Sustainable Diets Among Sociodemographically Diverse Populations in the US Before and During the COVID-19 Pandemic

by

Elizabeth Ludwig-Borycz

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Doctoral Committee:

Associate Professor Katherine Bauer, Chair
Associate Professor Ana Baylin
Associate Professor Andrew Jones
Dr. Allison Webster

Elizabeth Ludwig-Borycz

lizzer@umich.edu

ORCID iD: 0000-0002-7682-7587

Dedication

This dissertation is dedicated to my mom, Carol Ludwig, and mother-in-law, Jeanette Borycz.

Thank you for all you have done to encourage me to care for creation.

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Table of Contents

List of Tables

List of Figures

List of Appendices

Abstract

Agriculture is responsible for approximately 25% of greenhouse gas emission (GHGE) globally and is the single largest contributor to climate change. Ensuring Americans eat a sustainable diet, one that provides economic, socio-cultural, and political wellbeing along with flourishing human and ecological health, is essential for mitigating climate change. The aims of this dissertation were to 1) describe the extent to which dietary intake aligns with the human health dimension of sustainable diets through application of the EAT-Lancet Planetary Health Diet (PHD), and identify personal, behavioral, and socio-environmental correlates of the PHD among a socioeconomically and racially/ethnically diverse population-based sample of young adults, 2) identