable intake and decreased sugar-sweetened-beverage and beef intake, compared to a comparison group (Jay et al., 2019). Findings from my qualitative research at UCLA also support these findings. As one female undergraduate said, “I think in college I realized that my individual actions actually can make an impact…[I went vegan because of the] impact on the environment and as a political statement against the agribusiness industry” (Malan et al., 2019).

As previously discussed, more sustainable foods are often healthier (e.g., nutrient-rich plant foods), thus there is natural overlap among the dual goals of human and planetary health. As an extension of his work on process motivation, Robinson (2010) popularized the notion of connecting diet-related efforts to existing social and ideological movements. In short, participation in the social or ideological movement is considered the process motivator for health outcomes. The logic derives from the observation that individuals exhibit exceptional willingness and commitment to align their behavior with social and ideological causes (Robinson, 2010). These range from religious rules, such as abstention and fasting, to animal-rights activism through veganism. Robinson (2010) argues that rather than developing a new social movement around diet-related chronic disease prevention, we can identify existing movements with overlapping goals. The environmental movement provides strong alignment in terms of desired individual-level behaviors and community/societal level changes: 1) eat more fruits and vegetables and less red meat; 2) increase access to and affordability of target foods (Robinson, 2010).

As discussed in the Background chapter, the international community has recently mobilized around the promotion of diets that support human and planetary health (EAT-Lancet Commission, 2019). Of the six planetary boundaries threatened by food systems, climate change may be the most appropriate issue for alignment with dietary intervention. In a study of lessons learned from social movements, Economos et al. (2009) found that many key informants cited the importance of the public perceiving their issue as a crisis. Indeed, climate change is increasingly referred to as “an existential threat” to humanity, and there is growing public awareness of the link between food systems and climate change (Editors, 2019; Piper, 2019).

As of 2018, the majority of Americans believe both citizens (65%) and corporations (68%) should do more to address climate change (Marlon et al., 2018). Based on other social movements, Economos et al. (2009) recommend social change communication must be framed positively, be supported by a scientific consensus, and be repeated in multiple settings. At the early stages of social change, communication is needed to raise awareness, while environmental change and/or policy is typically needed to sustain systematic change (Economos et al., 2009). These lessons, combined with the theory of process motivation, provide strong rationale for exploring environmental sustainability—and specifically climate change—as a motivator for shifting diets.

Life course perspective

Second, I will discuss the life course perspective in order to contextualize and justify the focus of my research on an undergraduate university population and the issue of environmental sustainability. Life course is viewed as a theoretical orientation that considers not only the entirety of one’s life, but also the position of one’s life in historical and social context (Elder, 2003). Now widely used across social science disciplines, life course emerged from a period of research in the 1950s lacking depth and consideration of the complex lived experience (Elder, 2003). As the 20th century experienced rapid social and demographic changes—such as World World II, declining fertility, and increasing ethnic diversity in the US—it became clear how issues of social history and culture influence individuals’ lives (Elder, 2003). At the same time, the growth of longitudinal research demonstrated how human development continues past childhood and throughout life (Elder, 2003). These major trends prompted the now common field of inquiry into the continuity of human lives across changing contexts.

A life course approach to chronic disease epidemiology emphasizes the temporal ordering and long-term effects of experiences across the life span (Ben-Shlomo & Kuh, 2002). Applied to public health research and practice, the life course perspective can provide guidance in identifying social determinants of health and determining when and how to intervene. For example, Gee et al. (2012) employed a life course perspective to investigate how racism may affect health inequalities by structuring an individual's exposure to asset-building and disadvantageous contexts. Researchers have also considered how social ties at different life stages influence health behaviors throughout the life course (Umberson et al., 2011). Herman et al. (2014) suggest applying a life course perspective to understand how nutrition, from preconception to adulthood, may affect health trajectories and intergenerational differences. For this dissertation, the life course perspective lends four informative concepts and principles: transitions, sensitive periods, trajectories, and time and place.

Transitions refer to changes in states or roles, such as becoming a parent or starting a new job (Elder, 2003). Because transitions often involve natural modifications to identity or status, they are considered opportune times for health behavior intervention (Elder, 2003). Sensitive periods refer to developmental periods or transitions when certain experiences or exposures have a heightened effect on long-term health (Gee et al., 2012). It follows that interventions timed to reach individuals during sensitive periods promise heightened impact as well. Trajectories refer to pathways and patterns that are shaped by past experiences and predictive of future outcomes (Elder, 2003). Of note, this concept has been extended to dietary trajectories, as dietary intake has been shown to track over time (Craigie et al., 2011; Nelson et al., 2008). Finally, the time and place principle suggests the combination of historical time and geographic place shapes an individual's experience throughout the life course (Elder, 2003).

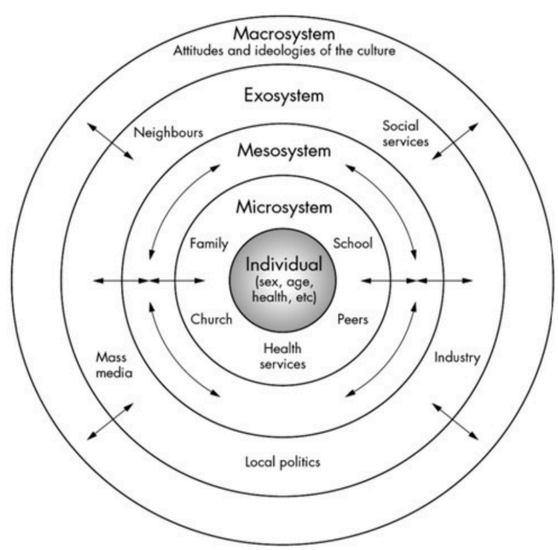
Entering college represents a classic transition in the life course as one takes on the new role of college student. In particular, residential university students experience changes in household, living companion, social group, schedule, and food environment—to name a few salient adjustments. This age group is also transitioning from adolescence into emerging adulthood, a sensitive period for the development of health-related behaviors (Nelson et al., 2008). In most industrialized countries, emerging adulthood refers to a distinct life period that begins in the late teens and extends through the twenties, typically ages 18-25 (Arnett, 2000). During this time, many young people obtain higher education, try out different jobs, develop intimate relationships, and explore varying worldviews (Arnett, 2000).

Arnett (2000) describes three conditions for reaching adulthood: accepting responsibility for one's self; making independent decisions; and becoming financially independent. As such, emerging adulthood is a crucial time for developing self-sufficiency, identity, and behavioral patterns—particularly eating behaviors (Arnett, 2000; Nelson et al., 2008). In a recent qualitative study conducted at UCLA, students described college as a time when they become more responsible for and thus more conscious of the implications of their food behaviors (Malan et al., 2019). As one male undergraduate said, "I didn't start thinking about my health until college. Even if I pondered about it in high school, there was no way I could decide about what I was gonna eat" (Malan et al., 2019). This quote illustrates the transition occurring during emerging adulthood in college—a shift in role and responsibilities. Although a large body of literature has focused on identity development in adolescence, Arnett (2000) suggests the majority and most consequential aspects of identity exploration occur during emerging adulthood.

Prior work has demonstrated that incorporating healthy behaviors into one's self concept supports lasting behavior change (Storer et al., 1997). This lasting change can be understood through the concept of trajectories. When individuals incorporate dietary changes into their identity, personal norms, and habits, they have essentially reshaped their dietary trajectory. As such, we would expect changes experienced during college to impact both short- and long-term outcomes. Finally, the time and place principle further informs the approach of connecting food choices to climate change: The current historical and geographic context of North America in 2019 makes climate change a timely and appropriate social issue to align with for dietary intervention.

Ecological perspective

Figure 7. Ecological systems model of development, Bronfenfrenner (1979)



Third, I will the describe the multilevel ecological perspective that informed the development and hypothesized impact of the intervention being studied. One of the most influential ecological models was proposed by Urie Bronfenbrenner (1979) to understand human development. His model explains the multiple, simultaneous levels of influence on the individual as micro-, meso-, exo-, and macrosystems—often depicted as concentric circles (Figure 7) (Bronfenbrenner, 1979). Microsystems, he explained, involve interpersonal interactions with others such as peers and family members. Mesosystems are made up of microsystems but refer to physical settings such as the school or home. Exo- and macrosystems involve broader social settings and systems of industry, politics, and ideologies (Bronfenbrenner, 1979). Importantly, these sub-systems do not operate in isolation: each affects and is affected by the others. By emphasizing the interaction across levels of influence, ecological frameworks help to explain complex health behaviors—and why they are often so hard to change.

Ecological frameworks can guide health behavior intervention planning and evaluation by emphasizing this interaction between individuals and their environments (Story et al., 2008). More specifically, Sallis, Owen, & Fisher (2008) delineate four core principles of ecological perspectives for public health research and practice: 1) multiple factors influence health behaviors; 2) influences interact across levels; 3) multi-level interventions should be most effective at changing behavior; and 4) ecological frameworks should be adapted to address specific health behaviors.

Story et al. (2008) developed a useful ecological framework specific to dietary behavior. As discussed in the Background chapter, individual factors include psychosocial and demographic characteristics that may influence dietary behavior through mechanisms such as motivation, outcome expectations, self-efficacy, and behavioral capability (Story et al., 2008). Environment refers to anything beyond the individual, including social, physical, and macro contexts (Story et al., 2008). The social environment includes social interactions that may influence dietary behavior through mechanisms such a role modeling, social support, and social norms (Story et al., 2008). The physical environment includes the places where people obtain and eat food, such as the university (Story et al., 2008). Upstream, macro-level environments include policy, economics, marketing, and societal norms that influence diet at the population level (Story et al., 2008).

Story et al.'s (2008) framework highlights the importance of physical environments and asserts that target dietary behaviors must be supported by available (present in the choice context), accessible (conveniently located, visible, identifiable, easy to choose), and affordable options. Although not included in Story et al.'s (2008) model, Caspi, Sorensen, Subramanian, & Kawachi (2012) also include the important physical environment dimension of acceptability, which refers to whether options meet standards for consumption. Of course, assessments of affordability and acceptability will vary across individuals, providing further illustration of environment-individual interactions. Indeed, individual factors such as demographics and cognitions mediate the relationship between the physical environment and food choice, where an individual's unique perception of the food environment partially explains his or her choices (Furst et al., 1996; Karen Glanz et al., 2005; Story et al., 2008).

Tensions between supply (environment) and demand (individual) may explain why some environment-focused interventions do not result in improved dietary behavior (Ortega et al., 2016). Counter to conventional wisdom, practitioners may experience the phenomenon: We built it, but they did not come. This perspective aligns well with the ecological principle that multi-level interventions will be most effective (Sallis et al., 2008). Social marketing strategies such as point-of-purchase signage are likely to complement supply-side interventions by stimulating consumer demand (Story et al., 2008). Changes in demand can be especially important when considered through the lens of reciprocal determinism. This ecological concept suggests that, just as environments shape individuals, individuals can shape their environments (Larson & Story, 2009). As such, increasing demand at the individual level should have broader implications through evolving social norms and signals to markets and decision-makers. The intervention studied in this dissertation took a multi-level, setting-based approach to dietary behavior change by 1) altering the food environment by introducing new plant-based menu items, and 2) addressing individual attitudes and behavior by launching a complementary social marketing campaign.

Expectancy-value model, behavioral economics, and reason-based choice

The development and evaluation of the intervention was also informed by the expectancy-value (EV) model and behavioral economics. Fishbein's (1963) early work serves as the foundation for EV models, which consider attitude to be the most important determinant of consumer behavior, such as food choices. Attitudes are thought to be based on an individual's outcome expectations—or beliefs—regarding a choice or product (Fishbein, 1963). Put simply, consumers will select a product when positive beliefs outweigh negative beliefs; the sum of this evaluation is measured by attitude. Unlike traditional economic theories, the EV model does not assume rational weighing of outcomes. Rather, the EV model accounts for the role of false cognitions, biases, and emotion in decision-making; it assumes only that attitudes are consistent with individually held beliefs (Ajzen, 2008).

Of note, the EV model posits that while people may hold many beliefs about products and choices, only the most salient (i.e., accessible) beliefs are thought to determine an individual's attitude (Ajzen, 2008). Furthermore, the stronger and more positive the beliefs, the more favorable the attitude (Ajzen, 2008). Based on this model, it was hypothesized the intervention would affect students' dietary behavior by 1) increasing awareness of Impossible™ plant-based meat, 2) increasing awareness of the carbon footprint of different foods, 3) increasing positive attitudes towards Impossible™ and other plant-based foods, and 4) increasing the salience of the carbon footprint of foods in the choice context (i.e., within the restaurant). The intervention employed social marketing to achieve these aims. The core theory of change was that the intervention would lead to improved awareness of and attitudes towards plant-based foods, which in turn would lead to increased sales of plant-based and decreased sales of animal-based foods.

The research was also informed by behavioral economics and the reason-based choice framework. The field of behavioral economics (i.e., "nudge") is based primarily on the dual process model of cognition (Szaszi et al., 2018; Thaler & Sunstein, 2009; Wilson et al., 2016). This model considers the phenomenon of bounded rationality, or the consistent diversion of human decisions from the "ideal" choice (Kahneman, 2003). It explains less rational influences on behavior and why interventions based on expectancy-value theories may fail to achieve desired outcomes—i.e., the attitude-behavior gap (Lehner et al., 2016). As discussed in the Background chapter, eating tends to be automatic and intuitive because it is common, repeated, and necessary for survival (Cohen & Farley, 2008). As such, humans are likely to employ heuristics to make satisfactory—rather than optimal—food decisions (Cohen & Farley, 2008).

Because cognitive effort is low and use of heuristics is high in food decision-making, small changes to the choice context can be influential (Vlaev et al., 2016; Wilson et al., 2016). This includes nudges such as information simplification and framing, which highlights a choice in a novel, vivid, or personally relevant way (Blumenthal-Barby & Burroughs, 2012; Wilson et al., 2016). These theoretical insights informed the integration of various nudges in the social marketing materials to capitalize on heuristic rather than rational processing. For example, an intuitive stoplight color coding scheme was used to simplify information about the carbon footprint of various foods. Behavioral economics also suggests a potential direct effect of the intervention on behavior, where individuals are nudged to act without any change in attitude; simply increasing the salience of plant-based options may change behavior.

The reason-based choice framework was employed in the experimental study (Aim 3) to explicitly test whether environmental sustainability framing is more effective than health framing in nudging consumers to choose a plant-based menu item. In line with behavioral economics, this framework emphasizes the limitations of cognitive processing and the importance of context in decision-making (Shafir et al., 1993). Shafir, Simonson, and Tversky (1993) suggest decision-makers often encounter conflict in decision-making but seek definitive reasons to justify their choices. According to this framework, framing manipulations can highlight different reasons for choosing a particular item and thus guide decision-making (Shafir et al., 1993). These insights support the investigation of framing effects on the choice of a plant-based menu item.

Diffusion of innovations theory

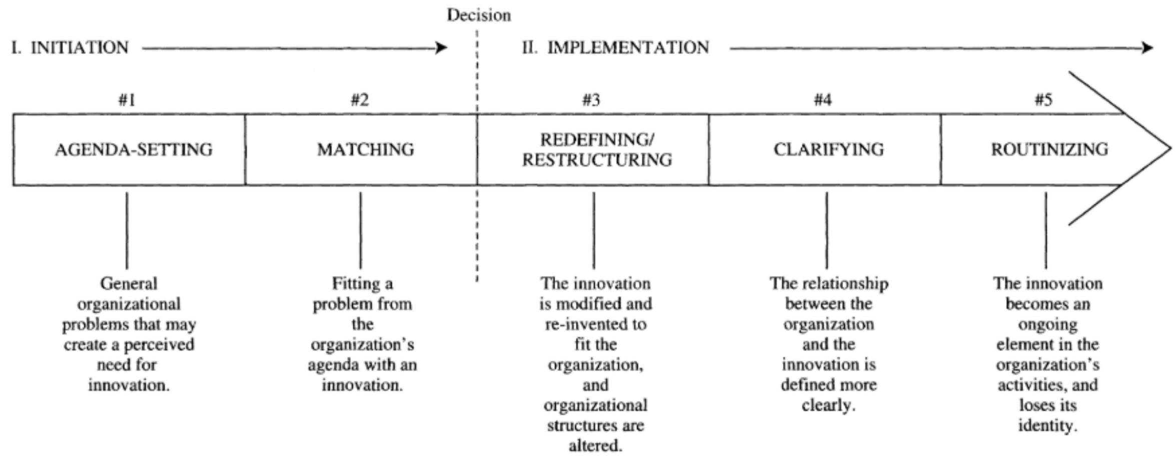
Finally, I utilized a five-stage model from diffusion of innovations theory to examine the process of developing and implementing the intervention. Over the past several decades, diffusion of innovations theory has played a valuable role in addressing the gap between research and practice (Oldenburg & Glanz, 2008). The model has been used to document the steps involved in the spread and adoption of public health interventions (i.e., innovations) and can be applied to both individual behavior and organizational or system changes (Oldenburg & Glanz, 2008).

At the organizational level, the theory can be useful for answering questions about why some interventions are adopted over others—despite evidence of relative effectiveness. In short, the literature suggests the imperative of fit between intervention attributes and the adopting organization and context (Oldenburg & Glanz, 2008). Rogers (2003) also describes innovation adoption as dependent upon both organizational and contextual factors. Organizational factors include individual (leader) qualities and characteristics of organizational structure such as size and centralization (Rogers, 2003). For example, large organizations with leaders who are open to change tend to be more innovative (Batras et al., 2016). Contextual factors refer to factors beyond the organization, such as policies and consumer demand, that influence an organization's operations (Rogers, 2003). When contextual factors put pressure on organizations to change, they are more likely to seek out and adopt an innovation (Batras et al., 2016).

Another application of the theory has been to understand how innovations are developed and implemented within organizations. Rather than identifying characteristics of successful organizations and innovations, this work has focused on the innovation process, documented through reported perspectives of key actors and organizational records (Rogers, 2003). Rogers (2003) delineates five stages in the process of innovation development and implementation within organizations: 1) agenda-setting, 2) matching, 3) redefining/restructuring, 4) clarifying, and 5) routinizing (Figure 8).

Agenda-setting refers to an organization identifying a problem perceived to require an innovation-based solution; it is often motivated by a performance gap or discrepancy between organization performance and expectations or goals (Rogers, 2003). Matching occurs when the organization considers fit and feasibility of an innovation to address the problem at hand. Together, agenda-setting and matching form the initiation—or development—phase of implementation, involving all preliminary research, consideration of options, and planning that precedes the decision to implement the innovation.

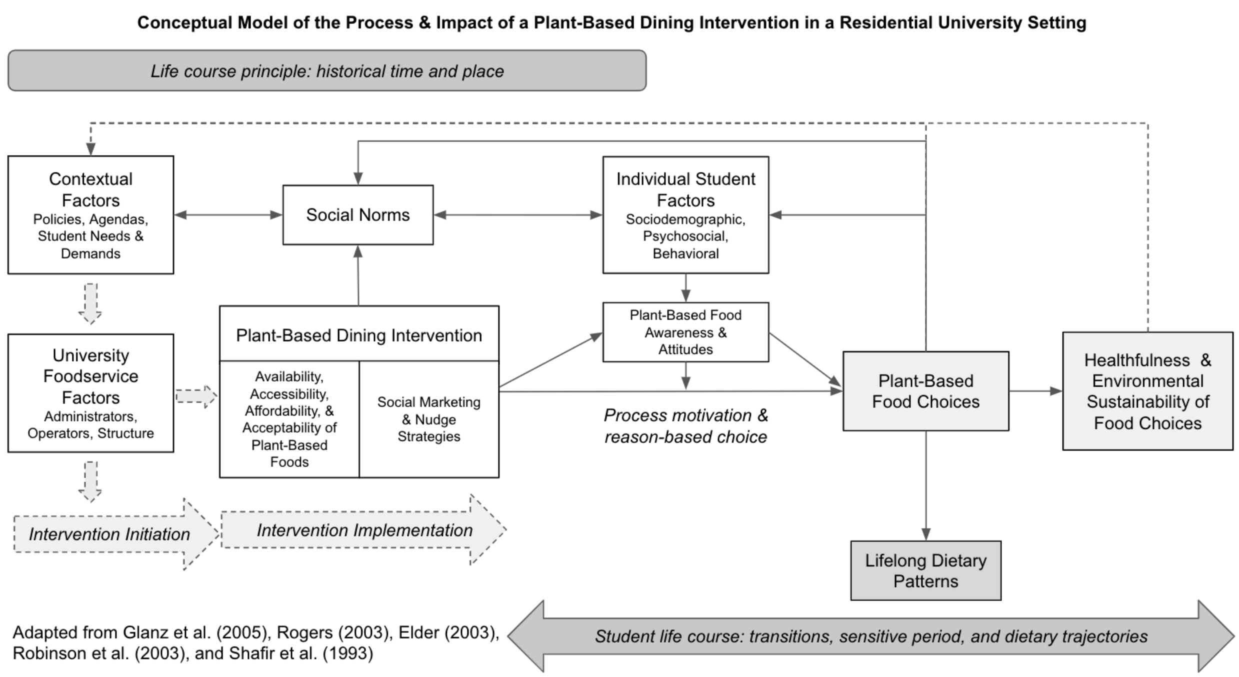
Figure 8. Five-Stage model of innovation development and implementation in an organization, Rogers (2003)



The second phase of implementation begins with redefining/restructuring both the innovation and the organization's operations to improve fit. Rogers (2003) suggests internally generated or re-invented innovations are more likely to achieve success than externally imposed, out-of-the-box interventions. When the organization's actors are able to interact with and co-create innovations, they are likely to be more receptive to the innovation, feel ownership over the process, and thus facilitate necessary organizational change required for implementation (Rogers, 2003). Next, clarifying involves achieving broader understanding and integration of the innovation into organizational operations. This stage may involve learning about and correcting for unwanted outcomes. Finally, routinizing refers to complete integration such that the innovation is no longer considered separate from usual operations; it is no longer considered an innovation at all (Rogers, 2003). Often, however, innovations are often abandoned rather than routinized during this final stage. This abandonment is also referred to as lack of sustainability or failed scale-up in intervention research and implementation science (Measure Evaluation Implementation Research Technical Working Group, 2012).

Integrated Conceptual Model

This dissertation took a multi-level approach the addressing the question of how academic and non-academic partners can collaborate to promote healthier, more sustainable diets. Aims One and Two considered the process and the effectiveness of collaborating with university foodservice leaders to develop and implement an intervention to reduce animal-based and increase plant-based food choices—a plant-based dining intervention. Aim Three tested the effects of environmental sustainability versus health menu framing as a nudge for individuals to select a plant-based menu option.

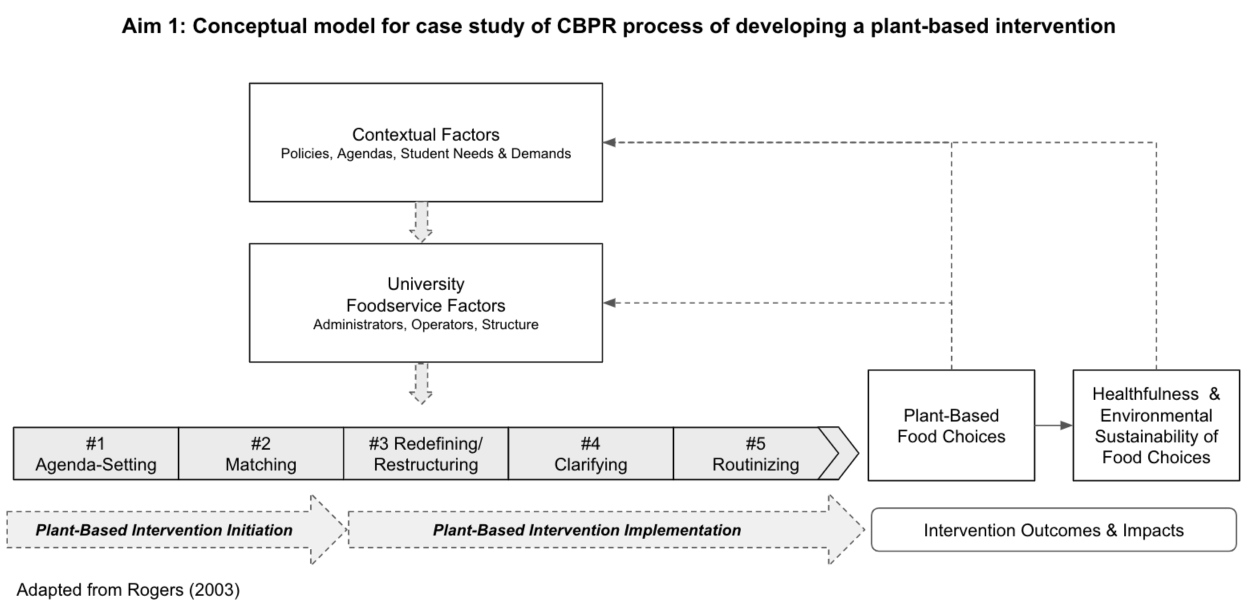


The research was informed by a range of theoretical frameworks and concepts, as described above. At the broadest level, the life course principles and concepts of transitions, sensitive period, dietary trajectories, and historical time and place informed the relevance of the research and are represented in dark grey boxes on the edges of the model. In addition, the extension of Plant-Based Food Choices to Lifelong Dietary Patterns is supported by life course theory. Reading from left to right, the model moves from considering contextual, organizational, and environmental influences to individual influences on food choices. Contextual Factors and University Foodservice Factors were considered in the case study (Aim 1) as determinants of organizational willingness to seek out and adopt an intervention. The two large grey arrows with dotted outlines represent the two broad phases in the five-stage model of intervention implementation in an organization: Intervention Initiation and Intervention Implementation, which were also explored in the case study (Aim 1). All dotted lines indicate factors, processes, and feedback that were conceptualized to influence the implementation of the intervention.

The intervention itself, Plant-Based Dining Intervention, was comprised of both changes to the physical food environment (the availability, accessibility, affordability, and acceptability of plant-based foods) and the climate-change-framed social marketing and nudge strategies. Informed by an ecological perspective, the expectancy-value model, behavioral economics, and process motivation, the intervention was hypothesized to increase Plant-Based Food Choices by improving Plant-Based Food Awareness and Attitudes and through direct effects of availability and other nudge strategies. In other words, awareness and attitudes were considered mediators, or intermediate outcomes, while food choices (i.e., entrée sales) were the key outcomes of interest. To evaluate the impact of the intervention on health and environmental sustainability, I assessed changes in red meat entrées sold, average nutritional content of entrées sold, and climate impact of entrées sold (Aim 2). Additional details are described in the following chapters.

Individual student factors were conceptualized as moderators of intervention effectiveness, where students whose values already aligned with the intervention would respond more favorably. Hypothesized moderators of health versus environmental sustainability framing effects were tested in Aim 3. In line with an ecological perspective, Plant-Based Eating Norms were recognized as a high-level driver of individual and organizational behavior. The model also illustrates the concept of reciprocal determinism by including two-way and left-oriented arrows between Plant-Based Eating Norms and Contextual Factors, Individual Student Factors, the Plant-Based Dining Intervention and Plant-Based Food Choices. Detailed conceptual models for Aims 1, 2, and 3 are presented below.

Aim One Conceptual Model



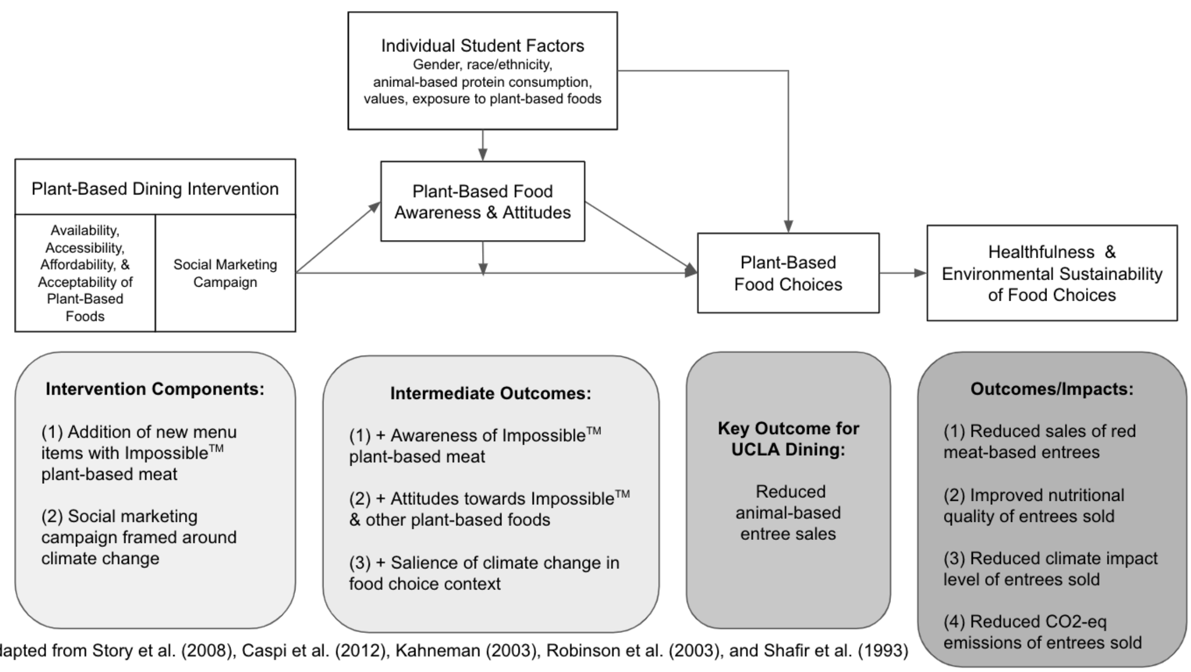
Note: The initiation phase includes the first two stages preceding the decision to implement the innovation; the implementation phase includes the last three stages of implementation.

Aim 1: Investigate the process of developing and implementing an intervention to reduce animal-based protein consumption in university dining, with a particular focus on collaboration between academic and non-academic partners.

The research questions and methods for Aim One were explicitly guided by the five-stage model developed by Rogers (2003) for understanding the process of innovation initiation and implementation in organizations. In addition, I identified organizational and contextual factors that served as barriers and/or facilitators to progressing through these five stages (Rogers, 2003). I also considered how the intervention outcomes evaluated in Aim 2 affected university foodservice leaders' decision to integrate or abandon the intervention.

Aim Two Conceptual Model

Aim 2: Conceptual model for natural experiment on CBPR plant-based intervention effectiveness



Adapted from Story et al. (2008), Caspi et al. (2012), Kahneman (2003), Robinson et al. (2003), and Shafir et al. (1993)

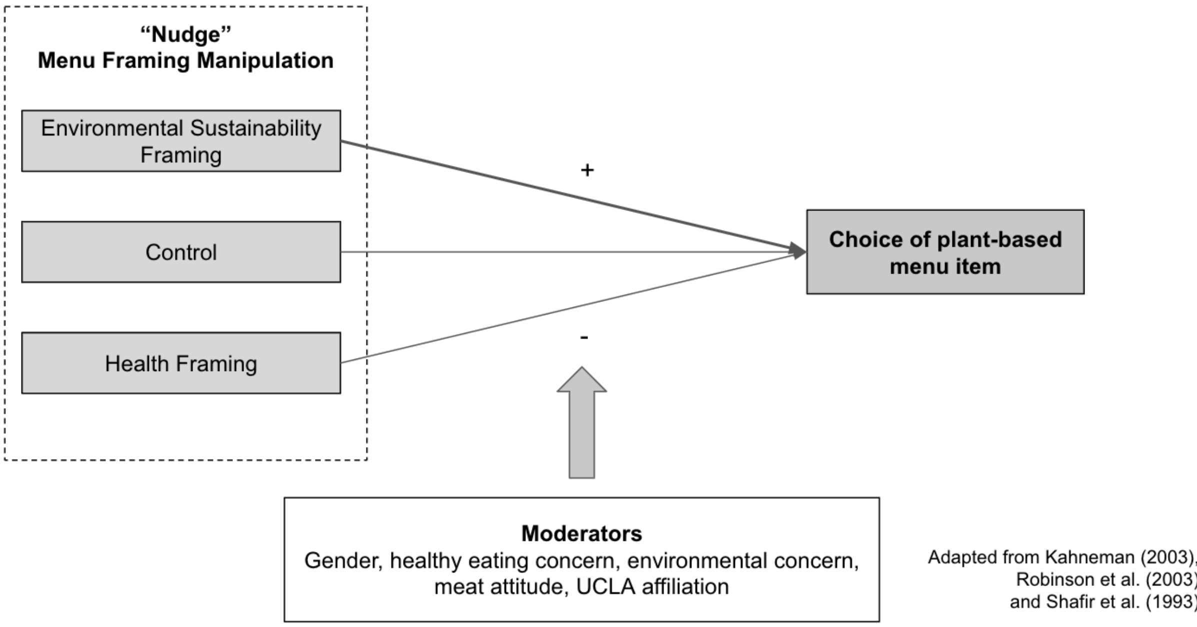
Aim 2: Assess the effectiveness of a university dining intervention developed through CBPR on the dual outcomes of healthfulness and environmental sustainability.

As discussed, multi-level dietary interventions addressing both supply and demand are most likely to be effective. The Impossible™ Foodprint Project intervention included two components: 1) the addition of new menu items with Impossible™ plant-based meat (supply), and 2) a complementary social marketing campaign framed around climate change (demand). Together, these components aimed to increase plant-based food choices by 1) increasing awareness of Impossible™ plant-based meat, 2) increasing awareness of the carbon footprint of different foods, 3) increasing positive attitudes towards Impossible™ and other plant-based foods, and 4) increasing the salience of climate change in the food choice context (i.e., restaurant). It was also hypothesized there would be a direct effect of the intervention on plant-based food choices.

I also hypothesized individual-level factors such as gender and values would predict the extent to which students are aware of and feel positively towards plant-based foods, and the extent to which they consume plant-based foods. While the intervention was designed to address foodservice leaders' primary goal of reducing animal-based protein consumption, multiple outcomes were assessed to determine the impacts of the intervention. These outcomes were determined according to evidence-based indicators of healthfulness and environmental impact: reduced red meat consumption, improved nutritional profile, and reduction in CO_2-eq emissions (i.e., carbon footprint) (A. Pan et al., 2012; Springmann et al., 2018; USDA & HHS, 2015). Additional details are described in the Methods chapter.

Aim Three Conceptual Model

Aim 3: Conceptual model for experiment on effect of menu framing on choice of plant-based menu item



> **Aim 3**: Determine whether environmental sustainability framing is more effective than health framing in "nudging" consumers to choose a plant-based menu item.

Aim Three experimentally tested the overarching hypothesis that dietary interventions connected to larger social movements, such as environmental sustainability, are more impactful than those focused on health-related outcomes (Robinson, 2010). Specially, the experiment tested whether environmental sustainability framing is a more powerful "nudge" than health framing in encouraging the choice of a plant-based menu item. Shafir et al.'s (1993) reason-based choice framework was used to conceptualize framing effects as reasons consumers use to justify choices under conflict. Based on prior evidence, it was hypothesized that individual factors such as gender and values/attitudes would moderate any observed effects (Lehner et al., 2016). UCLA affiliation was also hypothesized as a moderator based on evidence that college students may be especially motivated by social and environmental issues to change their diets (Hekler et al., 2010). Further details are described in the Methods chapter.

Overall, the integrated conceptual framework was well suited to guide the research questions and address the research aims. The framework also provided context for understanding the potential long-term impacts of intervening in a university setting and the rationale for framing dietary interventions around environmental sustainability. In short, the conceptual framework provided a multi-level roadmap for considering organizational, environmental, and individual factors that may influence the development and effectiveness of dietary interventions to promote healthier, more sustainable diets in a university setting. The following chapter will describe the specific research questions and hypotheses investigated to address the research aims.

CHAPTER THREE: RESEARCH AIMS

Overview of Research Aims

This chapter provides an overview of the primary research question and supporting research aims. For each of the three studies, I describe the overall aim, research questions, hypotheses, and support for hypotheses, as appropriate. Details regarding study design, sources of data, measures, and analyses will be discussed in Chapter Four.

> **Primary Research Question:** How can academics and non-academic foodservice leaders collaborate to promote healthier, more environmentally sustainable diets in a university setting?

This question was explored using a community-based participatory research (CBPR) approach, where university foodservice leaders were defined as my community partner. Each study addressed this question from a different angle, with Study One examining the collaborative process of developing and implementing an intervention; Study Two evaluating the effectiveness of that intervention; and Study Three building knowledge of menu framing effects to inform future intervention efforts.

Study One

Study One Aim: Investigate the process of developing and implementing an intervention to reduce animal-based protein consumption in university dining, with a particular focus on collaboration between academic and non-academic partners.

Study One Overview: Guided by Rogers' (2003) five-stage model of the innovation process in organizations, I defined the Impossible™ Foodprint Project intervention as the "innovation" and addressed the following research questions:

- **Question 1.1:** Agenda-Setting (Stage 1): What problem motivated foodservice leaders to seek an intervention-based solution; how did leaders identify and define the problem?
- **Question 1.2:** Matching (Stage 2): How did leaders work with the investigator to select an intervention to address the problem at hand?
- **Question 1.3:** Redefining/Restructuring (Stage 3): How did leaders work with the investigator to design the intervention and/or adapt their operations to improve fit and feasibility?
- **Question 1.4:** Clarifying (Stage 4): What, if any, information did foodservice leaders use to expand implementation and/or correct for unwanted outcomes?
- **Question 1.5:** Routinizing (Stage 5): To what extent was the intervention abandoned and/or integrated into normal foodservice operations?
- **Question 1.6:** What were the barriers and facilitators for foodservice to progress through the five stages in the organization innovation process: agenda-setting, matching, redefining/restructuring, clarifying, and routinizing?

Study One employed case study methodology to address the research questions outlined above. This involved collecting and analyzing data from numerous sources, including key informant interviews, documentation, participant observation, and archival records. Studying the complete process of developing and implementing the intervention—including identifying barriers and facilitators—is valuable for understanding intervention feasibility and addressing the gap between intervention research and practice.

Study Two

Study Two Aim: Assess the effectiveness of a university dining intervention developed through community-based participatory research CBPR on the dual outcomes of healthfulness and environmental sustainability.

Study Two Overview: Using a natural experimental study design, Study Two evaluated the effectiveness of the Impossible™ Foodprint Project intervention developed through CBPR to improve the healthfulness and environmental sustainability of students' food choices. Examining these dual outcomes—healthfulness and environmental sustainability— in a single study is crucial as there may be tradeoffs between the two outcomes. Exploring numerous operationalizations of these outcomes is also valuable for deeper examination of intervention impacts. For example, the Impossible™ plant-based meat introduced as part of the intervention is low in CO_2-eq emissions but high in sodium and saturated fat.

Healthfulness outcomes were operationalized as 1) reduction in red meat entrées sold, and 2) improved nutritional quality of entrées sold, including calories, fiber, sodium, saturated fat, and protein. High intake of red meat and certain nutrients—including sodium and saturated fat—has been linked with increased risk of mortality and chronic disease (Cogswell et al., 2016; A. Pan et al., 2012; Wang et al., 2016). Environmental sustainability outcomes were operationalized as 1) reduction in animal-based entrées sold, 2) reduction in climate impact level of entrées sold, and 3) reduction in CO_2-eq emissions (i.e., carbon footprint) of entrées sold. In general, animal-based foods generate more greenhouse gases (CO_2-eq) than plant-based foods, and greenhouse gases cause climate change (Springmann et al., 2018). In addition, a customer survey of approximately 200 students gathered student-reported data to assess satisfaction and individual-level factors that affect Impossible™ plant-based meat consumption. The following research questions and hypotheses were addressed:

- **Question 2.1a (Key Outcome for Community Partner):** To what extent does the intervention decrease sales of animal-based entrées?
  - **Hypothesis 2.1.1a:** The intervention decreases the proportion of animal-based entrées sold.
- **Question 2.1b (Animal-Based – Vegetarian Replacement):** To what extent does Impossible™ replace sales of existing vegetarian options at Rendezvous West?
  - **Hypothesis 2.1.1b:** The intervention decreases the proportion of existing vegetarian entrées sold.
- **Question 2.2 (Healthfulness – Red Meat):** To what extent does the intervention decrease sales of red meat-based entrées?
  - **Hypothesis 2.2.1:** The intervention decreases the proportion of red meat-based entrées sold.
- **Question 2.3 (Healthfulness – Nutritional Quality):** To what extent does the intervention improve the nutritional quality of entrées sold?
  - Build-your-own entrées and Special entrées were analyzed separately due to differences in menu and data collection structure. Build-your-own entrées do not include entrée components such as rice, beans, salsa, guacamole, and sour cream; Specials comprise complete entrées.

- **Hypothesis 2.3.1:** On average, the intervention decreases protein and unsaturated fat in build-your-own entrées sold.
- **Hypothesis 2.3.2:** On average, the intervention increases calories, fiber, saturated fat, and sodium in build-your-own entrées sold.
- **Hypothesis 2.3.3:** On average, the intervention decreases protein and unsaturated fat in Special entrées sold.
- **Hypothesis 2.3.4:** On average, the intervention increases calories, fiber, saturated fat, and sodium in Special entrées sold.

- **Question 2.4 (Environmental Sustainability – Climate Impact Level):** To what extent does the intervention reduce sales of high-impact entrées?
  - **Hypothesis 2.4.1:** The intervention increases the proportion of low-impact entrées sold.
  - **Hypothesis 2.4.2:** The intervention increases the proportion of medium-impact entrées sold.
  - **Hypothesis 2.4.3:** The intervention decreases the proportion of high-impact entrées sold.
- **Question 2.5 (Environmental Sustainability – Carbon Footprint):** To what extent does the intervention reduce the carbon footprint of entrées sold?
  - **Hypothesis 2.5.1:** On average, the intervention reduces the carbon footprint of entrées sold.
- **Question 2.6 (Individual Factors):** To what extent do individual-level factors affect Impossible™ consumption among students who dine at Rendezvous West?

- **Hypothesis 2.6.1:** Females, vegetarians, and those with higher exposure to plant-based meat are more likely to have tried Impossible™.

- **Question 2.7 (Barriers & Benefits):** What barriers and benefits do students perceive around consuming Impossible™ plant-based meat?

Support for hypotheses: The Impossible™ Foodprint Project intervention involves 1) the addition of new menu items with Impossible™ plant-based meat, and 2) a complementary social marketing campaign framed around climate change. Reviews of dietary interventions in micro-environments such as universities, restaurants, and hospitals found that altering the availability of food options along with educational or promotional point-of-service information can be effective for shifting behavior (Bianchi et al., 2018; Valdivia Espino et al., 2015). In addition, Camilleri et al. (2019) found that consumers significantly underestimate the carbon emissions of foods but shift purchases when presented with intuitive carbon information. As such, I hypothesized the intervention would be effective at decreasing sales of animal-based (i.e., red meat, poultry, seafood), red meat (i.e., beef and pork), and high-impact (i.e., beef) entrées. Due to decreases in high-impact entrée sales, I hypothesized the carbon footprint of entrées sold would also decrease.

Regarding nutritional quality, it was hypothesized that, on average, protein would decrease while calories, fiber, sodium, and saturated fat would increase in both build-your-own and Specials due to the nutritional content of Impossible™ plant-based meat. On average, compared to other entrée base options at Rendezvous West, Impossible™ is higher in calories, fiber, sodium, and saturated fat.

It was also hypothesized that individual-level factors affect Impossible™ plant-based meat consumption among students dining at Rendezvous West. Previous research suggests female college students are more likely to reduce or eliminate meat consumption based on values, and females in general are more likely to select plant-based menu options (Mooney & Walbourn, 2001; Zhou et al., 2019). Students who already consume low or no amounts of meat may be more open to trying a new plant-based option. Finally, due to the established effect of social influences on eating behavior—including modeling, reinforcement, social support, and information sharing—I hypothesized that higher exposure to Impossible™ through friends and other sources would be associated with higher Impossible™ consumption (Cruwys et al., 2015).

Study Three

Study Three Aim: Determine whether environmental sustainability framing is more effective than health framing in "nudging" consumers to choose a plant-based menu item.

Study Three Overview: Using a true experiment, Study Three tested whether environmental sustainability framing is a more powerful "nudge" than health framing in the choice of a plant-based menu item. This involved recruiting 450 UCLA undergraduate students and staff from the Sona participant pool through the Anderson Behavioral Lab. Participants were randomly assigned to one of three menu framing conditions (Control, Health, and Environmental Sustainability), given the choice between two menu options (chicken enchiladas and plant-based tacos), and asked to complete a questionnaire. The following research questions and hypotheses were addressed:

- **Question 3.1 (Framing Main Effects):** To what extent does framing affect choice of a plant-based menu item?
    - **Hypothesis 3.1.1:** Participants are more likely to choose a plant-based dish in the environmental sustainability framing condition, compared to control.
    - **Hypothesis 3.1.2:** Participants are not more likely to choose a plant-based dish in the health framing condition, compared to control (null effect).
    - **Hypothesis 3.1.3:** Environmental sustainability framing is a stronger "nudge" than health framing in the choice of a plant-based menu item.
- **Question 3.2 (Framing Effect Moderators):** To what extent do individual-level factors moderate framing effects?
    - **Hypothesis 3.2.1:** Gender moderates the effect of framing; health framing effects are positive among females and null among males; environmental sustainability effects are positive for both but stronger for females.
    - **Hypothesis 3.2.2:** Healthy eating concern moderates the effect of health and environmental framing; framing effects are weaker for those with high healthy eating concern.
    - **Hypothesis 3.2.3:** Environmental concern moderates the effect of environmental sustainability framing but not health framing; environmental sustainability framing effects are stronger for those with high environmental concern.
    - **Hypothesis 3.2.4:** Meat attitude moderates the effect of health and environmental sustainability framing; framing effects are weaker for those with the most positive meat attitudes.

- **Hypothesis 3.2.5:** UCLA affiliation moderates the effects of framing; health framing effects are positive for staff and null for students; environmental sustainability framing effects are positive for both but stronger for students.

Support for hypotheses: Because cognitive effort is low and use of heuristics is high in food decision-making, small changes to the choice context can be influential (Vlaev et al., 2016; Wilson et al., 2016). This includes "nudges" such as framing, which highlights a choice in a novel, vivid, or personally relevant way (Blumenthal-Barby & Burroughs, 2012; Wilson et al., 2016). Although health is intrinsically personal, and health concerns are reported as top drivers of food choice, studies suggest consumers consciously and subconsciously perceive food described as healthy as less enjoyable and less satisfying (Finkelstein & Fishbach, 2010; Köster, 2009; Raghunathan et al., 2006; Suher et al., 2016). Thus, despite consumers' general interest in health, health-framed "nudges" may have null or even counteractive effects.

In contrast, studies suggest consumers perceive foods containing eco-labels as tastier and higher quality (Magnier et al., 2016; Sörqvist et al., 2015). The novelty and timeliness of environmental sustainability framing may also be appealing, as healthy eating messages are pervasive, and consumers may suffer from issue fatigue. In line with the theory of process motivation, consumers may also feel better about choosing a menu item that is good for the environment rather than just good for themselves (Robinson, 2010). For these reasons, it was hypothesized that environmental sustainability framing would have a positive effect on choice of a plant-based item, while health framing would have a null effect, compared to the control condition.

It was also hypothesized that individual-level factors would moderate the effects of menu framing. It was expected that health framing effects would be positive among females and null among males, while environmental sustainability effects would be positive among both but stronger among females. This was based on evidence that females are more likely to make food decisions—particularly reject meat—based on values such as health and ethics (Mooney & Walbourn, 2001). In addition, it was expected that participants with high healthy eating concern would already be likely to choose the plant-based tacos and thus less affected by menu framing. In contrast, those with high environmental concern may not typically choose a more environmentally sustainable menu option because sustainability is not always salient in the food choice context (Guyader et al., 2017; Stubbs et al., 2018). Prior research found that pro-sustainability "nudges" such as carbon labels can shift behavior, and effects are stronger among more environmentally concerned consumers (Camilleri et al., 2019; Thøgersen & Nielsen, 2016).

Furthermore, it was hypothesized that participants with the most positive attitudes towards meat consumption would be highly unlikely to choose the plant-based menu item under any condition, thus framing would have a diminished effect. Those with positive attitudes towards meat consumption are less motivated by ethical concerns when making food choices and are committed to eating meat (Piazza et al., 2015). Finally, it was hypothesized that framing effects would differ by UCLA affiliation because health is likely more salient for older people (i.e., staff), while social and environmental issues may be more salient for students (Hekler et al., 2010; Jay et al., 2019; Malan et al., 2019).

The following chapter provides a complete description of the study designs, measures, data sources, and analyses used to investigate the above aims, research questions, and hypotheses.

CHAPTER FOUR: METHODS

Overview of Methods

This chapter describes the setting, methodological approach, Impossible™ Foodprint Project intervention, and specific methodological procedures used in the research. The chapter begins with a description of the university setting where all three studies took place. I then describe the community-based participatory research (CBPR) approach, which involved collaboration with my community partner, UCLA foodservice leaders. In comparison to traditional "outside expert" research, CBPR is driven by the community partner and involves determining effective real-world approaches for achieving organizational, behavioral, and social change (Minkler & Wallerstein, 2003). CBPR is increasingly recognized as an appropriate approach for enhancing intervention feasibility, building community capacity, and addressing complex social problems (Chen, 2010; Israel et al., 2005; Minkler & Wallerstein, 2003).

Next, I describe the designs, measures, data sources, and analyses for each of the three studies. Study One employed qualitative case study methodology to examine the process of developing and implementing an intervention through CBPR. Study Two involved a natural experiment with a pre-post nonequivalent comparison group design to assess the effectiveness of that intervention to improve both health and environmental sustainability outcomes. Study Three utilized a true experiment to build knowledge for foodservice leaders around the effects of health and environmental sustainability menu framing in nudging consumers to choose a plant-based menu item. Together, the three studies encompassed a deep investigation of the process and effectiveness of using CBPR to achieve the dual goals of health and environmental sustainability through university foodservice operations, while contributing novel insights into framing effects for use in future interventions.

Research Setting

University Overview: All three studies took place at the University of California, Los Angeles (UCLA), a large public university in Southern California. The diverse study body is comprised of approximately 31,000 undergraduates and 14,000 graduate students (UCLA Newsroom, 2019). Over 50% of undergraduates receive some kind of financial aid and 34% receive Federal Pell Grants—awards given only to undergraduates with exceptional financial need (UCLA, 2019a). In addition, almost one third of undergraduates who earn a degree are the first in their families to graduate from a four-year college or university—often referred to as "first generation" college graduates (UCLA Newsroom, 2019). In the 2017-18 academic year, 88% of undergraduate students were domestic and 11% were of international origin (UCLA, 2019b). Among domestic students, 28% were Asian, 27% were White, 22% were Hispanic, 5% were two or more races, 3% were African American, and 3% were other races (UCLA, 2019b). Fifty-seven percent of undergraduates and 60% of new freshmen were female (UCLA, 2019b). The university is highly ranked for academic, research, and community impact and is the most applied-to university in the country (UCLA Newsroom, 2019).

Residential University Food Environment: Studies One and Two focused on the residential food environment, operated by UCLA Dining within the university's Housing & Hospitality Services. In total, over 11,000 undergraduate students (approximately 37%) live in residential housing each year, with most students living there for the first two years of their undergraduate studies (UCLA Newsroom, 2019). In 2017-18, 98% of new freshmen and 51% of new undergraduate transfers lived in residential housing (UCLA, 2019b). All residential housing contracts include a meal plan, ranging from 11 meals per week ("Regular": no carry-over of unused meals) to 19P meals per week ("Premium": carry-over of unused meals through the end of each quarter). Rates for the 2019-2020 classic residence hall double room are presented in Figure 9 and range from $15,000 for 11 meals to $16,252 for 19P meals (UCLA Housing & Hospitality Services, 2019b). Meals are typically referred to as “swipes,” such that 11 meals per week would equate to 11 “swipes” per week.

Figure 9. Rates for 2019-2020 classic residence hall double room, UCLA

FULL PAYMENT PLAN	19P MEALS	14P MEALS	19 MEALS	14 MEALS	11 MEALS
Room portion	$10,421.88	$10,421.88	$10,421.88	$10,421.88	$10,421.88
Meal Plan portion	$5,791.20	$5,462.88	$5,171.04	$5,000.04	$4,539.48
Social Fee portion	$38.76	$38.76	$38.76	$38.76	$38.76
Total contract payment:	**$16,251.84**	**$15,923.52**	**$15,631.68**	**$15,460.68**	**$15,000.12**

A division of Housing & Hospitality Services, UCLA Dining includes over 600 team members and is one of the largest self-operating university systems in the country (UCLA Housing & Hospitality Services, 2019a). Dining operates four traditional all-you-care-to-eat restaurants and four quick-service restaurants, serving approximately 6.5 million meals per year (UCLA Housing & Hospitality Services, 2019a). Each all-you-care-to-eat restaurant is themed around cuisine from a different region of the world. Quick-service restaurants are similar to fast casual establishments such as Chipotle or Panda Express, where meals can be eaten in a café-style restaurant or taken to go. One meal “swipe” grants entry to an all-you-care-to-eat restaurant or provides a “combo meal” at a quick-service restaurant, usually consisting of an entrée and drink, and sometimes including a side dish. Residential restaurant offerings evolve as student and campus needs change. For example, the quick-service restaurant The Study was opened recently in the 2018-19 academic year. An overview of the university's residential restaurants as of the 2018-19 academic year is provided in Table 2.

Table 2. Description of UCLA's residential restaurants, 2018-19 academic year

Residential Restaurant	**Description**
All-You-Care-to-Eat (4)	Buffet-style restaurants where one meal "swipe" grants entry into the restaurant.
1) Bruin Plate	Health- and sustainability-themed all-you-care-to-eat restaurant.
2) Covel Commons	Mediterranean-inspired all-you-care-to-eat restaurant.
3) De Neve	All-you-care-to-eat restaurant, inspired by street food of the Americas.
4) FEAST	Pan-Asian all-you-care-to-eat restaurant.
Quick-Service (4)	Fast-casual restaurants where meals can be eaten café-style or taken to go. One meal "swipe" can be used to purchase a variety of combination meals.
1) Bruin Café	Specialty coffees, smoothies, pastries, sandwiches, salads, and soups.
2) Café 1919	Italian-themed café with specialty coffees, paninis, pizzas, salads, and gelato.
3) Rendezvous	Dual-themed restaurant with Latin dishes on the West side and Asian dishes on the East side. The East side also includes Boba beverages and desserts.
4) The Study at Hedrick	Craft-your-own sandwiches, pizzas, and salads, plus Northern European-inspired dishes, bakery, and beverage bar.

Source: https://housing.ucla.edu/dining-services/facilities-services-academic-year

Methodological Approach

To address the overarching research question of how academics and non-academic foodservice leaders can collaborate to promote healthier, more environmentally sustainable diets in a university setting, I employed a community-based participatory approach. UCLA's foodservice leaders were defined as my community partner: They helped define the research goals; drove the development and implementation of the intervention; provided access to key informants and other data sources; and shared ownership over research findings and reports.

Community-Based Participatory Research: In contrast to the traditional "outside expert" approach to intervention research, community-based participatory research (CBPR) involves true collaboration between communities and researchers (Minkler & Wallerstein, 2003). CBPR is not research for the sake of research; rather, it is a social change project that includes research alongside learning, developing relationships, and engaging in actions that yield benefits and build capacity for community partners (Minkler & Wallerstein, 2003). In short, key distinctions of CBPR include the following: 1) addresses community-identified rather than simply community-placed issues, 2) balances research with action for social change, and 3) shares ownership over decision-making and results (Israel et al., 2005; Minkler & Wallerstein, 2003). CBPR takes an iterative approach to research and seeks to determine effective real-world approaches for achieving organizational, behavioral, and social change (Israel et al., 2005).

CBPR is increasingly recognized as an appropriate approach for studying and addressing complex health and social problems (Minkler & Wallerstein, 2003). It is particularly appropriate for public health interventions, which may otherwise struggle with issues of viability in the real world (Chen, 2010; Israel et al., 2005). Indeed, numerous fields, including implementation science and evaluation research, have noted the failures of traditional top-down approaches for translating research into practice (Chen, 2010; Measure Evaluation Implementation Research Technical Working Group, 2012). Most notably, despite high internal validity and evidence of efficacy, interventions may lack adequate implementation, dissemination, and scale-up because they do not align with the community context (Chen, 2010; Measure Evaluation Implementation Research Technical Working Group, 2012). This results in a persistent gap between what we know to work in ideal conditions and what solutions are viable to meet community needs. CBPR addresses this gap by generating research questions and interventions from within the community.

Community Partner & Role of Researcher: For this dissertation, my community partner was UCLA foodservice leaders—a community comprised of Housing & Hospitality Services administrators, Dining operators, and nutrition and sustainability managers responsible for UCLA's residential food environment. In CBPR, the role of the researcher can take three forms—with increasing levels of involvement: initiator, consultant, and collaborator (Minkler & Wallerstein, 2003). As an initiator, the researcher initiates contact with the community and provides the impetus for community-driven research. As a consultant, the researcher also conducts or helps to conduct the research, taking care to transfer the gained knowledge (and thus power) back to the community partner. As a collaborator, the researcher takes the partnership a step further: The researcher often shares technical or academic skills useful for the community, while the community partner provides special knowledge of the community.

For this dissertation, I assumed the researcher as collaborator role, which included the following: contributing expertise to support intervention development and capacity building; facilitating and documenting the intervention process; evaluating the intervention's effectiveness; and providing novel evidence (Study Three experiment) for future intervention efforts. As a whole, the dissertation involved both action and research to effect organizational, behavioral, and social change to promote healthier, more environmentally sustainable food in a university setting (Israel et al., 2005).

CBPR Intervention Overview

Intervention Description – Impossible™ Foodprint Project: The development and implementation of the Impossible™ Foodprint Project was driven by UCLA foodservice leaders with the goal of reducing animal-based protein consumption. In general, this outcome is expected to have positive impacts for both health and environmental sustainability. The intervention included two overarching components: 1) the addition of new menu items with Impossible™ plant-based meat, and 2) a complementary social marketing campaign framed around climate change. The decision to use Impossible™ plant-based meat introduced some concerns around healthfulness. Impossible™ is a processed product made primarily from soy, coconut oil, and sunflower oil. Nutrition facts for a standard 4-oz portion are provided in Figure 10. Other ingredients include potato protein and soy leghemoglobin. Soy leghemoglobin is a protein that contains heme. Although the FDA approved Impossible™ as safe, heme has been identified as a potential mechanism by which red and processed meat is associated with increased cancer risk (Godfray et al., 2018). High saturated fat and sodium were specifc nutrients of concern. Additional intervention details are described in Study One Results. Rendezvous West

Figure 10. Impossible™ nutrition facts

Nutrition Facts	
3 servings per container	
Serving size	**4 oz (113g)**
Amount per serving	
Calories	**240**
	% Daily Value*
Total Fat 14g	**18%**
Saturated Fat 8g	**40%**
Trans Fat 0g	
Cholesterol 0mg	**0%**
Sodium 370mg	**16%**
Total Carbohydrate 9g	**3%**
Dietary Fiber 3g	**11%**
Total Sugars <1g	
Includes <1g Added Sugars	**1%**
Protein 19g	**31%**

Source: faq.impossiblefoods.com

residential restaurant was selected as the intervention pilot site due to high popularity and volume of animal-based protein consumption—especially beef.

Intervention Site – Rendezvous West: The intervention was piloted in Fall 2019 at Rendezvous, one of four quick-service residential restaurants at the university. Rendezvous is the university's second most popular quick-service restaurant (after The Study), serving over one million meals each year. Rendezvous is divided into two sides: a Latin-themed restaurant on the West side and an Asian-themed restaurant on the East side. Rendezvous West is similar in style and operation to the restaurant chain Chipotle, while Rendezvous East is similar to the restaurant chain Panda Express. The intervention was piloted only at Rendezvous West, while Rendezvous East served as a comparison site. Rendezvous West offers a build-your-own entrée option, where students can choose their entrée style (e.g., burrito, bowl, taco), base (e.g., chicken, steak, vegetable), sauce, and sides. Rendezvous West also offers quesadillas, nachos, guacamole, chips, and daily entrée specials (see Menu in Appendix I). The restaurant already offers vegetarian and vegan items, including plant-based chicken and cheese alternatives, but these items are much less popular than animal-based options. For example, in 2018-19, the restaurant sold over 39,000 chicken burrito bowls and 18,500 steak quesadillas, compared to approximately 11,700 vegetarian burrito bowls and 1,500 vegan spinach quesadillas.

A survey conducted with students in this study setting (n=1,156) in 2016 found that 28% of respondents reported eating at Rendezvous at least 4 times per week (unpublished data, see Appendix II). Male respondents were more likely to be high Rendezvous consumers than female respondents (36% vs. 24%) ($p<.001$). When compared to students who eat at Rendezvous less than 4 times per week, high Rendezvous consumers reported eating red meat significantly more frequently (6.42 vs. 5.61 times per week, $p<.001$) and were less likely to believe "healthy eating" means eating “less meat” (18% vs. 27%, p<.001), less likely to believe “healthy eating” means eating “more plants” (50% vs. 63%, p<.001), and less likely to believe it is “very important” to “eat healthy” (37% vs. 53%, p<.001), compared to lower consumers. Only 3% of high Rendezvous consumers reported being vegetarian, and less than 2% reported being vegan. As such, high Rendezvous consumers comprise a segment of students who may be less receptive to plant-based foods; however, given high meat consumption among this segment, there is also high potential for impact.

Study One Methods

Study One – Case Study of Intervention Process

Study One Aim: Investigate the process of developing and implementing an intervention to reduce animal-based protein consumption in university dining, with a particular focus on collaboration between academic and non-academic partners.

Study One Overview: Guided by Rogers' (2003) five-stage model of the innovation process in organizations, I defined the Impossible™ Foodprint Project intervention as the "innovation" and addressed the following research questions:

- **Question 1.1:** Agenda-Setting (Stage 1): What problem motivated foodservice leaders to seek an intervention-based solution; how did leaders identify and define the problem?
- **Question 1.2:** Matching (Stage 2): How did leaders work with the investigator to select an intervention to address the problem at hand?
- **Question 1.3:** Redefining/Restructuring (Stage 3): How did leaders work with the investigator to design the intervention and/or adapt their operations to improve fit and feasibility?
- **Question 1.4:** Clarifying (Stage 4): What, if any, information did foodservice leaders use to expand implementation and/or correct for unwanted outcomes?
- **Question 1.5:** Routinizing (Stage 5): To what extent was the intervention abandoned and/or integrated into normal foodservice operations?
- **Question 1.6:** What were the barriers and facilitators for foodservice to progress through the five stages in the organization innovation process: agenda-setting, matching, redefining/restructuring, clarifying, and routinizing?

Study One – Case Study Method: A case study is an empirical method that investigates a phenomenon and the real-life context in which that phenomenon occurs (Yin, 2003). Qualitative case study methodology is suitable for research involving how and why questions when: 1) the researcher does not have control over behavioral elements; 2) the phenomenon includes contemporary events; and 3) the boundaries between the phenomenon and context are not easily distinguished (Yin, 2003). Importantly, case studies allow researchers to examine the complete process of the phenomenon—how, why, and to end it occurs—when causal links are previously unknown or too complex to measure (Yin, 2003). As part of program evaluation, case studies can be used to comprehensively understand the process of program implementation, including contextual influences, unexpected outcomes, and evolutions of a program (Martinson & O'Brien, 2015). Case studies can answer questions typically not answerable by experiments or quasi-experiments, including essential questions about program adoption and sustainability. For example, one case study of drug intervention uptake produced the valuable finding that, despite limited effectiveness of the drug prevention program DARE, political salience increased uptake; in contrast, moral objection reduced uptake of needle syringe programs despite proven effectiveness (Oldenburg & Glanz, 2008).

In designing case studies, researchers must take care to address the fundamental question of how to define the unit of analysis—the "case" (Yin, 2003). Because this dissertation is concerned with how to develop and implement the intervention within the foodservice organization, this process was defined as the case. Like other methods, case studies benefit from the use of prior theory to guide data collection and analysis (Yin, 2003). As described in the Chapter Two, this study was guided by Rogers' (2003) model of the innovation process in organizations, which delineates five stages across the two broad stages of innovation initiation and implementation: 1) agenda-setting, 2) matching, 3) redefining/restructuring, 4) clarifying, and 5) routinizing (Rogers, 2003). In this case, the Impossible™ Foodprint Project intervention was defined as the "innovation" of interest. Using this model as a template not only enables the systematic collection and analysis of data, but also supports replication and analytic generalization (Yin, 2003). This is particularly important in single case study research, where generalizability is considered a weakness (Martinson & O'Brien, 2015; Yin, 2003). In short, designing the study around existing theory allows for greater comparison of the study's results.

Yin (2003) outlines six sources of data commonly used as evidence in case studies: documentation, archival records, interviews, direct observations, participant observation, and artifacts. In addition, Yin (2003) provides three principles to enhance the validity and reliability of data. The first principle, use multiple sources of data, is supported by the concept of triangulation, or the convergence of findings. When data from multiple sources corroborate the same findings, researchers can increase confidence that findings are valid and not due to bias or chance. The second principle, create a case study database, involves documenting and organizing data to improve reliability. The database will typically include case study memos and documents. The third principle, maintain a chain of evidence, also supports reliability. Ultimately, the case study report should ensure readers can logically derive conclusions based on the evidence presented (Yin, 2003).

Study One – Data Collection: In line with recommended procedures, I collected data from multiple sources—including interviews, documentation, participant observation, and archival records. All data were documented and organized in a Google Drive database. The study was certified exempt by the UCLA Institutional Review Board. Data sources and collection procedures are described as follows:

I. **Key Informant Interviews:** Key informants are individuals who participate in the phenomenon of interest, can provide special insights, and who often provide access to information or other data sources that are crucial to study (Yin, 2003). A list of key informant interview participants and their justification for selection is presented in Table 3. Interview guides were derived from research questions and observations and were tailored to fit each participant's specific role in the intervention process. Interview guides are provided in Appendix III. For example: a) In your view, what motivated [high-level foodservice leaders] to do this project? b) What did it take to launch the new menu items? c) To what extent do you think the project was successful? d) What outcomes or findings are most valuable to you? Interviews were conducted according to the participant's preference—either in person or by phone—to minimize participant burden. During each interview, I took detailed notes on a laptop computer. Directly following each interview, I elaborated upon the notes and wrote a memo documenting immediate reactions, salient evidence for answering the research questions, and emergence of any conflicting evidence or explanations.

II. **Documentation:** Documents collected as sources of data for this case study included the following: email communications; meeting agendas and minutes; and the formal intervention evaluation conducted in Study Two – Natural Experiment. Due to my role as a collaborator in this community-based participatory research (CBPR) project, I was included in communications and meetings regarding the intervention and had access to all evaluation data. Because I did not participate in all meetings and activities with operators, I utilized other data sources—including interviews and archival records—to obtain comprehensive information about the process.

Table 3. List and justification of key informant interview participants	
Participant Name, Title	**Justification for Selection**
Assistant Vice Chancellor (AVC), Housing & Hospitality Services (H&HS)	As head of H&HS, the AVC holds executive power over both the Dining and Marketing Services teams responsible for the implementation of the intervention. As the initiator of the intervention and primary decision-maker, he provided special insight into the agenda-setting, matching, clarifying, and routinization stages.
Senior Director of Food & Beverage, H&HS	As head of Food & Beverage, the Senior Director holds executive power over the Dining Services team. He was responsible for planning, designing, and overseeing Dining's role in the intervention. He is also the key decision-maker regarding Dining's budget. As such, he provided special insight into the matching, redefining/restructuring, and clarifying stages as well as barriers and facilitators for the process.
Senior Director, Organizational Performance & Communication, H&HS	As head of Organizational Performance & Communication, the Senior Director holds executive power over the Marketing Services team and serves as Chief of Staff for the AVC. She plays a key role in coordinating efforts between Dining and Marketing, including overseeing special projects. She provided special insight into the redefining/restructuring stage as well as barriers and facilitators for the process.
Nutrition Education Coordinator, H&HS – Dining Services	The Nutrition Education Coordinator is the gatekeeper of nutrition information provided by Dining Services for students. She provided special insight into the redefining/restructuring and clarifying stages.
Sustainability Manager, Residential Life, H&HS	The Sustainability Manager oversees and manages sustainability programs for residential housing and dining. As such, she provided special insight on existing efforts around procuring sustainable food and educating students about sustainability. She also assisted with data collection for the customer survey.
Food Services Manager, H&HS – Dining Services	The Food Services Manager serves as the General Manager for Rendezvous West, the residential restaurant where the intervention took place. He provided special insight into the redefining/restructuring and clarifying stages as well as barriers and facilitators for the process.

III. **Participant Observation:** In addition to collecting documents, I collected evidence through observation of the intervention process. This involved writing memos about the chronology of the process and observed barriers and facilitators. I also took photographs of the intervention site as additional evidence of implementation. My observation is classified as participant observation due to my role as a collaborator in this project (Yin, 2003). While participant observation facilitates valuable access to and understanding of the phenomenon being studied, this technique can also introduce bias (Yin, 2003). As such, I followed up on observations to ensure corroboration by other sources of evidence (i.e., triangulation of data) before drawing conclusions from these data.

IV. **Archival Records:** Archival records collected as sources of data for this case study included the following: organizational and administrative records (e.g., organizational chart); restaurant service and purchase records; electronic menus and nutritive analyses; and marketing materials. As my community partner, foodservice leaders provided access to relevant records. Additional records, such as publicly available websites and periodicals, were utilized to expand upon and/or confirm other evidence.

Study One – Analytical Procedures: In case study research, analysis relies heavily on the theoretical framework, presentation of evidence, and consideration of alternative interpretations (Yin, 2003). Although numerous analytic approaches exist, the preferred analytic strategy involves presenting evidence in response to the study's theoretical propositions, or theories about why things happen the way they do (Yin, 2003). This helps to focus interpretation of data around specific concepts. In this case study, Rogers' (2003) model of the innovation process in organizations served as the theoretical framework guiding all steps: developing the research questions, collecting data, analyzing and interpreting the data, and writing the results.

This descriptive case study involved qualitative analysis of multiple data sources to describe each of the five stages in the intervention process (addressing Questions 1.1.-1.5), as well as factors that influenced the foodservice organization to progress through the process (Question 1.6, barriers and facilitators). As is common in qualitative analysis, data collection and analysis occurred concurrently (Baxter & Jack, 2008). For example, observations and documentation informed the key informant interview guides. Specifically, I employed a time-series, or longitudinal, analysis technique to deductively organize data into the chronological logic of Rogers' (2003) five-stage process model (Yin, 2012).

This involved an iterative approach with integration of multiple data sources to maintain a chain of evidence and achieve triangulation, or convergence of findings (Yin, 2003, 2012). In addition to qualitatively analyzing observation memos, interviews, and documents, I drew on quantitative findings from Study Two to further support and illustrate results (Yin, 2012). Other scholars have used descriptive and longitudinal case study methodology to investigate intervention processes (Bisset et al., 2009; Goode et al., 2012; Martinson & O'Brien, 2015; Zhang et al., 2015).

Study Two Methods

Study Two – Natural Experiment to Evaluate CBPR Intervention Effectiveness

Study Two Aim: Assess the effectiveness of a university dining intervention developed through community-based participatory research (CBPR) on the dual outcomes of healthfulness and environmental sustainability.

Study Two Overview: Using a natural experimental study design, Study Two evaluated the effectiveness of the Impossible™ Foodprint Project intervention to improve the healthfulness and environmental sustainability of students' food choices. The following research questions and hypotheses were addressed:

- **Question 2.1a (Key Outcome for Community Partner):** To what extent does the intervention decrease sales of animal-based entrées?
    - **Hypothesis 2.1.1a:** The intervention decreases the proportion of animal-based entrées sold.
- **Question 2.1b (Animal-Based – Vegetarian Replacement):** To what extent does Impossible™ replace sales of existing vegetarian options at Rendezvous West?
    - **Hypothesis 2.1.1b:** The intervention decreases the proportion of existing vegetarian entrées sold.
- **Question 2.2 (Healthfulness – Red Meat):** To what extent does the intervention decrease sales of red meat-based entrées?
    - **Hypothesis 2.2.1:** The intervention decreases the proportion of red meat-based entrées sold.

- **Question 2.3 (Healthfulness – Nutritional Quality):** To what extent does the intervention improve the nutritional quality of entrées sold?
    - Build-your-own entrées and Special entrées were analyzed separately due to differences in menu and data collection structure. Build-your-own entrées do not include entrée components such as rice, beans, salsa, guacamole, and sour cream; Specials comprise complete entrées.
    - **Hypothesis 2.3.1:** On average, the intervention decreases protein in build-your-own entrées sold.
    - **Hypothesis 2.3.2:** On average, the intervention increases calories, fiber, sodium, and saturated fat in build-your-own entrées sold.
    - **Hypothesis 2.3.3:** On average, the intervention decreases protein in Special entrées sold.
    - **Hypothesis 2.3.4:** On average, the intervention increases calories, fiber, sodium, and saturated fat in Special entrées sold.
- **Question 2.4 (Environmental Sustainability – Climate Impact Level):** To what extent does the intervention reduce sales of high-impact entrées?
    - **Hypothesis 2.4.1:** The intervention increases the proportion of low-impact entrées sold.
    - **Hypothesis 2.4.2:** The intervention increases the proportion of medium-impact entrées sold.
    - **Hypothesis 2.4.3:** The intervention decreases the proportion of high-impact entrées sold.

- **Question 2.5 (Environmental Sustainability – Carbon Footprint):** To what extent does the intervention reduce the carbon footprint of entrées sold?
    - **Hypothesis 2.5.1:** On average, the intervention reduces the carbon footprint of entrées sold.
- **Question 2.6 (Individual Factors):** To what extent do individual-level factors affect Impossible™ consumption among students who dine at Rendezvous West?
    - **Hypothesis 2.6.1:** Females, vegetarians, and those with higher exposure to plant-based meat are more likely to have tried Impossible™.
- **Question 2.7 (Barriers & Benefits):** What barriers and benefits do students perceive around consuming Impossible™ plant-based meat?

Study Two –Measures

To answer research questions 2.1-2.5, I used UCLA Dining's administrative sales and nutritional data. These data are routinely collected and managed through FoodPro, a widely used foodservice data management platform. UCLA Dining uses FoodPro to manage inventory, menus, recipes, and nutritional content. FoodPro is also integrated with the Micros point-of-service system to track all service records (i.e., sales data). To answer research questions 2.6 and 2.7, I used data from a customer survey developed in partnership with foodservice leaders, which included both closed-ended and open-ended questions. Brief descriptions of the data sources are provided below, and additional details are described in the Data Sources section.

Sales & Nutritional Data: An overview of variable names, types, and definitions for questions 2.1-2.5 is presented in Table 4. A detailed description of the variables is presented below. Variables were created based on FoodPro records, UCLA Dining menus, and scientific literature on nutrition and dietary carbon footprint.

Table 4. List of variable names, types, and definitions for RQ 2.1-2.5 using administrative sales and nutritional data from FoodPro		
Variable name	**Variable type**	**Definition**
Independent Variables		
Pre/post	Dichotomous	Fall 2018 (Pre) Fall 2019 (Post)
Site	Categorical	Rendezvous West (Intervention) Rendezvous East (Comparison) Bruin Café (Comparison)
Outcome Variables		
Entrée Type (Rendezvous West only)		
Build-your-own	Dichotomous	Build-your-own entrées, coded based on menus
Special	Dichotomous	Special entrées, coded based on menus
Entrée Base		
Beef	Dichotomous	Beef entrées, coded based on menus
Pork	Dichotomous	Pork entrées, coded based on menus
Mixed	Dichotomous	Mixed meat entrées (beef, pork, poultry, seafood), coded based on menu
Poultry	Dichotomous	Poultry entrées, coded based on menus
Shrimp	Dichotomous	Shrimp entrées, coded based on menus
Fish	Dichotomous	Fish entrées, coded based on menus
Cheese-based	Dichotomous	Vegetarian entrées with at least 2 oz cheese, coded based on menus and recipes provided by Dining
Plant-based	Dichotomous	Vegetarian entrées with less than 2 oz cheese, coded based on menus and recipes provided by Dining
Impossible	Dichotomous	Impossible™ plant-based meat entrées, coded based on menus

Variable name	Variable type	Definition
Vegetarian	Dichotomous	Vegetarian entrées, including cheese, plant-based, and Impossible™
Other vegetarian	Dichotomous	Vegetarian entrées, excluding Impossible™
Healthfulness Outcomes		
Red meat	Dichotomous	Beef- and pork-based entrées
Nutrients of concern: Calories, saturated fat, sodium	Continuous	Calories (kcal), sat fat (g), and sodium (mg) per entrée
Beneficial/other nutrients: Fiber, protein, unsaturated fat	Continuous	Fiber (g), protein (g), and unsaturated fat (g) per entrée
Environmental Sustainability Outcomes		
Animal-based	Dichotomous	Meat and seafood-based entrées (beef, pork, mixed, poultry, shrimp, fish), coded based on menus
Low-impact	Dichotomous	0-25% Daily Value Dietary Carbon Footprint: Fish, Impossible™, and plant-based entrées
Medium-impact	Dichotomous	26-50% Daily Value Dietary Carbon Footprint: Pork, mixed, poultry, shrimp, and cheese entrées
High-Impact	Dichotomous	>50% Daily Value Dietary Carbon Footprint: Beef entrées
Carbon footprint	Continuous	CO_2-eq (g) per entrée Low-impact: 203 g CO_2-eq Medium impact: 836 g CO_2-eq High-impact: 2999 g CO_2-eq

I. Independent Variables (Sales & Nutritional Data):

a. Pre/post: The implementation of the Impossible™ Foodprint Project intervention was measured by the independent variable pre/post, treated as a dichotomous variable. All sales data collected during Fall 2018 were coded as pre (prior to intervention implementation), while all data collected during Fall 2019 were coded as post (post intervention implementation).

b. Site: For between-restaurant comparative analyses, I used site as a categorical independent variable. Site refers to residential restaurant site: Rendezvous West (Intervention), Rendezvous East (Comparison), and Bruin Café (Comparison). The effect of the Impossible™ Foodprint Project intervention was measured as the interaction of prepost*site.

II. Dependent Variables (Sales & Nutritional Data):

a. Build-your-own (Rendezvous West only): Because build-your-own items were analyzed separately from specials to address Research Question 2.3 (nutritional quality), a dichotomous variable build-your-own was coded yes/no for all Rendezvous West menu entrées. Printed menus were used to inform coding.

b. Special (Rendezvous West only): A nominal variable special was coded yes/no for all Rendezvous West entrées. Printed menus were used to inform coding.

c. Beef: To create higher-order outcome variables, all entrées were first coded by entrée base. A dichotomous variable beef was coded yes/no for all entrées. Printed name and menus were used to inform coding. Entrées containing multiple types of animal-based protein, such as the Surf and Turf burrito, are coded as mixed, described below.

d. Pork: A dichotomous variable pork was coded yes/no for all entrées. Printed name and menus were used to inform coding.

e. Mixed: A dichotomous variable mixed was coded yes/no for all entrées. Mixed dishes containing a combination of animal-based protein, such as the Surf & Turf Burrito and Three Taco Combo, were coded as yes. Printed name and menus were used to inform coding.

f. Poultry: A dichotomous variable poultry was coded yes/no for all entrées. Printed name and menus were used to inform coding.

g. Shrimp: A dichotomous variable shrimp was coded yes/no for all entrées. Printed name and menus were used to inform coding.

h. Fish: A dichotomous variable fish was coded yes/no for all entrées. Printed name and menus were used to inform coding.

i. Cheese-based: A dichotomous variable cheese-based was coded yes/no for all entrées. Printed name, menus, and recipes were used to inform coding, and items coded yes included only vegetarian entrées containing at least 2 ounces of cheese, such as the Spinach Quesadilla. This cutoff of 2 ounces was informed by a carbon footprint analysis and in consultation with the UCLA Dining Dietitian. Based on methodology developed by Leach et al. (2016), 2 ounces of cheese accounts for a substantial portion (25%) of the daily value of the carbon footprint of a healthy diet. In addition, 2 ounces of cheese is equivalent to a one-cup serving of dairy (USDA & HHS, 2015). Mixed dishes containing both cheese and meat or seafood, such as the Steak Quesadilla, were coded as that respective meat or seafood.

j. Plant-based: A dichotomous variable plant-based was coded yes/no for all entrées. Printed name, menus, and recipes were used to inform coding, and all vegetarian dishes containing < 2 ounces cheese, including Impossible™ plant-based meat entrées, were coded as yes.

k. Impossible: A dichotomous variable Impossible was coded yes/no for all entrées. Printed name and menus were used to inform coding.

l. Vegetarian: A dichotomous variable vegetarian was coded yes/no for all entrées. Cheese-based and plant-based were coded yes, all others as no.

m. Other vegetarian: A dichotomous variable vegetarian was coded yes/no for all entrées. Cheese-based and plant-based were coded yes, all others as no. Impossible entrées were then coded as no as well. This variable was created to allow for examination of changes in sales of other vegetarian items following the introduction of Impossible™.

n. Animal-based: A dichotomous variable animal-based was coded yes/no for all entrées. Beef, pork, mixed, poultry, shrimp, and fish were coded yes; cheese-based and plant-based were coded no. Although cheese is technically animal-based, it is not typically considered an animal-based protein because it is not animal meat. In this case, animal-based is the inverse of vegetarian.

o. Red meat: A nominal variable red meat was coded yes/no for all entrées. All beef, pork, and mixed entrées are coded yes.

p. Calories: Calories is a continuous variable measured in kcal units.

q. Protein: Protein is a continuous variable measured in grams.

r. Unsaturated fat: Unsaturated fat is a continuous variable measured in grams.

s. Saturated fat: Saturated is a continuous variable measured in grams.

t. Sodium: Sodium is a continuous variable measured in milligrams.

u. Fiber: Fiber is a continuous variable measured in grams.

v. Low-impact: A dichotomous variable low-impact was coded yes/no for all entrées. Plant-based and fish were coded yes and all other entrée bases were coded no. This classification is based on methodology developed by Leach et al. (2016), which considers the contribution of foods to the total carbon footprint of a healthy reference diet (i.e., % daily value). The healthy reference diet is based on the USDA 2010

Dietary Guidelines for Americans and includes food category intake guidelines in grams (USDA & HHS, 2010). Food intake amounts are then multiplied by carbon footprint factors and summed to create the daily carbon footprint of a healthy reference diet (2.2kg or 2,200 grams C02-eq). Detailed calculations are provided in Appendix IV (Food Label Toolkit, Leach et al., 2018). Entrée bases that contributed up to 25% of the daily footprint value were classified as low-impact, 26-50% were classified as medium-impact, and above 50% were classified as high-impact. The standard serving size of an entrée base is 4 ounces, thus this value was used for calculations. Calculations for entrée base carbon footprint daily value calculations are presented in Table 5.

w. Medium-impact: A dichotomous variable medium-impact was coded yes/no for all entrées. Cheese, pork, poultry, shrimp, and mixed were coded yes and all other entrée bases were coded no. See classification description above.

x. High-impact: A dichotomous variable high-impact was coded yes/no for all entrées. Beef was coded yes and all other entrée bases were coded no. See classification description above.

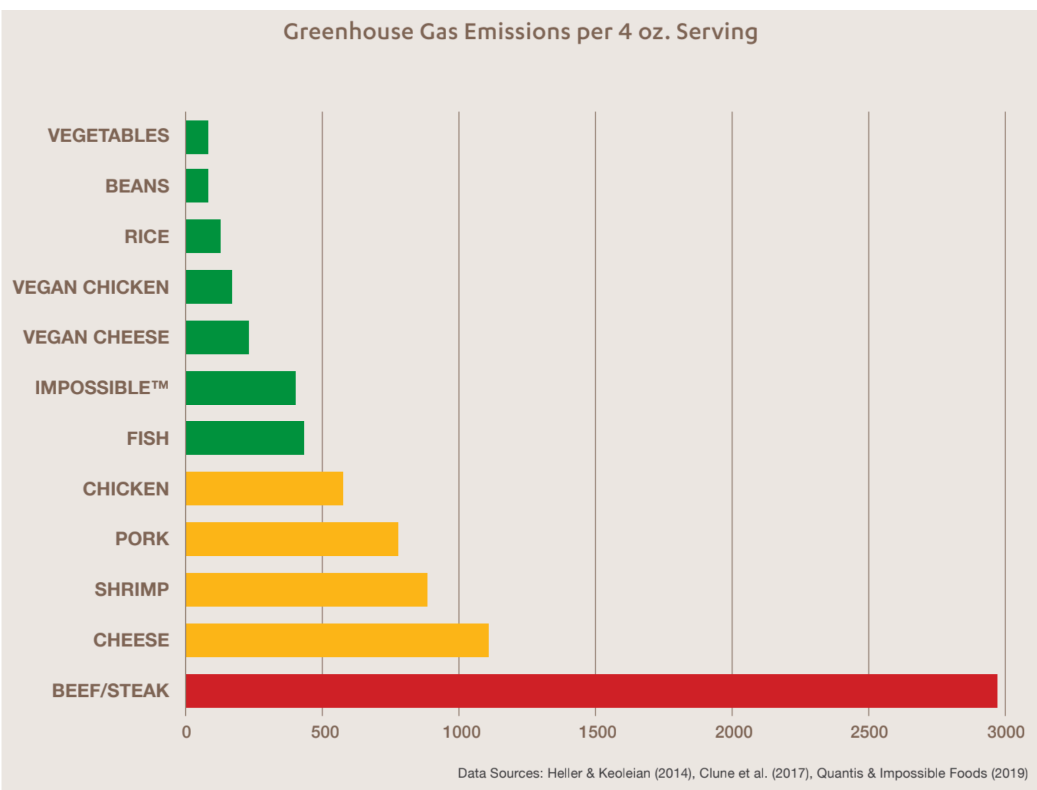
y. Carbon footprint: A continuous variable carbon footprint was measured in grams C02-eq. Each entrée was assigned a value based on impact level. For low-impact entrées, I calculated an average value for a 4-oz serving of fish and plant-based entrées (203 g CO_2-eq). For medium-impact entrées, I calculated an average value for a 4-oz serving of cheese, shrimp, pork, and poultry (836 g CO_2-eq). For high-impact entrées, I calculated the value for a 4-oz serving of beef (2999 g CO_2-eq).

Table 5. Entrée base impact level classification, carbon footprint, and % daily value (DV) of dietary carbon footprint

Entrée base	Carbon Footprint (grams CO_2-eq per 4 ounces)	% DV Carbon Footprint
High-Impact		
Beef	2999	137
Medium-Impact		
Cheese	1109	50
Shrimp	885	40
Pork	779	35
Poultry	573	26
Low-Impact		
Fish	434	22
Impossible™	397	20
Plant-based	83-233	4-18

Data sources: Heller & Keoleian (2014), Clune et al. (2017), Quantis & Impossible Foods (2019), Leach et al., (2016). Entrée bases ≤ 25% DV classified as low-impact, 26-50% classified as medium-impact, and above 50% classified as high-impact.

Figure 11. Entrée base impact level classification illustrated in traffic light colors, Impossible™ Foodprint Project



Customer Survey Data: In response to foodservice leaders' evaluation priorities, we also conducted a customer survey of approximately 200 students at the intervention site. In line with a CBPR approach, the investigator took care to ensure the questionnaire was designed to answer specific questions of interest to the community partner (Minkler & Wallerstein, 2003). Foodservice leaders were most interested in who was choosing Impossible™ and customer satisfaction. Thus, the large majority of questionnaire items were developed specifically for this study, rather than adopted from prior work. For example, beliefs addressed goals specific to the Impossible™ Foodprint Project intervention, such as providing plant-based options perceived as a satisfying alternative to animal meat. Additional details about foodservice leaders' intervention goals are described in Study One Results.

Following recommended procedures, the questionnaire was pretested with a group of seven undergraduate student employees at Rendezvous West (Bourque & Fielder, 2003). As a result of the pretest, the investigator incorporated student suggestions on response options to the question, "Why haven't you tried Impossible™ at Rendezvous West?" In addition, the investigator removed a question about willingness to reduce meat consumption because students felt it was inappropriate and would not be answered honestly: "In recent times, meat consumption is being increasingly debated on the grounds of environmental sustainability, health and safety concerns, and animal rights/welfare. Please indicate your willingness to reduce meat consumption." Based on student feedback, the investigator also revised the wording of several items to improve clarity.

Based on the final questionnaire, the following variables were used to answer for questions 2.6-2.7. An overview of variable names, types, and definitions is presented in Table 6.

The final questionnaire is included in Appendix V, and the survey is described further in the Data Sources section below.

Table 6. List of variable names, types, and definitions for RQ 2.6-2.7 using customer survey data		
Variable name	**Variable type**	**Definition**
Independent Variables		
Gender	Categorical	Male, female, other
Year in School	Categorical	First, second, third or higher
Race/ethnicity	Categorical	White, East Asian, South Asian, Hispanic/Latinx, Black, Other/Mixed
Tried elsewhere	Dichotomous	Tried Impossible™ or similar product elsewhere (yes/no)
Friends tried Impossible™	Ordinal	None, some, most
Impossible™ items ordered	Categorical	Impossible™ California Burrito, Impossible™ build-your-own entrée, both (Yes questionnaires only)
Belief Impossible™ is delicious	Interval	5-point Likert agreement scale
Belief Impossible™ has smaller carbon footprint than meat	Interval	5-point Likert agreement scale
Belief Impossible™ is satisfying alternative	Interval	5-point Likert agreement scale
Belief Dining should continue serving Impossible™	Interval	5-point Likert agreement scale
Animal-based protein intake	Interval	7-point frequency scale, ranging from never to at least once/day for beef, pork, poultry, and seafood
Eats red meat	Dichotomous	Yes/no based on reported animal-based protein intake
Dietary pattern	Categorical	Omnivore/vegetarian/pescatarian based on reported animal-protein intake
Importance of climate change	Interval	5-point Likert importance scale
Importance of eating a healthful diet	Interval	5-point Likert importance scale
Importance of animal rights	Interval	5-point Likert importance scale
Dependent Variables		
Tried Impossible™ at Rendezvous West	Dichotomous	Yes/no based on questionnaire version
Frequency ordered	Ordinal	Never, only once, 2-5 times, 6-10 times, more than 10 times
Repeat consumer	Dichotomous	Frequency ordered > only once (Yes questionnaires only)

III. Independent Variables (Customer Survey Data):

a. Gender: A categorical variable gender was created based on a question with response options: male, female, other.

b. Year in School: A categorical variable year in school was created based on a question with response options: first, second, third or higher.

c. Race/ethnicity: A categorical variable race/ethnicity was created based on a question with response options: East Asian, South Asian, Black/African American, Hispanic/Latinx, Native American/Native Pacific Islander/Native Alaskan, White/Caucasian, Other. East Asian and South Asian were included as separate categories given high rates of vegetarianism among South Asians (Jaacks et al., 2016).

d. Tried elsewhere: A dichotomous variable (yes/no) was created based on the question: "Have you tried the Impossible™ burger, Beyond Meat™, or similar products anywhere other than Rendezvous West?"

e. Friends tried Impossible™: An ordinal variable was created based on the question: "How many of your friends have tried Impossible™ meat?" Response options included: None, some, most.

f. Impossible™ items ordered: A categorical variable was created based on the question: "Which menu items have you tried with Impossible™ meat at Rendezvous West? Check all that apply:" This question was included only on the "Yes" version of the questionnaire. Response options included: Impossible™ California Burrito, Impossible™ build-your-own entrée.

g. Belief Impossible™ is delicious: An interval variable was created based on agreement with the statement: "Impossible™ meat is delicious." Response options included a 5-point Likert agreement scale, ranging from disagree to agree.

h. Belief Impossible™ has a smaller carbon footprint than meat: An interval variable was created based on agreement with statement: "Impossible™ meat has a smaller carbon foodprint than animal meat." Response options included a 5-point Likert agreement scale, ranging from disagree to agree.

i. Belief Impossible™ is a healthy option: An interval variable was created based on agreement with statement: "Impossible™ meat is a healthy option." Response options included a 5-point Likert agreement scale, ranging from disagree to agree.

j. Belief Impossible™ is a satisfying alternative: An interval variable was created based on agreement with statement: "Impossible™ meat is a satisfying alternative to animal meat." Response options included a 5-point Likert agreement scale, ranging from disagree to agree.

k. Belief Dining should continue serving Impossible™: An interval variable was created based on agreement with statement: "I would like Rendezvous West to continue serving Impossible™ meat." Response options included a 5-point Likert agreement scale, ranging from disagree to agree.

l. Animal-based protein intake: An interval variable was created based on reported consumption frequency, with phrasing: "Please indicate how often you have eaten each of the following since the beginning of Fall Quarter: Beef, pork, poultry, fish/seafood." Response options included a 7-point frequency scale: never, less than once/month, 1-3 times/month, once per week, 2-4 times per week, 5-6 times per week, at least once per day.

m. Eats red meat: A dichotomous variable was coded based on reported animal-based protein intake. Responses > never for beef and/or pork were coded yes.
n. Dietary pattern: A categorical variable was coded based on reported animal-based protein intake. Responses of never for all categories were coded as vegetarian. Responses of > never for fish/seafood only were coded as pescatarian. All others were coded as omnivore.
o. Importance of climate change: An interval variable was created based on the question: "Compared to other things in your life, please indicate the importance of...climate change." Response options included a 5-point Likert scale ranging from unimportant to very important. This item was adapted from Hekler et al. (2010).
p. Importance of eating a healthful diet: An interval variable was created based on the question: "Compared to other things in your life, please indicate the importance of...eating a healthful diet." Response options included a 5-point Likert scale ranging from unimportant to very important. This item was adapted from Hekler et al. (2010).
q. Importance of animal rights: An interval variable was created based on the question: "Compared to other things in your life, please indicate the importance of...animal rights." Response options included a 5-point Likert scale ranging from unimportant to very important. This item was adapted from Hekler et al. (2010).

IV. Dependent Variables (Customer Survey Data):

a. Tried Impossible™ at Rendezvous West: A dichotomous variable was created based on the version of the questionnaire. During questionnaire administration, participants were first asked whether they had tried Impossible™ at Rendezvous West. Based on their response, they were given the yes or no version of the questionnaire.

b. Frequency ordered: An ordinal variable Impossible™ consumption frequency was created based on 1) version of the questionnaire completed (yes/no), and 2) the question on the yes questionnaire: "Approximately how many times have you eaten Impossible™ plant-based meat at Rendezvous West? Please provide your best guess." Response options included: only once, 2-5 times, 6-10 times, more than 10 times. All no questionnaires were coded as never.

c. Repeat consumer: A dichotomous variable repeat consumer was created based on the frequency ordered variable, where > only once was coded as yes and all other responses coded as no.

Study Two – Natural Experimental Study Design

Natural experimental studies involve studying a policy, program, or other change that is not directly manipulated by the researcher (Taillie et al., 2017). Natural experiments are valuable for understanding the effectiveness of an intervention in the real world (Taillie et al., 2017). Because the interventions studied are driven by real-world actors, natural experiments provide valuable insights into feasibility, which can support generalizability and scale-up (Taillie et al., 2017). Due to these strengths, researchers and funding agencies such as the National Institutes of Health have identified natural experiments as a promising approach for studying food environment interventions (Hunter et al., 2014). However, internal validity can be compromised in natural experiments and thus is a key area of concern.

Similar to quasi-experiments, natural experiments may suffer from bias in estimating intervention effects due to internal validity threats, including selection, secular trends, interfering events, maturation, and seasonality (Rossi et al., 2004; Taillie et al., 2017). Selection bias occurs when outcomes are attributable to characteristics that motivate participation in the intervention rather than the intervention itself (Rossi et al., 2004). In food retail interventions, this could involve a shift in patronage based on health-consciousness, rather than improvements among existing customers (Taillie et al., 2017). Secular trends refer to long-term or population-level trends that may artificially inflate or deflate observed intervention effects (Rossi et al., 2004). For example, national red meat consumption has declined over the past few decades, beginning in the 1980s, thus students may reduce consumption irrespective of the intervention (Daniel et al., 2011). Interfering events are similar to secular trends but refer to shorter-term events (Rossi et al., 2004). For example, a warning delivered by Surgeon General during the study period to limit red meat consumption would likely influence behavior. Maturation refers to natural developmental processes that may influence outcomes of interest (Rossi et al., 2004). This is particularly relevant in a college setting where students are adapting to new independence and new social and physical environments (Deliens et al., 2014). Timing of interventions and data collection is also crucial, as outcomes may vary due to seasonality. According to university foodservice leaders, students' dining behaviors are highly variable as they explore new options at the start of each academic year; however, behaviors and preferences tend to stabilize after a few weeks.

To minimize bias in estimating effectiveness, this study utilized a pre-post nonequivalent comparison group design (Rossi et al., 2004). This included comparing outcomes across identical time periods and utilizing comparison sites to represent the counterfactual (Taillie et al., 2017). More specifically, outcomes at Rendezvous West during the intervention period (post) were compared to 1) outcomes at Rendezvous West during the same period one year prior (pre), and 2) changes in outcomes at two comparison sites, Rendezvous East and Bruin Café. Utilizing identical time periods addresses threats of maturation and seasonality as students' dietary behaviors followed the same natural progression during the pre and post periods. As discussed above, this is crucial given the natural variation in students' dietary behaviors over the course of the academic year. Using comparison sites addressed secular trends and interfering events, as outcomes were subject to the same external temporal influences.

Study Two – Comparison Sites: Rendezvous East and Bruin Café served as comparison sites for this study. Although the original study design included only Bruin Café as a comparison site, Rendezvous East was added due to unanticipated menu changes at Bruin Café and some unforeseen issues with Bruin Café data, described below. It should be noted the study sites vary in important ways, including menu offerings and student patronage. At baseline, Rendezvous West served more red meat, specifically beef, while Rendezvous East served more seafood, and Bruin Cafe served more poultry. Despite these differences, the overall proportion of animal-based entrée sales was quite similar: 83% at Rendezvous West, 81% at Rendezvous East, and 79% at Bruin Café. In addition, a survey conducted in Fall 2016 (n=1,156) found that students who frequent Bruin Café several times per week were more likely to be female, more likely to value healthy eating, and more likely to believe eating less meat is healthy, compared to students who frequent Rendezvous (unpublished data). The survey also found that almost 40% of students who frequent Rendezvous also frequent Bruin Café, indicating a large degree of overlap (unpublished data). Separate data were not available for Rendezvous East and West.

It is also worth noting that Rendezvous East and West occupy a single establishment and are managed and operated by a single foodservice team. The restaurants share dining tables and an online menu landing page. As such, both sites received the intervention's in-restaurant table tents and online link to the campaign webpage. However, the restaurants remain distinct enough to be treated as separate sites: They are divided into separate sides, with separate entrances, lines, registers, and screens displaying menus and promotional materials. The restaurants are also thematically different (East is Asian, West is Latin), with separate menus. Impossible™ plant-based meat was only implemented at Rendezvous West, and only Rendezvous West received the intervention's stanchion sign (key educational piece with carbon footprint scorecard), "Swap the Meat, Save the Planet" promotional banner, check stand sign, promotional screens, and Low Carbon Foodprint green Earth icons on the menus. Contamination is not limited to Rendezvous East, however, as students typically frequent a variety of quick-service residential restaurants, resulting in widespread exposure to the intervention among Bruin Café customers as well.

Overall, the fact that the study sites are located within the same residential food environment and serve the same population of students is both a strength and a weakness. While it is valuable to understand the relative impact of the intervention within the population and context of interest, contamination likely led to reduced observed intervention effects. Furthermore, outcomes could reflect selection bias (i.e., shifts in patronage) rather than improvements in consumption patterns. Key outcomes compared between the Rendezvous West, Rendezvous East, and Bruin Café included sales of animal-based entrées, red meat entrées, and entrée impact level. Due to logistical constraints and differences in menu formats (e.g., build-your-own option at Rendezvous), nutrients were not compared across sites. Contamination and shifts in patronage are considered further in the Discussion chapter.

Study Two – Data Sources

This study made efficient use of routinely collected administrative sales and nutritional data. UCLA Dining's Administrative Specialist manages all foodservice data using FoodPro, a widely used complete food management system. Beyond recipe, nutrition, and purchase data, FoodPro is integrated with Dining's Micros point-of-service system to record all quick-service restaurant point-of-service transactions. In response to foodservice leader priorities, we also conducted a brief customer survey with students at the intervention site. Data sources included the following:

Sales and Nutritional Data: The Administrative Specialist provided two Excel datasets containing quick-service residential restaurant sales for the 2018-19 academic year (pre): 1) total annual restaurant sales with nutritional data, and 2) annual restaurant sales by week. The Administrative Specialist also programmed FoodPro to email me weekly Excel datasets with restaurant sales totals by-week during Fall 2019 (post). All Excel databases exported from FoodPro are itemized by menu item (rows) and summarized as portions served (column). Additional columns include location, FoodPro recipe number, FoodPro name, printed name, portion size, and portion unit. The total annual dataset also includes nutritional data, with columns for calories, protein, carbohydrates, fiber, sugars, total fat, saturated fat, cholesterol, and sodium. By-week datasets include a column for week-of. For Rendezvous West, build-your-own menu items, such as burritos, are recorded as multiple items, with separate rows for entrée base (e.g., Shredded Steak Burrito Bowl), sauces (e.g., salsa, sour cream), and sides (e.g., Mexican rice, black beans). Thus, in order to accurately assess nutritional content of entrées, I subset the data and analyzed build-your-own items separately from specials. Additional details are described in the Analysis section below.

I used the 2018-19 dataset with total annual sales and nutritional data as my master dataset for preliminary data processing and coding. This included extracting data only from Rendezvous and Bruin Café and coding 445 rows of data (menu items) according to site, entrée type (Rendezvous West Only), meal type, and entrée base. Site coding was needed because Rendezvous East and West were not separated in sales datasets. Entrée type coding was needed to stratify entrées for nutritional analyses. Meal type coding was needed because beverages, breakfast/dessert, and fruit were excluded from analysis; only lunch and dinner entrées were included in the analytic sample. Entrée base coding was needed for higher-order outcome variable coding. Codes from the master dataset were then mapped on to all by-week sales datasets using Python. This involved writing a script to automate match-merging by unique ID code, which included a combination of FoodPro recipe ID, portion size, portion unit, and location. Coded datasets were saved as Comma delimited (.csv) files and imported to Stata for additional processing and analysis, described below. To create my dataset for analysis, I merged all weekly datasets from Fall 2018 and Fall 2019. Weeks 0 and 11 (finals) were dropped due to inconsistencies in operating hours and student schedules. Snapshots of the 2018-19 total annual dataset and by week dataset are presented below:

Figure 12. Snapshot of 2018-19 total annual restaurant sales and nutritional content dataset

RecipeNumber	FoodproName	PrintedName	Portior	Portic	PortionsServed	Calories (kcal)	Protein (g)	Carb (g)	Fiber (g)
071128	REND BURRITO MACHACA	Machaca Breakfast Burrito	1	EACH	751	575	33	51	3
071129	REND BEEF DICED SOPES	Beef Sopes	1	EACH	2742	314	24	24	4
071130	REND BEEF SOPES SHREDDED	Shredded Beef Sopes	1	EACH	417	390	25	23	4
071171	REND SHREDDED BEEF BURRITO	Shredded Beef Burrito	1	EACH	16142	653	41	40	2
071173	REND SHREDDED BEEF TACO SALAD	Shredded Beef Taco Salad	1	EACH	775	432	36	7	3
071174	REND SHREDDED BEEF NACHOS	Shredded Beef Nachos	1	EACH	5650	1738	68	118	22
071176	REND SHREDDED BEEF TACOS	Shredded Beef Tacos	2	EACH	1989	538	38	26	4
071177	REND SHREDDED BEEF BURRITO BOWL	Shredded Beef Burrito Bowl	1	EACH	14708	400	34	0	0
075141	REND CHICKEN QUESADILLA	Chicken Quesadilla	1	EACH	43654	822	47	51	3
075142	REND BEEF QUESADILLA SIRLOIN	Steak Quesadilla	1	EACH	28100	848	60	43	2
075154	REND SHREDDED BEEF QUESADILLA	Shredded Beef Quesadilla	1	EACH	11014	1059	63	45	3
081081	REND CONGEE RAINBOW	Rainbow Congee Rice Porridge	6	OZ	1191	74	2	10	0
081082	REND PORK CARNITAS TACOS	Pork Carnitas Tacos	2	EACH	1669	143	3	25	0
081083	REND PORK TONKATSU	Pork Tonkatsu	20	OZ	31475	552	43	56	5
081090	REND PORK TACOS AL PASTOR	Pork Tacos Al Pastor Style	2	EACH	1256	429	22	29	1
081136	REND PORK SPARE RIB KOREAN PLATE	BBQ Korean Pork Spare Ribs	15	OZ	29915	882	35	38	3
081158	REND PORK CARNITAS BURRITO	Pork Carnitas Burrito	1	EACH	14419	429	34	41	2
081160	REND PORK CARNITAS TACO SALAD	Pork Carnitas Taco Salad	1	EACH	830	207	29	8	3
081162	REND PORK CARNITAS BURRITO BOWL	Pork Carnitas Burrito Bowl	1	EACH	10480	175	27	1	0
081164	REND PORK AL PASTOR TACO SALAD	Pork Al Pastor Taco Salad	1	EACH	345	308	21	10	3
081166	REND PORK AL PASTOR BURRITO	Pork Al Pastor Burrito	1	EACH	8324	530	26	44	2
081167	REND PORK AL PASTOR BURRITO BOWL	Pork Al Pastor Burrito Bowl	1	EACH	7214	276	19	4	1

Figure 13. Snapshot of 2018-19 restaurant sales by week dataset

WeekOf	Location	RecipeNu	FoodproName	PrintedName	Portio	Portio	PortionsServ
10/14/18	Rendezvous	201010	REND FRUIT CUP 16OZ	Fruit Cup	12	OZ	12
10/14/18	Rendezvous	217078	REND PANCAKES BUTTERMILK	Pancake Breakfast	2	EACH	321
10/14/18	Rendezvous	217079	REND FRENCH TOAST	French Toast Breakfast	1	SERV	422
10/14/18	Rendezvous	219012	REND CHURRO	Churros	1	SERV	146
10/14/18	Rendezvous	221013	REND TORTILLA CHIP STRIPS FLOUR	Tortilla Chip Strips	1	OZ	2974
10/14/18	Rendezvous	221065	REND GUACAMOLE	Guacamole	1	OZ	10744
10/14/18	Rendezvous	221213	REND CHUNKY ROASTED SALSA HOUSE	House Salsa	1	OZ	2526
10/14/18	Rendezvous	221253	REND SALSA SOUR CREAM & CHIPOTLE	Sour Cream & Chipotle Salsa	1	OZ	517
10/14/18	Rendezvous	221254	REND SALSA SOUR CREAM CILANTRO LIME	Sour Cream Cilantro Lime Sals	1	OZ	493
10/14/18	Rendezvous	221255	REND SALSA YELLOW TOMATO & HABANERO	Yellow Tomato & Habanero Sal	1	OZ	385
10/14/18	Rendezvous	221256	REND SALSA CASCABEL & THYME	Cascabel Pepper & Thyme Sals	1	OZ	397

Purchase Data: The original study proposed to include purchase totals (in pounds) for the following protein food categories: beef, pork, poultry, shrimp, fish, cheese, and Impossible™. These data were intended for use in calculating the carbon footprint outcome. Unfortunately, it proved overly demanding and infeasible for the Administrative Specialist to provide purchase data for individual study sites, as data are typically aggregated for all residential restaurants. As such, I estimated carbon footprint based on entrée impact level classification, described above.

Patronage: The Administrative Specialist provided patronage counts for all residential restaurants during the pre (2018-19) and post (2019-20) periods. Patronage data were used for "sanity checks" on sales data and to examine any shifts in patronage across residential restaurants.

Manager Tracking Sheets: The General Manager at Rendezvous shared his Fall 2018 and Fall 2019 Excel tracking sheets, which include daily and weekly point-of-service sales totals for his restaurants. These sheets were used to cross-check sales data from FoodPro for Rendezvous.

Customer Survey: Development and pretesting of the questionnaire is described above. The final questionnaire is included in Appendix V. Per recommendation by the Housing & Hospitality Sustainability Manager, the survey took place during week 8 of the Fall 2019 quarter. This week was chosen to maximize length of exposure to the intervention while avoiding potential effects of the academic finals period on student behavior and volunteer availability. Data collection took place at Rendezvous West over three days (Monday, Thursday, and Friday) from 11:15am-1:00pm to reach various cross-sections of students during the restaurant's busy lunch hour. The Rendezvous General Manager suggested the lunch hour as an appropriate time to conduct the survey because students typically wait in line for 5-10 minutes. Questionnaires were administered orally, face-to-face by the investigator, Sustainability Manager, and four student volunteers (referred to hereafter as the survey team). All survey team members completed the CITI Human Subjects Research training, and the investigator conducted an additional training on study goals and protocols. This involved reviewing and discussing the study information sheet, script, and questionnaire, followed by role-playing.

Potential participants were approached while waiting in line at Rendezvous West and asked three screener questions: 1) if they were 18 years or older, 2) if they had already completed the survey, and 3) if they had tried the Impossible™ plant-based meat at Rendezvous. Students who were under 18 or had already completed the survey were informed they were ineligible. Students who had tried Impossible™ at Rendezvous were given one version of the questionnaire (yes), and students who had not tried it were given another version (no). Questionnaires were color-coded to improve ease of administration. The questionnaire took less than five minutes to complete, and no identifying information was collected. All data collection protocols were certified exempt by the university's IRB.

Study Two – Data Monitoring & Processing

As discussed, all sales data and nutritional data were provided by UCLA Dining's Administrative Specialist, who manages routine administrative data collection using FoodPro. Sales are recorded by unique recipe identification number, which ideally results in a complete and comprehensive sales database for all transactions. However, upon my identification of discrepancies in the data (described below), the Administrative Specialist reported that FoodPro will not record transactions if foodservice staff make menu changes without inputting or updating the recipe identification number. In addition, technical FoodPro glitches (i.e., system down) can result in missed our double-counted transaction records. Due to my collaborative relationship with the Rendezvous General Manager, I was able to utilize his point-of-service tracking records to validate the Rendezvous sales data from FoodPro. This was not feasible for Bruin Café.

Following preliminary processing (described above), I conducted additional processing in close communication with my community partner, which involved more manual examination of the data. First, I compared total sales by week in the pre and post periods. I inquired about weeks with low counts and was advised of work stoppages and holidays, which explained observed patterns. Because the Administrative Specialist advised me that some sales transactions may be missed or double-counted in the sales records (as described above), I did the following: 1) ran checks for duplicates, 2) ran checks for menu items present in one pre/post period but not the other, and 3) compared sales data to point-of-service tracking sheets at Rendezvous West. In a perfect data scenario, only the new Impossible™ menu items would be unique to the post period. In reality, I found and deleted 12 observations (i.e., rows) with duplicate data on the following four variables: unique recipe identification number (recipeid), week, pre/post (prepost), and portions sold (portionsserved). These variables were selected for the duplicate check because weekly sales data (week) should include unique row totals of portions sold (portionsserved) for each menu item (recipeid) in each study period (prepost). I also identified (by recipeid) 17 menu items at Bruin Café, five menu items at Rendezvous East, and one item at Rendezvous West (other than Impossible™ items) present in pre and not post, and vice versa. I then reviewed printed menus and discussed menu changes with the Executive Chef. At Rendezvous West, one item (Creamy Chipotle Vegetable Burrito) was available for a limited period of four weeks in Fall 2018, comprising <.01% of sales in that period. At Rendezvous East, two new shrimp items (Shrimp Ceviche Roll & Shrimp Ceviche Box) were added to the menu in Fall 2019 (post), comprising <.01% of sales in that period. These items were maintained in the dataset to reflect real-world operations.

At Bruin Café, several issues were identified. I learned Dining scaled back the number of soups available from seven to three and replaced two salads (Seafood Cobb Salad and Chinese Wonton Salad) with two new salads (Harvest Roasted Vegetable Salad and Strawberry, Broccoli, Chicken, & Apple Salad). These items made up approximately 3% of sales in each period; they were maintained to reflect real-world operations. A second issue involved a change in tracking (via recipeid) the Santa Fe Pepper Salad and Caesar Wrap from pre to post: In the post period, recipeid reflected whether recipes were vegetarian or contained chicken, while in the pre period they did not. As such, I could not determine in the pre period whether menu items sold were vegetarian or not. To minimize bias in estimating outcomes, I dropped these items from both periods, which comprised 3% of sales in pre and 4% of sales in post.

The major issue at Bruin Café involved items that were present on the menu (i.e., available) in both periods but missing from sales data in the pre period. This included seven popular dishes comprising approximately 17% of sales in post: Grilled Chicken Bowl, Roasted Salmon Bowl, Turkey & Mozzarella Sandwich, Jalapeno Mac & Cheese, Chili Dog, Avocado BLT, and Clam Chowder. The Administrative Specialist reported he conducted his audit in Spring of 2019, thus any data discrepancies in Fall 2018 would not have been noted or corrected by Dining. A discussed above, these discrepancies occur due to communication issues when items are not cross-referenced between the point-of-service and FoodPro. To balance the sales records, I excluded these items from analysis for both the pre and post periods.

After aligning the pre and post datasets, I examined week-by-week sales for each entrée base category (beef, pork, poultry, shrimp, fish, cheese-based, plant-based) by site. I found unusually low counts for beef in weeks 2, 5, 6 and 10 of Fall 2018 at Rendezvous West. I then examined counts by each beef menu item and found unusually low counts for the California Steak Burrito (<1,000) in these weeks. I compared the General Manager's tracking sheet with the sales records and found perfect matches for all weeks except those listed above. As such, I corrected the FoodPro sales data with the tracking sheet data. I discussed making these changes with the Administrative Specialist, and he agreed this was the appropriate approach to correctly capture sales of the California Steak Burrito. The final analytic sample includes 645,822 lunch and dinner entrées sold at the three study sites. As a final check on accuracy of the sample, I compared the sales totals to patron counts provided by the Administrative Specialist. Sales numbers and pre-post trends aligned with patron counts, which similarly indicated an approximate 11% decrease in patronage at Bruin Café and an approximate 2% total increase at Rendezvous. These sales data were used to answer Research Questions 2.1-2.5.

Data from the customer survey were used to answer Research Questions 2.6 and 2.7. The customer survey was conducted during week 8 of the intervention (Fall 2019). In total, 254 questionnaires were collected, and 39 were dropped from analysis due to incomplete data. For example, some participants only completed one side of the questionnaire. This left an analytic sample of 215 complete cases, with 119 "No" observations (55%) and 96 "Yes" observations (45%). In addition, "Yes" observations were coded as "repeat" or "one-time" consumers based on their response to the question: "How many times have you ordered Impossible™ at Rendezvous West?" Those who answered "Only once" were coded as one-time consumers, and all others as repeat consumers. Open-ended questions were coded using an inductive grounded theory approach, described below (Bradley et al., 2007).

Study Two – Analytical Procedures

Following data processing, I subset the data appropriately and ran descriptive statistics to examine distributions of all variables. This included examining means and standard deviations for continuous variables and frequency distributions for categorical variables. For the sales and nutritional data, I then created contingency tables to examine bivariate relationships between the independent variable prepost and all outcomes, subset by site. All analyses were conducted using Stata version 15.1 (StataCorp, 2017). Given the aggregated structure of my data, I used the frequency weights option (fweights) for all analysis. My units of analysis included: 1) proportion of total entrées sold, 2) nutritional content per entrée sold, and 3) carbon footprint per entrée sold. Analyses are described below according to type of outcome.

Sales and Nutritional Data – Dichotomous Outcomes (Animal-Based, Red Meat-Based, Climate Impact Level): For all dichotomous (yes/no) outcomes, data were subset by site (intervention/comparison), and Chi-Square tests were used to determine whether the proportion of entrées sold significantly changed from pre- to post-implementation of the intervention. In addition to analyzing pre/post changes within site, I used a difference-in-difference approach to compare changes in outcomes between sites. This involved using logistic regression models with prepost, site, and prepost*site predictors. A significant prepost*site interaction indicated an intervention effect.

Sales and Nutritional Data – Continuous Outcomes (Nutritional Quality, Carbon Footprint): Continuous outcome variables included calories, unsaturated fat, saturated fat, sodium, protein, fiber, and carbon footprint. Analyses for continuous outcomes were conducted for Rendezvous West only (within restaurant pre/post). Analyses for nutritional outcomes were conducted for all entrées and subset by build-your-own (yes/no) and special (yes/no). T-tests were used to determine whether, on average, nutritional content and carbon footprint per entrée varied from pre- to post-implementation of the intervention.

Customer Survey Data: The key outcome variables were whether the participant had tried Impossible™ (yes/no) and whether he/she was a repeat consumer (yes/no). Only bivariate and stratified analyses were conducted. Although I originally proposed ordinal logistic regression, the proposed ordinal frequency variable (never/once/more than once) did not meet the assumption of proportionality. Instead, the two previously mentioned outcome variables were used. Wilxocon Rank Sum, Kruskall Wallis, and Chi-Square tests were used to assess significance of differences between groups. Non-parametric tests were used due to non-normal distributions and small sample size. In addition, the following open-ended questions on the yes questionnaire were analyzed using an inductive approach to generate themes around barriers and benefits: “Please tell us what you like (if anything) about Impossible™ meat at Rendezvous West”; “Please tell us what you dislike (if anything) about Impossible™ meat at Rendezvous West.” The investigator reviewed all comments and allowed themes to emerge. Using an iterative process, concepts were refined into codes and then applied. The constant comparison method was used to ensure coded comments captured the same theme (Bradley et al., 2007). Multidimensional comments were coded into more than one theme. Illustrative quotes were selected based on representativeness of each theme.

Study Three Methods

Study Three – Menu Framing Experiment

Study Three Aim: Determine whether environmental sustainability framing is more effective than health framing in "nudging" consumers to choose a plant-based menu item.

Study Three Overview: Using a true experimental design, Study Three tested whether environmental sustainability framing is a more powerful "nudge" than health framing in an online choice experiment through Qualtrics. The key outcome was whether participants chose chicken enchiladas or plant-based tacos. The following research questions and hypotheses were addressed:

- **Question 3.1 (Framing Main Effects):** To what extent does framing affect choice of a plant-based menu item?
    - **Hypothesis 3.1.1:** Participants are more likely to choose a plant-based dish in the environmental sustainability framing condition, compared to control.
    - **Hypothesis 3.1.2:** Participants are not more likely to choose a plant-based dish in the health framing condition, compared to control (null effect).
    - **Hypothesis 3.1.3:** Environmental sustainability framing is a stronger "nudge" than health framing in the choice of a plant-based menu item.
- **Question 3.2 (Framing Effect Moderators):** To what extent do individual-level factors moderate framing effects?
    - **Hypothesis 3.2.1:** Gender moderates the effect of framing; health framing effects are positive among females and null among males; environmental sustainability effects are positive for both but stronger for females.

- **Hypothesis 3.2.2:** Healthy eating concern moderates the effect of health and environmental framing; framing effects are weaker for those with high healthy eating concern.
- **Hypothesis 3.2.3:** Environmental concern moderates the effect of environmental sustainability framing but not health framing; environmental sustainability framing effects are stronger for those with high environmental concern.
- **Hypothesis 3.2.4:** Meat attitude moderates the effect of health and environmental sustainability framing; framing effects are weaker for those with the most positive meat attitudes.
- **Hypothesis 3.2.5:** UCLA affiliation moderates the effects of framing; health framing effects are positive for staff and null for students; environmental sustainability framing effects are positive for both but stronger for students.

Study Three – Experimental Study Design

True experiments typically provide the strongest evidence of a causal relationship (Fehrenbacher, 2013). Unlike other study designs, experiments involve control through both the manipulation of an independent variable (i.e., condition) and random assignment of participants to one or more conditions (Fehrenbacher, 2013). In addition to establishing clear hypotheses, steps in experimental study design include: 1) determining the conditions (i.e., independent variables) to be manipulated; 2) determining the outcomes (i.e., dependent variables) to be measured; 3) determining the intervening or control variables to be measured; 4) specifying the sample; 5) specifying the randomization procedure; and 6) determining the analytical plan (Fehrenbacher, 2013). Manipulation and randomization enhance the internal validity of experiments; however, several threats remain when conducting experiments with human participants. Of note, participants may react to researchers, procedures, or perceived expectations rather than exhibiting truthful behavior (Fehrenbacher, 2013).

These biases can be addressed by minimizing interaction with researchers, carefully constructing study instructions or cover stories, and obtaining additional measures or checks of participant tendencies that may affect responses (Fehrenbacher, 2013). In addition, the reliability and validity of measures is essential for strong experimental studies. Reliability typically refers to replicability, where a measure of a stable construct will produce the same results on a separate occasion (Crosby et al., 2006). Validity of measures typically refers to construct validity, or the ability of a measure to fully capture the concept of interest (Crosby et al., 2006). Careful selection and use of established measures supports reliability and validity. Furthermore, representativeness of the participant sample affects the experiment's external validity, or relevant extension to the real world. Thus, participants should be selected to represent populations of interest. External validity can also be limited by lack of realism in experiments, where the study setting lacks important contextual elements (Fehrenbacher, 2013). For example, asking study participants about a hypothetical food choice may fail to account for real-world influences of time pressure and other sensory stimulation. As such, experiments can be a valuable method for understanding psychological processes and principles that can then be tested later in real-world settings.

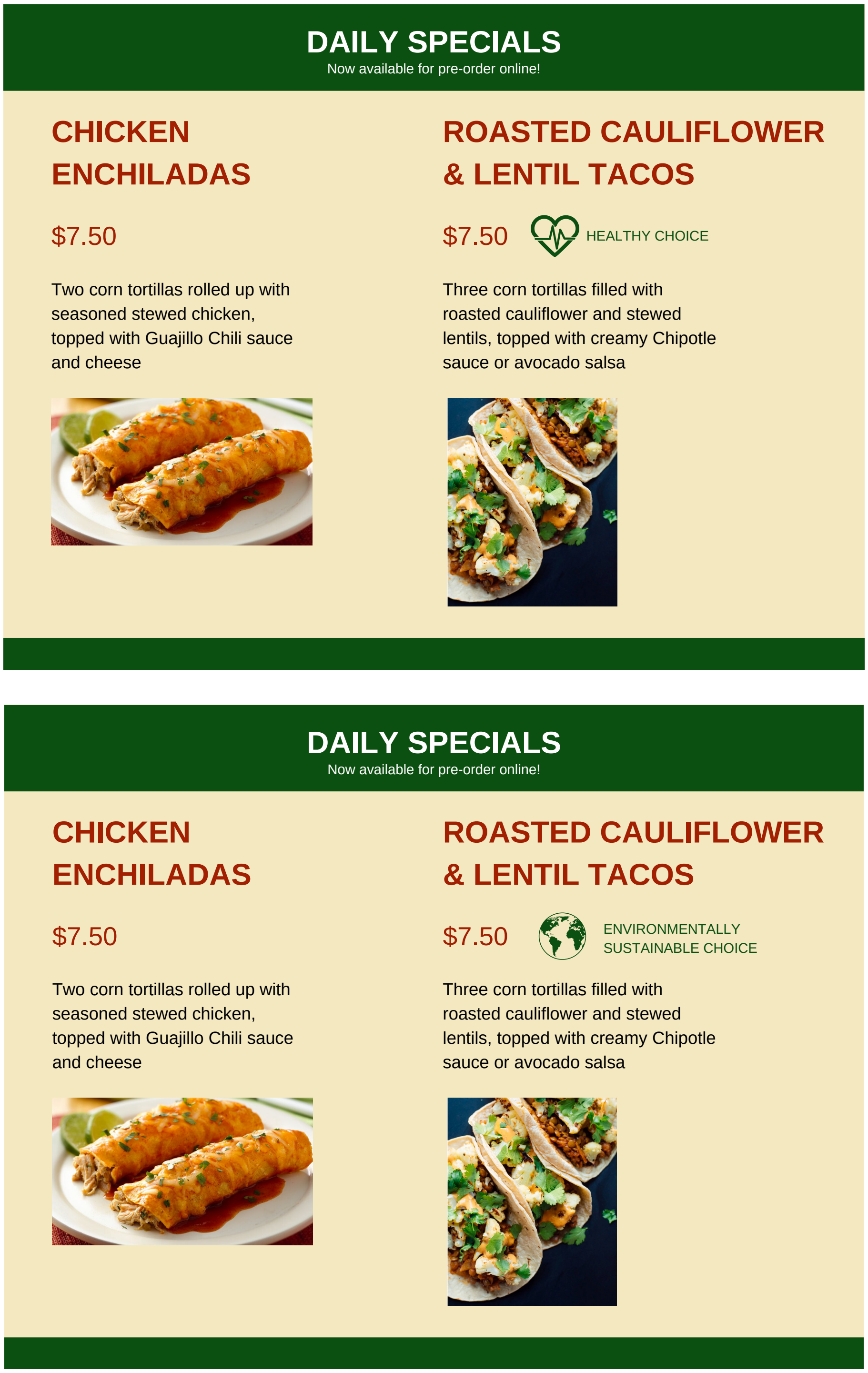
Study Three – Participants and Procedure

Because this experiment was conducted within the broader CBPR framework, it was developed to ensure relevance to the community partner. Specifically, participants were recruited from within the UCLA community, and the choice task scenario explicitly mentioned UCLA Dining. In short, the experiment aimed to build the knowledge base for university foodservice leaders to promote healthier, more environmentally sustainable foods.

The study involved recruiting 450 undergraduate students and staff through the UCLA Anderson Behavioral Lab's cloud-based participant management platform, Sona Systems. Sona maintains a participant pool, and eligible participants can sign up for studies through the system. The experiment took place online through Qualtrics. Participants were sent a link to the study, told they were providing feedback on a new online ordering system for the university's restaurants, and incentivized with $5. The key outcome was whether participants chose chicken enchiladas or plant-based tacos. Menu framing was manipulated to create three conditions: control (no framing), health framing, and environmental sustainability framing. Participants were randomly assigned to one of the three conditions and given the same task and questionnaire.

Upon initiating the study, participants read the study information sheet and provided informed consent. They were then shown the menu in one of the three conditions. All conditions presented the same two menu items: 1) chicken enchiladas, and 2) roasted cauliflower and lentil tacos (i.e., plant-based tacos). The two menu items were both be priced at $7.50 and included comparable descriptions and photographs. The health framing condition included a heart health icon with the phrase "Healthy Choice" next to the tacos. The environmental sustainability framing condition included an Earth icon with the phrase "Environmentally Sustainable Choice" next to the tacos. See framing conditions in Figure 14 below. Participants were asked to make a choice between the two menu items, followed by a series of questions about healthy eating and environmental concern, current dietary consumption, and sociodemographics. The study information sheet and questionnaire is included in Appendix VI. The study was certified exempt by the IRB.

Figure 14. Health and environmental sustainability menu framing conditions



<u>Study Three – Measures</u>

Variables names, types, and definitions are presented in Table 7. In addition, detailed descriptions are provided below.

I. Independent Variable:

a. Condition: The categorical independent variable condition was created based on the participant's randomly assigned condition: control/health/sustainability.

II. Dependent Variables:

a. Choice: The key outcome of interest was whether participants chose the chicken enchiladas or plant-based tacos. The dichotomous variable (0=chicken enchiladas, 1=plant-based tacos) was created based on the question, "If you had to choose one, which dish would you order?"

b. Anticipated enjoyment (Ancillary analyses): In ancillary analyses (see Chapter Three Results), anticipated enjoyment of chosen menu item was explored as an additional outcome. This interval variable was created based on the question: "How much do you think you would enjoy eating this dish?" Response options included a 7-point Likert scale, ranging from not at all to very much.

Table 7. List of variable names, types, and definitions for menu framing experiment		
Variable name	**Variable type**	**Definition**
Independent Variable		
Condition	Categorical	Control, health, environmental sustainability
Dependent Variables		
Choice	Dichotomous	Plant-based tacos Chicken enchiladas
Anticipated enjoyment (Ancillary analyses)	Interval	7-point Likert scale, ranging from not at all to very much
Moderator/Stratifying Variables		
Gender	Categorical	Male, female, other
Healthy eating concern	Interval	2 items; 5-point Likert agreement scale, adapted from Van Loo et al. (2017)
Environmental concern	Interval	4 items; 5-point Likert agreement scale, adapted from Kilbourne & Pickett (2008)
Meat attitude	Interval	8 items, 4 dimensions; 5-point Likert agreement scale, adapted from Piazza et al. (2015)
UCLA Affiliation	Dichotomous	Undergraduate student, staff
Dietary pattern	Categorical	Omnivore, pescatarian, vegetarian, vegan; based on reported dietary pattern: "Which of the following best describes your diet?"
Omnivore	Dichotomous	Omnivore Veg/pesca (vegetarian, vegan, pescatarian)
Manipulation Check Variables		
Healthiness rating	Interval	7-point Likert scale, ranging from not at all healthy to very healthy
Sustainability rating	Interval	7-point Likert scale, ranging from not at all sustainable to very sustainable
Other Demographic Variables		
Age	Continuous	Reported age in years
Race/ethnicity	Categorical	White, East Asian, South Asian, Hispanic/Latinx, Black, Other/Mixed

III. Moderator Variables:

a. Gender: A nominal variable gender was coded as male/female/other.

b. Healthy eating concern: This variable is conceptualized to represent an individual's attitude towards healthy eating. It was adapted from Van Loo et al. (2017) and includes two items measured on a 5-point scale, ranging from disagree to agree. For example: "Healthy eating is very important to me." The original measure included five items (Cronbach's α=0.91) but was shortened to reduce participant burden (Van Loo et al., 2017). Items were combined into a composite score and dichotomized at the 75th percentile to isolate the top 25% as pro-healthy-eating.

c. Environmental concern: This variable is conceptualized to represent an individual's attitude towards environmental sustainability. It was adapted from Kilbourne and Pickett (2008) and includes four items measured on a 5-point scale, ranging from disagree to agree. For example: "I am very concerned about the environment." The original measure included six items (Cronbach's α=0.81) but was shortened to reduce participant burden (Kilbourne & Pickett, 2008). Items were combined into a composite score and dichotomized at the 75th percentile to isolate the top 25% as pro-environment.

d. Meat attitude: This variable is conceptualized to represent an individual's attitude towards eating meat. It was adapted from Piazza et al. (2015) and designed to capture the four dimensions of reasons for eating meat: normal (e.g., "Most people eat meat"); natural ("It is natural to eat meat"); necessary ("A healthy diet requires at least some meat"); and nice ("Meat is delicious"). These dimensions were found to capture the majority (83-91%) of reasons people give for eating meat (Piazza et al., 2015). The adapted scale included 8 items (2 for each dimension) measured on a 5-point scale, ranging from disagree to agree. The original measure included sixteen items (Cronbach's α=0.93) but was shortened to reduce participant burden. Items were combined into a composite score and dichotomized at the 75th percentile to isolate the top 25% as pro-meat.

e. UCLA affiliation: A nominal variable affiliation was coded as student/staff.

IV. Manipulation Check Variables:

a. Healthiness rating: To check whether the framing conditions were successful at influencing perception of the menu items, participants were asked to rate the healthiness of both dishes: "How would you rate the healthiness of the Chicken Enchiladas/Roasted Cauliflower and Lentil Tacos?" Response options included a 7-point scale, ranging from not at all healthy to very healthy.

b. Sustainability rating: Participants were also asked to rate the environmental sustainability of both dishes: "How would you rate the environmental sustainability of the Chicken Enchiladas/Roasted Cauliflower and Lentil Tacos?" Response options included a 7-point scale, ranging from not at all sustainable to very sustainable.

V. Other Demographic Variables:

a. Dietary pattern: This categorical variable was measured by a question adapted from a questionnaire designed by Wang et al. (unpublished) for UCLA students: "Which of the following best describes your diet?" Response options included: Vegan; Vegetarian; Pescatarian; I avoid foods with gluten; I have no special diet; Other (please specify). Response options included brief descriptions of dietary patterns to aid accurate response. Vegan, vegetarian, and pescatarian were coded as such; all other responses were coded as omnivore.

b. Omnivore: This dichotomous variable was coded based on dietary pattern. Omnivore was coded as yes, all others as no.

c. Age: Age is a continuous variable measured in self-reported years.

d. Race/ethnicity: This categorical variable was measured by the question "What is your race/ethnicity?" Response options included East Asian/East Asian-American (please specify); South Asian / South Asian-American (please specify; Black / African-American; Hispanic/Latino; Native American / Native Pacific Islander / Native Alaskan White; Caucasian; Other (please specify). East Asian and South Asian were included as separate categories given high rates of vegetarianism among South Asians (Jaacks et al., 2016).

Study Three – Data Processing

Following recruitment of 450 study participants from the Sona participant pool, the experiment was closed. The experiment dataset was downloaded in .csv format from Qualtrics then imported to Stata for analysis. Participants who reported "Other" gender were dropped due to small subgroup size (n=9). Two participants (n=2) who reported being vegetarian but chose the chicken enchiladas were dropped due to inconsistent reporting. Two participants (n=2) missing responses for UCLA affiliation were also dropped. This left an analytic sample of 437. In some analyses, participants who reported following a vegetarian/pescatarian/vegan diet (n=49, 11.2% of sample) were excluded to create an "omnivore" sample. The omnivore sample (n=388) is intended to represent the conceptual target population, or individuals whose decision between the chicken enchiladas and plant-based tacos could be swayed.

Cronbach's alphas were computed for the three scale variables*: healthy eating concern*, *environmental concern*, and *meat attitude*. The two items comprising healthy eating concern had an alpha of 0.83. The four items comprising environmental concern had an alpha of 0.81. It was discovered during analysis that one of the eight items comprising the adapted meat attitude scale was unintentionally left off of the Qualtrics questionnaire. This left a total of seven items to measure meat attitude, with a single item to measure the "nice" dimension of meat attitude ("Meat is delicious"). To improve the alpha for meat attitude, one of "normal" dimension items ("Most people eat meat") was dropped, resulting in six items and a final alpha of 0.83. Scales were dichotomized at the 75th percentile to examine potential differential effects among the top 25% of participants with particularly strong beliefs.

Study Three Analytical Procedures

Following data processing, I ran descriptive statistics to examine distributions of all variables. This included examining means and standard deviations for continuous variables and frequency distributions for categorical variables. I then stratified by UCLA affiliation and examined distributions to clarify sample characteristics. All analyses were conducted using Stata version 15.1 (StataCorp, 2017).

Framing Main Effects: The key outcome variable was choice, a dichotomous variable. The key independent variable was condition, a categorical variable. Chi-square tests and logistic regression models were used to determine whether choice varied by condition.

Framing Effect Moderators: Hypothesized moderator variables included gender, healthy eating concern, environmental concern, meat attitude, and UCLA affiliation. To test for moderation, I first examined choice by condition, stratified by the hypothesized moderating variables. Next, I ran a series of logistic regression models and included each variable as an interaction term with condition (e.g., gender*condition). Significant interaction terms indicated a moderation effect.

Conclusion

As described above, this dissertation employed a community-based participatory research approach and a variety of rigorous methodologies to address the overarching research aim and specific research questions. Study One involved a qualitative case study to investigate the process of developing and implementing the Impossible™ Foodprint Project. Study Two used a natural experiment with a pre-post non-equivalent comparison group design to evaluate the Impossible™ Foodprint Project intervention. Study Three conducted an original true experiment to determine whether environmental sustainability framing is more effective than health framing in "nudging" consumers to choose a plant-based menu item. Results from the three studies are presented in the following three chapters.

CHAPTER FIVE: STUDY ONE RESULTS

Study One Overview: Case Study of Intervention Process

Study One employed case study methodology to describe and examine the process of collaboration between the investigator and university foodservice leaders to develop and implement an intervention to promote healthier, more environmentally sustainable food choices. This involved collecting and analyzing numerous sources of data, including key informant interviews, documentation, participant observations, and archival records. Results are presented in narrative form according to each research question. Research questions were informed by Rogers' (2003) five-stage model of the innovation process in organizations—agenda-setting, matching, redefining/restructuring, clarifying, and routinizing. Table 8 provides an overview of the team's key meetings and actions taken throughout the process of intervention initiation and implementation. Furthermore, results for Question 1.6 are presented in Table 9, which summarizes the facilitators and barriers for foodservice leaders to progress through the five-stage process.

Question 1.1: Agenda-Setting (Stage 1): What problem motivated foodservice leaders to seek an intervention-based solution; how did leaders identify and define the problem?

UCLA Dining's expressed unmet goal of reducing animal-based protein consumption motivated foodservice leaders to seek out, design, implement, and evaluate an intervention. This goal emerged through foodservice leaders' involvement in two initiatives that encourage dining intervention research and facilitate collaboration among academics and operators: the campus-wide Semel Healthy Campus Initiative (HCI) and the nation-wide Menus of Change University Research Collaborative (MCURC). HCI supports campus programs and research to promote health and wellbeing at UCLA. MCURC convenes scholars and university dining leaders to improve the health and environmental sustainability of menus. Foodservice leaders' involvement in these initiatives supported 1) identification and definition of the problem (failure to reduce animal-based protein consumption); 2) interest in developing *and* studying an intervention to address the problem; and 3) confidence to collaborate with university researchers. Furthermore, involvement in MCURC and HCI offers foodservice leaders an opportunity to share and be acknowledged for their leadership in dining interventions both on the UCLA campus and nationally.

UCLA's Assistant Vice Chancellor (AVC) of Housing & Hospitality, who oversees UCLA Dining, serves on the Healthy Campus Initiative (HCI) steering committee and co-leads its food and nutrition working group (EatWell). The AVC led UCLA in hosting the Menus of Change University Research Collaborative (MCURC) annual meeting in 2017, and UCLA's Dining Director and Nutrition Education Coordinator regularly attend monthly MCURC member calls and EatWell meetings on campus. The AVC reported growing awareness of the problems related to food systems, nutrition, human health, and climate change as a result of his leadership roles in HCI and MCURC. He cited the importance of exposure to experts whose life work involves addressing these issues, many of which, he said, are connected through high demand for and consumption of meat. In discussing the AVC's motivation for the intervention with other team members, several commented on his deep personal interest in food and health, with one team member describing dining improvement as the AVC's "passion project."

In 2019, as part of MCURC, UCLA Dining began tracking and reporting year-over-year animal-based protein consumption, measured in pounds of protein purchased. Between the 2017-18 and 2018-19 academic years, Dining documented a 3% increase in animal-based protein consumption on a per-meal basis (unpublished data). These data, coupled with an understanding of his operation's potential for positive impact, prompted the AVC to seek out an intervention-based solution for reducing animal-based protein consumption in his operation. Furthermore, the AVC reported that MCURC encourages universities to study their interventions, given gaps in knowledge around intervention effectiveness and the "living laboratory" nature of university dining settings—high levels of unilateral control, access to large amounts of data, and close proximity to researchers.

The eventual collaboration between foodservice leaders and the investigator was primarily supported by the infrastructure of the HCI. Prior relationships and collaborative research experience facilitated trust and confidence among partners. Specifically, the investigator had served as the graduate student researcher and coordinator for the HCI's EatWell group, where she developed relationships with the AVC and Dining Director over several years. When the investigator approached the AVC in November 2018 with the idea to conduct an applied research project for her dissertation, the AVC was immediately open to collaboration. In reflecting on his openness to collaboration, the AVC described the investigator as a "trusted partner."

The investigator's original idea for an intervention was to redesign menus to highlight healthier, more environmentally sustainable options. Following the initial decision to collaborate, the AVC introduced the investigator to UCLA Dining's marketing and FoodPro team to discuss intervention feasibility and available data. UCLA Dining uses FoodPro to collect and manage data on food purchases, service records (i.e., sales), menus, recipes, and nutritional content. The FoodPro team provided the investigator with access to sales data, as requested, and the marketing team set up a meeting to discuss the intervention. At this meeting, the marketing team suggested the investigator explore the possibility of integrating environmental sustainability messages on Dining's new self-service kiosks. Self-service kiosks allow customers to place orders by interacting with a touch-screen menu. The investigator explored this possibility but was met with resistance from the IT team who program the kiosks; they were not interested in reprogramming the content on the machines.

About six months later, the AVC reached out to the investigator to share findings from the MCURC data collection. He was disappointed to see that animal-based protein consumption had increased, rather than decreased. These findings reinvigorated the collaboration and prompted the investigator to request a meeting with AVC and Dining Director to discuss new ideas for an intervention. At this point, the AVC agreed to schedule a meeting and took a more active role in leading the intervention. Beyond the goal of reducing animal-based protein consumption, MCURC's and HCI's emphasis on research shaped the definition of project success from the start. As the AVC reported, "[The intervention] will be successful because we will have learned something."

Question 1.2: Matching (Stage 2): How did leaders work with the investigator to select an intervention to address the problem at hand?

The matching stage involved one key project initiation meeting with high-level leaders, led by the Assistant Vice Chancellor (AVC) of Housing & Hospitality Services. Following the agenda-setting stage described above, the AVC's office scheduled the project initiation meeting with the investigator and two high-level leaders: Dining Director and Director of Organizational Performance & Communication. At this meeting, the AVC clarified his dual goals of a) implementing and b) studying an intervention to reduce animal-based protein consumption in

UCLA Dining's residential restaurants. These goals aligned with the investigator's original goal of promoting healthier, more environmentally sustainable food choices given that replacing animal-based protein with high-quality plant foods typically confers benefits for both human and planetary health (Willett et al., 2019). The team then discussed and made decisions about the following agenda items: 1) measurable outcomes; 2) intervention pilot location; 3) intervention strategies; and 4) roles and responsibilities.

After discussing available data for residential dining operations, the team decided to intervene at a quick-service restaurant rather than the all-you-care-to-eat dining halls: Itemized entrée sales data are available for quick-service restaurants, allowing for greater precision in measuring intervention outcomes. The AVC then chose Rendezvous West as the pilot quick-service location given his knowledge of the high volume of meat entrées sold and the stable year-over-year menu—allowing for baseline comparison. The AVC identified one particularly popular meat menu item, the California Steak Burrito, as a worthy target for intervention. The team then brainstormed intervention strategies aligned with the leaders' expressed mission to deliver an enjoyable, delicious dining experience and to educate students. This led the team to select two strategies: 1) introduce a new, delicious plant-based menu item to compete with the California Steak Burrito; and 2) launch a social marketing/education campaign. The AVC then delegated development of specific intervention materials: The Dining Director would lead the development of the new plant-based menu item, and investigator would lead the development of the social marketing/education campaign and evaluation plan, with supervision from the Director of Organizational Performance. The team decided it would be feasible to pilot the intervention in Fall 2019 and assess performance at the end of the quarter to determine whether to adjust or continue.

In selecting strategies, it was important to foodservice leaders to maintain choice and satisfaction among students. For example, the strategy of reducing the portion size of animal-based protein in quick-service entrées was considered inappropriate as a 4-ounce portion is standard in foodservice. In general, foodservice leaders preferred the approach of providing additional menu options rather than changing or taking away existing options. The social marketing/education strategy was supported by the investigator's previous experience through HCI and MCURC. In an HCI focus group study, she found that students reported being motivated by social and environmental issues to change their food choices and that residential students appreciate educational information in dining halls (Malan et al., 2019). In an MCURC study, the investigator and her co-authors found evidence of reduced ruminant meat consumption (i.e., beef, lamb) among college students who completed a one-unit academic course on food systems and the environment (manuscript in preparation). Exposure to the latter study at an HCI meeting had already prompted the AVC to consider how his operation could expand the reach of key course content in his operation. Because UCLA's Housing & Hospitality Services maintains an internal marketing department with graphic designers, the team already had capacity to produce creative assets for the campaign. The AVC was confident that, together, the investigator and marketing team were capable of developing a social marketing/educational campaign about the environmental impacts of food.

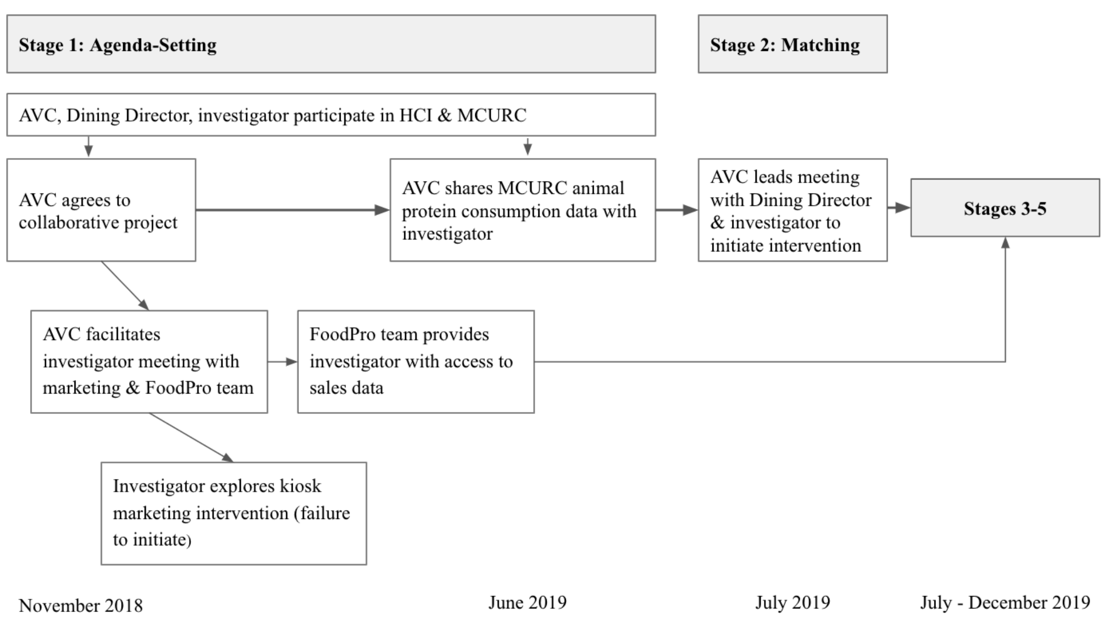
These two stages (Agenda-Setting and Matching) comprised the initiation phase of the intervention. The following stages comprise the intervention implementation phase. An overview of key project meetings and intermediary actions in each phase is presented in Table 8. A schematic of the chronology of these two stages is presented in Figure 15.

<table>
<tr><th colspan="3">Table 8. Overview of key meetings and intermediary actions in process of initiating and implementing the intervention, UCLA Dining, 2018-2020</th></tr>
<tr><td colspan="3">Phase 1: Intervention Initiation (Stages 1-2)</td></tr>
<tr><td colspan="3">Prior to Project Initiation Meeting:
• Investigator approaches Assistant Vice Chancellor (AVC) to conduct applied research project with UCLA Dining (November 2018)
o AVC, Dining Director, and investigator already connected through Semel Healthy Campus Initiative Center at UCLA
o AVC connects investigator with marketing & FoodPro team; investigator explores kiosk marketing intervention but fails to initiate
• AVC identifies UCLA Dining’s unmet goal of reducing animal-based protein consumption through participation in Menus of Change University Research Collaborative (June 2019)</td></tr>
<tr><td>Meeting Topic, Date, Coordination</td><td>Attendees</td><td>Agenda Items → Meeting Outcomes</td></tr>
<tr><td>Project Initiation, July 2019, AVC’s Office</td><td>• Assistant Vice Chancellor (AVC) of Housing & Hospitality Services (H&HS)
• Director of Organizational Performance & Communication, H&HS
• Dining Director
• Investigator</td><td>• Project goal → Reduce animal-based protein consumption, evaluate efforts
• Measurable outcomes → Itemized quick-service restaurant sales, customer survey, pounds of protein purchased
• Intervention pilot location → High volume of animal-based protein/high potential for impact (Rendezvous West quick-service restaurant)
• Intervention strategies to address goal → AVC decides: Intervention to align with UCLA Dining’s mission: deliver enjoyable experience, educate students
• Roles & responsibilities → AVC decides: Dining Director to lead development of new menu item; investigator to lead development of education materials</td></tr>
<tr><td colspan="3">Phase 2: Intervention Implementation (Stages 3-5)</td></tr>
<tr><td colspan="3">Between Meetings:
• Dining Director decides to introduce Impossible™ plant-based meat menu items
• Investigator develops project overview presentation on motivation (background science) and goals to share with team
• Director of Org Performance organizes meeting with input on attendees from Dining Director</td></tr>
</table>

<table>
<tr><th>Meeting Topic, Date, Coordination</th><th>Attendees</th><th>Agenda Items → Meeting Outcomes</th></tr>
<tr><td>Project Kickoff, July 2019, Director of Org Performance</td><td>• Director of Organizational Performance & Communication, H&HS
• Associate Dining Director
• Rendezvous General Manager, Dining Services
• Senior Graphic Designer, Marketing & Communications, H&HS
• UCLA Media Manager, Residential Life
• Investigator</td><td>• Introductions → Clarify roles and facilitate collaboration
• Project overview → Clarify project motivation and goals
• Project rollout → Clarify alignment between project and current operations; identify outstanding questions
• Timeline → Action items and deadlines</td></tr>
<tr><td colspan="3">Between Meetings:
• Culinary team develops Impossible™ recipes
• Dining Director decides to offer Impossible™ as a weekly special and daily option on the build-your-own line
• Culinary team works with Rendezvous General Manager on new menu item rollout
• Investigator connects with Sustainability Manager through AVC and Nutrition Education Coordinator through MCURC
• Investigator develops evidence-based education/social marketing content in collaboration with Nutrition Education Coordinator
• Director of Org Performance organizes meeting with input on attendees from investigator</td></tr>
<tr><th>Meeting Topic, Date, Coordination</th><th>Attendees</th><th>Agenda Items → Meeting Outcomes</th></tr>
<tr><td>Marketing Content Review, August 2019, Director of Org Performance</td><td>• Director of Organizational Performance & Communication, H&HS
• Associate Dining Director
• Rendezvous General Manager, Dining Services
• Creative Director, Marketing & Communications, H&HS
• Graphic Designer, Marketing & Communications, H&HS
• Nutrition Education Coordinator, Dining Services
• Sustainability Manager, H&HS
• Administrative Specialist, Dining Services
• Investigator</td><td>• Review of education/social marketing content developed by investigator and Nutrition Education Coordinator → Team provides feedback and collectively decides on campaign name "Impossible™ Foodprint Project"
• Platforms & timeline → Action items and deadlines</td></tr>
</table>

<table>
<tr><td colspan="3">Between Meetings:
Graphic Designer and Creative Director design creative assets for education/social marketing campaign based on content from investigator and Nutrition Education Coordinator
Administrative Specialist creates campaign webpage on Dining website with content from investigator
Nutrition Education Coordinator adds “Low Carbon Foodprint” Earth icons to online menus menu for Rendezvous West based on criteria from investigator</td></tr>
<tr><td>Meeting Topic, Date, Coordination</td><td>Attendees</td><td>Agenda Items → Meeting Outcomes</td></tr>
<tr><td>Final Creative Asset Review, September 2019, Investigator</td><td>Creative Director, Marketing & Communications, H&HS
Graphic Designer, Marketing & Communications, H&HS
Investigator</td><td>Review of creative assets → Finalize education/social marketing campaign creative assets for approval by Associate Dining Director</td></tr>
<tr><td colspan="3">After Final Creative Asset Review:
Associate Dining Director approvals all education/social marketing campaign creative assets
New Impossible™ menu items launch at Rendezvous West with start of Fall quarter
Graphic Designer leads deployment of education/social marketing campaign creative assets; coordinates with Rendezvous West General Manager for in-restaurant materials
Investigator oversees and documents all coordination and implementation; meets weekly with Rendezvous West General Manager to monitor intervention implementation through end of Fall quarter (December 2019)</td></tr>
</table>

Figure 15. Schematic of chronology of initiation (Stages 1 and 2) of Impossible™ Foodprint Project



Question 1.3: Redefining/Restructuring (Stage 3): How did leaders work with the investigator to design the intervention and/or adapt their operations to improve fit and feasibility?

As described above, the matching stage resulted in the Assistant Vice Chancellor's selection of a dual-strategy pilot intervention at UCLA Dining's quick-service restaurant Rendezvous West in Fall 2019: 1) introduce a new, delicious plant-based menu item to compete with the California Steak Burrito; and 2) launch a social marketing/education campaign about the environmental impact of food. To kick off the project with the broader foodservice leadership team, the Director of Organizational Performance & Communication organized a meeting with input on attendees from the Dining Director. Attendees included the Rendezvous General Manager and Graphic Designer who were key players in the implementation of the new menu item and social marketing/education campaign, respectively. At the meeting, the investigator presented a project overview to clarify the motivation (i.e., background science) and goals of the project. In addition, the team discussed roles, responsibilities, and the project timeline. Unfortunately, the Dining Director, Nutrition Education Coordinator, Sustainability Manager, and Creative Director were not present at this meeting, resulting in some confusion and fragmentation of efforts. These issues were corrected later through additional face-to-face meetings organized by the investigator.

The Dining Director led the development of the new plant-based menu item with his culinary team. He reported that menu item development was primarily driven by "likeability—taste, smell, all the things to get you to eat it." Additionally, he reported that in order to appeal to meat-eaters, the item must be perceived as a satisfying alternative to meat. Given these criteria, the culinary team considered the new plant-based meat products gaining popularity in the marketplace. Although the investigator, Nutrition Education Coordinator, and Dining Director expressed concerns about the nutritional merits of plant-based meat products, the Dining Director reported viewing the products as a potential "gateway" food for students to consume more plant-based diets.

Between the two most popular plant-based meat products from Beyond Meat™ and Impossible Foods™, the Director selected Impossible™ due to a better taste profile. He reported that his conference center customers reacted negatively when the restaurant switched from Impossible™ to Beyond™ burgers. Impossible™ was also preferable to Beyond™ at the time due to availability in bricks rather than patties, which facilitated handling for menu items such as burritos. Unlike the conference center and other restaurants, however, the premium cost of Impossible™ would not be handed down to customers at Rendezvous West. Because students "pay" for quick-service restaurant meals with pre-purchased meal plans, all available menu items essentially cost the same amount for students. For the few guests who purchase meals with cash, Impossible™ was priced $2 higher than beef options ($10 vs. $8). Still, despite the fact that Impossible™ would cost UCLA Dining more than all current animal-based protein offerings at Rendezvous West, the Director considered it a good investment and feasible for the pilot intervention: "Let's give [students] the option, let's try it. If it's overwhelmingly successful, then we'll reassess."

The second phase of developing the new plant-based menu item involved adapting Impossible™ plant-based meat to fit the Rendezvous West Latin restaurant concept and menu format, which includes daily entrée specials and a build-your-own line, similar to restaurant chain Chipotle. As the culinary team often does when developing new menu offerings, they looked to see what popular restaurants and chefs were doing. Inspired by Taco Bell's use of

Beyond Meat™, the culinary team used a Del Bell Taco Seasoning (Cornstarch, Onion Powder, Garlic Powder, Smoked Paprika, Chili Powder, Cumin, Sugar, Cayenne Pepper) to flavor the Impossible™ plant-based meat. Beyond adding the seasoning, the product required no special handling and could be cooked similarly to ground beef. The Rendezvous General Manager reported simple rollout as the “saving grace” for his team: the new Impossible™ menu items could be prepared quickly, without special training, and without waste. Once the Impossible™ recipe was finalized for Rendezvous West, the Director decided it would be feasible to offer 1) an Impossible™ California Burrito Special on Thursdays, and 2) Impossible™ plant-based meat as a protein option every day on the build-your-own line.

With supervision from the Director of Organizational Performance & Communication, the investigator led the development and implementation of the social marketing/educational campaign using theory-driven principles and techniques. Social marketing aims to address both individual behaviors and broader social norms by altering behavioral outcome expectations (Verbeke, 2005). Social marketing goes beyond information provision and emphasizes the exchange of positive outcomes for behavior (Lee & Kotler, 2016). By aligning desired behaviors with existing values, social marketing can both improve individual attitudes toward and normalize behavior (Kraak et al., 2017; Lee & Kotler, 2016).

In this case, materials were designed to address behavioral outcome expectations regarding the environmental impacts of students’ food choices. Specifically, the goal was to increase positive beliefs about the new Impossible™ menu items—and plant-based foods in general. While plant-based foods confer numerous environmental benefits when compared to animal-based foods, the investigator chose to focus on climate change given the salience (i.e., urgency and widespread public concern) of this issue. As such, all materials were framed around climate change, with a clear message of exchanging behavior for a positive outcome: “Swap the Meat, Save the Planet.”

In addition, the investigator employed “nudge” techniques when designing informational materials. Nudges are intended to enable and guide desired behavior by altering the presentation of choices or related information (Blumenthal-Barby & Burroughs, 2012). Acknowledging cognitive limitations in information processing and decision making, nudges essentially offer short cuts to the desired choice. Using the nudge technique of translating information, the investigator developed an intuitive traffic light scheme to present information in a carbon footprint “scorecard” for entrée base options at Rendezvous West. High-impact options were presented in red, medium-impact options in yellow, and low-impact options (including Impossible™) in green. Development of the traffic light scheme is described in the Methods chapter. The investigator’s prior experience through HCI—conducting focus groups with UCLA students, educating students about dietary carbon footprint, and evaluating the previously mentioned academic course on food systems and sustainability—also supported her capacity to create the campaign materials for the UCLA residential student population.

The Dining Services Nutrition Education Coordinator was a key player in the development and implementation of the social marketing/educational campaign. The Coordinator brought decades of experience creating educational materials at a large medical consortium plus knowledge of the available platforms and processes for implementing materials within UCLA Dining. Specifically, the Nutrition Education Coordinator emphasized the importance of using images rather than text to communicate key messages. Unfortunately, however, the Nutrition Education Coordinator was not included in the initial project kickoff meeting, and the investigator had to independently seek her out.

Once the investigator had developed the theory-driven campaign content, the Coordinator advised the investigator on available marketing platforms. These included 1) in-restaurant stanchion signs, table tents, spotlight screens, check stand posters, and menus, plus 2) Dining's online webpages and menus, which are frequently utilized by students. Together, the Nutrition Education Coordinator and investigator tailored campaign content for each platform. For example, all in-restaurant materials emphasized images and simple action-oriented messages, while the online webpage provided longer-format information where interested individuals could learn more. The Nutrition Education Coordinator also discovered a "Low Carbon Foodprint" green Earth icon that was available for tagging items on online menus but was currently not in use. In line with the nudge technique of making information visible, the Nutrition Education Coordinator and investigator decided to implement this icon as part of the campaign. All low-impact menu items (including the new Impossible™ menu items) would be tagged. This involved specifying low-impact criteria for vegetarian dishes containing cheese (a high-impact food): all vegetarian dishes with less than two ounces of cheese were classified as low-impact. Additional details are described in the Methods chapter.

Once the investigator and Nutrition Education Coordinator had drafted all social marketing/educational campaign materials, the Director of Organization Performance organized a review meeting. At this meeting, the team provided feedback on the materials and decided on the campaign name "Impossible™ Foodprint Project." The investigator then finalized the materials to reflect the feedback, and the Graphic Designer produced and deployed all creative assets (Appendix VII) with approval from the Associate Dining Director. The Administrative Specialist created the campaign webpage and promotional links, and the Nutrition Education

Coordinator added the Low Carbon Foodprint icons to online menus for Rendezvous West (Appendix VIII).

Despite eventual implementation, the social marketing/education campaign proved challenging. Following the kickoff meeting, intervention efforts became siloed into operations/culinary and marketing/education, resulting in a lack of communication between those working on the campaign and the Rendezvous General Manager. In addition, the Graphic Designer was new to her position, and the Director of Organization Performance was in the midst of transitioning out of Housing & Hospitality Services. These personnel issues contributed to confusion regarding processes, roles, and responsibilities. Given the novelty of the multi-platform social marketing/education campaign, additional project management—including more in-person meetings with the full team—was needed. In particular, the investigator and Nutrition Education Coordinator should have developed the in-restaurant marketing materials in collaboration with the Rendezvous General Manager who knows his operation best and is the gatekeeper for implementation. Relying on the Graphic Designer to coordinate implementation of the in-restaurant materials was not appropriate for this project. Once she realized these shortcomings, the investigator started meeting regularly in person with the Rendezvous General Manager at the start of Fall quarter. The General Manager reported this regular face-to-face communication was essential to a productive collaboration with the investigator.

Question 1.4: Clarifying (Stage 4): What, if any, information did foodservice leaders use to expand implementation and/or correct for unwanted outcomes?

Foodservice leaders used nutrition information, student feedback, sales data, and financial data to clarify intervention implementation. Continuous communication among the

Directors, Nutrition Education Coordinator, Rendezvous General Manager, and investigator enabled information sharing and rapid response. For example, the Nutrition Education Coordinator and investigator reviewed the nutrition facts of the new Impossible™ menu items once the recipes were finalized. The investigator then shared this information with the Dining Director and communicated concerns around the high level of sodium in the recipes. The Director then instructed the culinary team to reduce the sodium, and a revised recipe was used throughout the intervention.

UCLA Dining typically collects student feedback through "Text and Tell" comments and weekly Peer Review Board Meetings, where student representatives report student needs and suggestions to UCLA Housing & Hospitality Services. The Rendezvous General Manager shared comments with the investigator, and the investigator attended a Peer Review Board Meeting. "Text and Tell" feedback was limited to less than five comments (all critical) about Impossible™ being too salty or oily, and student representatives expressed only positive feedback about taste and appreciation for UCLA Dining's efforts around environmental sustainability. The Rendezvous General Manager also shared anecdotal evidence from student staff that customers loved the new Impossible™ menu items. Sales data confirmed students' positive response to the new menu items, with sales increasing week-over-week throughout the quarter. Sales data are routinely collected through FoodPro, and the Rendezvous General Manager routinely tracks specials (including all new Impossible™ menu items) at the point-of-service. The Rendezvous General Manager's tracking data served as a valuable check on the validity of the investigator's findings (FoodPro data). Both data sources confirmed that, on average, approximately 200 Impossible™ build-your-own items were sold each day (~15% of build-your-own sales) and over 350 Impossible™ California Burritos were sold each Thursday (~26% of California Burrito sales) in the Fall 2019 pilot quarter. Complete sales results are presented in Study Two Results.

As part of the intervention evaluation, the investigator also conducted a novel analysis with the FoodPro data to answer the primary research question of whether the intervention reduced animal-based protein consumption. This involved extensive data processing, including coding all menu items according to entrée base (beef, pork, chicken, shrimp, fish, cheese, plant-based) and whether the entrée was animal-based (yes/no). Sales data from the pilot intervention period (Fall 2019) were then compared to a pre-intervention baseline period (Fall 2018). Results showed that, while total patronage increased 13% at Rendezvous West from Fall 2018 to Fall 2019, the total proportion of animal-based entrées sold significantly decreased by 9%, from 83% to 76% ($n=266{,}113$, $p<.001$). For build-your-own entrées, the proportion of animal-based entrées significantly decreased by 13%, from 88% to 77% ($n=141{,}053$, $p<.001$). For California Burritos, the proportion of California Steak Burritos decreased by 21%, from 85% to 67% ($n=25{,}017$, $p<.001$). Complete results of this analysis are presented in Study Two Results.

The Assistant Vice Chancellor (AVC) and Dining Director also asked the investigator to conduct a customer survey to further understand student consumer characteristics, attitudes, and experience with Impossible™. The investigator developed the survey instrument with input from foodservice leaders to ensure results were useful to all parties. The questionnaire was then pilot tested with a group of Rendezvous student staff and revised with their feedback. The AVC connected the investigator with the Sustainability Manager for support conducting the survey, which involved Sustainability student staff and HCI volunteers administering over 200 two-minute pen-and-paper questionnaires to Rendezvous customers while they waited in line at the restaurant. The Sustainability Manager, Sustainability student staff, and HCI volunteers completed human subjects training (CITI Certification) and received survey administration training from the investigator. The Sustainability Manager was motivated to engage her staff in the research activities given alignment with sustainability goals and students' interest in gaining research skills. All survey procedures were approved by the university's IRB, Associate Dining Director, and Rendezvous General Manager.

The majority of students surveyed (n=215, 77%) and 94% of those who had tried Impossible™ (n=96) somewhat agree or agree they would like Rendezvous to continue serving Impossible™ plant-based meat. Over 80% of those surveyed and 95% of those who had tried Impossible™ agree it has a lower carbon footprint than animal meat. Furthermore, 83% of students who reported ordering Impossible™ at Rendezvous West (n=96) reported following omnivorous diets, and 80% reported consuming red meat. Almost all (90%) students who had tried Impossible™ somewhat agree or agree it is delicious, and 85% somewhat agree or agree it is a satisfying alternative to animal meat. These findings suggest the new plant-based menu item not only reached the target audience of meat-eaters but also met the Dining Director's goals around likeability and satisfaction.

Given the aforementioned concerns about the nutritional merits of Impossible™, the survey also asked students if they believe Impossible™ is a healthy option. The finding that 66% of participants agree or somewhat agree Impossible™ is a healthy option was viewed as problematic by the investigator, Nutrition Education Coordinator, and Dining Director. Although the social marketing campaign focused only on carbon footprint, the team concluded Impossible™ benefits from a "health halo" through use of the term plant-based. When discussing this outcome with the Nutrition Education Coordinator, she emphasized the responsibility of

Impossible™ to improve the healthfulness of their product: "They should work on using healthier fats and less sodium, using other seasonings to give it flavor…they could do better."

The survey also found that students value climate change (mean=3.42) as significantly more important, on average, than eating a healthy diet (mean=3.10) and animal rights (mean=2.61) (both $p<.001$). In open-ended comments about what students "like" about Impossible™, 52% of responses (n=89) revolved around positive flavor/texture, 30% specifically mentioned the similarity to animal meat, and 22% mentioned environmental sustainability or carbon footprint. Complete results of the survey are presented in Study Two Results.

Taken together, the student feedback and sales data created a clear picture of Impossible™'s success for the Dining Director: It reduced sales of animal-based entrées and was well received by students. As they key decision-maker, the Dining Director decided to continue serving the Impossible™ menu items at Rendezvous West. However, he reported Impossible™ was not rolled out in other residential restaurants due to cost. While the culinary team will occasionally feature Impossible™ in recipes at other locations, it has not been made available on a regular basis. The culinary team is currently exploring other plant-based meat options to find a more affordable alternative for expanding rollout. The Sustainability Manager reported cost is a consistent challenge with sustainable food procurement. She explained that chefs are some of the best sustainability partners because they care about using quality ingredients customers love, but sustainable products are often not financially feasible—especially protein. She described students' apparent interest in plant-based eating as potentially financially beneficial for university foodservice if chefs can focus on using whole, plant-based foods rather than specialty products like Impossible™.

Foodservice leaders also considered the social marketing/educational campaign a success based on Impossible™ sales and survey results. In particular, foodservice leaders were surprised by survey results indicating students' positive beliefs about Impossible™ and greater concern for climate change over healthy eating. These findings helped contextualize the Impossible™ sales data and suggest students respond well to messages framed around climate change. The Nutrition Education Coordinator was particularly inspired to leverage students' interest in climate change to promote healthy eating. The campaign's educational webpage received an average of 422 views per week (4,228 total) throughout the quarter, further demonstrating students' interest in the topic of food and climate change.

Question 1.5: Routinizing (Stage 5): To what extent was the intervention abandoned and/or integrated into normal foodservice operations?

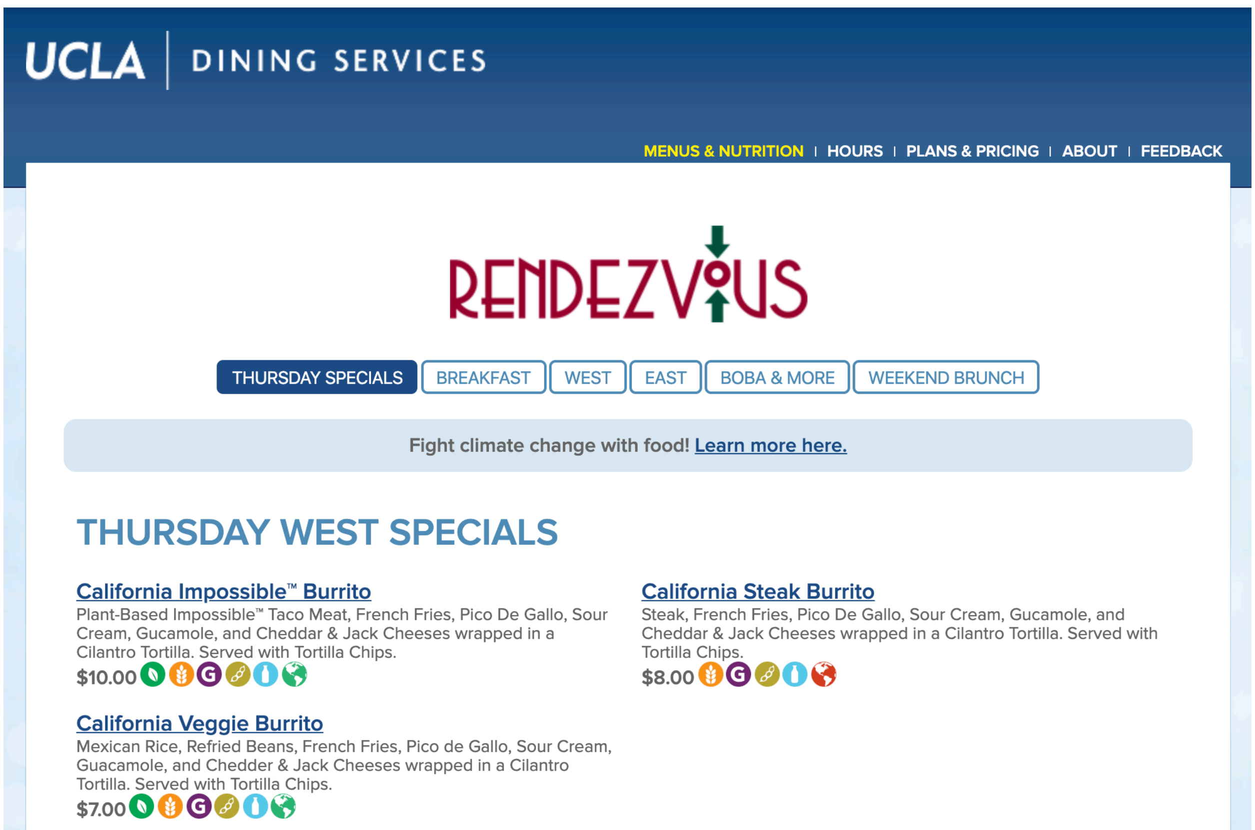
Developed collaboratively by foodservice leaders and the investigator, the intervention piloted at Rendezvous West in Fall 2019 comprised: 1) introducing new menu items with Impossible™ plant-based meat, and 2) launching a social marketing/education campaign framed around climate change. As discussed, foodservice leaders considered both intervention components to be effective, and their active co-creation of the intervention facilitated feasibility and ownership. Following the Fall 2019 pilot intervention period, the Impossible™ menu items were integrated into normal operations at Rendezvous West, and the climate change campaign was expanded throughout UCLA Dining. The Nutrition Education Coordinator's collaboration with the investigator on the intervention campaign materials supported her capacity to lead the expansion of these efforts. As previously mentioned, the cost of Impossible™ made expansion to other locations unaffordable.

With approval from the Associate Dining Director and creative asset support from marketing, the Nutrition Education Coordinator expanded the intervention campaign materials to be deployed at other residential restaurants. Specifically, she worked with the investigator to revise the carbon footprint “scorecard” and created new stanchion signs and table tents. The intervention campaign logo was removed from all materials, and the “Low Carbon *Food*print” icon was changed to “Low Carbon *Foot*print” for greater standalone clarity. In addition, the Nutrition Education Coordinator created and added a new “High Carbon Footprint” red Earth icon to all items that met the criteria. Although the team observed other campuses using a three-tier traffic light system (green, yellow, red), they decided to label only green and red items to minimize operational burden and label fatigue. The investigator provided additional technical assistance to adapt the original carbon footprint classification scheme to reflect new guidelines from the EAT-*Lancet* Commission and to enable feasible rollout (EAT-*Lancet* Commission, 2019). This involved creating simplified carbon footprint labeling guidelines, which are presented in Appendix IX.

The Administrative Specialist also updated the intervention’s educational webpage and promotional links to reflect ongoing efforts by UCLA Dining to provide low-carbon footprint food options and educate students about fighting climate change with food. A screenshot of the Rendezvous West online menu with expanded intervention components in Winter 2020 is presented in Figure 16. The screenshot illustrates the continued integration of Impossible™ on the menu, continued use of the “Low Carbon Footprint” green Earth icon, new use of the “High Carbon Footprint” red Earth icon, and revised promotion link to the climate change education webpage: “Fight climate change with food! Learn more here.”

Finally, the success of the intervention inspired foodservice leaders to update the existing potato-based vegetarian build-your-own menu option at Rendezvous West in Winter 2020. In line with the Menus of Change University Research Collaborative (MCURC) principles to increase high-quality plant proteins and reduce potatoes on menus, the culinary team created a new lentil recipe. The Nutrition Education Coordinator and investigator helped with naming the dish (Spiced Red Lentils) and creating promotional materials framed around climate change. The performance of the new dish is currently being evaluated.

Figure 16. Rendezvous online menu screenshot with expanded intervention components, UCLA Dining, Winter 2020



Question 1.6: What were the barriers and facilitators for foodservice to progress through the five stages in the organization innovation process: agenda-setting, matching, redefining/restructuring, clarifying, and routinizing?

Facilitators and barriers for progressing through the five stages are summarized in Table 9. Results are also described in narrative form below.

Table 9. Summary of facilitators and barriers for foodservice to progress through five stages in the organization innovation process, UCLA Dining, 2018-2020		
	Stage 1: Agenda-Setting	
Facilitators	High-level involvement in existing initiatives to address problem	• High-level foodservice leaders already involved in Menus of Change University Research Collaborative (MCURC) and Semel Healthy Campus Initiative (HCI), both of which encourage dining intervention research and facilitate collaboration among academics and operators • High-level leaders' openness to research supported by involvement in MCURC and HCI; "[The intervention] will be successful because we will have learned something." • Involvement in MCURC and HCI offers foodservice leaders an opportunity to share and be acknowledged for their leadership on dining interventions
	Personal interest among decision-makers	• Key decision-maker, Assistant Vice Chancellor of Housing & Hospitality (AVC), possessed deep awareness of and personal interest in food system problems; team referred to dining improvement as AVC's "passion project"
	Sharing, tracking, & reporting data	• AVC open to sharing routinely collected sales and purchase data for research and evaluation • Tracking and reporting of animal-based protein consumption for MCURC led AVC to identify unmet goal and prompted his leadership on intervention
	Prior relationships & trust	• High-level foodservice leaders and investigator had previously established relationship over several years through HCI; AVC referred to student as a "trusted partner"
Barrier	Lack of internal leadership & buy-in	• Investigator initially struggled to initiate intervention → overcome when identification of unmet goal prompted AVC's leadership

Stage 2: Matching		
Facilitators	Utilization of routinely collected data and institutional knowledge	• Team identified measurable outcomes using routinely collected data • Team selected the pilot intervention location using knowledge of 1) potential for impact based on restaurant sales; 2) feasibility of pre-post evaluation based on planned operational changes
	Internal selection of appropriate strategies	• AVC led selection of intervention strategies aligned with UCLA Dining's mission and strengths: providing an enjoyable experience for and educating students • Foodservice leaders take pride "being the best" and "doing the right thing" at UCLA; leaders recognize a high-quality housing & dining experience attracts high-quality students
	Experience with/exposure to related interventions	• Investigator was involved in other HCI and MCURC research that supported decision to employ social marketing/education campaign about environmental impacts of food • AVC inspired to expand reach of academic interventions through his operation
	Leveraging existing capacity	• Intervention strategies leveraged existing capacity and expertise, including innovative culinary team, graphic designers, experienced Nutrition Education Coordinator, Sustainability team, and investigator with expertise in connections between food and environmental sustainability
Barrier	Desire to maintain existing options & choice	• Foodservice leaders preferred the approach of providing additional menu options rather than changing or taking away existing options; this prevented the use of strategies such as reducing portion size or limiting meat items on menu
Stage 3: Redefining/ Restructuring		
Facilitators	Observations of others using the intervention	• Culinary team aware of new plant-based meat alternatives gaining popularity in marketplace • Culinary team looked to popular restaurants when adapting Impossible™ to fit Latin restaurant concept; inspired by Taco Bell's use of Beyond Meat™ in tacos and burritos
	Short-term pilot	• Dining Director considered added expense of Impossible™ feasible for a short-term pilot intervention: "Let's give [students] the option, let's try it. If it's overwhelmingly successful, then we'll reassess."

Stage 3: Redefining/ Restructuring		
Facilitators	Simple rollout	• Rendezvous General Manager reported simple preparation as the "saving grace" for Impossible™ rollout: the new menu items could be prepared quickly, without special training, and without waste
	Use of theory-driven principles & experience	• The investigator employed theory-driven social marketing principles and "nudge" techniques when designing the social marketing/educational materials • The investigator's previous experience through HCI supported her capacity to produce campaign materials for UCLA residential student population
	Identification & mobilization of organizational change-agents & gatekeepers	• The Nutrition Education Coordinator and Sustainability Manager inherently occupy roles as organizational change-agents aligned with the intervention goal; identifying, building capacity for, and mobilizing these change-agents facilitated implementation, evaluation, and expansion of the intervention • Rendezvous General Manager was gatekeeper for intervention implementation; he reported regular face-to-face meetings with the investigator was essential for a productive partnership
Barriers	Insufficient meeting attendance	• Incomplete meeting invitation lists and lack of attendance by those invited resulted in some confusion around roles and fragmentation of efforts
	Personnel transitions	• New and transitioning-out personnel added to confusion around processes, roles, and responsibilities
	Lack of project management & coordination with operators	• Novelty of the multi-platform social marketing/education campaign required additional project management—including more in-person meetings with the full team • Development and implementation of social marketing/education materials not sufficiently coordinated with Rendezvous General Manager who knows his operation best and is the gatekeeper for intervention implementation
Stage 4: Clarifying		
Facilitators	Continuous communication & information sharing	• Continuous communication among the Directors, Nutrition Education Coordinator, Rendezvous General Manager, and investigator enabled information sharing and rapid response • Multiple data sources used to confirm validity of investigator's findings

Stage 4: Clarifying		
Facilitators	Co-creation & administration of new evaluation tools	• Investigator developed customer survey with input from foodservice leaders to ensure results useful to all parties • Questionnaire pilot tested with Rendezvous student staff • Sustainability Manager motivated to assist with research activities given alignment with sustainability goals and students' interest in research
	Use of multiple data sources	• Customer survey results helped contextualize Impossible™ sales data and suggest students respond well to messages framed around climate change • Financial data informed decision to limit integration of Impossible™ to only Rendezvous West
Barrier	Limitations of administrative data	• Utilizing administrative data is efficient for research purposes; however, it can be subject to errors and may require extensive processing to answer research questions • Collaboration between investigator and foodservice leaders was needed to ensure validity of results
Stage 5: Routinizing		
Facilitators	Co-creation of intervention materials, resulting in enhanced capacity for expansion	• Through co-creation of intervention materials and collaboration with investigator, Nutrition Education Coordinator developed capacity to expand climate change social marketing/education campaign • As a result of intervention, culinary team open to expanding plant-based menu offerings
	Ongoing, informal partnership with investigator	• Investigator provided additional technical assistance to support expansion of education/social marketing: revised "scorecard" and created simplified carbon footprint labeling guidelines • Investigator advised on marketing of new vegetarian dish at Rendezvous West
Barrier	Cost	• Despite its success, Impossible™ was not rolled out at other residential restaurants due to cost

Facilitators for agenda-setting include: involvement in existing initiatives; personal interest among decision-makers; sharing, tracking, and reporting data; and prior relationships. For this intervention, the academic and non-academic partners' mutual involvement in the university's Healthy Campus Initiative and Menus of Change University Research collaborative were crucial to problem definition, motivation, and collaboration. In addition, the AVC's personal interest and leadership ensured the project was a priority for his organization. Prior to his leadership on the project, the investigator was unable to get buy-in from Dining staff to develop an intervention.

Facilitators for progressing through the matching stage include: utilization of routinely collected data and institutional knowledge; internal selection of appropriate strategies; experience with/exposure to related interventions; and leveraging existing capacity. In this case, foodservice leaders were more open to strategies such as piloting new menu items and providing education—rather than taking existing menu options away. Facilitators for redefining/restructuring the intervention to improve fit and feasibility included: observations of others using the intervention; implementing a short-term pilot; use of theory-driven principles and experience; and identification and mobilization of organizational change-agents and gatekeepers. In the university setting, key personnel likely include staff focused on nutrition or sustainability education/operations and restaurant general managers. Failure to coordinate efforts among individuals who do not usually work together can result in barriers to implementation.

For the clarifying stage, facilitators include: continuous communication and information sharing; co-creation and administration of new evaluation tools; and uses of multiple sources of data. Shared creation and ownership of data collection instruments and outcomes ensured foodservice leaders received information they needed to determine whether to continue the intervention. Although the evaluation study made efficient use of administrative data, some errors in FoodPro management system required extensive effort to investigate and address. Finally, progression through the routinizing stage was facilitated by: co-creation of intervention materials and an ongoing informal relationship with the investigator. As result of the intervention, foodservice leaders developed capacity and confidence to expand plant-based menu offerings and efforts to promote low-carbon-footprint foods. Despite the success of the Impossible™ product, it was not expanded due to cost. As described by the Sustainability Manager, cost is a common challenge in sustainable food procurement.

Conclusion

Findings from Study One highlight the value of the university's involvement in existing health and sustainability initiatives for intervention agenda-setting and collaboration among academics and non-academic partners. In addition, results suggest university foodservice leaders may be particularly open to strategies such as piloting new menu items and providing education—rather than taking existing menu options away. Furthermore, co-creation of intervention materials and feedback from multiple data sources enhanced the capacity of foodservice leaders to expand efforts to promote plant-based and other low-carbon-footprint foods. Lack of coordination with restaurant operators emerged as a barrier to initial implementation of the social marketing campaign, while cost prevented scale-up of Impossible™ menu items beyond the pilot intervention restaurant. Overall, results from Study One suggest the CBPR approach facilitated the development, implementation, and sustainability of the intervention by enabling intervention ownership, feasibility, feedback, and capacity building for university foodservice leaders.

CHAPTER 6: STUDY TWO RESULTS

Study Two Overview: Natural Experiment to Evaluate CBPR Intervention Effectiveness

Study Two employed a natural experimental pre-post study design with nonequivalent comparison groups to evaluate the effectiveness of the Impossible™ Foodprint Project intervention to 1) reduce animal-based entrée sales (key outcome for community partner), and 2) improve the healthfulness and environmental sustainability of entrées sold. The intervention was piloted at a UCLA quick-service residential restaurant, Rendezvous West, in Fall 2019 (ten weeks). Fall 2018 (ten weeks) served as the baseline period. UCLA's quick-service residential restaurants Rendezvous East and Bruin Café served as comparison sites. Administrative sales and nutrition data were used to answer Questions 2.1-2.5. Although the original study design included only Bruin Café as a comparison site, Rendezvous East was added due to unanticipated menu changes at Bruin Café and issues with Bruin Café data, described in the Data Processing section of the Methods chapter. The final analytic sample included 645,822 lunch and dinner entrées sold at the three study sites during the two study periods (Table 10).

Results are presented below according to research questions. Questions 2.1-2.5 address changes in both the healthfulness and environmental sustainability of students' food choices from Fall 2018 (pre) to Fall 2019 (post). Exploring numerous operationalizations of these outcomes is valuable for deep examination of intervention impacts, as there may be tradeoffs between outcomes. For example, compared to many animal-based protein foods, Impossible™ plant-based meat is low in CO_2-eq emissions but high in sodium and saturated fat. Question 2.2b was added following conversations with UCLA's Sustainability Manager about the extent to which Impossible™ was capturing sales of other, previously available, vegetarian items.

Questions 2.6 and 2.7 were answered using data from a brief survey of students waiting in line at Rendezvous West during week 8 (n=215).

Table 10. Sales data analytic sample: Total lunch and dinner entrée sales during the pre and post study periods, by study site, UCLA Dining, Fall 2018 and 2019

	Fall 2018 (Pre)	Fall 2019 (Post)	Change, %	Total
Rendezvous West (Intervention)	124,792	141,321	16,529 (13%)	266,113
Rendezvous East (Comparison)	118,765	106,333	-12,432 (-10%)	225,098
Rendezvous Total	243,654	247,654	4,097 (2%)	491,211
Bruin Café (Comparison)	81,693	72,918	-8,775 (-11%)	154,611
Total	325,250	320,572	-4,678 (-1%)	645,822

Note: Analytic sample created using sales data routinely collected through FoodPro by UCLA Dining

Question 2.1a (Key Outcome for Community Partner): To what extent does the intervention decrease sales of animal-based entrées?

Table 11 shows the proportion of entrée sales by entrée base category in Fall 2018 (pre), Fall 2019 (post), and the percent change from pre to post. Although research questions only address changes in animal-based (RQ 2.1) and red-meat-based (RQ 2.2) entrées, all entrée base categories are presented to further illustrate shifts in sales.

Table 11. Pre, post, and relative percent change in proportion entrée sales by entrée base category and study site, UCLA Dining, Fall 2018 and 2019 (n=645,822)									
	Rendezvous West (Intervention)[a]			Rendezvous East (Comparison)[b]			Bruin Café (Comparison)[c]		
Entrée Base	**Pre %**	**Post %**	**Relative Change**	**Pre %**	**Post %**	**Relative Change**	**Pre %**	**Post %**	**Relative Change**
Animal-Based[d]	83.1	75.8	-9%	80.9	83.1	3%	78.6	77.5	-1%
Red Meat[e]	44.7	41.0	-8%	30.0	31.3	4%	31.1	28.5	-8%
Beef	35.8	32.5	-9%	12.5	13.2	6%	15.6	14.4	-8%
Pork	6.0	5.8	-3%	17.5	18.2	4%	12.2	11.5	-6%
Mixed	2.9	2.7	-17%	0	0		3.3	2.6	-21%
Poultry	35.9	31.9	-11%	37.2	37.9	2%	43.6	46.2	6%
Fish	2.3	2.3	-0%†	4.8	5.1	6%†	2.7	2.8	4%
Shrimp	0.2	0.6	200%	8.8	8.9	0%†	0.6	0	-100%
Vegetarian[f]	16.9	24.2	43%	19.3	16.9	-12%	21.4	22.5	5%
Plant-Based	11.5	19.3	68%	19.3	16.9	-12%	12.7	14.3	13%
Cheese-Based	5.4	5.1	-6%	0	0		8.7	8.3	-5%

[a]For entrées sold at Rendezvous West, n=124,792 for pre and n=141,321 for post
[b]For entrées sold at Rendezvous East, n=118,765 for pre and n=106,333 for post
[c]For entrées sold at Bruin Café, n=81,693 for pre and n=72,918 for post
[d]Animal-based includes red meat, poultry, fish, and shrimp entrées (RQ 2.1)
[e]Red meat includes beef, pork, and mixed meat entrées (RQ 2.2)
[e]Vegetarian includes plant-based and cheese-based entrées without animal meat (i.e., no red meat, poultry, fish, shrimp)
Chi-Square tests used to compare pre and post proportions, all changes significant at p<.01 unless noted†

The proportion of animal-based entrées sold—including red meat, poultry, fish, and shrimp—at the intervention site, Rendezvous West, significantly *decreased* by 9% (raw change 7.3%), from 83.1% to 75.8% (p<.001). At the adjacent comparison site, Rendezvous East, where the menu was unchanged, the proportion of animal-based entrées significantly *increased* by 3%

(raw change 2.2%), from 80.9% to 83.1% (p<.001). At the secondary comparison site, Bruin Café, the proportion of animal-based entrées significantly *decreased* by 1% (raw change 1.1%), from 78.6% to 77.5% (p<.001).

To compare changes across sites, I used a logistic regression model to predict whether an entrée sold was animal-based (1=yes, 0=no) and included interaction terms for time (pre/post) and site (Rendez West/Rendez East/BCafe). Significant interaction terms indicated an intervention effect. Based on the model, there was a significant difference in the pre/post changes at Rendezvous West compared to both Rendezvous East (p<.001) and Bruin Café (p<.001): animal-based entrée sales decreased more at Rendezvous West than Bruin Café (absolute difference 7%), while sales increased at Rendezvous East (absolute difference 11%). The logistic model is included in Appendix X.

Question 2.1b (Animal-Based – Vegetarian Replacement): To what extent does Impossible™ replace sales of existing vegetarian options at Rendezvous West?

Overall, Rendezvous West sold 16,079 Impossible™ plant-based meat items in the post period (Fall 2019), comprising 11.4% of total lunch and dinner entrée sales. As previously reported, this coincided with a 9% *decrease* in the proportion of animal-based entrée sales (raw change 7.3%), but it also coincided with a significant 24% *decrease* in other vegetarian entrée sales (raw change 4.1%, p<.001). To further understand these trends, I examined *build-your-own* entrée sales and *California Burrito Special* sales separately (Table 12). As part of the intervention in Fall 2019, Impossible™ was made available *every day* on the *build-your-own* entrée line and *once per week* on Thursdays as a new option for the *California Burrito Special*.

Table 12. Pre, post, and relative percent change in proportion animal-based, Impossible™, and other vegetarian entrée sales at Rendezvous West, UCLA Dining, Fall 2018 and 2019

	Pre, %	Post %	Relative Change
All Entrées			
	(n=124,792)	**(n=141,321)**	
Animal-based	83.1	75.8	-9%
Impossible™	0	11.4	
Other Vegetarian	16.9	12.8	-24%
Build-your-own Entrées[a]			
	Pre, % (n=62,739)	**Post, % (n=78,314)**	**Relative Change**
Animal-based	88.4	77.3	-13%
Impossible™	0	15.1	
Other Vegetarian	11.7	7.6	-35%
California Burrito Special[b]			
	Pre, % (n=11,151)	**Post, % (n=13,866)**	**Relative Change**
California Steak	85.9	67.1	-21%
California Impossible™	0	26.2	
California Veggie	14.7	6.7	-54%

[a]Build-your-own entrées available daily at Rendezvous West
[b]California Burrito Special available once/week on Thursdays at Rendezvous West
Chi-Square tests used to compare pre and post proportions, all changes significant at p<.001

For *build-your-own entrées*, Impossible™ comprised 15.1% of sales in Fall 2019. The proportion of animal-based build-your-own entrées sold significantly *decreased* by 13% (raw change 11.1%), from 88.4% to 77.3%, and the proportion of other vegetarian entrées significantly *decreased* by 35%, from 11.7% to 7.6% (raw change 4.1% both p<.001). For the *California Burrito Special*, California Impossible™ Burritos comprised 26.2% of sales in Fall 2019. The proportion of California Steak Burritos sold significantly *decreased* by 21% (18.8%

raw decrease), from 85.3% to 67.1%, and the proportion of California Veggie Burritos significantly *decreased* by 54%, from 14.7% to 6.7% (raw change 8%, $p<.001$).

Question 2.2 (Healthfulness – Red Meat): To what extent does the intervention decrease sales of red meat-based entrées?

The proportion of red meat-based entrées sold—including beef, pork, and mixed red meat—at the intervention site, Rendezvous West, significantly *decreased* by 8% (raw change 3.7%), from 44.7% to 41.0% ($p<.001$). At Rendezvous East, the proportion of red meat-based entrées significantly *increased* by 4% (raw change 1.3%), from 30.0% to 31.3% ($p<.001$). At Bruin Café, the proportion of red meat entrées significantly *decreased* by 8% (raw change 2.6%), from 31.1% to 28.5% ($p<.001$).

Based on a logistic model predicting whether an entrée sold was red meat-based (yes/no), there was a significant difference in the pre/post changes at Rendezvous West compared to Rendezvous East ($p<.001$), but not compared to Bruin Café ($p=0.91$). There was a clear difference in trends between Rendezvous West and East, where the proportion of red meat entrées sold decreased at West and slightly increased at East (absolute difference 12%). However, trends were similar at Rendezvous West and Bruin Café. The logistic model is included in Appendix X.

Question 2.3 (Healthfulness – Nutritional Quality): To what extent does the intervention improve the nutritional quality of entrées sold?

As part of the Impossible™ Foodprint Project intervention, Impossible™ plant-based meat was added as a daily option for *build-your-own* entrées and a California Burrito *Special* option once per week on Thursdays. In FoodPro, the nutritional content of build-your-own entrées reflects only the entrée base and tortilla or salad (i.e., no sauces or sides). For example, nutritional data for Chicken Tacos reflects only the chicken entrée base and corn tortillas—not the optional rice, beans, guacamole, sour cream, and salsas. The nutritional content of *Special* entrées includes all recipe components. For reference, nutritional content of the available *build-your-own* entrée base options (4-oz portion) is presented in Table 13. Nutritional content of the available *California Burrito Special* options is presented in Table 14.

Table 13. Nutritional content of entrée base options (4-oz portion) available daily at Rendezvous West, UCLA Dining, Fall 2019

Entrée base	Calories (kcal)	Protein (g)	Fiber (g)	Unsat Fat (g)	Sat Fat (g)	Sodium (mg)
Shredded Beef	400.0	34.3	0.0	16.9	11.2	158.5
Pork Al Pastor	276.4	18.9	0.6	13.7	6.4	323.4
Steak	240.0	31.0	0.1	9.4	3.3	310.7
Chicken	214.0	18.0	0.6	9.0	2.8	417.0
Fish	175.8	33.6	0.2	2.8	1.2	338.5
Pork	175.3	27.1	0.1	4.1	2.1	277.0
Vegetarian	120.7	2.0	3.1	6.6	0.6	771.4
Average	228.9	23.6	0.7	8.9	3.9	370.9
Impossible™	290.0	19.8	4.1	8.3	8.2	391.9

Table 14. Nutritional content of California Burrito Special options available once/week on Thursdays at Rendezvous West, UCLA Dining, Fall 2019

California Burrito	Calories (kcal)	Protein (g)	Fiber (g)	Unsat Fat (g)	Sat Fat (g)	Sodium (mg)
California Veggie	1216.0	31.4	18.3	31.7	11.7	1828.0
California Steak	825.0	39.2	7.0	28.1	12.8	1137.2
Average	1020.5	35.3	12.6	29.9	12.2	1482.6
California Impossible™	863.0	30.8	10.0	27.2	16.5	1198.2

Nutritional changes for all lunch and dinner entrées (n=266,113) sold at Rendezvous West are presented in Table 15. On average, entrées sold at Rendezvous West in Fall 2018 (pre) contained 600.5 calories (kcal), 34.3 g protein, 4.5 g fiber, 19.9 g unsaturated fat, 10.8 g saturated fat, and 952.6 mg sodium. During the intervention in Fall 2019 (post), the average entrée sold contained 21.3 fewer calories (kcal) and lower quantities of nutrients of concern: 0.2 fewer g saturated fat and 26.9 fewer mg sodium. Quantities of other nutrients also decreased: 0.7 fewer g protein, 0.1 fewer g fiber, and 1.5 fewer g unsaturated fat. All decreases were statistically significant at p<.01 using t-tests.

Table 15. Pre, post, and change in average nutrient composition of lunch and dinner entrées sold at Rendezvous West, UCLA Dining, Fall 2018 (Pre) and 2019 (Post)

	All entrées (n=266,113)					
	Calories (kcal)	**Protein (g)**	**Fiber (g)**	**Unsat Fat (g)**	**Sat Fat (g)**	**Sodium (mg)**
Pre (n=124,792)	600.5	34.3	4.5	19.9	10.8	952.6
Post (n=141,321)	579.1	33.6	4.4	18.4	10.6	925.7
Change	-21.3	-0.7	-0.1	-1.5	-0.2	-26.9

T-tests used to compare pre and post average values, all changes significant at p<.01

Given the structure of the Rendezvous West menu and FoodPro data, I also stratified entrées into two groups for analysis: *build-your-own entrées* (n=141,053) and *Special* entrées (n=125,060). In addition, I examined changes just among the *California Burrito Special*, available only on Thursdays. When examining the stratified data, the trends in results differ notably (Table 16).

Compared to Fall 2018 (pre), the average *build-your-own* entrée sold in Fall 2019 (post) contained 25.4 *more* calories (kcal) and higher quantities of nutrients of concern, including 0.9

more g saturated fat and 22.8 more mg sodium (all p<.001). Other changes to build-your-own entrée sales include 0.7 more g fiber, 0.6 more g fiber, and 0.3 more g unsaturated fat (all p<.001). Compared to Fall 2018 (pre), the average *Special* entrée sold in Fall 2019 (post) contained 15.7 (kcal) *fewer* calories, while saturated fat and sodium were statistically unchanged. Other changes to the average *Special* entrée include 0.4 fewer g protein, 0.1 fewer g fiber, and 1.3 fewer g unsaturated fat (all p<.01). Furthermore, I examined changes just among the *California Burrito Special*. Compared to Fall 2018 (pre), the average *California Burrito Special* sold in Fall 2019 (post) contained 21.3 *fewer* calories and 39.3 *fewer* mg sodium (p<.001). Protein decreased by 1.6 g, fiber decreased by 0.1 g, unsaturated fat decreased by 0.5 g, and saturated fat increased by 1.1 g (all p<.001).

Table 16. Pre, post, and change in average nutrient composition of lunch and dinner entrées sold at Rendezvous West, UCLA Dining, Fall 2018 (Pre) and 2019 (Post), stratified by entrée type

	Calories (kcal)	Protein (g)	Fiber (g)	Unsat Fat (g)	Sat Fat (g)	Sodium (mg)
			Build-your-own entrées (n=141,053)			
Pre (n=62,739)	326.3	25.8	1.3	9.9	3.9	585.5
Post (n=78,314)	351.7	26.5	1.9	10.2	4.8	608.2
Change	25.4	0.7	0.6	0.3	0.9	22.8
			Special entrées (n=125,060)			
Pre (n=62,053)	877.7	42.9	7.6	30.0	17.8	1323.8
Post (n=63,007)	862.0	42.5	7.5	28.7	17.8	1320.3
Change	-15.7	-0.4	-0.1	-1.3	0.0†	-3.5†
			California Burrito Special (n=25,017)			
Pre (n=11,151)	882.5	38.1	8.6	28.7	12.6	1238.8
Post (n=13,866)	861.2	36.5	8.5	28.1	13.7	1199.5
Change	-21.3	-1.6	-0.1	-0.5	1.1	-39.3

T-tests used to compare pre and post average values, all changes significant at p<.05 unless noted†

Question 2.4 (Environmental Sustainability – Climate Impact Level): To what extent does the intervention reduce sales of high-impact entrées?

Entrée sales by climate impact level are presented in Table 17. The proportion of low-impact entrées sold—including plant-based and fish entrées—at the intervention site, Rendezvous West, significantly *increased* by 54% (raw change 7.5%), from 13.9% to 21.4% (p<.001). At Rendezvous East, the proportion of low-impact entrées sold significantly *decreased* by 21% (raw change 4.9%), from 23.9% to 19.0% (p<.001). At Bruin Café, the proportion of low-impact entrées sold significantly *increased* by 11% (raw change 1.7%), from 15.3% to 17.0% (p<.001).

At Rendezvous West, the proportion of medium-impact entrées sold—including shrimp, chicken, pork, and cheese-based dishes—significantly *decreased* by 8% (raw change 4.3%), from 50.4% to 46.1% (p<.001). At Rendezvous East, the proportion of medium-impact entrées significantly *increased* by 7% (raw change 4.3%), from 63.6% to 67.9% (p<.001). There was no significant change in the proportion of medium-impact entrées sold at Bruin Café (p=.054).

At Rendezvous West, the proportion of high-impact entrées sold—including only beef entrées—significantly *decreased* by 9% (raw change 3.3%), from 35.8% to 32.5% (p<.001). At Rendezvous East, the proportion of high-impact entrées sold significantly *increased* by 5% (raw change 0.7%), from 12.5% to 13.2% (p<.001). At Bruin Café the proportion of high-impact entrées sold significantly *decreased* by 8% (raw change 1.2%), from 15.6% to 14.4% (p<.001).

Table 17. Pre, post, and relative percent change in proportion entrée sales by climate impact level and study site, UCLA Dining, Fall 2018 and 2019 (n=645,822)

	Rendezvous West (Intervention)[a]			Rendezvous East (Comparison)[b]			Bruin Café (Comparison)[c]		
	Pre %	**Post %**	**Relative Change**	**Pre %**	**Post %**	**Relative Change**	**Pre %**	**Post %**	**Relative Change**
Low[d]	13.9	21.4	54%	23.9	19.0	-21%	15.3	17.0	11%
Medium[e]	50.4	46.1	-8%	63.6	67.9	7%	69.1	68.7	-1%†
High[f]	35.8	32.5	-9%	12.5	13.2	5%	15.6	14.4	-8%

[a]For entrées sold at Rendezvous West, n=124,792 for pre and n=141,321 for post
[b]For entrées sold at Rendezvous East, n=118,765 for pre and n=106,333 for post
[c]For entrées sold at Bruin Café, n=81,693 for pre and n=72,918 for post
[d]Low-Impact: Plant-based entrées with < 2 oz cheese and fish
[e]Medium-Impact: Shrimp, chicken, pork, and cheese-based entrées (> 2 ounces cheese)
[f]High-Impact: Beef entrées
Chi-square test used to compare pre and post proportions, all changes significant at p<.05 unless noted†

Based on a logistic model predicting whether an entrée sold was low-impact (yes/no), there was a significant difference in the pre/post changes at Rendezvous West compared to both Rendezvous East ($p<.001$) and Bruin Café ($p<.001$): low-impact entrée sales increased significantly more at Rendezvous West than Bruin Café (absolute difference 44%), while sales decreased at Rendezvous East (absolute difference 75%). A logistic model predicting whether an entrée sold was medium-impact (yes/no) indicated a difference in the pre/post changes at Rendezvous West compared to both Rendezvous East ($p<.001$) and Bruin Café ($p<.001$): medium-impact entrée sales decreased significantly more at Rendezvous West than Bruin Café (absolute difference 8%), while sales increased at Rendezvous East (absolute difference 15%). A logistic model predicting whether an entrée sold was high-impact (yes/no) also indicated a significant difference in the pre/post changes at Rendezvous West compared to both Rendezvous East ($p<.001$) and Bruin Café ($p<.01$): high-impact entrée sales decreased significantly more at

Rendezvous West than Bruin Café (absolute difference 1%), while sales increased at Rendezvous East (absolute difference 14%). The logistic models are included in Appendix X.

Question 2.5 (Environmental Sustainability – Carbon Footprint): To what extent does the intervention reduce the carbon footprint of entrées sold

On average, lunch and dinner entrées sold at Rendezvous West in Fall 2018 (pre) contributed 1,522 g CO_2-equivalent (CO_2-eq). In Fall 2019 (post), this value significantly decreased by 117 to 1,405 g CO_2-eq (7.7% change, $p<.001$). At 141,321 entrées sold in Fall 2019, this equates to 16,534,557 g (16.4 metric tons) of CO_2-eq saved. To calculate average carbon footprint, I assigned a carbon footprint value to each entrée based on impact-level categorization. For low-impact entrées, I calculated an average value for a standard 4-oz serving of fish, plant-based meat, plant-based cheese, beans, and vegetables (203 g CO_2-eq). For medium-impact entrées, I calculated an average value for a standard 4-oz serving of cheese, shrimp, pork, and poultry (836 g CO_2-eq). For high-impact entrées, I calculated the value for a standard 4-oz serving of beef (2999 g CO_2-eq). This method differs from the proposed carbon footprint calculation due to limitations in obtaining purchase data from my community partner. It proved overly demanding and infeasible for the Administrative Specialist to provide purchase data for individual study sites, as data are typically aggregated for all residential restaurants.

Question 2.6 (Individual Factors): To what extent do individual-level factors affect Impossible™ consumption among students who dine at Rendezvous West?

Of the 215 customer survey observations included in the analytic sample, 96 (45%) had tried Impossible™ at Rendezvous West ("Yes") and 119 (55%) had not ("No"). Participant characteristics by whether they had tried Impossible™ (No/Yes) are presented in Table 18. Over half (56%) of total participants are male, 43% are female, and 1% reported “Other” gender. Forty percent of participants are first-year undergraduates, 36% are second-year, and 23% are third-year. One-third are White, 20% are East Asian (e.g., Chinese, Japanese, Korean), 15% are Hispanic/Latinx, 15% are Other/Mixed, 13% are South Asian (e.g., Indian, Afghani, Pakistani), and 3% are Black. There were no significant differences between the groups in terms of gender, year in school, or race/ethnicity. Although not statistically significant ($p=.08$), the proportion of East Asian participants was more than twice as high in the Yes group (27% vs. 13%), suggesting East Asian participants were more likely to have tried Impossible™ than participants from other racial/ethnic groups. Indeed, of the East Asian participants in the sample, the majority (61%) had tried Impossible™ at Rendezvous West (data not shown). For all other race/ethnic groups, less than half of participants had tried Impossible™ (data not shown). White participants were the second most likely racial/ethnic group to have tried Impossible™ (49%).

Table 18. Demographic characteristics of undergraduate survey participants by whether they had tried Impossible™ plant-based meat at Rendezvous West (No/Yes), UCLA Dining, Fall 2019 (n=215)

	No (Hadn't Tried)		Yes (Had Tried)		Total	
	n	%	n	%	n	%
Gender						
Male	63	53	58	60	121	56
Female	56	47	36	38	92	43
Other gender	0	0	2	2	2	1
Year in School						
First	51	43	36	38	87	40
Second	41	34	37	39	78	36
Third	27	23	23	24	50	23
Race/Ethnicity						
White	37	31	35	36	72	33
East Asian	16	13	26	27	42	20
Hispanic/Latinx	22	18	11	11	33	15
Other/Mixed	22	18	11	11	33	15
South Asian	18	15	10	10	28	13
Black	4	3	3	3	7	3
Total	119	100	96	100	215	100

Participants were given a "No" or "Yes" version of the questionnaire according to their response to the question: "Have you tried Impossible™ at Rendezvous West?"
No statistically significant differences were found between "No" and "Yes" groups using Chi-Square tests

To further understand Impossible™ consumption, we first asked students about their Impossible™ exposure and behavior (Table 19). Blank columns indicate the question was not included in that group's version of the questionnaire. All participants were asked whether they had tried Impossible™ or a similar product (e.g., Beyond Meat™) elsewhere and how many of their friends had tried Impossible™ at Rendezvous West. Students who had tried Impossible™ at Rendezvous West were significantly more likely to have tried it or a similar product elsewhere, and significantly more likely to report that some or most of their friends had tried Impossible™ at Rendezvous West. Among those who had tried Impossible™ at Rendezvous West, the majority (71%) ordered it more than once, 49% had tried the Impossible™ California Burrito

(Thursday Special), 70% had tried Impossible™ on the build-your-own line (available daily), and 23% had tried both.

Table 19. Customer survey participant exposure and behavior by whether they had tried Impossible™ at Rendezvous West, UCLA Dining, Fall 2019

	No (n=119)		Yes (n=96)		Total (n=215)	
	n	**%**	**n**	**%**	**n**	**%**
Tried Elsewhere*	15	13%	53	55%	68	32%
Friends Tried Impossible™**						
None	26	22%	5	5%	31	14%
Some	89	75%	76	79%	165	77%
Most	4	3%	15	16%	19	9%
Frequency Ordered						
Only Once			28	29%		
2-5 Times			37	39%		
6-10 Times			21	22%		
More than 10 Times			10	10%		
Impossible™ Items Ordered						
Impossible™ California Burrito			47	49%		
Impossible™ Build-Your-Own			67	70%		
Both			22	23%		

*p<.05, **p<.01, ***p<.001; Chi-Square used to test for significant differences between groups

Participants' reported beliefs are presented in Table 20. Beliefs are summarized as mean rating on a 5-point agreement scale (0-4) and proportion of those who somewhat agree or agree with each statement. Overall, 46% of participants somewhat agree or agree Impossible™ is delicious, 88% somewhat agree or agree Impossible™ has a smaller carbon footprint than animal meat, 66% somewhat agree or agree Impossible™ is a healthy option, 57% somewhat agree or agree Impossible™ is a satisfying alternative to animal meat, and 77% somewhat agree or agree they would like Rendezvous West to continue serving Impossible™. Beliefs significantly varied between the two groups. Participants who had tried Impossible™ at Rendezvous West (Yes) were more likely to somewhat agree or agree with all statements and rated their agreement with all statements significantly more strongly.

Table 20. Customer survey participant beliefs about Impossible™ [a] by whether they had tried Impossible™ at Rendezvous West, UCLA Dining, Fall 2019 (n=215)

	No (n=119)	Yes (n=96)	Total (n=215)
Mean agreement score[a] (Mean, SD)			
Delicious***	2.06 (0.63)	3.36 (0.78)	2.64 (0.96)
Smaller carbon footprint***	3.38 (0.92)	3.80 (0.64)	3.57 (0.83)
Healthy option*	2.76 (0.96)	3.06 (0.99)	2.89 (0.98)
Satisfying alternative***	2.29 (1.03)	3.32 (0.85)	2.75 (1.08)
Continue serving***	3.05 (0.91)	3.77 (0.59)	3.37 (0.86)
Proportion somewhat agree/agree[b] (n, %)			
Delicious***	13 (11%)	86 (90%)	99 (46%)
Smaller carbon footprint**	90 (82%)	91 (95%)	189 (88%)
Healthy option*	70 (59%)	71 (74%)	141 (66%)
Satisfying alternative***	41 (35%)	82 (85%)	123 (57%)
Continue serving***	75 (63%)	90 (94%)	165 (77%)

[a]Beliefs measured using 5-point Likert agreement scale (0-4)
[b]Somewhat agree/agree (%) includes responses 3="Somewhat agree" and 4="Agree"
*p<.05, **p<.01, ***p<.001: Wilcoxon Rank Sum and Chi-Square used to test for significant differences between groups

Participants' reported dietary behavior is presented in Table 21. Dietary behavior is summarized as mean intake frequency on a six-point frequency scale: 0="Never"; 1="Less than once/month"; 2="1-3 times/month"; 3="Once per week"; 4="2-4 times/week"; 5="5-6 times/week"; and 6="At least once/day." Percentage of those who eat red meat includes those who reported eating beef or pork at a frequency greater than "Never." Dietary pattern categories were also created based on frequency scores, where those who reported "Never" eating animal-based protein (beef, pork, poultry, seafood) were classified as Vegetarian, those who reported "Never" eating animal-based protein except seafood were classified as Pescatarian, and all others were classified as Omnivores.

Table 21. Participant dietary behavior by whether they had tried Impossible™ at Rendezvous West, UCLA Dining, Rendezvous West customer survey, Fall 2019

	No (n=119)	**Yes (n=96)**	**Total (n=215)**
Animal-based protein intake frequency score[a] (Mean, SD)			
Beef	2.88 (1.73)	2.38 (1.83)	2.66 (1.79)
Pork	2.12 (1.62)	1.90 (1.65)	2.02 (1.63)
Poultry*	3.61 (1.87)	3.01 (1.90)	3.34 (1.90)
Seafood	1.92 (1.58)	2.14 (1.65)	2.02 (1.61)
Eat red meat (n, %)[b]	105 (88%)	77 (80%)	182 (85%)
Dietary pattern* (n,%)[c]			
Omnivore	113 (95%)	80 (83%)	193 (90%)
Vegetarian	6 (5%)	12 (13%)	18 (8%)
Pescatarian	0	4 (4%)	4 (2%)

[a]Dietary intake measured using 7-point frequency scale: 0="Never"; 1="Less than once/month"; 2="1-3 times/month"; 3="Once per week"; 4="2-4 times/week"; 5="5-6 times/week"; and 6="At least once/day."
[b]Includes those who reported consuming beef or pork at frequency > 0
[c]Dietary pattern variables created based on dietary intake frequency responses
*p<.05, **p<.01, ***p<.001: Wilcoxon Rank Sum and Chi-Square used to test for significant differences between groups

Students reported consuming poultry most frequently (mean=3.34), followed by beef (mean=2.66), pork (mean=2.02), and seafood (mean=2.02). Results suggest that, on average, participants consume poultry 1-4 times per week, beef almost once per week, and seafood and pork 1-3 times per month. The majority (85%) reported consuming red meat. Ninety percent of participants follow an omnivorous dietary pattern, 8% are vegetarian, and 2% are pescatarian. There were no significant differences between groups in animal-based protein intake frequency, except poultry: Participants who had tried Impossible™ reported consuming poultry significantly less frequently. Participants who had tried Impossible™ and were significantly more likely to be vegetarian (13%) compared to than those who had not tried Impossible™ (5%).

Table 22. Participant values by whether they had tried Impossible™ at Rendezvous West, UCLA Dining, Rendezvous West customer survey, Fall 2019

	No (n=119)	Yes (n=96)	Total (n=215)
Mean importance rating[a] (Mean, SD)			
Healthful diet*	2.99 (0.93)	3.24 (0.83)	3.10 (0.89)
Animal rights	2.61 (1.02)	2.61 (1.16)	2.61 (1.08)
Climate change	3.36 (0.77)	3.50 (0.74)	3.42 (0.76)
Proportion rated very important[b] (n,%)			
Healthful diet*	37 (31%)	43 (45%)	80 (37%)
Animal rights	20 (17%)	25 (26%)	45 (21%)
Climate change	60 (50%)	60 (63%)	120 (56%)

[a]Values measured using 5-point Likert importance scale (0-4) with phrasing: "Compared to other things in your life, please rate the importance of…"
[b]Very important (%) includes only responses 4="Very important"
*p<.05, **p<.01, ***p<.001: Wilcoxon Rank Sum and Chi-Square used to test for significant differences between groups

Participants' reported values are presented in Table 22. Values are summarized as mean rating on a 5-point importance scale (0-4) and proportion of those who rated each value as "very important." Compared to other things in their life, participants rated climate change as most important (mean=3.42), followed by eating a healthful diet (mean=3.10) and animal rights (mean=2.61). A Wilcoxon signed rank test showed that mean climate change rating was significantly higher than mean rating of both eating a healthful diet and animal rights (both p<.001). Over half (56%) of participants rated climate change as very important, 37% rated eating a healthful diet as very important, and 21% rated animal rights as very important. When comparing values among the two groups, those who had tried Impossible™ (Yes) were significantly more likely to rate eating a healthful diet as very important (45% vs. 31%). Participants who had tried Impossible™ (Yes) were also more likely to rate animal rights and climate change as very important, but these differences were not statistically significant.

Question 2.7 (Barriers & Benefits): What barriers and benefits do students perceive around consuming Impossible™ plant-based meat?

To further understand students' perceived barriers to trying the new Impossible™ menu items at Rendezvous West, we asked those who had not tried Impossible™ (n=119): "Why haven't you tried Impossible™ at Rendezvous West?" Participants could select more than one response, and response options were developed in collaboration with Rendezvous West student staff: "Heard bad things"; "Tried elsewhere, didn't like"; "Unfamiliar"; "Unwilling to spend swipe" (i.e., unwilling to pay); "Allergy"; "Other." The most common reason chosen was "Unfamiliar" (39%), followed by "Other" (33%) and "Unwilling to spend a swipe" (29%) (Table 23). Open-ended "Other" responses are provided in Appendix XI; the majority of responses indicated a preference for animal meat.

Table 23. Customer survey participant responses to why they haven't tried Impossible™ at Rendezvous West, UCLA Dining, Fall 2019 (n=119)

	n	%
Unfamiliar	46	39
Other	39	33
Unwilling to spend swipe	35	29
Tried elsewhere, didn't like	6	5
Heard bad things	3	3
Allergy	1	1

Note: % do not add to 100 because participants could select more than one response

To further understand barriers and benefits to repeat consumption, I limited my analysis to those who had tried Impossible™ at Rendezvous West (n=96) and compared those who reported ordering Impossible™ only once (one-time consumers) to those who reported ordering Impossible™ more than once (repeat consumers). Twenty-nine percent (n=28) of those who had tried Impossible™ at Rendezvous West were one-time consumers and 71% (n=68) were repeat consumers. Participant characteristics by whether they were a repeat consumer are presented in Table 24. There were no significant gender or year-in-school differences in the likelihood of being a repeat consumers. The likelihood of being a repeat consumer significantly varied by race/ethnicity ($p<.05$). All South Asian participants were repeat consumers, followed by white (83%), Other/Mixed (73%), Black (67%), Hispanic/Latinx (64%), and East Asian (46%) participants. While East Asians were most likely to have tried Impossible™, they were least likely to be repeat consumers. Results should be interpreted with caution due to small cell sizes.

Table 24. Customer survey participant characteristics by whether a repeat Impossible™ consumer at Rendezvous West, UCLA Dining, Fall 2019 (n=96)

	One-time consumer (n=28)		Repeat consumer (n=68)	
	n	%	n	%
Gender				
Male	17	29	41	71
Female	11	31	25	69
Other gender	0	0	2	100
Year in School				
First	12	33	24	67
Second	10	27	27	73
Third	6	26	17	74
Race/Ethnicity*				
White	6	17	29	83
East Asian	14	54	12	46
Hispanic/Latinx	4	36	7	64
Other/Mixed	3	27	8	73
South Asian	0	0	12	100
Black	1	33	2	67

*p<.05, **p<.01, ***p<.001: Chi-Square used to test for significant differences between groups

Participant dietary behavior and beliefs by whether they were a repeat consumer are presented in Table 25. None of the one-time consumers reported following vegetarian/pescatarian diets, compared to 24% of repeat consumers (p<.01). In other words, all vegetarian/pescatarian survey participants were repeat consumers. Almost all (96%) one-time consumers reported eating red meat, compared to 74% of repeat consumers (p=.01). Similarly, repeat consumers reported significantly less frequent intake of all animal-based protein foods (all p<.05), except seafood, compared to one-time consumers.

Table 25. Customer survey participant dietary behavior and beliefs by whether a repeat Impossible™ consumer at Rendezvous West, UCLA Dining, Fall 2019 (n=96)	One-time consumer (n=28)	Repeat consumer (n=68)
Vegetarian/pescatarian (n,%)[c]* **	0	16 (24%)
Eats red meat (n,%)[b]*	27 (96%)	50 (74%)
Animal-based protein intake frequency (Mean, SD)[a]		
Beef frequency*	3.24 (1.56)	2.06 (1.84)
Pork intake frequency*	2.46 (1.84)	1.66 (1.52)
Poultry frequency**	3.86 (1.21)	2.66 (1.94)
Seafood frequency	2.39 (1.57)	2.03 (1.68)
Beliefs[d]		
Delicious (Mean, SD)***	2.89 (0.79)	3.56 (0.70)
Smaller carbon footprint (Mean, SD)	3.79 (0.50)	3.80 (0.70)
Healthy option (Mean, SD)	2.96 (0.10)	3.10 (0.99)
Satisfying alternative (Mean, SD)***	2.82 (1.02)	3.53 (0.68)

[a]Dietary intake frequency measured using 7-point frequency scale: 0="Never"; 1="Less than once/month"; 2="1-3 times/month"; 3="Once per week"; 4="2-4 times/week"; 5="5-6 times/week"; and 6="At least once/day."
[b]Includes those who reported consuming beef or pork at frequency > 0 "Never"
[c]Vegetarian/pescatarian created based on dietary intake frequency responses
[d]Beliefs measured using 5-point Likert agreement scale (0-4)
*p<.05, **p<.01, ***p<.001: Wilcoxon Rank Sum and Chi-Square used to test for significant differences between groups

Of the four Impossible™ beliefs assessed, only beliefs about the sensory experience of eating Impossible significantly differed between one-time and repeat consumers. Repeat consumers agreed significantly more strongly that Impossible™ is delicious (3.56 vs. 2.89, p<.001) and a satisfying alternative to animal meat (3.53 vs. 2.81, p<.001). Given the significance of these beliefs, I then explored whether sensory beliefs differ by individual characteristics (Table 26).

Belief about deliciousness significantly varied by values, but not gender, race/ethnicity, or dietary pattern. Those who rated eating a healthful diet as "very important" agreed significantly more strongly that Impossible™ is delicious, compared to those who rated eating a healthful diet as less important (3.63 vs. 3.15, $p<.01$). Those who rated climate change as "very important" also agreed significantly more strongly that Impossible™ is delicious, compared to those who rated climate change as less important, (3.55 vs. 3.06, $p<.01$). Belief that Impossible™ is a satisfying alternative to animal meat varied significantly by race/ethnicity and values, but not gender or dietary pattern. Satisfaction rating was highest among Hispanic/Latinx participants (mean=3.62) and lowest among East Asian participants (mean=2.92) ($p<.05$). Satisfaction ratings were significantly higher among those who rated eating a healthful diet as "very important," compared to those who rated eating a healthful diet as less important (3.60 vs. 3.09, $p<.01$). Satisfaction ratings were also significantly higher among those who rated climate change as "very important," compared to those who rated climate change as less important, (3.47 vs. 3.09, $p<.05$). In other words, values and race/ethnicity may affect beliefs about the sensory experience of eating Impossible™, which in turn affects repeat consumption.

Table 26. Sensory beliefs[a] (mean, SD) about Impossible™ among those who had tried Impossible™ at Rendezvous West by individual characteristics, UCLA Dining, Fall 2019 (n=96)

	Delicious	Satisfying Alternative
Gender		
Female (n=36)	3.31 (0.86)	3.50 (0.70)
Male (n=58)	3.38 (0.75)	3.21 (0.93)
Other Gender (n=2)	4.00 (0.00)	3.50 (0.71)
Race/Ethnicity		*
East Asian (n=26)	3.12 (0.77)	2.92 (0.74)
South Asian (n=10)	2.90 (1.20)	3.00 (1.05)
Black (n=3)	2.67 (1.53)	3.00 (1.00)
Hispanic/Latinx (n=11)	3.64 (0.51)	3.64 (0.67)
White (n=35)	3.60 (0.55)	3.57 (0.78)
Other/Mixed (n=11)	3.55 (0.69)	3.55 (0.93)
Dietary Pattern		
Vegetarian/pescatarian (n=16)	3.56 (0.78)	3.63 (0.72)
Omnivore (n=80)	3.33 (0.78)	3.26 (0.87)
Eating a Healthful Diet Value	**	**
Healthful diet very important	3.63 (0.54)	3.60 (0.66)
Healthful diet less important	3.15 (0.89)	3.09 (0.93)
Animal Rights Value		
Animal rights very important	3.52 (0.71)	3.40 (0.91)
Animal rights less important	3.31 (0.80)	3.30 (0.84)
Climate Change Value	*	*
Climate change very important	3.55 (0.62)	3.47 (0.77)
Climate change less important	3.06 (0.92)	3.08 (0.94)

[a]Beliefs measured using 5-point Likert agreement scale (0-4)
*p<.05, **p<.01, ***p<.001: Wilcoxon Rank Sum and Kruskall Wallis used to test for significant differences between groups

Finally, we asked participants to provide open-ended responses about what they “like” and “dislike” about Impossible™. Of the 96 participants who had tried Impossible™ at Rendezvous West, 89 (93%) provided responses about what they “like” and 49 (51%) provided responses about what like “dislike”; comments that said “nothing” or “n/a” were excluded. As described in the Data Processing section, comments were coded using a grounded theory approach, and comments could be coded into more than one theme. The constant comparison method was used to ensure coded comments captured the same theme (Bradley et al., 2007). An overview of the “like” comment coding is illustrated in Table 27. The majority of “like” comments (52%) praised the general flavor/feel/texture of Impossible™, while 30% specifically mentioned the similarity to animal meat, and 22% mentioned environmental benefits.

Table 27. Overview of 89 open-ended comments on what participants “like” about Impossible™ at Rendezvous West, UCLA Dining, Fall 2019

Theme	% Comments	Illustrative Comments
Flavor/feel/texture	52%	“It’s really good, nice texture” “Love it, great taste, good addition”
Similarity to animal meat	30%	“I like how it looks, feels, and tastes like meat” “It tastes like real beef and much better carbon footprint”
Environment/ sustainability	22%	“Good taste, low carbon footprint” “Environmentally Friendly”
Meat alternative	9%	“Alternative” “That it is a good alternative to animal meat”
Vegan/vegetarian	8%	“A good option for vegans! I like meat replacements that are not tofu.” “vegan, tasty”
Nutrition/protein	7%	“non-meat high protein option” “It is really good and not as unhealthy as reg. meat”

Note: Comments could be coded in multiple themes; thus, percentages do not add to 100.

An overview of the “dislike” coding is provided in Table 28. Because “dislike” comments about texture were more distinct and frequent than “like” comments about texture, taste/flavor and texture were divided into separate themes. Almost 30% of comments addressed poor flavor/feel, with some describing the product as too oily or salty and others describing it as too dry. Other comments addressed issues around texture (24%) or concerns around health and nutrition (18%). Open-ended comments are provided in Appendix XII.

Table 28. Overview of 49 open-ended comments on what participants "dislike" about Impossible™ at Rendezvous West, UCLA Dining, Fall 2019

Theme	% Comments	Illustrative Comments
Flavor/feel (includes dry/oily)	29%	"Very greasy, kind of salty" "Not very juicy"
Texture	24%	"Consistency is crumbly" "Don't love the texture"
Health/nutrition	18%	"I've heard it's not the healthiest, + getting veggies is the best option in terms of sustainability" "not any healthier than regular meat"
Availability	10%	"They don't offer it on nachos :(" "its unavailable alot"
Preparation	10%	"texture, temperature (too cold)" "It needs to be mixed in with other food to not be noticeable"
Other	8%	"hurt my stomach" "not very filling"

Note: Comments could be coded in multiple themes; thus percentages do not add to 100.

Conclusion

The results presented above provide a comprehensive assessment of the effectiveness of the Impossible™ Foodprint Project intervention to 1) reduce animal-based entrée sales (key outcome for community partner), and 2) improve the healthfulness and environmental sustainability of entrées sold. The analytic sample included 645,822 entrées sold at the three study sites during the Fall 2018 (pre) and Fall 2019 (post) academic quarters. During the post period, new menu items with Impossible™ plant-based meat comprised over 11% of entrée sales at the intervention site. At the same time, the proportion of animal-based entrée sales decreased by 9% (7% raw change, 83% to 76%), a significantly greater decrease than the two comparisons sites.

Intervention effects on healthfulness were somewhat unclear. While the proportion of red meat entrées sold significantly decreased by about 8% at the intervention site (4% raw change, 45% to 41%), a similar decrease was observed at Bruin Cafe, resulting in an unclear intervention effect. Small but statistically significant nutritional changes were observed at the intervention site: On average, each entrée sold contained slightly fewer calories and slightly lower quantities of protein, fiber, unsaturated fat, saturated fat, and sodium. However, nutritional outcomes varied when stratifying by entrée type: Nutritional outcomes for build-your-own entrées were worse than for specials, likely due to the nutritional quality of the new Impossible™ menu items relative other available options.

Intervention effects on environmental sustainability were clearer. The proportion of low-impact entrée sales increased by 54% at the intervention site (7% raw change, 14% to 21%), a significantly greater increase than the two comparison sites. This corresponded with an 8% decrease in the mean carbon footprint of each entrée sold at the intervention site, from 1,522 to 1,405 g CO_2-equivalent (117 g decrease).

Results from the customer survey (n=215) found no statistically significant differences with respect to gender, race/ethnicity, or consumption of beef, pork, or seafood when comparing participants who had tried Impossible™ to those who had not. In comparing one-time versus repeat consumers, we found significant differences across most behavioral and cognitive factors measured. In general, repeat consumers consumed less animal-based protein and were more likely to believe Impossible™ is delicious and a satisfying alternative to animal meat. We also found evidence that values and race/ethnicity may affect beliefs about the sensory experience of eating Impossible™, which in turn affects repeat consumption.

CHAPTER 7: STUDY THREE RESULTS

Study Three Overview: Menu Framing Experiment

Study Three employed a true experimental design to test whether environmental sustainability framing is a more powerful "nudge" than health framing in the choice between chicken enchiladas and plant-based tacos. Choice of the plant-based tacos was the key outcome of interest. The online choice experiment took place through Qualtrics, and 450 UCLA undergraduate students and staff were recruited through the UCLA Anderson Behavioral Lab's Sona Systems participant pool. Participants were randomly assigned to one of three menu framing conditions: control (no framing), health framing, or environmental sustainability framing (Figure 17, see complete materials in Methods chapter). All three conditions presented participants with the same two menu items: 1) chicken enchiladas, and 2) roasted cauliflower and lentil tacos (i.e., plant-based tacos). Participants were then asked to make a choice between the two items, followed by a series of questions about their values, attitudes, current dietary behavior, and sociodemographics.

Figure 17. Health framing menu icon (left) and environmental sustainability framing icon (right) used in menu framing experiment

Sample Characteristics and Key Variable Distributions

Participant characteristics by UCLA student/staff affiliation are presented in Table 29. Data are stratified by affiliation given the emphasis of this dissertation on students and hypothesized differences between students and staff. There were no statistically significant differences in characteristics across conditions, indicating successful randomization (data not shown). Of the 437 participants maintained in the analytic sample, 352 (79%) are undergraduate students and 85 (21%) are staff. Females comprised the majority of the sample, including 80% of student participants and 84% of staff. Mean age is 20.2 years for students and 35.3 years for staff. Over half (51%) of student participants are Asian, compared to 29% of staff. About 20% of students and 32% staff are White; 16% of students and 11% of staff are other/multi race/ethnicity; 11% of students and 20% of staff are Hispanic/Latinx; 2% of students and 6% of staff are Black; and 1% of students and 4% of staff are Native/Pacific Islander. Compared to the UCLA undergraduate student population, our sample of students is more likely to be female, Asian, and other/multi race/ethnicity, and less likely to be Hispanic/Latinx (UCLA Undergraduate Profile, 2019). About 11% of students and 11% of staff reported following vegetarian, vegan, or pescatarian diets.

Distributions of menu framing experimental condition and menu item choice are presented in Table 30. Of the 437 participants maintained in the analytic sample, 145 (33%) had been randomly assigned to the control condition, 145 (33%) to the health framing condition, and 147 (34%) to the environmental sustainability (enviro) framing condition. Of the two menu items presented in the experiment, 62% of participants chose the chicken enchiladas and 38% chose the plant-based tacos.

Table 29. Characteristics of UCLA participants by student/staff affiliation, menu experiment, UCLA, Fall 2019 (n=437)

	Students, n (%) (n=352)	Staff, n (%) (n=85)	UCLA Student Population[a]
Gender, n (%)			
Female	282 (80)	71 (84)	58%
Male	70 (20)	14 (16)	42%
Age			
Mean (SD)	20.2 (2.2)	35.3 (10.9)	
Race/Ethnicity, n (%)			
Asian	157 (51)	24 (29)	28%
East Asian	129 (37)	21 (25)	-
South Asian	48 (14)	3 (4)	-
White	70 (20)	27 (32)	27%
Other/Multi	56 (16)	9 (11)	8%
Hispanic/Latinx	40 (11)	17 (20)	22%
Black	6 (2)	5 (6)	3%
Native/Pacific Islander	3 (1)	3 (4)	<1%
Dietary Pattern, n (%)			
Omnivore	312 (89)	76 (89)	
Vegan/Vegetarian/Pescatarian	40 (11)	9 (11)	

[a]UCLA Undergraduate Profile 2018-19 (UCLA, 2019)

Table 30. Menu framing experimental condition and menu item choice (n,%) by affiliation, menu experiment, UCLA, Fall 2019

	Students (n=352)	Staff (n=85)	Total (n=437)
Menu framing condition			
Control	120 (34)	25 (29)	145 (33)
Health	115 (34)	30 (35)	145 (33)
Environmental sustainability	117 (33)	30 (35)	147 (34)
Menu item choice			
Chicken enchiladas	223 (63)	38 (45)	270 (62)
Plant-based tacos	129 (37)	47 (55)	167 (38)

No significant differences in condition or choice between students and staff using Chi-Square tests

Question 3.1 (Framing Main Effects): To what extent does framing affect choice of a plant-based menu item?

Hypothesis 3.1.1: Participants are more likely to choose a plant-based dish in the environmental sustainability framing condition, compared to control.

Results failed to support Hypothesis 3.1.1. A chi-square test on the proportion of participants choosing the plant-based tacos indicated no significant difference between the control and environmental sustainability (enviro) framing conditions, with approximately 40% of participants choosing tacos in the enviro condition, compared to 39% in control (p=0.98). Results among the omnivore sample (i.e., excluding vegetarian/pescatarian/vegan participants, n=388) were similar: Approximately 33% of participants in the enviro condition chose tacos, compared to 31% in control (p=0.75). Table 31 summarizes menu item choice by condition.

Table 31. Menu framing condition by choice of menu item and sample, menu experiment, UCLA, Fall 2019

	Full Sample (n=437)		Omnivore Sample (n=388)	
	Plant-Based Tacos, n (%)	**Chicken Enchiladas, n (%)**	**Plant-Based Tacos, n (%)**	**Chicken Enchiladas, n (%)**
Control	57 (39.3)	88 (60.1)	39 (30.7)	88 (69.3)
Health	52 (35.9)	93 (64.1)	36 (27.9)	93 (72.1)
Enviro	58 (39.5)	89 (60.5)	43 (32.6)	89 (67.4)
Total	167 (38.2)	270 (61.8)	118 (30.4)	270 (69.6)

No significant differences across conditions using Chi-Square tests

A simple logistic regression of condition on choice of the plant-based tacos (1=tacos, 0=enchiladas) is shown in Table 32 for both the full sample (n=437) and omnivore sample (n=388). The overall models were not significant, and there was no significant effect of condition on choice.

Table 32. Logistic regression of condition on choice of plant-based tacos, menu experiment, UCLA, Fall 2019

	Odds Ratio (95% CI)	
	Full Sample (n=437)	**Omnivore Sample (n=388)**
Condition		
Control	Ref	Ref
Health	0.86 (0.53-1.39)	0.87 (0.51-1.50)
Enviro	1.00 (0.63-1.61)	1.25 (0.65-1.84)
Constant	0.65* (0.46-0.90)	0.44*** (0.31-0.65)
Pseudo R^2	0.00	0.00
Chi^2	0.77	0.71

Overall models not significant
*p<0.05, **p<0.01, ***p<.001

Hypothesis 3.1.2: Participants are <u>*not*</u> *more likely to choose a plant-based dish in the health framing condition, compared to control (null effect).*

Results supported the null effects hypothesized in 3.1.2. A chi-square test on the proportion of participants choosing the plant-based tacos indicated no significant difference between the health framing condition and control, with approximately 36% of participants choosing tacos in the health condition, compared to 39% in control (p=0.54) (Table 31). Similar results were found in the omnivore sample: Approximately 28% of participants in the health framing condition chose the plant-based tacos, compared to 31% in control (p=0.62). Results from the simple logistic regression are presented in Table 32; there were no significant effects of condition on choice.

Hypothesis 3.1.3: Environmental sustainability framing is a stronger "nudge" than health framing in the choice of a plant-based menu item.

Results failed to support Hypothesis 3.1.3. A chi-square tests on the proportion of participants choosing the plant-based tacos indicated no significant difference between the health and environmental sustainability framing conditions, with 36% of participants choosing tacos in the health condition, compared to 40% in enviro (Table 31, p=0.53). Similar results were found in the omnivore sample: Approximately 28% of participants in the health condition chose the plant-based tacos, compared to 33% in enviro (p=0.41). Logistic regression models are presented in Table 32. When switching the condition reference category to enviro, there was no significant differences between health and enviro framing conditions (OR=1.17, 95% CI: 0.73-1.87, p=0.53).

Summary of Findings – Question 3.1 (Framing Main Effects)

We failed to find support for hypotheses suggesting main effects of menu framing on choice of the plant-based tacos. We found no significant differences in the proportion of participants choosing tacos between the control, environmental sustainability, or health framing menu conditions in the full sample or the omnivore sample. One explanation for null effects is weak experimental stimuli. In questions designed as menu framing manipulation checks, we asked participants to rate the healthiness and environmental sustainability of the two menu items: "How would you rate the [healthiness/environmental sustainability] of the [Chicken Enchiladas/Roasted Cauliflower and Lentil Tacos]?" Ratings were reported on a 1-7 scale, ranging from 1="Not at all" to 7="Very." Difference in participants' ratings between the two menu items (tacos - enchiladas) by condition are shown in Table 33. In general, participants rated the plant-based tacos about 2 points healthier and more environmentally sustainable than the tacos. However, neither healthiness (p=.052) nor sustainability (p=0.593) difference ratings significantly varied by framing condition, suggesting no effect of framing on participants' perceptions of menu items on these two factors. This issue is addressed further in the Discussion chapter.

Table 33. Manipulation checks: Mean (SD) difference in ratings between plant-based tacos and chicken enchiladas, menu experiment, UCLA, Fall 2019 (n=388)

	Healthiness Difference	**Sustainability Difference**
Control (n=127)	1.9 (1.2)	2.1 (1.5)
Health (n=129)	2.1 (1.1)	2.1 (1.6)
Enviro (n=132)	2.2 (1.1)	2.3 (1.7)
Kruskal-Wallis tests	p=.052	p=.593

Question 3.2 (Framing Effect Moderators): To what extent do individual-level factors moderate framing effects?

The omnivore sample (n=388), conceptualized as the target population, was used to test the hypotheses below. Distributions of value and meat attitude variables by affiliation are presented in Table 34. Healthy eating concern, environmental concern, and meat attitude are summarized in the table as composites of the items included in each variable. Items were measured using 5-point agreement scales, ranging from 1="Disagree" to 5="Agree"; higher values indicate stronger/more positive values/attitudes. Mean environmental concern and meat attitude were similar for students and staff. However, staff had significantly higher ratings for healthy eating concern than students (4.2 vs. 4.0, p<.01). For bivariate analyses and hypothesis testing, variables were dichotomized at the 75th percentile.

Table 34. Mean (SD) values and meat attitude by affiliation, menu experiment, UCLA, Fall 2019

	Students (n=352)	Staff (n=85)	Total (n=437)
Healthy Eating Concern**[a]	4.0 (0.8)	4.2 (0.7)	4.0 (0.8)
Environmental Concern[b]	4.4 (0.6)	4.4 (0.6)	4.4 (0.6)
Meat Attitude[c]	3.4 (0.8)	3.4 (0.9)	3.4 (0.8)

[a]Healthy eating concern adapted from Van Loo et al. (2017); mean of two items measured on 5-point scale, ranging from disagree to agree (1-5)
[b]Environmental concern adapted from Kilbourne and Pickett (2008); mean of four items measured on 5-point scale, ranging from disagree to agree (1-5)
[c]Meat attitude adapted from Piazza et al. (2015); mean of six items measured on 5-point scale, ranging from disagree to agree (1-5)
**p<.01, Wilcoxon Rank Sum tests for significant differences between students and staff

Table 35 shows the number and proportion of participants in the omnivore sample (n=388) who chose the plant-based tacos by framing condition (columns), stratified by the hypothesized moderating variables (rows): gender, UCLA affiliation, healthy eating concern, environmental concern, and meat attitude. Total columns show overall differences between subgroups. Chi-square tests were used to test for within subgroup differences across conditions and for differences between subgroup totals. There were no significant differences across framing conditions for any of the subgroups (all p>.05), suggesting no conditional framing effects. However, observed differences among staff should be noted. Although not statistically significant (p=0.13), the proportion of staff who chose the plant-based tacos was less than half in the health framing condition (26%), compared to control (55%). It is possible that small cell sizes prevented us from detecting a true negative health framing effect among staff. It should also be noted that male and pro-meat subgroups had cell sizes less than ten, indicating very low power to detect potential differences across conditions.

Table 35. Number and proportion chose plant-based tacos by hypothesized framing effect moderator and framing condition in omnivore sample, menu experiment, UCLA, Fall 2019 (n=388)

	Framing Condition							
	Control		Health		Environmental Sustainability		Total	
Hypothesized Moderator	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Gender								
Female (n=308)	34	33.3	30	29.4	38	36.5	102	33.1*
Male (n=80)	5	20.0	6	22.2	5	17.9	16	20.0
UCLA affiliation								
Staff (n=76)	11	55.0	7	25.9	11	37.9	29	38.2
Student (n=312)	28	26.2	29	28.4	32	31.1	89	28.5
Healthy eating concern								
Not pro-healthy eating (n=300)	28	26.7	22	22.2	29	30.2	79	26.3
Pro-healthy eating (n=88)	11	50.0	14	46.7	14	38.9	39	44.32**
Environmental concern								
Not pro-environment (n=308)	26	26.3	26	25.7	30	27.8	82	26.6
Pro-environment (n=80)	13	46.4	10	35.7	13	54.2	36	45.0**
Meat attitude								
Not pro-meat (n=280)	33	36.3	29	32.2	38	38.4	100	35.7***
Pro-meat (n=108)	6	16.7	7	18.0	5	15.2	18	16.7

No significant within subgroup differences across framing conditions using Chi-square tests
*p<.05, **p<.01, ***p<.001 significant differences between subgroup totals using Chi-square tests
Note: Small cell sizes (n<10) for male and pro-meat subgroups

When comparing totals, we observed notable differences between subgroups. For gender, a significantly greater proportion of females (33%) than males (20%) chose the plant-based tacos (p=.02). For affiliation, a greater proportion of staff (38%) than students (29%) chose the plant-based tacos, but this difference was not statistically significant (p=.10). For healthy eating concern, those with pro-healthy-eating values were significantly more likely to choose the plant-based tacos (44%) than those without (26%, p<.01). Similarly, for environmental concern, those with pro-environment values were significantly more likely to choose the plant-based tacos (45%) than those without (27%, p<.01). Finally, for meat attitude, a significantly smaller proportion of those with pro-meat values (17%) chose the plant-based tacos, compared to those without (36%, p<.001).

Hypothesis 3.2.1: Gender moderates the effect of framing; health framing effects are positive among females and null among males; environmental sustainability effects are positive for both but stronger for females.

Results failed to support Hypothesis 3.2.1. As shown in Table 35, there were no significant differences in the proportion who chose the plant-based tacos by condition for females (p=0.55) or males (p=0.92). In a logistic regression on choice of the plant-based tacos (1=tacos, 0=enchiladas), I included the interaction term gender*condition (Table 36). The overall model was not significant (Chi-square=6.84, p=.23), and no coefficients were significant.

Table 36. Logistic regression on choice of plant-based tacos, testing gender*condition interaction, menu experiment, UCLA, Fall 2019 (n=388)

	Odds Ratio (95% CI)
Menu Framing Condition	
Control	Ref
Health	0.83 (0.46-1.51)
Enviro	1.15 (0.65-2.04)
Gender	
Female	Ref
Male	0.50 (0.17-1.45)
Condition*Gender	
Health*Male	1.37 (0.32-5.91)
Enviro*Male	0.76 (0.17-3.36)
Constant	0.50 (0.33-0.76)*
Pseudo R^2	0.01
Chi^2	6.84

Overall model not significant; no significant interaction
*p<0.05

Hypothesis 3.2.2: Healthy eating concern moderates the effect of health and environmental framing; framing effects are weaker for those with high healthy eating concern (pro-healthy).

Results failed to support Hypothesis 3.2.2 . As shown in Table 35, there were no significant differences in the proportion who chose the plant-based tacos by condition for pro-healthy (p=0.68) or not pro-healthy (p=0.45). In a logistic regression on choice of the plant-based tacos (1=tacos, 0=enchiladas), I included the interaction term pro-healthy*condition (Table 37). The overall model was significant (Chi-square=12.36, p=.03), but the interaction terms were not significant. The significant pro-health coefficient indicates that, in the control condition, those with pro-healthy eating values had 2.75 times the odds of choosing the plant-based tacos than those without pro-healthy eating values (p=.04).

Table 37. Logistic regression on choice of plant-based tacos, testing healthy eating concern*condition interaction, menu experiment, UCLA, Fall 2019 (n=388)

	Odds Ratio (95% CI)
Menu Framing Condition	
Control	Ref
Health	0.79 (0.41-1.49)
Enviro	1.19 (0.64-2.20)
Healthy eating concern	
Not pro-heathy	Ref
Pro-healthy	2.75 (1.07-7.05)*
Condition*Pro-healthy	
Health*Pro-healthy	1.11 (0.31-3.98)
Enviro*Pro-healthy	0.53 (0.16-1.84)
Constant	0.36 (0.24-0.56)***
Pseudo R^2	0.03
Chi^2	12.36*

*p<0.05, **p<.01, ***p<.001

Hypothesis 3.2.3: Environmental concern moderates the effect of environmental sustainability framing but not health framing; environmental sustainability framing effects are stronger for those with high environmental concern.

Results failed to support Hypothesis 3.2.3. As shown in Table 35, there were no significant differences in the proportion who chose the plant-based tacos by condition for pro-environment (p=0.40) or not pro-environment (p=0.94). In a logistic regression on choice of the plant-based tacos (1=tacos, 0=enchiladas), I included the interaction term pro-environment*condition (Table 38). The overall model was significant (Chi-square=11.60, p=.04), but the interaction terms were not significant. The significant pro-environment coefficient indicates that, in the control condition, those with pro-environment values had 2.43 times the odds of choosing the plant-based tacos than those without pro-healthy eating values (p=.04).

Table 38. Logistic regression on choice of plant-based tacos, testing environmental concern*condition interaction, menu experiment, UCLA, Fall 2019 (n=388)

	Odds Ratio (95% CI)
Menu Framing Condition	
Control	Ref
Health	0.93 (0.51-1.83)
Enviro	1.07 (0.58-2.00)
Environmental concern	
Not pro-environment	Ref
Pro-environment	2.43 (1.02-5.79)*
Condition*Pro-environment	
Health*Pro-environment	0.66 (0.19-2.29)
Enviro*Pro-environment	1.26 (0.36-4.42)
Constant	0.35 (0.23-0.26)***
Pseudo R^2	0.02
Chi^2	11.60*

*p<0.05, **p<.01, ***p<.001

Hypothesis 3.2.4: Meat attitude moderates the effect of health and environmental sustainability framing; framing effects are weaker for those with the most positive meat attitudes.

Results failed to support Hypothesis 3.2.4 . As shown in Table 35, there were no significant differences in the proportion who chose the plant-based tacos by condition for pro-meat (p=0.95) or not pro-meat (p=0.67). In a logistic regression on choice of the plant-based tacos (1=tacos, 0=enchiladas), I included the interaction term pro-meat*condition (Table 39). The overall model was significant (Chi-square=15.31, p<.01), but the interaction terms were not significant. The significant pro-meat coefficient indicates that, in the control condition, those with pro-meat attitudes had 0.35 times the odds (i.e., 65% lower odds) of choosing the plant-based tacos than those without pro-meat attitudes (p=.04).

Table 39. Logistic regression on choice of plant-based tacos, testing meat attitude*condition interaction, menu experiment, UCLA, Fall 2019 (n=388)

	Odds Ratio (95% CI)
Menu Framing Condition	
Control	Ref
Health	0.83 (0.45-1.55)
Enviro	1.09 (0.61-1.97)
Meat attitude	
Not pro-meat	Ref
Pro-meat	0.35 (0.13-0.93)*
Condition*Pro-meat	
Health*Pro-meat	1.31 (0.34-5.04)
Enviro*Pro-meat	0.82 (0.20-3.38)
Constant	0.57 (0.37-0.87)*
Pseudo R^2	0.03
Chi^2	15.31**

*p<0.05, **p<.01, ***p<.001

Hypothesis 3.2.5: UCLA affiliation moderates the effects of framing; health framing effects are positive for staff and null for students; environmental sustainability framing effects are positive for both but stronger for students.

Results indicate marginal evidence in contrast to Hypothesis 3.2.5. As shown in Table 35, there were no significant differences in the proportion of students who chose the plant-based tacos by condition (p=0.73). Although results were not statistically significant, proportions varied widely for staff: 55% in control, 26% in health framing, and 38% in enviro framing (p=0.13). In a logistic regression on choice of the plant-based tacos (1=tacos, 0=enchiladas), I included the interaction term affiliation*condition (Table 40). The overall model was not significant (Chi-square=7.35, p=0.19), but this may be due to small cell sizes and lack of power to detect true differences. The significant student coefficient suggests that, in the control condition, undergraduate students had 0.30 times the odds (i.e., 70% lower odds) of choosing the plant-based tacos than staff (p=.01). In addition, the marginally significant health coefficient indicates that, among staff, those in the health framing condition had 0.29 times the odds (i.e., 71% lower odds) of choosing the plant-based tacos than those in the control condition (p=.047). Similarly, the health*student interaction term is borderline significant, further indicating that the effect of health framing may depend on UCLA affiliation, where the effect is negative for staff and null or slightly positive for students (OR=0.29*3.91=1.13, p=.052). Given that the overall model is not significant, these results are simply indications of potential trends that should be clarified or replicated in future work.

Table 40. Logistic regression on choice of plant-based tacos, testing affiliation*condition interaction, menu experiment, UCLA, Fall 2019 (n=388)	
	Odds Ratio
Menu Framing Condition	
Control	Ref
Health	0.29 (0.08-0.98)*
Enviro	0.50 (0.16-1.60)
Affiliation	
Staff	Ref
Student	0.30 (0.11-0.77)*
Condition*Affiliation	
Health*Student	3.91 (0.99-15.46)
Enviro*Student	2.54 (0.69-9.36)
Constant	1.22 (0.51-3.00)
Pseudo R^2	0.02
Chi^2	7.35

Overall model not significant
*p<0.05, **p<.01, ***p<.001

Summary of Findings – Question 3.2 (Framing Effect Moderators)

Using stratified bivariate analyses and logistic regression models with interaction terms, we failed to find support for hypotheses suggesting gender, healthy eating concern, environmental concern, and meat attitude moderate the effects of menu framing on choice of the plant-based tacos. We found some evidence that framing effects may depend on UCLA affiliation (student/staff). Results suggest health framing may have *counteractive* effects, where staff are *less* likely to choose the plant-based tacos in the health framing condition, compared to control. This is noteworthy given that staff reported greater concern for healthy eating, compared to students. There were no significant effects of environmental sustainability framing in any of the subgroups.

Conclusion

The results presented above address research questions 3.1 and 3.2 concerning main effects and conditional effects of health and environmental sustainability menu framing on participants' choice between chicken enchiladas and plant-based tacos. A summary of findings is presented in Table 41. Results indicate no main effects of menu framing, while results on conditional effects were less clear. Overall, we recruited low numbers of male (n=74) and staff (n=85) participants, which may have hindered our ability to detect framing effects within subgroups. In some cases, cell sizes were smaller than 10 and as small as 5. We found marginal evidence that health framing had negative effects among staff and null effects among students. While I had hypothesized positive effects of health framing among staff, it appears health framing may have counteractive effects. Because the overall model testing the affiliation*condition interaction was not significant, additional research is needed. Ancillary analyses presented below explore the extent to which framing may affect anticipated enjoyment of chosen dish, even if it does not affect choice.

Table 41. Study three summary of findings, menu experiment, UCLA, Fall 2019		
Framing Main Effects		
Analyses	**Support for Hypotheses**	**Relevant Findings**
Chi-Square tests of proportions in full sample (n=437)	No support	Proportion chose plant-based tacos: Control: 39% Health: 36% Enviro: 40% (p=0.78)
Logistic regression in omnivore sample (theoretical target, n=388)	No support	Control: Ref Health: OR=0.87 (95% CI: 0.51-1.50) Enviro: OR=1.25 (95% CI: 0.65-1.84)
Framing Effect Moderators		
Interactions tested in logistic regression models, controlling for gender	**Support for Hypotheses**	**Relevant Findings**
Gender*Condition	No support	
Healthy eating concern*Condition	No support	
Environmental concern*Condition	No support	
Meat attitude*Condition	No support	
Affiliation*Condition	Contrary evidence	Students: No effects of condition Staff: Potentially counteractive effects of health framing on choice of plant-based item, compared to control (OR=.29, p=.047, overall model not significant)

Ancillary Analyses & Findings

Question 3.3 (Ancillary Analyses): To what extent do values and menu framing affect anticipated enjoyment of chosen menu item—even if they do not predict choice?

Beyond food choice, enjoyment of food may influence eating experience and subsequent behavior (Turnwald & Crum, 2019). Although reported enjoyment of a dish following actual consumption provides the best measure of enjoyment, anticipated or imagined enjoyment may provide some indication of an individual's mindset or satisfaction regarding his or her experience. Thus, following choice of menu item, participants were asked, "How much do you think you would enjoy eating this dish?" Response options ranged from 1="Not at all" to 7="Very much" on a 7-point scale. For these analyses, the full sample (n=437) was used.

Table 42. Anticipated enjoyment[a] of chosen menu item by choice and menu framing condition, menu experiment, UCLA, Fall 2019 (n=437)

	Control	Health	Enviro
Plant-Based Tacos			
Mean (SD)	5.65 (1.11)	5.21 (1.16)	5.72 (1.12)†
n	57	52	58
Chicken Enchiladas			
Mean (SD)	5.36 (1.34)	5.14 (1.14)	5.28 (1.16)
n	88	93	89
Total*			
Mean (SD)	5.48 (1.26)	5.17 (1.15)	5.46 (1.19)
n	145	145	147

[a]Anticipated enjoyment measured on 7-point scale, 1="Not at all" to 7="Very much"
*p<.05, Overall anticipated enjoyment significantly differs across conditions
†p<.05, Anticipated enjoyment of plant-based tacos significantly higher in enviro framing condition, compared to health framing

Anticipated enjoyment of chosen dish by choice and menu framing condition is presented in Table 42. When comparing overall ratings across conditions (total rows), anticipated enjoyment was lowest in the health framing condition (5.17) and similar in the control (5.48) and enviro (5.46) conditions. These overall differences were statistically significant using a Kruskal Wallis test (p=.04). Ratings for each dish followed a similar pattern, but differences between the three conditions were not statistically significant. Of note, anticipated enjoyment of both dishes was lower in the health framing condition, compared to control. For environmental sustainability framing, anticipated enjoyment of the plant-based tacos was slightly higher and chicken enchiladas was slightly lower, compared to control. In pairwise comparisons, anticipated enjoyment of the plant-based tacos was significantly higher in the environmental sustainability framing condition, compared to health framing (p=.03). No other pairwise comparisons were statistically significant. In sum, results suggest health framing may "infect" or detract from enjoyment of both dishes, while environmental sustainability framing may increase the appeal of the plant-based dish and reduce the appeal of the meat-based dish. Additional research is needed to clarify and replicate results.

CHAPTER EIGHT: DISCUSSION

This dissertation employed a community-based participatory research approach to investigate how academics and non-academic foodservice leaders can collaborate to address gaps in the development, implementation, and evaluation of interventions to promote healthier, more environmentally sustainable diets. Although there is high scientific agreement that we can simultaneously improve human and planetary health through dietary shifts, interventions targeting these dual outcomes remain understudied (IPCC, 2019). Plant-based foods tend to be both healthier and more environmentally sustainable than animal-based foods, but this is not always the case (Hu et al., 2019; Tilman & Clark, 2014). In addition, there remains a gap between research and practice due to lack of clarity regarding intervention feasibility and potential for scale-up (Chen, 2010; Roy et al., 2015; Szaszi et al., 2018).

Universities may be particularly promising settings for dietary intervention given high levels of unilateral control and students' unique developmental period (Nelson et al., 2008; Seymour et al., 2004). Some educational interventions suggest college students are motivated by social and environmental issues to change their diets, but this notion has not been sufficiently tested or applied in more upstream interventions (Hekler et al., 2010; Jay et al., 2019). To address these gaps, this dissertation conceptualized and conducted three studies to investigate: 1) the process of developing and implementing an intervention; 2) the effectiveness of that intervention to improve both health and environmental sustainability; and 3) whether environmental sustainability framing is more powerful than health framing in "nudging" consumers to choose a plant-based menu item. All research was conducted at the University of California, Los Angeles to build capacity for university foodservice leaders and academics to expand intervention efforts in university settings.

Guided by the diffusion of innovation framework, *Study One* qualitatively described and examined the *process* of developing and implementing the Impossible™ Foodprint Project—an intervention to reduce animal-based protein consumption in university dining. Results described each of the five stages in the intervention process, plus barriers to and facilitators for progressing through those stages: 1) agenda-setting, 2) matching, 3) redefining/restructuring, 4) clarifying, and 5) routinizing (Rogers, 2003).

Most notably, foodservice leaders' involvement in two existing health- and sustainability-focused initiatives facilitated Stage 1, agenda-setting, which involved the identification and definition of a problem, plus the motivation to address that problem. As a result of issue exposure and data tracking through the Menus of Change University Research Collaborative (MCURC), foodservice leaders identified their unmet goal of reducing animal-based protein consumption as a problem to address through intervention. Through the campuswide Semel Healthy Campus Initiative (HCI), foodservice leaders had developed trust and a prior working relationship with the investigator who served as their partner for the intervention. Because both MCURC and HCI promote and provide recognition for applied research, foodservice leaders saw value in studying their intervention efforts. The key decision-maker's personal interest in health and food supported his leadership and willingness to prioritize the intervention and research for his organization.

Stage 2 of the intervention process, matching, involved selecting an intervention to address the problem identified in Stage 1. In this case, foodservice leaders sought intervention strategies aligned with their expressed mission to deliver an enjoyable dining experience and to educate students. This led decision-makers to select two strategies: 1) introduce new, delicious plant-based menu items; and 2) launch a social marketing/education campaign about the environmental impact of food. In selecting strategies, it was important to foodservice leaders to maintain choice and satisfaction among students. They were more open to strategies such as piloting new menu items and providing education—rather than restricting choices. The chosen strategies also built upon the team's culinary strengths and prior research conducted on campus. For example, the investigator had been involved in two studies demonstrating students' interest in and responsiveness to information about connections between food systems and the environment (Malan et al., 2019; Jay et al., 2019).

Findings regarding Stages 1 and 2 of the intervention process align well with prior work. Within the diffusion of innovation literature, scholars note organizational and contextual factors that may encourage organizations to seek out and select interventions. These include qualities of the organization's leader, such as openness to change, and contextual factors that put pressure on organizations, such as policies and consumer demands (Rogers, 2003; Batras et al., 2016). In this case, relevant contextual factors included pressure from Menus of Change and the Healthy Campus Initiative to improve the healthfulness and environmental sustainability of dining operations, plus pressure from students to deliver preferred menu options. Rogers (2003) suggests innovation is often motivated by a discrepancy between organizational performance and goals. In this case, the key decision-maker was motivated by data collected for MCURC showing his organization had failed to reduce year-over-year animal-based protein consumption. Furthermore, the internally driven selection of strategies—as opposed to intervention by an external investigator—ensured the intervention aligned with the organization's broader agenda (Minkler & Wallerstein, 2003). For example, foodservice leaders' desire to preserve choice is warranted, as a study in a university setting found reduced choice negatively impacted customer satisfaction (Mirosa et al., 2016).

Stage 3, redefining/restructuring, involved designing the intervention and adapting operations to improve fit and feasibility. The Dining Director led the development of the new plant-based menu items, focusing on "likeability" as a key guiding principle. The Director reported that, in order for the intervention to meet its goal of reducing animal-based protein consumption, students must perceive the new plant-based menu items as attractive, delicious, and satisfying alternatives to meat. This notion is supported by scientific literature demonstrating that sensory-affective responses to aspects of food such as taste, smell, and appearance are some of the strongest predictors of food choices (Birch, 1999; Eertmans et al., 2001; Furst et al., 1996). In addition, research has shown that experiences of satiety (i.e., feeling full and satisfied) affect subsequent food intake, further supporting the Director's focus on sensory experience (Guyomard et al., 2012).

Ultimately, the Dining Director chose to use Impossible™ plant-based meat in the new menu items. Impossible™ is high in fat from coconut and sunflower oils (14g total fat in 4 oz), and fat generally improves sensory perceptions of food palatability and quality (Drewnowski, 1997). In addition, the Impossible™ product was easy to handle and fit well with the pilot intervention restaurant's menu format when prepared like ground taco meat. Other studies have found foodservice staff are often reluctant to implement interventions involving menu changes due to concerns around consumer satisfaction and operational complexities (Filimonau & Krivcova, 2017; Fitzgerald et al., 2016; Volpe et al., 2013). In contrast, the internal development of menu items in this case not only maximized acceptability among student consumers, but also supported implementation by giving foodservice ownership over the intervention.

Because it involved novel activities and collaboration among actors who do not usually work together, the social marketing campaign required more input from and coordination by the investigator. In community-based participatory research (CBPR), the investigator can take on a collaborator role, which involves sharing academic knowledge and technical skills useful for the community (Minkler & Wallerstein, 2003). In this case, the investigator used theory-driven principles of social marketing, behavioral economics (i.e., “nudging”), and carbon footprint life-cycle assessments to inform campaign development. For example, the investigator decided to frame the campaign around climate change, where choosing low-carbon-footprint foods (behavior) was positioned as a way to fight climate change and save the planet (outcome). In addition to presenting information about the carbon footprint of foods, the campaign promoted the tagline, “Swap the meat, save the planet.” This social marketing approach went beyond information provision and emphasized the exchange of positive outcomes for behavior (Lee & Kotler, 2016). In line with the theory of process motivation, the outcome was participation in a social movement (i.e., fighting climate change/saving the planet), rather than health (T. N. Robinson, 2010b).

Using a CBPR approach, the social marketing campaign also involved utilizing and building upon the partner organization’s existing knowledge and capacity. Specifically, the nutrition education coordinator, website manager, and marketing staff provided guidance on available marketing platforms and executed all campaign implementation. Co-creation of campaign materials also built capacity for the nutrition education coordinator—an intervention champion—to integrate the topic of food and climate change into ongoing nutrition education efforts. Johnson et al. (2004) suggest building expertise and strengthening champion roles are key strategies for intervention sustainability. From a CBPR perspective, this means the academic partner ensures appropriate knowledge is transferred to the non-academic partner to sustain the intervention (Minkler & Wallerstein, 2003).

Although the social marketing campaign was successfully implemented, restaurant operators' limited involvement emerged as a missed opportunity. For example, while the restaurant's general manager was heavily involved in implementing the new menu items, he was not included in the marketing meetings due to oversights by the investigator and broader team. It became apparent during campaign implementation that this general manager could have contributed valuable insights around the design and placement of marketing materials. Indeed, he knows his operation and customers best. Furthermore, involving the general manager in developing the marketing campaign could have established greater buy-in and facilitated the in-restaurant changes needed during implementation—e.g., putting out signage, updating menus (Rogers, 2003). To make up for this oversight, the investigator met with the general manager weekly throughout intervention implementation. Other researchers have noted the importance of close relationships between investigators and operators for ensuring foodservice intervention fidelity (Volpe et al., 2013). As evidenced in this case, it can be challenging for outside investigators to know which stakeholders to involve in what aspects of the intervention. Future efforts should allow additional time for investigators to build relationships with diverse stakeholders prior to developing the intervention.

Stage 4, clarifying, involved learning from a variety of data sources, including nutritional data, sales data, customer survey data, and financial data. Ongoing communication between the investigator and Dining Director ensured timely feedback on progress and responsiveness to concerns. For example, Impossible™ recipes were revised after the investigator voiced concerns around high levels of sodium. Sales data provided information about the performance of the new menu items, and survey data helped to clarify and contextualize sales results. Of note, the CBPR approach enabled investigation of foodservice-driven research questions. The researcher coded and analyzed all administrative sales data to determine the reduction in animal-based entrée sales, and the survey assessed the Dining Director's sensory outcomes of interest—beliefs that Impossible™ is delicious and a satisfying alterative to animal meat. The researcher was also able to utilize the project data to assess additional outcomes of interest, such as proportion of red meat entrées sold and carbon footprint of entrées sold. Furthermore, the survey provided confirmation for framing the social marketing campaign around climate change: Students reported valuing climate change as significantly more important, on average, than eating a healthy diet. This finding further emboldened the nutrition education coordinator and broader team to expand efforts to promote low-carbon-footprint foods. Johnson et al. (2004) suggest intervention outcome evaluation is necessary because stakeholders are more likely to sustain an intervention if they believe it is effective. In this sense, CBPR can be particularly valuable for ensuring evaluation research addresses the non-academic partner's outcomes of interest.

Stage 5, routinizing, refers to whether the intervention was abandoned and/or integrated into normal operations. In this case, the new Impossible™ menu items were integrated into normal operations at the pilot intervention restaurant due to high student satisfaction and demonstrated effectiveness of the intervention. However, Impossible™ was not expanded to other restaurants due to the high cost of the product. This outcome may be unique to institutions such as schools, universities, and some workplaces where the cost of premium products is not handed down to customers. In these settings, Dining Directors are responsible for managing food costs within budget constraints, where healthier and/or more sustainable products may cost more than alternatives (Kimmons et al., 2012; Niebylski et al., 2014; Volpe et al., 2013). To overcome the cost barrier, foodservice leaders in this case reported looking for other, more affordable plant-based meat products. At this time, however, they have not found a product that meets their standards for sensory appeal.

Of the various social marketing components developed for the intervention, several were integrated into normal operations, including carbon footprint menu icons, table tents focused on food and climate change, and signage for digital screens and stanchion signs with the carbon footprint scorecard. The sustainability of these components was enabled by existing infrastructure in the dining operation and strengthening of the nutrition education coordinator's role as a champion of the intervention (Johnson et al., 2004). Strategies involving point-of-purchase signage and menu design are typically low-cost and appealing to both foodservice leaders and consumers, particularly college students (J. Guthrie et al., 2015). Previous research suggests college students appreciate food information in university dining facilities and, when asked, say they want labeling interventions to continue (Malan et al., 2019; Seward et al., 2016). As demonstrated in this case, messaging about the environmental impact of food may be particularly well-received given the importance of climate change among students. Overall, results from Study One confirm the CBPR approach facilitated the development, implementation, and sustainability of the intervention by enabling intervention ownership, feasibility, feedback, and capacity building for university foodservice leaders.

Study Two employed a natural experiment with a pre-post nonequivalent comparison group study design to evaluate 1) whether the Impossible™ Foodprint Project intervention met foodservice leaders' goal of reducing animal-based entrée sales, and 2) the impact of the intervention on the healthfulness and environmental sustainability of entrées sold. During the post period (Fall 2019), new menu items with Impossible™ plant-based meat comprised over 11% of entrée sales at the intervention site. From pre to post, the proportion of animal-based entrée sales significantly decreased by 9% (raw change 7%, 83% to 76%) at the intervention site, while the proportion of animal-based entrée sales increased by 3% at one comparison site and decreased by 1% at the other comparison site. In short, there was a significantly greater decrease in animal-based entrée sales at the intervention site, compared to comparison sites, indicating an intervention effect. As discussed, these results were interpreted by foodservice leaders as evidence of intervention success.

However, a closer look at the changes in distribution of sales by entrée base (e.g., beef, pork, poultry, Impossible™, other vegetarian) revealed some interesting nuances. For example, while the new Impossible™ plant-based menu items did appear to capture some of the animal-based entrée sales (9% decrease), they also captured a portion of sales from existing vegetarian entrées (24% decrease). In addition, among animal-based entrées, the proportion of poultry entrées decreased slightly more than the proportion of beef entrées, 11% (raw change 4%, 36% to 32%) versus 9% (raw change 3%, 36% to 33%). While shifting from beef to Impossible™ plant-based meat saves a substantial amount of CO_2-eq per 4-oz serving (2999 g CO_2-eq for beef vs. 397 for Impossible™), shifting from poultry to Impossible™ is less beneficial (573 g CO_2-eq per 4-oz serving of poultry) (Heller & Keoleian, 2014; Khan et al., 2019). Furthermore, from a health perspective, replacing beef with Impossible™ may confer health benefits by reducing red meat consumption, but the health implications of replacing poultry with Impossible™ remain unknown (Bouvard et al., 2015).

These nuances were explored explicitly in research questions addressing the impact of the intervention on healthfulness and environmental sustainability. With respect to healthfulness, Study Two assessed the extent to which the intervention 1) decreased the proportion of red meat entrées sold and 2) improved the nutritional profile of entrées sold. While the proportion of red meat entrées sold (including beef and pork) significantly decreased by about 8% at Rendezvous West, the intervention site (raw change 4%, 45% to 41%), a similar 8% decrease was observed at the Bruin Cafe comparison site (raw change 2%, 31% to 29%). A difference-in-difference analysis indicated no significant intervention effect on red meat sales. Given our familiarity with the university study setting and knowledge of each residential restaurant's customer base, these results can be interpreted several ways.

One explanation is spillover or contamination, where the reduction in red meat sales observed at the Bruin Café comparison site occurred as a result of students' exposure to the intervention's social marketing at Rendezvous West (Rossi et al., 2004). This is likely, as a survey conducted in the same setting found almost 40% of students (n=1,156) reported eating at both Rendezvous and Bruin Café at least once per week (unpublished data). In other words, there is a large degree of consumer overlap in patronage between the study sites. At the same time, the intervention effect of increasing the availability of plant-based menu items is reflected in the shifts in sales from red meat to other options. At the intervention site, Rendezvous West, we observed a large 68% increase in plant-based entrées (including Impossible™), while at Bruin Café we observed smaller increases in both plant-based entrées (13%) and poultry (6%) entrée sales.

This contamination explanation, however, is complicated by findings at the other comparison site, Rendezvous East. Here, we observed a 4% increase in red meat entrée sales from pre to post (raw change 1%, 30% to 31%). When comparing Rendezvous West to East, the difference-in-difference analysis indicated a significant intervention effect. We also observed a 12% decrease in plant-based entrée sales at Rendezvous East from pre to post (raw change 2%, 19% to 17%). Because Rendezvous West and East share a dining room, it is even more likely that Rendezvous East customers were exposed to the social marketing at Rendezvous West. The question, then, becomes: Why did red meat sales increase at Rendezvous East (comparison) while they decreased and Rendezvous West (intervention) and Bruin Café (comparison)? Selection bias may provide some explanation. In food environment interventions, select bias refers to shifts in patronage rather than shifts in consumption (Taillie et al., 2017). It is possible that students seeking plant-based menu options shifted from Rendezvous East to West following the intervention, resulting in increased plant-based entrée sales at Rendezvous West and decreased plant-based entrée sales and Rendezvous East. Given the proximity of Rendezvous East and West, these shifts are highly plausible. When comparing total entrée sales from pre to post, we observed a 13% increase in sales at Rendezvous West, a 10% decrease in sales at Rendezvous East, and an 11% decrease in sales at Bruin Café.

It is also plausible that, in general, frequent Rendezvous customers were less receptive to the intervention than students who frequent other residential dining restaurants. For example, the survey previously mentioned (n=1,156) found that students who frequent Rendezvous several times per week are more likely to be male, less like to value healthy eating, and less likely to believe eating less meat is healthy, compared to students who frequent Bruin Café several times per week (unpublished data). Unfortunately, Rendezvous was included as a single location in the survey, so we cannot compare characteristics of those who frequent Rendezvous East versus West. Still, these data suggest that, of students exposed to the intervention's social marketing campaign, those who frequent Bruin Café may have been more receptive to the campaign messages than those who frequent Rendezvous. Overall, both contamination and selection bias likely contributed to observed changes in red meat entrées across all three study sites.

As a second assessment of healthfulness, Study Two examined changes in the nutritional composition of entrées sold at the intervention site, Rendezvous West (n=266,113). The extent of nutritional improvements was somewhat mixed. Compared to Fall 2018 (pre), the average entrée sold in Fall 2019 (post) contained 21.3 fewer calories (kcal) and lower quantities of nutrients of concern: 0.2 fewer g saturated fat and 26.9 fewer mg sodium. Quantities of other nutrients also decreased: 0.7 fewer g protein, 0.1 fewer g fiber, and 1.5 fewer g unsaturated fat. On average, American diets are too high in calories, saturated fat, and sodium, and too low in fiber (Dietary Guidelines Advisory Committee, 2015). In addition, consuming more unsaturated fat than saturated fat may reduce risk of chronic disease (McCullough et al., 2002). Observed nutritional changes were statistically significant given the large sample size; however, small magnitudes suggest the intervention had a negligible impact on the nutritional quality of entrées sold overall.

Given the structure of the Rendezvous West menu and FoodPro data, nutritional analyses were also stratified by entrée type: build-your-own and special. The build-your-own entrée format is similar to the restaurant chain Chipotle, and nutritional content reflects only the entrée base (e.g., beef, pork, etc.) and style (e.g., tacos, burrito, salad); rice, beans, and sauces are not included. For build-your-own entrées (n=141,053), compared to Fall 2018 (pre), the average entrée sold in Fall 2019 (post) contained 25.4 more calories (kcal) and higher quantities of nutrients of concern, including 0.9 more g saturated fat and 22.8 more mg sodium. Potentially beneficial changes to build-your-own entrée sales include 0.6 more g fiber and 0.3 more g unsaturated fat. These changes make sense given the new Impossible™ option is slightly higher in calories, fiber, saturated fat, and sodium than the other build-your-own entrée base options available, on average. Although build-your-own changes are less favorable than observed changes overall, magnitudes remain small.

For specials (n=125,060), compared to Fall 2018 (pre), the average special entrée sold in Fall 2019 (post) contained 15.7 (kcal) fewer calories, while saturated fat and sodium were statistically unchanged. Other changes to the average special entrée include 0.1 fewer g fiber and 1.3 fewer g unsaturated fat. Again, these changes make sense given the new Impossible™ California Burrito Special is lower in calories, fiber, and unsaturated fat than the available California Veggie and California Steak Burritos, on average. Again, the magnitudes of significant changes were small, and some changes were nonsignificant. Unlike the new build-your-own Impossible™ option, which was available every day, the Impossible™ California Burrito Special was available only on Thursdays.

In sum, nutritional changes were small and depended on stratification by entrée type (build-your-own, special), indicating the importance of both menu item availability and substitution. It is also important to note that overall sales of build-your-own entrées increased by 25% from pre to post, while Special sales increased only 2%. Nutritional changes observed for all entrées sold likely reflect these changes in the distribution of entrée type. As such, stratifying by entrée type provides a clearer picture of nutritional impacts. Nutritional outcomes for build-your-own entrées were worse than for specials, likely due to the nutritional quality of the new Impossible™ menu items relative other available options. Behavioral shifts play a role as well, where substituting Impossible™ for shredded beef would result in nutritional improvements but substituting Impossible™ for chicken would increase calories and saturated fat. We also observed heterogeneity in menu item quality across nutrients. For example, the available fish and vegetable build-your-own options were relatively low in saturated fat but relatively high in sodium. In addition, the California Veggie Burrito was higher in calories and sodium than the California Steak Burrito.

One study evaluating sodium in university canteen meals found the highest levels of sodium in fish and vegetarian dishes (Barbosa et al., 2017). Because sodium may be added in attempt to increase consumer acceptance, food environment interventions must be cautious of sodium content when promoting nutrient dense menu options (Kremer et al., 2009). For example, one intervention in a hospital cafeteria found that, despite the enhanced nutritional quality of available options, the sodium content of side dishes purchased tripled (Vadiveloo et al., 2017). Because plant-based meat products such as Impossible™ are relatively high in sodium when unprepared, foodservice leaders must take care to limit added sodium during preparation. As discussed in Study One results, the original Impossible™ recipes developed for this intervention were modified to reduce sodium.

The relatively high saturated fat content of Impossible™ is also worth noting. While fat is needed for acceptable palatability, and higher fat content generally improves perceptions of quality, the plant-based meat industry should be encouraged to reformulate products with healthier fats (Dietary Guidelines Advisory Committee, 2015; Drewnowski, 1997; Savell & Cross, 1988). The relatively high sodium and saturated fat content of Impossible™ were key concerns for the nutrition education coordinator/dietitian involved in the intervention. Furthermore, she was concerned that Impossible™ contains soy leghemoglobin, a protein containing heme. Although the FDA approved soy leghemoglobin as a safe additive, heme has been identified as a potential mechanism by which red and processed meat is associated with increased cancer risk (FDA, 2019; Godfray et al., 2018). Finally, although not addressed in this study, researchers have noted concerns around the ultra-processed nature of plant-based meat products such as Impossible™ (Hu et al., 2019). Consuming ultra-processed foods has been linked with higher calorie intake and weight gain (Hall et al., 2019).

With respect to environmental sustainability, Study Two evaluated the extent to which the intervention reduced the climate impact level (low, medium, high) and carbon footprint of entrées sold. Climate impact level was classified based on methodology developed by Leach et al. (2016), which considers the contribution of foods to the total carbon footprint of a healthy reference diet (i.e., % daily value). For this dissertation, entrée bases (4-oz portion) contributing up to 25% of the daily dietary carbon footprint were classified as low-impact, 26-50% were medium-impact, and above 50% were high-impact. In contrast to the foodservice leaders' broad goal of reducing animal-based protein consumption (i.e., meat, poultry, and seafood), this evidence-based classification scheme did not result in a clear plant-based versus animal-based pattern. Specifically, cheese and fish emerged as special cases.

Due to the density of cheese, and because it comes from cows, the carbon footprint of a 4-oz portion of cheese has a higher carbon footprint than both pork and poultry, contributing 50% of the daily dietary carbon footprint in this study (Heller & Keoleian, 2014; Leach et al., 2016). At the same time, a 2-oz portion of cheese is considered one serving of dairy, and cheese is often eaten in even smaller portions as a condiment (USDA & HHS, 2015). The collaborative nature of this research allowed the investigator to review menus and discuss recipes with the nutrition education coordinator. It was discovered that many vegetarian options contained cheese, though amounts of cheese varied widely. Thus, to reflect scientific evidence and ensure feasibility, the investigator and nutrition education coordinator decided to classify all vegetarian dishes containing at least 2 oz of cheese as cheese-based, and vegetarian dishes containing less than 2 oz of cheese as plant-based. For example, the mushroom and spinach quesadilla with 3 oz of cheese was classified as cheese-based and the bean and cheese burrito with 1 oz of cheese was classified as plant-based. All cheese-based entrées were then classified as medium-impact while all plant-based entrées (including new Impossible™ menu items) were classified as low-impact.

The carbon footprint of fish varies widely depending on species and production method (e.g., aquaculture, trawling, non-trawling) (Clune et al., 2017). Still, average carbon footprint values for fish tend to be lower than other animal-based protein options such as poultry and pork (Clune et al., 2017; Heller & Keoleian, 2014). Similar to the approach used for cheese, the investigator consulted the university foodservice partner to review the recipes and determine an acceptable classification scheme. Both the nutrition education coordinator and sustainability manager were consulted. Beyond variance in carbon footprint, the team considered that fish production imposes other significant environmental impacts, such as overfishing and habitat loss (Bahadur Kc et al., 2018). Because all fish used at Rendezvous West was certified sustainable, the team felt comfortable including fish in the low-impact category, which included labeling fish entrées with the Low Carbon Footprint Icon.

Based on these classification rules, there were clear positive intervention effects on the climate impact level of entrées sold. From pre (Fall 2018) to post (Fall 2019), the proportion of low-impact entrée sales increased by 54% at Rendezvous West, the intervention site (raw change 7%, 14% to 21%), a significantly greater increase than the two comparison sites. The proportion of low-impact entrée sales decreased by 21% at Rendezvous East and increased by 11% at Bruin Café. As discussed, low-impact entrées included fish entrées and plant-based entrées (vegetarian entrées with less than 2 oz cheese). The proportion of medium-impact entrée sales decreased by 8% at Rendezvous West (raw change 4%, 50% to 46%), a significantly greater decrease than the 7% increase in medium-impact entrée sales at Rendezvous East and 1% decrease at Bruin Café. Medium-impact entrées included chicken, pork, shrimp, and cheese-based entrées (vegetarian entrées with at least 2 oz cheese). High-impact entrée sales decreased by 9% at Rendezvous West (raw change 3%, 36% to 33%), a significantly greater decrease than the 5% increase at Rendezvous East and 8% decrease at Bruin Café. High-impact entrées included only beef entrées. Although difference-in-difference analyses indicated significant and consistently beneficial intervention effects on climate impact outcomes, changes observed at the comparison sites remain equivocal. Compared to the intervention site, changes at Bruin Café were similar but smaller in magnitude, while changes at Rendezvous East were in opposite directions. These findings are similar to findings for red meat, thus similar explanations may be appropriate. As discussed above, changes may be partly attributable to contamination, selection bias, or both.

Observed intervention effects are consistent with prior studies finding strong evidence of effectiveness for interventions that combine point-of-purchase information with availability of options (Valdivia Espino et al., 2015). In a systematic review of interventions to reduce meat consumption, Bianchi et al. (2018) found that three of four interventions providing meat alternatives along with educational materials were effective. Like this intervention, interventions employing “nudges” such as simplifying information, providing visual signifiers, and highlighting ideal-type behavior have demonstrated positive effects (Lehner et al., 2016). Framing messaging around climate change may have been particularly well received in this setting. Previous studies have found college students are motivated by social and environmental issues to improve their eating behaviors in general and to specifically reduce meat consumption (Hekler et al., 2010; Jay et al., 2019; Malan et al., 2019).

As discussed in the Background chapter, combined strategies to address both supply and demand tend to be most effective. However, given the simultaneous implementation of the new menu items and social marketing campaign, we were unable to determine the effectiveness of each component in isolation. For example, it is unknown how well the new Impossible™ menu items would have sold without the social marketing campaign. Furthermore, it is unknown which aspects of the social marketing campaign—menu icons, stanchion sign, table tents, etc.—were most effective. Additional research is needed to better understand the effectiveness of each strategy.

As a final step in evaluating the impact of the intervention on environmental sustainability, I quantified the carbon footprint reduction per entrée sold at the intervention site. The shifts in climate impact level described above corresponded with an 8% decrease in mean carbon footprint per entrée sold, from 1,522 to 1,405 g CO_2-equivalent (117 g decrease). With 141,321 entrées sold at the intervention site in Fall 2019, this equates to approximately 16.4 metric tons of CO_2 saved—the equivalent of driving 42,000 miles (EPA, 2018). As a pilot project, this intervention has potential to scale. In the 2018-19 academic year, UCLA Dining served 6,392,048 meals (unpublished data). Reducing each of these meals by the 117 g CO_2-eq achieved in the pilot project would result in 751 million metric tons of CO_2 saved—the equivalent of taking more than 163 cars off the road (EPA, 2018).

Similar to recent hypothetical analyses done by Jay et al. (2019), this decrease can also be understood in the context of carbon footprint reduction targets. Under President Obama's Climate Action Plan to meet the Paris Climate Accord, the United States aimed to reduce greenhouse gas emissions by 326 million metric tons per year (17% below 2005 levels) (Jay et al., 2019). On a per capita basis, this amounts to 2,764 grams of CO_2 per person per day. The 117 g decrease per meal observed as a result of the intervention equates to about 4% of that target. In other words, extrapolated to the broader US, reducing the carbon footprint of one daily meal by an average of 177 g would amount to 4% of the reduction required to meet the Paris Climate Accord.

It is also valuable to consider the mean carbon footprint per entrée sold relative to carbon footprint targets developed specifically for diet. The healthy reference diet proposed by Leach et al. (2016) equates to 2,200 g CO_2-eq per day. This reference diet is based on the USDA 2010 Dietary Guidelines for Americans and does not explicitly consider carbon footprint boundaries (USDA & HHS, 2010). The planetary health diet recently proposed by Willett et al. (2019), which considers both nutrition and planetary boundaries, equates to a more stringent 1,780 g CO_2-eq per day. Prior to the intervention, the average meal sold at Rendezvous West contributed 1,522 g CO_2-eq, or 70% and 86% of the Leach et al. (2016) and Willett et al. (2019) reference diets, respectively. Following the intervention, the average meal sold contributed 1,405 g CO_2-eq, or 64% and 79%. At both timepoints, and using both reference diets, the average meal sold contributed more than 50% of a customer's daily dietary carbon footprint, suggesting too many high-impact beef entrées were sold. Future interventions and research should consider these analyses when setting targets for low-carbon-footprint institutions and restaurants.

Findings from the customer survey (n=215) helped contextualize sales data and provided additional information for foodservice leaders to evaluate the intervention. Results highlight the importance of exposure to plant-based meat products through peers and other venues in determining whether students had tried Impossible™ at the intervention site. Other research conducted in this setting found students often seek out familiar food and rely on peers for dietary guidance (Malan et al., 2019). Indeed, peers influence eating behavior through multiple mechanisms such as modeling, reinforcement, social support, and information sharing (DiMaggio & Garip, 2012; Larson & Story, 2009; Umberson, Crosnoe, & Reczek, 2011). When comparing participants who had tried Impossible™ to those who had not, there were no statistically significant differences with respect to gender, race/ethnicity, or consumption of beef, pork, or seafood. These results suggest a broad range of students was open to trying the new plant-based menu items, including males, students of color, and regular meat-eaters who may be challenging to reach (Gossard & York, 2003). However, those who had tried Impossible™ reported consuming poultry significantly less frequently, were significantly more likely to be vegetarian (13% vs. 5%), and rated healthy eating as significantly more important than those who had not tried Impossible™. Although data are cross-sectional, it is possible this significant difference in poultry consumption reflects the observed decrease in poultry entrées sold, where students were choosing the new Impossible™ menu items instead of poultry. Of all animal-based entrée categories (beef, pork, poultry, shrimp, fish), we observed the largest sales decrease for poultry.

It was not surprising that vegetarians and those who value healthy eating were significantly more likely to have tried the new Impossible™ menu items. Although differences were not statistically significant, those who value climate change were also more likely to have tried Impossible™ (63% vs. 50%). Individuals respond differently to changes in food availability, as individual preferences interact with food environments (Hawkes et al., 2015). In addition, theories of social marketing suggest interventions are most likely to be effective when messaging aligns with the target population's existing values (Lee & Kotler, 2016). Although messaging did not explicitly reference vegetarianism or health, plant-based eating tends to align with these values. It is also worth noting that survey participants reported valuing climate change significantly more than healthy eating. This finding provided additional support for the intervention's focus on climate change and encouraged foodservice leaders to expand culinary efforts and messaging around fighting climate change with food.

Of those who had tried Impossible™ at Rendezvous West (n=96), the majority (71%) reported ordering it more than once, suggesting high customer satisfaction. Indeed, of those who had tried Impossible™, the majority (>70%) somewhat agreed or agreed Impossible™ is delicious, has a smaller carbon footprint than animal meat, is a healthy option, and is a satisfying alternative to animal meat. Almost all (94%) reported they would like the intervention site to continue serving Impossible™. In comparing one-time versus repeat consumers, we found significant differences across most behavioral and cognitive factors measured. In general, repeat consumers consumed less animal-based protein and were more likely to believe Impossible™ is delicious and a satisfying alternative to animal meat. These sensory beliefs did not vary by gender but did differ by race/ethnicity and values. Sensory ratings were highest among White and Hispanic/Latinx students and those who value climate change and healthy eating. These findings underscore the subjective experience of eating, where cultural preferences and mindset may influence sensory perception (Guyomard et al., 2012; Hauser et al., 2011). Open-ended comments reinforced the importance of sensory experience, with the majority of positive and negative comments addressing various aspects of flavor, feel, and texture. In addition, 22% of positive comments addressed environmental benefits, while 18% of negative comments addressed concerns around health and nutrition.

Taken together, Studies One and Two address gaps in the literature by a) describing the process and b) evaluating the effectiveness of developing and implementing a university dining intervention using a community-based participatory research (CBPR) approach. Unlike traditional "outside expert" research, CBPR is driven by a non-academic partner and seeks to determine effective real-world approaches for achieving organizational, behavioral, and social change (Israel et al., 2005). As such, CBPR is ideal for enhancing intervention feasibility and building capacity for action (Chen, 2010; Israel et al., 2005; Minkler & Wallerstein, 2003). Results suggest CBPR can be appropriate for dietary intervention in this setting, especially when existing infrastructure supports intervention agenda-setting and collaboration among foodservice leaders and academic partners. Academic partners should take care to foster intervention ownership among foodservice leaders and provide information and technical assistance, as needed. This approach is likely to result in sustainable, scalable institutional change, which requires comprehensive engagement and education of all relevant stakeholders (Kimmons et al., 2012). Furthermore, trust and commitment to collaborative research facilitated the utilization of available administrative data, collection of primary data, and identification of outcomes valuable for all parties.

The strategies employed in the Impossible™ Foodprint intervention provide an example of finding synergy between institutional feasibility and evidence-based practice. While foodservice leaders developed plant-based menu items most appropriate for their operation and goal of reducing animal-based protein consumption, the investigator provided academic expertise and leadership to develop and execute the social marketing campaign. Foodservice leaders' decision to use Impossible™ plant-based meat provided a novel opportunity to study the impact of introducing this product in an institutional setting. As discussed, plant-based foods tend to confer both health and environmental benefits, but this is not always the case (Hu et al., 2019; Tilman & Clark, 2014). Study Two is one of the first studies to concurrently assess health and environmental sustainability in intervention evaluation. Results suggest clear improvements for environmental sustainability but more equivocal impacts on health. In addition, it remains unclear the extent to which outcomes reflect changes in consumption or shifts in patronage. Still, high customer satisfaction and sustained demand for the plant-based product were powerful forces of feedback: Foodservice leaders decided to expand plant-based menu offerings and messaging about food and climate change. In this sense, plant-based meat products may play an important role in building awareness and demand for plant-based foods in general. Increased demand for and institutional purchasing of plant-based foods can stimulate a food system response, thus resulting in broader system-level change (Hawkes et al., 2015).

Results discussed thus far provide some evidence in support of this dissertation's overarching hypothesis that environmental sustainability is an effective motivator for dietary shifts in a university setting. Students responded favorably to the Impossible™ Foodprint Project, which was framed around climate change, and survey participants reported valuing climate change as more important than healthy eating. In addition, foodservice leaders were at least in part motivated to seek out an intervention to reduce environmental impact. However, Studies One and Two were not able to explicitly compare environmental sustainability versus health approaches for dietary behavior change. To do so, *Study Three* utilized an online experiment to test whether environmental sustainability framing is more effective than health framing in "nudging" university consumers to choose a plant-based menu option. This is the first between-subject experiment to compare these two approaches. To my knowledge, only one, less rigorous study has attempted this comparison. Osman & Thorton (2019) compared the effects of health-related traffic light labels, carbon-related traffic light labels, and dual health and carbon labeling on meal choice. Compared to the control condition, all three conditions positively shifted choices, but there were no significant difference between conditions in the magnitude of change (Osman & Thornton, 2019). Because the researchers used a within-subjects repeated choice experiment, these results are likely confounded by transfer across conditions. In other words, results may reflect an individual's general response to labeling rather than distinct effects of each labeling approach.

In Study Three of this dissertation, we found no statistically significant differences in choice across menu framing conditions: 39% of participants chose the plant-based tacos in the control condition, 36% in the health condition, and 40% in the environmental sustainability condition. In short, there was no clear evidence the environmental sustainability condition performed better or worse than the control condition in facilitating choice of the plant-based menu option. Although Study Three found no significant effects of environmental sustainability framing, there was some evidence that health menu framing may unintentionally nudge away from plant-based menu options among UCLA staff. The observed negative effects of health framing align with previous research. Although health is intrinsically personal, and health concerns are reported as top drivers of food choice, studies suggest consumers consciously and subconsciously perceive food described as healthy as less enjoyable and less satisfying (Finkelstein & Fishbach, 2010; Köster, 2009; Suher et al., 2016). Still, effects were small, and the experiment yielded null results for the majority of hypotheses tested. Lack of support for hypotheses may be explained by the fact that 1) menu framing stimuli were not strong enough to yield effects, and 2) effects were difficult to detect given the size and composition of our sample.

With respect to point one, we found that participants' perceptions of the menu items did not vary by condition. As a manipulation check, participants were asked to rate the healthiness and environmental sustainability of each menu item. Sufficiently strong stimuli would have resulted in different healthiness and sustainability ratings in the respective menu framing conditions. Instead, we found no significant differences by condition in mean ratings of the two dishes, nor in the difference between the ratings of the two dishes. We did, however, find significant difference in ratings based on participants' choice: Those who chose the chicken enchiladas rated that dish as significantly healthier and more environmentally sustainable than those who chose plant-based tacos. It seems that, in rating the menu items, participants were informed more by their own behavior than the information provided in the menu framing conditions.

When considered along with the null results, these findings suggest stronger stimuli are needed to produce the desired effect. In other words, a shove—rather than a nudge—may be needed to drive individuals to choose a plant-based menu option. Additional research could explore this hypothesis by re-running the experiment with more novel, vivid, or compelling menu frames. For example, stimuli could specifically highlight carbon footprint rather than general environmental sustainability, given the salience and urgency of climate change. Stimuli could also include a more extreme menu option, such as a beef, rather than chicken, as chicken is one of the more sustainable animal proteins. Camilleri et al. (2019) found an intuitive carbon label to be effective at reducing choice of beef soup by increasing awareness of the carbon footprint of beef (i.e., awareness mediated the effect of the label on choice). In contrast to the stimuli used in our experiment, the stimuli employed by Camilleri et al. (2019) produced a significant shift in participants' perceptions of the menu items, which in turn affected choice.

Point two considers the size and composition of our sample. Due to the community-based participatory nature of the research, we purposively sampled undergraduate students and staff from the UCLA community. However, this sampling approach resulted in a largely homogeneous sample, where the majority of participants held relatively similar values/attitudes around healthy eating concern, environmental concern, and meat consumption (coefficients of variation all < 1). In addition, differential response rates from the Sona participant pool resulted in a sample including 79% undergraduate students and 80% females, with fewer than 40 males and staff in each condition. When testing for conditional effects of the menu framing conditions among males and staff, some cell sizes were less than ten. This could explain null and borderline results as statistical artifacts rather than a lack of effect. To address these issues, future research could oversample males and staff at UCLA as well as students and staff from other universities to include more variability in values and attitudes.

It is also worth noting that meat attitude appeared to be a particularly strong determinant of menu item choice. Those with the most pro-meat attitudes (top 25th percentile) were less than half as likely to choose the plant-based tacos than those with less positive attitudes (17% vs. 36%, respectively). The construct meat attitude encompasses the justifications or reasons why people eat meat, including beliefs that eating meat is delicious, normal, natural, and necessary for a healthful diet (Piazza et al., 2015). In a nationally representative survey, Neff et al. (2018) found the predominant reason among those who were not reducing meat consumption was the belief that a healthy diet includes meat (Neff et al., 2018). In addition, as discussed above, sensory experience is one of the strongest predictors of food choice (Sobal & Bisogni, 2009). When considered in conjunction with results from Studies One and Two, these findings underscore the culinary necessity and challenge of developing delicious, satisfying plant-based menu options that can compete with meat-based options. Furthermore, we must consider consumer concerns around the nutritional merits of plant-based foods. Beyond specific concerns with plant-based meat alternatives, consumers may perceive whole-food plant-based options as insufficient to meet their nutritional needs. Addressing concerns around taste and satisfaction will likely enhance intervention efforts to promote plant-based foods. Indeed, prior research supports the use of taste-oriented language and subtle, benefit-focused nutrition messages (e.g., protein-packed) to encourage healthy food choices (Turnwald et al., 2017; Turnwald & Crum, 2019; Wagner et al., 2015). More widespread education about overconsumption of protein and the adequacy of plant sources to provide protein may also be needed (Dietary Guidelines Advisory Committee, 2015).

In ancillary analyses, I also examined potential cognitive—rather than behavioral—effects of menu framing. We were interested in the extent to which framing affected mindset even if it did not affect choice. In line with the dissertation's broader hypothesis of process motivation, we hypothesized that, compared to health framing, environmental sustainability framing would improve anticipated enjoyment of the plant-based menu item (Robinson, 2010). While healthy eating is focused on the self, sustainable eating is more altruistic, potentially providing a sense of "feel good" satisfaction. In contrast to the healthy-is-unappealing phenomenon, some studies have found consumers perceive foods containing eco-labels as tastier and higher quality (Magnier et al., 2016; Sörqvist et al., 2015). Still, eco-labels tend to be most effective among those with pro-sustainable values (Guyader et al., 2017).

Results suggest menu framing may affect anticipated enjoyment of a chosen menu item. Overall, we found that anticipated enjoyment significantly differed across menu framing conditions ($p=.04$): It was lowest in the health framing condition (mean=5.17) and similar in the control (5.48) and environmental sustainability (5.46) conditions. Compared to the other conditions, environmental sustainability framing appeared to influence the choice context by increasing anticipated enjoyment of the plant-based tacos and decreasing anticipated enjoyment of the chicken enchiladas. Although these cognitive effects were not strong enough to affect behavior in this experiment, altering mindsets may affect longer-term learning and preferences for plant-based foods (Turnwald & Crum, 2019). In this sense, environmental sustainability framing is a more promising approach than health framing to encourage more plant-based dietary patterns. Additional research is needed to replicate and/or clarify results.

Simultaneously promoting human and planetary health through dietary shifts is a growing field. Future studies should continue to investigate feasible, effective strategies to address these dual outcomes in universities and other settings. For example, research could explore the acceptability and impact of adopting carbon footprint targets in restaurants and institutional foodservice. It would also be valuable to assess in isolation the effectiveness of 1) introducing menu items with plant-based meat, and 2) climate-change-framed social marketing. Researchers could also investigate the "gateway" food concept proposed by the Dining Director in this research: Do plant-based meat alternatives encourage readiness for broader dietary shifts byway of the transtheoretical model (i.e., stages of change) (K Glanz & Bishop, 2010)? Despite the benefits of plant-based meat alternatives observed in this study—including feasibility, carbon footprint reduction, and customer satisfaction—healthfulness remains unclear. Additional research is needed to further understand the short- and long-term health implications of substituting plant-based meat products for other foods, including red meat, poultry, legumes, and vegetables. Studies could also explore strategies for overcoming cost barriers for institutions to provide healthier, more environmentally sustainable options. Finally, future research should continue to test the effectiveness of nudges framed around environmental sustainability to shift not only choices but mindsets around food. Highlighting climate change may be a particularly promising approach.

Limitations

Given the community-based participatory research approach and focus on the university setting, this dissertation is limited in generalizability. The Impossible™ Foodprint Project intervention was developed in collaboration with UCLA foodservice leaders to enhance fit and feasibility within the specific context of residential dining at UCLA. At the same time, interventions driven by real-world actors are especially feasible, which may support scale-up in similar settings. Although Study One involved a single case study, the use of an established theoretical framework not only enabled the systematic collection and analysis of data, but also supports replication and analytic generalization. In addition, the investigator's involvement in the intervention may have introduced bias into Study One results. To address this concern, the investigator conducted analyses using an iterative process and multiple sources of data to achieve triangulation, or the convergence of findings.

The natural experimental design employed in Study Two is inherently limited in internal validity due to lack of randomization and control. As discussed above, both contamination and selection bias likely contributed to observed sales outcomes across the three study sites. Despite these limitations, natural experiments are valuable for evaluating outcomes in the context of real-world food environments. Indeed, it is important to consider how changing menus at one restaurant may affect other restaurants within residential dining. Despite the large sample size (n=645,822) and efficient use of existing FoodPro infrastructure, Study Two was also limited by available administrative data. Unfortunately, administrative errors resulted in some duplicate and missing data in the FoodPro sales records. Of note, seven popular Bruin Café menu items were missing from the Fall 2018 (pre) sales records. In the post period, these items comprised approximately 17% of sales. To minimize bias in estimating outcomes, the seven items were dropped from the post period; however, it is unknown whether excluding these items meaningfully affected results. Of the seven menu items, two were poultry, two were pork, two were seafood, and one was cheese-based. If changes in sales of these excluded items did not match observed patterns for each entrée base category, data could mischaracterize true events. As such, Bruin Café outcomes should be interpreted with caution.

We used peer-reviewed life cycle analyses (LCA) to calculate the carbon footprint of foods; however, we relied on a non-peer-reviewed study for Impossible™ plant-based meat due to lack of available peer-reviewed literature (Khan et al., 2019). Although this is not ideal, the Impossible™ LCA was conducted by third party analysts, and the carbon footprint estimate is within 0.5 g CO_2-eq/g product of the peer-reviewed analysis of a similar product, Beyond Meat™ (3.5 for Impossible™ vs. 4.0 for Beyond Meat™) (Heller & Keoleian, 2018). Compared to conventional beef, these estimates suggest a 4-oz portion of the plant-based products generate 89-90% less greenhouse gas emissions than conventional beef (Heller & Keoleian, 2018; Khan et al., 2019). It should also be noted that evaluation of impacts on health and environmental sustainability were limited in scope. Many other important outcomes could be considered, including health biometrics, antibiotic use in animal agriculture, and environmental land, chemical, and water use in food production.

Furthermore, the customer survey included in Study Two used a convenience sample of approximately 200 students. This sample likely reflects the intervention site customer base but is not representative of the broader UCLA residential student population. The survey was conducted in response to the non-academic partners' priorities and designed to gather information about the specific intervention and context. All responses were self-reported and thus may be subject to social desirability and recall biases. Findings from the survey are not generalizable to other universities or sites serving Impossible™ but may be used as a starting point to inform future research.

Finally, because Study Three was designed to inform university-based intervention efforts, study participants included only UCLA students and staff. Again, generalizability of results may be limited to this and similar populations. Menu item choice and other questionnaire responses were also self-reported and thus potentially subject to social desirability and recall biases. Because the experiment utilized a simulated online choice task, Study Three may not adequately capture the contextual factors that influence decision-making in real-world food environments. For example, food choices made in residential dining restaurants may be subject to influences such as time pressure, social pressure, and sensory stimulation. Due to the novel comparison of health versus environmental sustainability menu framing, it was appropriate to conduct a simulated experiment prior to a field study. Indeed, the experiment can be considered a preliminary test to understand psychological processes and principles that can then be tested in real-world settings. As consumers increasingly order food online, we can be confident in the realism of the choice task. Findings may also inform interventions designed for online food environments.

Conclusion

This dissertation contributes to our understanding of how academic and non-academic partners can collaborate to promote healthier, more environmentally sustainable diets in a university setting. Overall, results from Study One confirm the benefits of a community-based participatory research (CBPR) approach for facilitating the development, implementation, and sustainability of interventions by enabling intervention ownership, feasibility, capacity building, and customer satisfaction. CBPR may be especially appropriate for dietary intervention when existing infrastructure supports intervention agenda-setting and collaboration among foodservice leaders and academic partners. By describing the process of intervention development and implementation, Study One addresses gaps in the literature regarding why and how interventions take shape.

Results from Study Two suggest the intervention developed through CBPR was successful in meeting foodservice leaders' goal of reducing animal-based protein consumption. During the intervention period, the new Impossible™ plant-based menu items comprised over 11% of entrée sales at the intervention site, and the proportion of animal-based entrée sales significantly decreased by 9%. However, deeper examination of intervention impacts revealed a more nuanced assessment. While results demonstrate clear improvements for environmental sustainability, health impacts remain equivocal. This study is among the first to integrate health and environmental sustainability outcomes in intervention evaluation.

Average changes in calories and nutrients were statistically significant but small in magnitude. Nutritional improvement also depended on stratification by entrée type. Importantly, collaboration between the investigator and foodservice leaders addressed the level of high sodium in initial recipes. Because plant-based meat products such as Impossible™ are relatively high in sodium when unprepared, foodservice leaders must take care to limit added sodium during preparation. The issue of entrée substitution also emerged as a nutritional concern: Following the introduction of Impossible™ menu items, we observed decreases not only in red meat entrée sales, but also in poultry and other vegetarian options. The nutritional implications of substituting plant-based meat alternatives for poultry and other vegetable-based options remain unknown.

The intervention appeared to reduce environmental impact by reducing the carbon footprint of entrées sold. The proportion of low-impact entrée sales increased by 54%, while medium-impact and high-impact entrée sales decreased. These shifts in climate impact level corresponded with an 8% decrease in mean carbon footprint per entrée sold, from 1,522 to 1,405 g CO_2-equivalent (117 g decrease). Extrapolated to the broader US, reducing the carbon footprint of one daily meal by an average of 177 g would amount to 4% of the reduction required to meet the Paris Climate Accord.

Study Three found no clear evidence that environmental sustainability framing is more effective than health framing in "nudging" university consumers to choose a plant-based menu item. However, there was some evidence health framing had counteractive effects among staff. Ancillary analyses suggest environmental sustainability framing may improve mindset about plant-based foods even if it does not affect choice. This may be valuable for developing preferences for plant-based foods, thus additional research is warranted. Given relatively low awareness of the environmental impact of food choices, simple icons like those used in Study Three may not be sufficient for effecting behavior change. Multi-component strategies, such as the social marketing campaign employed in the intervention, may be more appropriate.

Taken together, the three studies conducted in this dissertation provide a meaningful contribution to dietary intervention research and practice. Although scientists agree we can simultaneously improve human health and environmental sustainability through dietary shifts, feasible and effective ways to achieve needed shifts remain elusive. This dissertation demonstrates the promise of leveraging academic and non-academic collaboration in a university setting to take action while contributing novel insights to the field. Specifically, university foodservice leaders' decision to launch Impossible™ menu items provided one of the first opportunities to study the health and environmental sustainability implications of introducing new plant-based meat products. High consumer satisfaction suggests plant-based meat products may play an important role in building awareness and demand for plant-based foods in general. Overall, findings from this dissertation support the notion that environmental sustainability can be a powerful motivator for dietary shifts, especially among college students. However, sensory experience is paramount in food choice, and developing appealing, satisfying, and healthful plant-based foods remains an important culinary—and public health—challenge.

Appendix I. Rendezvous West menus, Fall 2018

Appendix II. Characteristics, beliefs, and behaviors of Rendezvous consumers

Reported frequency of eating at Rendezvous

	n	%
More than once a day	24	2.08
Once every day	41	3.55
4-6 times a week	253	21.89
1-3 times a week	438	37.89
1-3 times a month	220	19.03
Less than once a month	87	7.53
Never	93	8.04
Total	1,156	100.00

Rendezvous "high consumers":

- Almost a third (28%) of respondents reported eating at Rendezvous *at least 4 times per week*. These students will be considered "high consumers."
- Rendezvous high consumers reported *eating red meat more frequently* than lower consumers: 6.42 times per week on average, compared to 5.61. This difference is significant ($p<.001$).
- Rendezvous high consumers reported *eating vegetables less frequently* than lower consumers: 2.2 times per day on average, compared to 2.9. This difference is significant ($p<.001$).
- *Males* are significantly more likely to be high consumers (36%) than females (24%) ($p<.001$).
- Rendezvous high consumers are significantly *less likely to be vegetarian* (3.1%) than lower consumers (6.3%) ($p=.03$).
- Rendezvous high consumers are *less likely to be vegan* (1.9%) than lower consumers (3.2%) ($p=.22$, not significant).
- About a quarter (25%) of survey respondents believe "healthy eating" means eating "less meat." Rendezvous high consumers are significantly *less likely to believe this* (18%) than lower consumers (27%) ($p<.01$).
- Almost 60% of survey respondents believe "healthy eating" means eating "more plants." Rendezvous high consumers are significantly *less likely to believe this* (50%) than lower consumers (63%) ($p<.001$).
- About 50% of survey respondents believe it is "very important" to "eat healthy. Rendezvous high consumers are significantly *less likely to believe this* (37%) than lower consumers (53%) ($p<.001$).

Data source: "What's On Your Plate, Bruins?" survey conducted in Fall 2015/Spring 2016.

Appendix III. Key informant interview guides

<u>Assistant Vice Chancellor (AVC), Housing & Hospitality Services (H&HS)</u>

(July 2019)

1. For the purposes of the research, I'm considering the beginning of this project to be you emailing me the year-over-year change in animal protein consumption
    a. Can you talk a bit about your motivation to start collecting that data and how you decided this was a "problem" you wanted to address?
2. How did your involvement with groups such as HCI and MCURC influence this process?
3. Quite quickly in our planning meeting, you narrowed in on Rendezvous and the beef burritos as a target for intervention…can you explain that thought process?
4. When we discussed different strategies for reducing animal protein -- such as "stealth" reduction of portion size or marketing new plant-based items -- you indicated you wanted education to be part of the project.
    a. Can you talk more about that?
    b. What are your goals for the education/marketing side of the intervention?
5. As I understand it, your overall goal is to reduce overall animal protein consumption.
    a. Is this how you would define success for the project?
6. Anything else you would like to add?

<u>Senior Director of Food & Beverage, H&HS</u>

(July 2019)

1. As part of our collaboration on this project, I'll be researching and documenting both the effectiveness and the viability of the intervention--so, looking whether it works and how you all made it happen.
2. What were the main practical considerations for your team when coming up with the new plant-based item?
    a. Are there potential obstacles to consider?
    b. Any unintended consequences – positive or negative – you are thinking about?
3. What costs or resources are involved in the new rollout?
4. What are the main barriers you foresee as limiting student uptake of the new menu item?
    a. Are you confident we can reach students across different subgroups? If not, what can be done to change this?
5. How would you define success for the project?
    a. What are some of the most important outcomes for you to see?
6. Do you think other universities would be willing and able to do something similar once we are done? Why or why not?
7. Anything else you would like to add?

Follow-up (February 2020)

1. I wanted to follow up on the financial impact of Impossible™ and your plans moving forward.
2. When we spoke last, you mentioned the high cost of Impossible™ as a potential problem, but you decided to continue serving it at Rendezvous.
    a. Can you tell me about that decision?
3. Will you be expanding Impossible™ to other dining locations? Why or why not?
4. Anything else you would like to add?

Senior Director, Organizational Performance & Communication, H&HS

(July 2019)

1. Part of my goal with this research is to write a case study go share with others interested in similar work.
2. Since you were so involved and such a champion for the healthy vending project, I thought we could start by looking back at that experience.
    a. Do you see any key similarities or differences for operations or research?
    b. Any key lessons learned that you want to apply to this project?
3. Do you have a clear sense yet what the scope of the marketing effort will be?
    a. Who on your team are the key people that will make all this happen?
    b. How does this fit into their typical workflow?
    c. How can I be helpful to your team?
4. Anything else you would like to add?

Food Services Manager, H&HS – Dining Services

(December 2019)

1. To start, can you please briefly describe your title and responsibilities at Rendezvous?
2. You have been doing this a long time. Have you ever done something like this, which involved introducing a new product, and educational campaign, and research?
3. Can you tell me about how the whole Impossible project was introduced on your end?
4. Excluding the marketing piece, what did it take on your end to launch the new menu items?
5. Had you worked directly with [nutrition education coordinator, sustainability manager] or others before this?
6. In your view, what motivated [high-level leaders] to do this project?
7. To what extent do you think the project was successful?
    a. Why do you think this was the case?
    b. Any unexpected outcomes or surprises?
8. Talking a bit more about the marketing piece…there are a lot of things I learned and have noted about the process, but I'm also interested in your take on how things could have been improved?
9. Do you have any comments about how the research has been conducted and/or could be improved in the future?
10. Anything else you would like to add?

Sustainability Manager, Residential Life, H&HS

(December 2019)

1. Please tell me about your role as Nutrition Education Coordinator at UCLA.
    a. What, if any, working groups or other committees are you involved with?
2. In your view, what motivated [high-level leaders] to do this project?
3. Had you worked directly with [nutrition education coordinator, general manager] or others before this?
4. For me, it was challenging in the beginning to figure out who to talk to and how to effectively work with the team up here. If we were to do this again, how do you think that could have been improved?

5. To what extent do you think the project was successful?
    a. Why do you think this was the case?
    b. Any unexpected outcomes or surprises?
6. If you could make any changes at UCLA Dining to achieve healthier, more sustainable diets, what you it entail?
7. Concerning the research, what outcomes or findings are most valuable to you in your role as Sustainability Manager?
8. Do you think other campuses could do something like this? Why or why not?
9. Anything else you would like to add?

<u>Nutrition Education Coordinator, H&HS – Dining Services</u>

(December 2019)

1. Please tell me about your role as Nutrition Education Coordinator at UCLA.
    a. What, if any, working groups or other committees are you involved with?
    b. How long has sustainability or climate change been part of the work you are doing?
2. In your view, what motivated [high-level leaders] to do this project?
3. Had you worked directly with [sustainability mananger, general manager] or others before this?
    a. What was it like to collaborate with different partners outside your usual day-to-day operations?
4. For me, it was challenging in the beginning to figure out who to talk to and how to effectively work with the team up here. If we were to do this again, how do you think that could have been improved?
5. To what extent do you think the project was successful?
    a. Why do you think this was the case?
    b. Any unexpected outcomes or surprises?
6. If you could make any changes at UCLA Dining to achieve healthier, more sustainable diets, what you it entail?
7. Can we talk about more about plant-based meat alternatives like Impossible and how you think they can fit into efforts to shift diets to be healthier and more sustainable?
8. Do you think other campuses could do something like this? Why or why not?
9. You played a huge role in shaping the project, and now these efforts are expanding!
    a. Can you tell me more about what you're working on now?
10. Anything else you would like to add?

Appendix IV. Healthy reference diet carbon footprint calculations, Food Label Toolkit, Version 1, Leach et al. (2018)

	Nutritional information					Footprint factors			Healthy diet footprints		
	Grams per day	kcal / kg food	kcal / day	g protein / g food	g protein / day	Carbon			Carbon (kg CO2-eq)		
	2200 calorie diet	*USDA*	*USDA*	*USDA*	*USDA*	*kg CO_2 eq / kg product*	*kg CO_2 eq / 1,000*	*kg CO_2 eq / kg protein*	*/kg product*	*/1,000 kcal*	*/kg protein*
Animal Products											
Chicken	40	1964	79	0.17	7.0	5.1	2.6	29.0	0.20	0.20	0.20
Pork	20	2540	51	0.18	3.5	6.9	2.7	38.9	0.14	0.14	0.14
Beef	20	2341	47	0.18	3.6	26.5	11.3	145.2	0.53	0.53	0.53
Milk	280	2426	679	0.04	11.1	1.3	0.6	33.9	0.38	0.38	0.38
Cheese	30	3324	100	0.19	5.6	9.8	2.9	52.0	0.29	0.29	0.29
Eggs	30	1098	33	0.12	3.5	3.5	3.2	30.5	0.11	0.11	0.11
Fish	30	1088	33	0.18	5.4	3.8	3.5	21.3	0.11	0.11	0.11
Vegetable Products											
Grains	120	3383	406	0.09	11.1	0.6	0.2	6.3	0.07	0.07	0.07
Rice	40	3600	144	0.07	2.6	1.1	0.3	17.2	0.05	0.05	0.05
Fruits	220	766	169	0.00	1.1	0.4	0.5	74.3	0.08	0.08	0.08
Beans	40	1343	54	0.09	3.6	0.8	0.6	8.7	0.03	0.03	0.03
Potatoes	100	1544	154	0.02	2.2	0.2	0.1	9.4	0.02	0.02	0.02
Vegetables	200	461	92	0.02	3.5	0.7	1.6	41.2	0.15	0.15	0.15
Nuts	10	5798	58	0.19	1.9	1.2	0.2	6.3	0.01	0.01	0.01
Oils	20	6776	136	0.00	0.1	1.6	0.2	0.0	0.03	0.03	0.03
Total	**1200**		**2233**		**66**				**2.2**	**2.2**	**2.2**
Units									*kg CO_2-eq*	*kg CO_2-eq*	*kg CO_2-eq*
		Guidelines:	**2200**		**46-56**						
Source: USDA 2010 Dietary Guidelines											

Appendix V. Rendezvous West customer survey questionnaire

RENDEZVOUS IMPOSSIBLE™ SURVEY: YES

1) How often do you eat at Rendezvous West?
- ❑ Less than once a month
- ❑ 1-3 times a month
- ❑ 1-3 times a week
- ❑ 4-6 times a week
- ❑ At least once a day

2) Have you tried the Impossible™ burger, Beyond Meat™, or similar products anywhere other than Rendezvous West?
- ❑ No
- ❑ Yes (please specify): ____

3) Which menu items have you tried with Impossible™ meat Rendezvous West? Select all that apply:
- ❑ Impossible™ California Burrito
- ❑ Impossible™ build-your-own entree (burrito, bowl, tacos, salad)
- ❑ Other (please specify): ____

4) Approximately how many times have you eaten Impossible™ meat at Rendezvous West? Provide your best guess:
- ❑ Only once
- ❑ 2-5 times
- ❑ 6-10 times
- ❑ More than 10 times

5) How many of your friends have tried Impossible™ meat? Please provide your best guess:
- ❑ None
- ❑ Some
- ❑ Most

6) Please tell us what you like or dislike, if anything, about Impossible™ meat at Rendezvous West:

Like: ____

Dislike:____

7) Please indicate the extent to which you disagree or agree with the following statements about Impossible™ meat:

	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree
Impossible™ meat is delicious	o	o	o	o	o
Impossible™ meat has a smaller carbon foodprint than animal meat	o	o	o	o	o
Impossible™ meat is a healthy option	o	o	o	o	o
Impossible™ meat is a satisfying alternative to animal meat	o	o	o	o	o
I would like Rendezvous West to continue serving Impossible™ meat	o	o	o	o	o

PLEASE TURN OVER

8) Please indicate how often you have eaten each of the following since the beginning of Fall Quarter:

	Never	Less than once/month	1-3 times/month	Once per week	2-4 times/week	5-6 times/week	At least once per day
Beef	o	o	o	o	o	o	o
Pork	o	o	o	o	o	o	o
Poultry	o	o	o	o	o	o	o
Fish/Seafood	o	o	o	o	o	o	o

9) Compared to other things in your life, please indicate the importance of:

	Unimportant	Slightly important	Moderately important	Important	Very important
Eating a healthful diet	o	o	o	o	o
Animal rights	o	o	o	o	o
Climate change	o	o	o	o	o

10) With which gender do you identify?

- ❑ Female
- ❑ Male
- ❑ Other (please specify): ________________________________

11) What is your year in school?

- ❑ First
- ❑ Second
- ❑ Third or higher

12) What is your race/ethnicity? Please check one:

- ❑ East Asian; East Asian-American (please specify): ____________________
- ❑ South Asian; South Asian-American (please specify):___________________
- ❑ Black; African-American
- ❑ Hispanic; Latinx
- ❑ Native American / Native Pacific Islander / Native Alaskan
- ❑ White; Caucasian
- ❑ Other (please specify): ________________________________

13) Any other comments? ____

____

THANK YOU!

RENDEZVOUS IMPOSSIBLE™ SURVEY: NO

1) How often do you eat at Rendezvous West?

- ❑ Less than once a month
- ❑ 1-3 times a month
- ❑ 1-3 times a week
- ❑ 4-6 times a week
- ❑ At least once a day

2) What do you most often order at Rendezvous West (please list one item)?____

3) Have you heard about the brand Impossible™ Foods?

- ❑ No
- ❑ Yes, please specify: → Where? ____

→ What did you hear? ____

4) Have you tried the Impossible™ burger, Beyond Meat™, or similar products anywhere other than Rendezvous West?

- ❑ No
- ❑ Yes (please specify): ____

5) How many of your friends have tried Impossible™ meat? Please provide your best guess:

- ❑ None
- ❑ Some
- ❑ Most

6) Why haven't you tried Impossible™ meat at Rendezvous West? Select all that apply:

- ❑ Tried elsewhere and didn't like it
- ❑ Heard bad things (please specify): ____
- ❑ Unfamiliar/Not sure what it is
- ❑ Not willing to spend a swipe on it
- ❑ Allergy
- ❑ Other (please specify): ____

7) Please indicate the extent to which you disagree or agree with the following statements about Impossible™ meat:

	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree
Impossible™ meat is delicious	o	o	o	o	o
Impossible™ meat has a smaller carbon footprint than animal meat	o	o	o	o	o
Impossible™ meat is a healthy option	o	o	o	o	o
Impossible™ meat is a satisfying alternative to animal meat	o	o	o	o	o
I would like Rendezvous West to continue serving Impossible™ meat	o	o	o	o	o

PLEASE TURN OVER

8) Please indicate how often you have eaten each of the following since the beginning of Fall Quarter:

	Never	Less than once/month	1-3 times/month	Once per week	2-4 times/week	5-6 times/week	At least once per day
Beef	o	o	o	o	o	o	o
Pork	o	o	o	o	o	o	o
Poultry	o	o	o	o	o	o	o
Fish/Seafood	o	o	o	o	o	o	o

9) Compared to other things in your life, please indicate the importance of:

	Unimportant	Slightly important	Moderately important	Important	Very important
Eating a healthful diet	o	o	o	o	o
Animal rights	o	o	o	o	o
Climate change	o	o	o	o	o

10) With which gender do you identify?
- ❑ Female
- ❑ Male
- ❑ Other (please specify): ______________________________

11) What is your year in school?
- ❑ First
- ❑ Second
- ❑ Third or higher

12) What is your race/ethnicity? Please check one:
- ❑ East Asian; East Asian-American (please specify): ___________________
- ❑ South Asian; South Asian-American (please specify):__________________
- ❑ Black; African-American
- ❑ Hispanic; Latinx
- ❑ Native American / Native Pacific Islander / Native Alaskan
- ❑ White; Caucasian
- ❑ Other (please specify): ______________________________

13) Any other comments? ____

____

THANK YOU!

Appendix VI. Study three information sheet and questionnaire

STUDY SESSIONS INSTRUCTIONS

1

This study consists of multiple tasks.

Please read each question carefully and respond with your initial, or gut reaction.

There are no right or wrong answers. We are simply interested in your own preferences and opinions.

[GO TO NEXT SCREEN]

***NEW* UCLA DINING PRE-ORDER SERVICE**

UCLA Dining is in the early stages of testing a new online pre-ordering service for students and staff.

This service would allow customers to pre-order one of two daily specials and skip the line when they pick up their order.

To maintain efficiency of operations, two specials are available for pre-order online. All other dishes must be ordered in the restaurant.

For this study task, you are asked to imagine that you are choosing between the following two specials shown on the following screen page. Please read the descriptions of the two specials: [Press click]

[GO TO NEXT SCREEN]

AD (1)

[GO TO NEXT SCREEN]

---

1. If you had to choose one, which dish would you order?

- ☐ Roasted Cauliflower and Lentil Tacos
- ☐ Chicken Enchiladas

2. Please tell us the main reasons you chose this dish: [open-ended]

____

____

____

3. How much do you think you would enjoy eating this dish?

Not at all Very Much

1 2 3 4 5 6 7

[GO TO NEXT SCREEN]

---

1. How would you rate the healthiness of the Chicken Enchiladas?

Not at all healthy Very healthy

1 2 3 4 5 6 7

2. How would you rate the healthiness of the Roasted Cauliflower and Lentil Tacos?

Not at all healthy Very healthy

1 2 3 4 5 6 7

3. How would you rate the environmental sustainability of the Chicken Enchiladas?

Not at all sustainable Very sustainable

1 2 3 4 5 6 7

4. How would you rate the environmental sustainability of the Roasted Cauliflower and Lentil Tacos

Not at all sustainable Very sustainable

1 2 3 4 5 6 7

[GO TO NEXT SCREEN]

---

1. To what extent do you think **plant-based** foods are healthier than **meat-based** foods?

Not at all Very much so

1 2 3 4 5 6 7

2. To what extent do you think **plant-based** foods more environmentally-sustainable than **meat-based** foods?

Not at all Very much so

1 2 3 4 5 6 7

[GO TO NEXT SCREEN]

---

1. UCLA Dining is currently looking to expand our menu and would like your input on a new product on the market. Please tell us what you have heard about Impossible™ meat: [open-ended]

2a. Have you ever tried Impossible™ meat? Yes No

2b. If you answered "No", how **interested** are you in trying Impossible™ meat?

Not at all Very much so

1 2 3 4 5 6 7

[GO TO NEXT SCREEN]

UCLA NEWSROOM FEEDBACK

We are interested in your opinion of UCLA Newsroom content. For this study task, please read a recent Newsroom article and provide your feedback.

[GO TO NEXT SCREEN]

As internet turns 50, speakers look to the ‘possibilities of tomorrow’

UCLA Newsroom | October 30, 2019

From its humble origins as a message that cut off too early to a network of computers and devices that instantaneously connects billions of people around the world, the internet has come a long way in its 50 years.

In honor of the birth of the technology that has completely remade modern life, a who’s who of technologists, thinkers, activists, engineers and executives gathered in front of a sold-out crowd at UCLA’s iconic Royce Hall Oct. 29 to celebrate the internet’s achievements and take a hard look at how our technological interconnectedness can be made safer, more secure and a tool to help create a more just world.

During the day-long event, called Internet 50: From Founders to Futurists, Los Angeles Mayor Eric Garcetti presented UCLA’s Leonard Kleinrock with a key to the city. A team led by Kleinrock, distinguished professor of computer science at the UCLA Samueli School of Engineering, sent the first message over the Arpanet — the precursor to today’s internet. On the evening of Oct. 29, 1969, the researchers began to transmit the command “LOGIN” from their workstation in room 3420 of UCLA’s Boelter Hall to a terminal at Stanford Research Institute. The system crashed, but not before the first two letters, “LO,” had been sent. Soon after, the network was restored, the intended message was transmitted in its entirety and a new connected era was born.

[GO TO NEXT SCREEN]

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1. Please rate the interestingness of this article.

Not at all interesting — Very interesting

1 2 3 4 5 6 7

[GO TO NEXT SCREEN]

DIETARY BACKGROUND SURVEY

1. How often do you usually eat fruits and vegetables?

	Rarely or Never	**1-3 times per month**	**Once per week**	**2-4 times/week**	**5-6 times/week**	**Once per day**	**More than once per day**
Fruits (e.g. bananas, apples, oranges, berries, etc.)							
100% fruit juices							
Green & leafy vegetables (e.g. lettuce, broccoli, bok choy, etc.)							
Other vegetables (e.g. carrots, cauliflower, corn, potatoes NOT including French fries)							
Beans and peas (e.g. black, pinto, lentils, chickpeas)							

2. How often do you usually eat these protein foods?

	Rarely or Never	1-3 times/month	Once per week	2-4 times/week	5-6 times/week	Once per day	More than once per day
Beef							
Lamb							
Pork							
Poultry							
Fish (seafood)							

[GO TO NEXT SCREEN]

ATTITUDE SURVEY

Please indicate the extent to which you disagree or agree with each of the following statements:

1. I am very concerned about the environment.

Disagree Neither Agree

1 2 3 4 5

2. Humans are severely abusing the environment.

Disagree Neither Agree

1 2 3 4 5

3. I would be willing to reduce my consumption to help protect the environment.

Disagree Neither Agree

1 2 3 4 5

4. Major social changes are necessary to protect the natural environment.

Disagree Neither Agree

1 2 3 4 5

[GO TO NEXT SCREEN]

Please indicate the extent to which you disagree or agree with each of the following statements:

1. It is natural to eat meat.

Disagree Neither Agree

1 2 3 4 5

2. It is necessary to eat meat in order to be healthy.

Disagree Neither Agree

1 2 3 4 5

3. Most people eat meat.

Disagree Neither Agree

1 2 3 4 5

4. Meat is delicious.

Disagree Neither Agree

1 2 3 4 5

5. It is normal to eat meat.

Disagree Neither Agree

1 2 3 4 5

6. It is unnatural to eat a completely plant-based diet.

Disagree		Neither		Agree
1	2	3	4	5

7. Meals without meat would be bland and boring.

Disagree		Neither		Agree
1	2	3	4	5

8. A healthy diet requires at least some meat.

Disagree		Neither		Agree
1	2	3	4	5

[GO TO NEXT SCREEN]

HEALTH BACKGROUND QUESTIONS

Please indicate the extent to which you disagree or agree with each of the following statements:

1. Healthy eating is very important to me.

Disagree		Neither		Agree
1	2	3	4	5

2. I am very concerned about the health-related consequences of what I eat.

Disagree		Neither		Agree
1	2	3	4	5

3. Which of the following best describes your diet?

- ☐ Vegan (I do not eat animal products like poultry, meat, seafood, eggs, or dairy)
- ☐ Vegetarian (I eat eggs and/or dairy, but no poultry, meat, or seafood)
- ☐ Pescatarian (I eat eggs, dairy, and/or seafood, but no poultry or meat)
- ☐ I avoid foods with gluten
- ☐ I have a special diet for religious or philosophical reasons (please specify: ________________________)
- ☐ I have a special diet for medical reasons (please specify: ________________________)
- ☐ I have no special diet
- ☐ Other (please specify: __________________________________)

4. Describe the types of exercise you engage in every week:
- ☐ I exercise intensely at least 5 days a week
- ☐ I exercise moderately
- ☐ I am active, but do not engage in deliberate exercise
- ☐ I am not very active

5. What is your weight? __________ lbs.

6. What is your height? __________ ft. __________ in.

[GO TO NEXT SCREEN]

DEMOGRAPHIC QUESTIONS

1. With which **gender** do you identify?
- ☐ Female
- ☐ Male
- ☐ Other (please specify): ________________________________

2. What is your **age**? __________

3. What is your **UCLA affiliation**?
- ☐ Undergraduate student
- ☐ Graduate student
- ☐ Staff
- ☐ Neither

4. What is your **race/ethnicity**? Please check one.
- ☐ East Asian; East Asian-American (please specify____________________)
- ☐ South Asian; South Asian-American (please specify____________________)
- ☐ Black; African-American
- ☐ Hispanic; Latino
- ☐ Native American / Native Pacific Islander / Native Alaskan
- ☐ White; Caucasian
- ☐ Other (please specify_______________________)

5. What is your annual household (family) income (in U.S. dollars)?

- ☐ 0–24,999
- ☐ 25,000–49,999
- ☐ 50,000–74,999
- ☐ 75,000–99,999
- ☐ 100,000–149,999
- ☐ 150,000–199,999
- ☐ 200,000-299,999
- ☐ 300,000 +
- ☐ Not sure/Decline to answer

6. Circle the number that best corresponds to your views:

Right-wing orientation Centrist Left-wing orientation

-4 -3 -2 -1 0 1 2 3 4

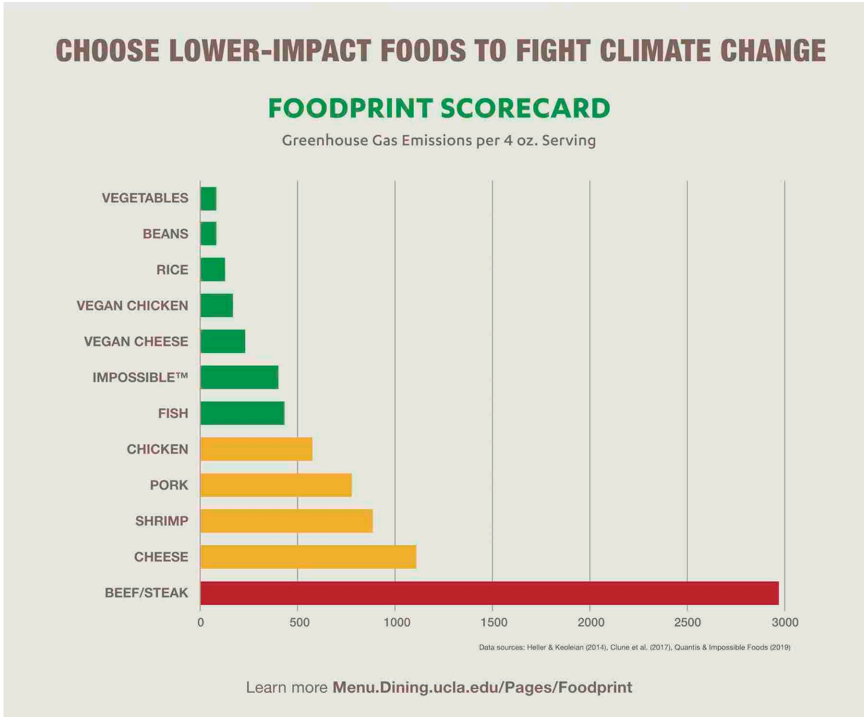
7. Please rate how well the following statement describes **you: "**I go to a place of worship regularly."

1 2 3 4 5 6 7

Not at all *Very Much So*

[GO TO NEXT SCREEN]

Appendix VII. Impossible™ Foodprint Project creative assets




IMPOSSIBLE™ CALIFORNIA BURRITO
IMPOSSIBLE™ FOOD PRINT PROJECT
SWAP THE STEAK. SAVE THE PLANET.
CO2
CO2
IMPOSSIBLE™
CO2
ONE CALIFORNIA STEAK BURRITO HAS 4x THE CARBON FOODPRINT OF A CALIFORNIA IMPOSSIBLE™ BURRITO.


POTATO ENCHILADAS
IMPOSSIBLE™ FOOD PRINT PROJECT
JOIN THE CLIMATE CHANGE FOOD FIGHT.
Try Low Carbon Foodprint menu items. Look for the logo!
Low Carbon Foodprint

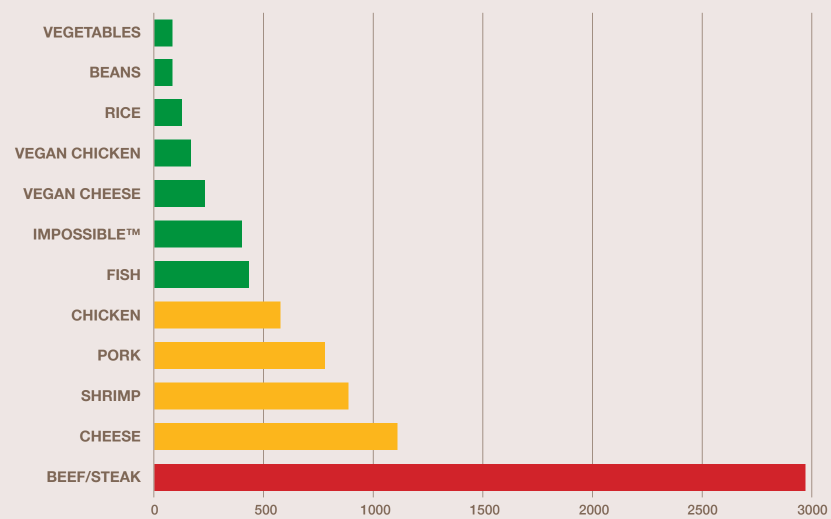
IMPOSSIBLE™ FOOD PRINT PROJECT

CHOOSE LOWER-IMPACT FOODS.
FIGHT CLIMATE CHANGE.

Livestock is a major contributor to climate change, responsible for 14.5% of global greenhouse gas emissions.[1] That's more than the entire transportation sector.[2]

FOODPRINT SCORECARD

Greenhouse Gas Emissions per 4 oz. Serving



Data Sources: Heller & Keoleian (2014), Clune et al. (2017), Quantis & Impossible Foods (2019)

Studies indicate that *reducing*—rather than eliminating—meat and dairy intake (especially beef) is a viable strategy for mitigating greenhouse gas emissions within safe limits.[3,4]

Learn more **Menu.Dining.ucla.edu/Pages/Foodprint**

1. United Nations Intergovernmental Panel on Climate Change (IPCC) – IPCC Climate Change and Land Report (2019)
2. Food and Agriculture Organization of the United Nations (FAO), GHG emissions by livestock
3. Springmann, M., Clark, M., Mason-D'Croz, D., Wiebe, K., Bodirsky, B. L., Lassaletta, L., ... & Jonell, M. (2018). Options for keeping the food system within environmental limits. Nature, 562(7728), 519.
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IMPOSSIBLE™ FOOD PRINT PROJECT

SWAP THE MEAT. SAVE THE PLANET.

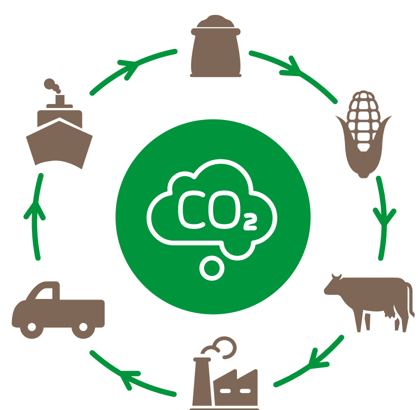
1 BEEF BURRITO HAS THE SAME FOODPRINT AS ABOUT **10 VEGGIE BURRITOS.**

1 beef burrito with cheese, sour cream, and rice (3,493 grams C02-equivalent)
1 veggie burrito with beans, guacamole, and rice (355 grams C02-equivalent)

Data Source: Heller & Keoleian (2014)

WHAT IS A FOODPRINT?

- The carbon footprint of food—i.e. *foodprint*—includes every step in the growing, harvesting, processing, and distributing of food around the world.
- Each step involves using resources and releasing greenhouse gases, which are quantified in carbon-equivalent units (CO2-eq).
- Clearing forests, raising livestock, and using fossil fuels for fertilizers and machinery contribute a large share of emissions in the food system.[5]



WHY DOES BEEF HAVE SUCH A BIG FOODPRINT?

- Growing and transporting food to feed livestock requires many more resources than eating food directly.
- Cows produce methane (mostly by burping) and nitrous oxide (from manure)—greenhouse gases 56x and 280x more potent than CO2, respectively.[6]

5. United Nations Intergovernmental Panel on Climate Change (IPCC) – IPCC Climate Change and Land Report (2019)
6. EAT-Lancet Commission – Summary Report of the EAT-Lancet (2019)

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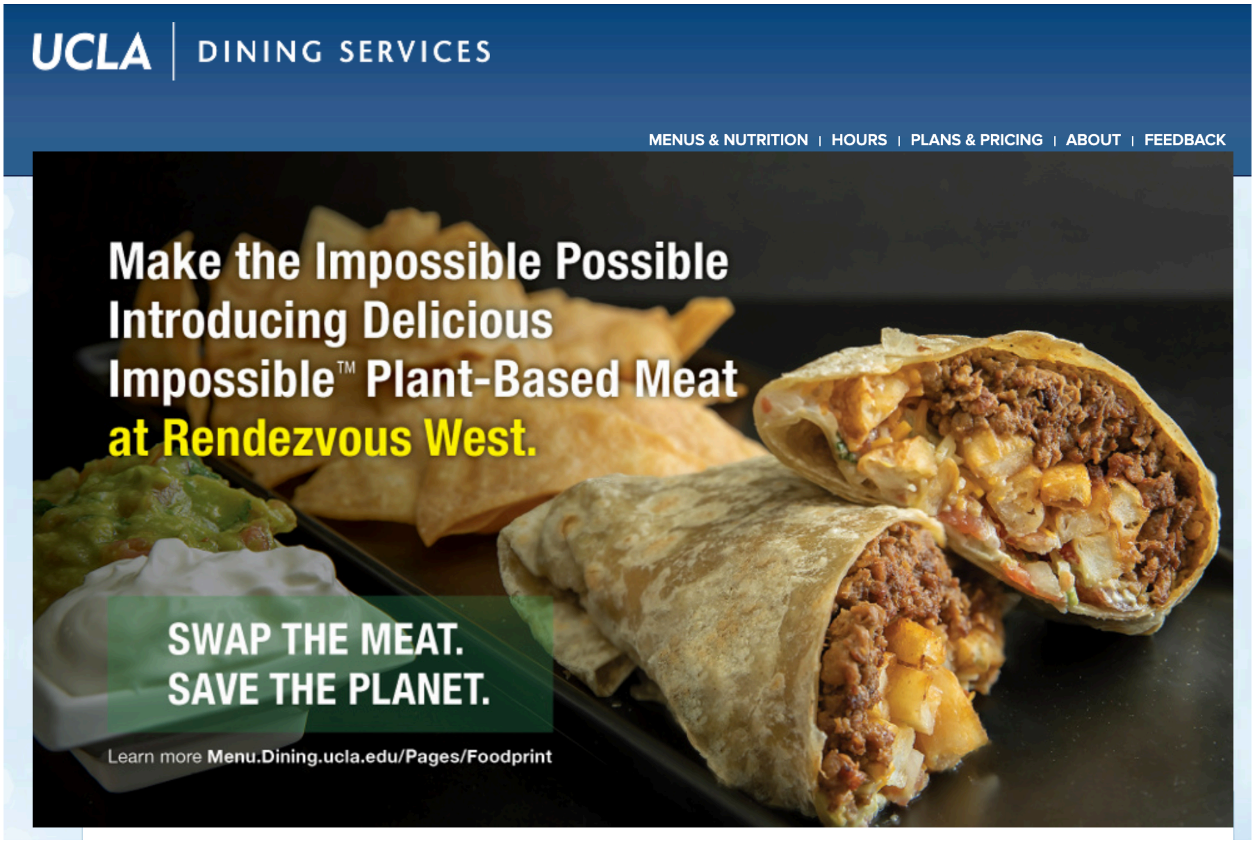
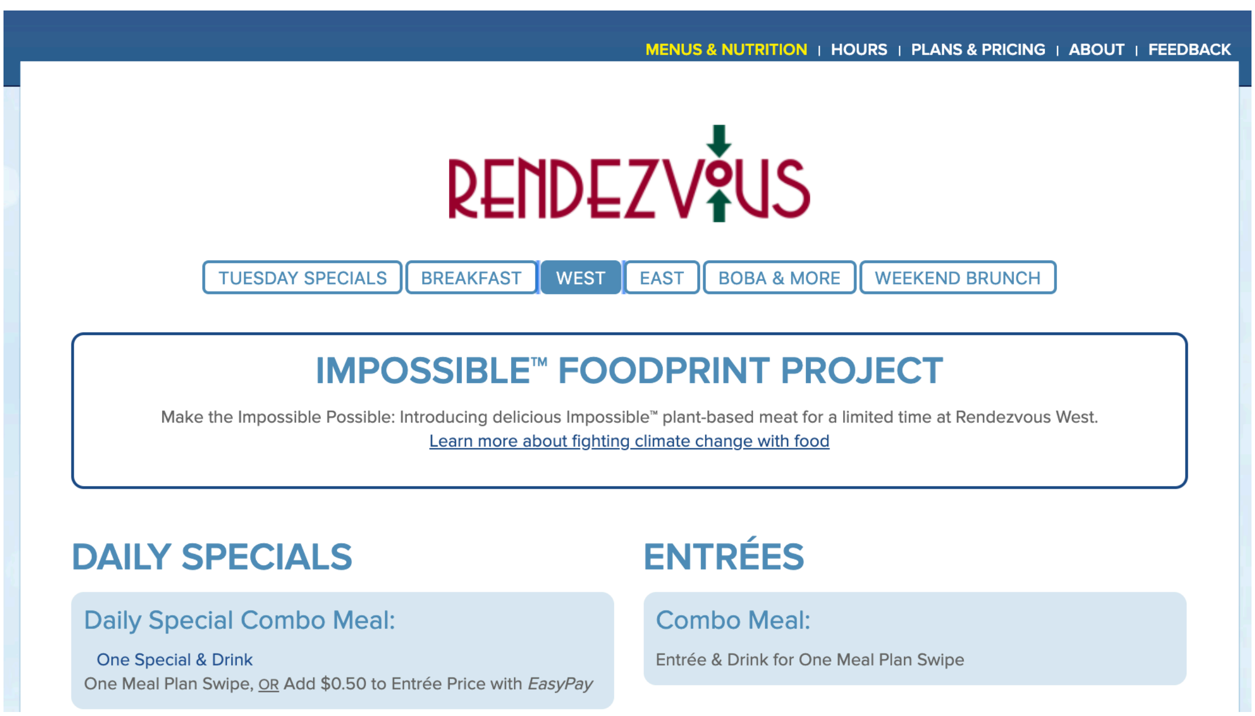
Appendix VIII. Impossible™ Foodprint Project online materials





California Impossible™ Burrito

Plant-Based Impossible™ Taco Meat, French Fries, Pico De Gallo, Sour Cream, Gucamole, and Cheddar & Jack Cheeses wrapped in a Cilantro Tortilla. Served with Tortilla Chips.

$10.00

Legend

Powered by FoodPro®

- Vegetarian Menu Option
- Vegan Menu Option
- Contains Peanuts
- Contains Tree Nuts
- Contains Wheat
- Contains Gluten
- Contains Soy
- Contains Dairy
- Contains Eggs
- Contains Crustacean Shellfish
- Contains Fish
- Halal Menu Option
- Low Carbon Foodprint

Low Carbon Foodprint

Minimize your foodprint

Minimizing the carbon footprint of your food—i.e. your *foodprint*—can make a meaningful impact on climate change and our planet. A foodprint includes every step in a food's life cycle—the growing, harvesting, processing, and distributing of food around the world. Each step involves using resources and releasing greenhouse gases, which are quantified in carbon-equivalent units (CO2-eq).[4] Clearing forests, raising livestock, and using fossil fuels for fertilizers and machinery contribute a large share of emissions in the food system.[1]

In general, animal-based foods have a larger footprint than plant-based foods. That's because growing food to feed animals requires many more resources than eating food directly. Plus, ruminant animals like cows produce methane (mostly by burping) and nitrous oxide (from manure), greenhouse gases 56x and 280x more potent than CO2, respectively.[1,5]

Reducing your meat and dairy intake is an impactful way to minimize your foodprint—especially if you're a big meat eater. In fact, studies modeling a variety of climate change mitigation strategies indicate that shifts to diets with **less** meat and dairy—and **much less** beef—are *crucial* for mitigating greenhouse gas emissions within safe limits.[5,6,7]

In short, lower foodprint diets follow a "Flexitarian" pattern—with **more** plant foods, such as fruits, vegetables, nuts, and legumes; **less** meat, dairy, and sugar; and **much less** beef.[1,5,6,7]

Impossible™ Foodprint Project

If you want to minimize your foodprint, we want to help. That's why we're introducing the Impossible™ Foodprint Project, along with Impossible™ plant-based meat—a delicious new option for meat lovers. We teamed up with campus researchers to provide data from life cycle assessments (LCAs) on the foodprint of our menu options. Our goal is to deliver delicious options and science-based transparency so you can choose what works for you.

In fall 2019, a pilot of the Impossible™ Foodprint Project will launch at one of our most popular quick-service restaurants, Rendezvous West. We'll study how students respond—and we'll measure changes in the foodprint of the meals we serve.

Appendix. IX. Carbon footprint labeling guidelines and scorecard, developed as a result of Impossible™ Foodprint Project

Carbon Footprint Labeling Guidelines, UCLA Dining and Malan et al. (2020)	
Low Carbon Footprint	**Notes**
Vegan	
Vegetarian AND Cheese ≤ 1.5oz	1.5 oz cheese = 24% DV Carbon Footprint
Eggs ≤ 2 OR Liquid Eggs ≤ 4oz	4oz eggs = 23% DV Carbon Footprint; 1 large egg = 2oz
Mollusks ≤ 8oz	Clams, mussels, oysters, scallops
Fin Fish ≤ 4oz	All UCLA purchases of listed fin fish species are certified sustainable and using low carbon footprint methods (e.g., pond aquaculture)
High Carbon Footprint	**Notes**
Beef	
Lamb	
Any Dish with Cheese ≥ 3.5 oz	3.5 oz cheese = 55% DV Carbon Footprint
Note: Calculations provided in Carbon Footprint Labeling Scorecard and Planetary Health Diet Carbon Footprint Calculations spreadsheets to follow	

Carbon Footprint Labeling Scorecard, UCLA Dining and Malan et al. (2020)					
Food Item	**g CO_2 - eq/g product**	**Carbon Footprint 1oz***	**%DV* 1oz**	**Carbon Footprint 4oz**	**%DV 4oz**
Beef	26.5	749.86	42%	2999.43	169%
Lamb	22.9	649.22	36%	2596.86	146%
Cheese (3.5 oz)	9.8	277.26	16%	970.42	55%
Shrimp	7.8	221.13	12%	884.52	50%
Pork	6.9	194.76	11%	779.06	44%
Poultry (chicken and turkey)	5.1	143.17	8%	572.67	32%
Yogurt (8 oz)*	2.0	56.70	3%	490	28%
Eggs	3.5	100.36	6%	401.44	23%
Impossible plant-based meat™	3.5	99.23	6%	396.90	22%
Salmon	3.1	87.32	5%	349.27	20%
Other pelagic fish	2.5	71.44	4%	285.77	16%
Mollusks	2.0	56.70	3%	226.80	13%
Plant-based cheese	2.0	56.70	3%	226.80	13%
Plant-based chicken	1.5	42.53	2%	170.10	10%
Nuts	1.2	33.17	2%	132.68	7%
Rice	1.1	32.32	2%	129.28	7%
Beans and legumes (includes soy)	0.8	22.11	1%	88.45	5%
Vegetables	0.7	20.70	1%	82.78	5%
Fruits	0.4	10.32	1%	41.28	2%

Red: > 50% DV
Yellow: 26-50% DV
Green: 0-25% DV
***28.35 grams per ounce**
***100% daily value (DV) Planetary Health Diet = 1780 g CO_2-eq (Willett et al., 2019)**

Planetary Health Diet Carbon Footprint Calculations based on Willett et al. (2019)							
Food group	**g CO_2-eq/g**	**midpoint g/day**	**oz/ day**	**oz/ week**	**kcal/ day**	**kcal/g**	**g CO_2-eq/day**
Whole grains	1.25	232	8.18	57.28	811	3.50	290
Starchy veg	0.21	50	1.76	12.35	39	0.78	11
Vegetables	0.73	300	10.58	74.08	78	0.26	219
Fruits	0.36	200	7.05	49.38	126	0.63	72
Dairy (using whole milk)	1.34	250	8.82	61.73	153	0.61	335
Beef, lamb, and pork	14.37	14	0.49	3.46	30	2.14	201
Chicken and other poultry	5.05	29	1.02	7.16	62	2.14	146
Eggs	3.54	13	0.46	3.21	19	1.46	46
Fish	3.83	28	0.99	6.91	40	1.43	107
Legumes	0.78	75	2.65	18.52	284	3.79	59
Nuts	1.17	50	1.76	12.35	291	5.82	59
Added unsaturated oils	1.63	40	1.41	9.88	354	8.85	65
Added saturated oils	11.92	11.8	0.42	2.91	96	8.14	141
All sugars	0.96	31	1.09	7.65	120	3.87	30
Total diet					**2503**		**1780**

Appendix. X. Study Two logistic regression models for difference-in-difference analyses

Table 44. Study Two logistic regression models for difference-in-difference analyses, UCLA Dining, Fall 2018 and 2019 (n=645,822)

	Odds Ratios				
	Animal-Based	Red Meat	Low-Impact	Medium-Impact	High-Impact
Study Site					
Rendezvous West	Ref	Ref	Ref	Ref	Ref
Bruin Cafe	0.75***	0.57***	1.13***	2.20***	0.33***
Rendezvous East	0.86***	0.53***	1.95***	1.72***	0.26***
Prepost					
Pre	Ref	Ref	Ref	Ref	Ref
Post	0.64***	0.86***	1.74***	0.84***	0.87***
Site*Prepost					
Bruin Café*Post	1.46***	1.00†	0.65***	1.16***	1.05**
Rendezvous East*Post	1.82***	1.23***	0.43***	1.44***	1.22***
Constant	4.92***	0.81***	0.16***	1.02*	0.56***
Pseudo R^2	0.01	0.01	0.01	0.03	0.06
Chi^2	3323***	10860***	5715***	24349***	38003***

***p<0.001, **p<0.01
†Not significant
Note: Study site coefficients compare odds of outcome at baseline; Post coefficient indicates change in odds of outcome at Rendezvous West (intervention site) from pre to post; Site*Prepost indicates difference in change from pre to post, compared to Rendezvous West

Appendix. XI. Customer survey open-ended “Other” responses to why haven’t tried Impossible™ at Rendezvous West (“No” participants only)

I prefer other meat options (steak, chicken)
I like chicken
haven't felt full after eating Impossible meat
I like steak
Other Preferences
don't really eat meat
I like meat
Still going to
never really cared to try it, but might try it now
not interested/forget
I really really like the chicken quesadilla
Protein concerns? Nutrition
Don't like texture bec. seems meaty & I'm veg
vegetarian so not keen on eating it
line too long
I like meat more
I prefer real meat
just haven't gotten to it
only available once/week
scared to try new things
not sure if it'll help gain weight, I wanna gain.
doesn't have the carbs I need
I would rather have other things
People in front of me order the Cali Steak Burrito, not the Cali Impossible Burrito
It's not meat...call it something else (ex: possible not-meat)
Prefer eating at Rende East!
I like chicken/beef more
just don't want
It's good, I just prefer chicken
Haven't had the chance
Not interested
Don't live on hill and swipes are expensive
Not real meat
Not interested
I just haven't yet
I haven't felt like it yet

no desire, but it's a cool option for people to want to eat meat
Haven't had the chance!
I LOVE Meat
I don't eat meat
really like chicken bowl
prefer other options
I like veggies more, I don't like meat
I like chicken
other vegetarian options
It's not available in the items I like
willing I haven't yet
I like meat
the smell of meat/looking at it in my food makes me sick (vegetarian)
Too lazy to say many words

Appendix. XII. Customer survey open-ended responses to what participants "Like" and "Dislike" about Impossible™ at Rendezvous West ("Yes" participants only)

Like	Dislike
tastes pretty good	
Impossible meat has a great texture and taste and I feel good after eating it	Nothing really!
good alternative	could have more flavor
tastes pretty good	
it tastes like meat	apparently it has a lot of fat and salt
Better for environment, good seasoning, doesn't taste "fake"	From what I understand, less healthy (in some regards) than REAL meat
it tastes like real meat	
It tastes good! Like better than I expected!	It needs to be mixed in with other food to not be noticeable
That it is a good alternative to animal meat	
Good taste, low carbon footprint	
Pretty spot on meat replacement	
the flavor is good	
sustainability yay	I want impossible nachos!
good for environment	doesn't taste as good as real meat
Environmentally Friendly	
tastes like real meat	
tastes like meat	
tastes similar to real meat	
I like that it tastes really close to meat	nothing really
It actually tastes like meat	It's kind of dry
Texture is better than steak	Pricing needs to be lower than steak
I like how it looks, feels, and tastes like meat	Lower protein content than meat
alternative	
It's really good, nice texture	Serving size sometimes?
Kind of tastes like meat	Kind of doesn't [taste like meat]
Environmentally Friendly	Too much seasoning/too salty
the flavor, impact of environment	greasy feel sometimes
Impossible meat is the only thing that I will eat	
The taste is good	Texture is a little weird, low protein compared to steak
I like how it is a healthy alternative	
I liked it; it is a good substitute and I don't feel as bloated	
Tastes good	Not the healthiest
Inclusive	

Flavor, possibly better for environment	consistency is crumbly
Texture is good	too salty, not very healthy necessarily
Taste like meat	
Tastes pretty similar to meat	Nutritionally not the best. Regular meat is probably healthier. (soy product)
The lesser environmental impact idea	Don't like the ground meat texture
A good option for vegans! I like meat replacements that are not tofu.	Needs to be cooked slightly longer usually
Taste, texture	
N/A	N/A
It tastes like meat	
tastes like real meat	too oily
Tastes like meat	Not very juicy
tastes like beef :)	
I like the taste + it's far more sustainable than beef	I've heard it's not the healthiest, + getting veggies is the best option in terms of sustainability
The taste is amazing and it's not very greasy; I love everything	
plant based	still oily + high in sodium
taste, texture, similarity to meat	not very filling
it tastes good, it has a better enviro impact	n/a! :)
Love it, great taste, good addition	Nothing
It has nice flavor and texture	
Delicious!	Could I get it on nachos?
eco-friendly + a lot of options for vegans :)	nothing!
taste great and like that you do not pay extra	
Taste, healthiness, vegan	Texture
its pretty good	its unavailable alot
it's a good option because I'm vegetarian	
flavor	I wish it was in steak chunks instead of grounded
Love it	It scares me how much it tastes like meat
it tastes like real beef and much better carbon footprint	
It tastes good & resembles meat	I can tell it's not real meat
It is really good and not as unhealthy as reg. meat	They don't offer it on nachos :(
non-meat option	not any healthier than regular meat
vegan, tasty	none
vegan, tasty	
good for environment but I don't usually eat red meat	
It is a fairly good meat substitute	It's very greasy

	Too dry
I LOVE IT! The flavor & texture is great!	The small portion
The flavor of it	The consistency
Simulates taste + texture of meat very well	very greasy, kind of salty
nothing in particular	n/a
Tastes good	I do not dislike
I like the idea behind what they're doing w/ the Impossible meat + save the planet!	didn't care for the taste :(
Tasted good	hurt my stomach
The environmental benefits	
non-meat high protein option	
Taste, alt. option	texture, temperature (too cold)
It does taste like meat	The texture does not resemble meat
it tastes pretty good & has a low carbon footprint	n/a
tastes delicious, feels like I'm helping reduce methane emissions :)	nothing
The texture feels genuine	
well cooked and great	
flavor	texture, too mushed up
tastes like real meat	doesn't taste like pork (I like pork)
	I personally do not eat meat so I dislike the taste but I think it's a good alternative to real meat
Tastes good, good replacement	
taste like meat	taste kind of greasy
love it	N/A
LIT. good for the environment	nothing
Tastes good like a 4th meat	
it's lit, and I'm...(can't read)	nothing, it's literally perfect (sometimes [once] they ran out tho)
pretty neutral, flavor was good	didn't love texture
Taste just like meat	nothing
It's healthier, more environmental, and tastes better + vegetarian	
It tastes like red meat	
flavor	texture
environmentally friendly, tastes good, healthy	
The flavor, texture	how it crumbles
It is very similar to the real deal + tastes great	N/A
It's similar to meat + better for the environment	it tastes a little different

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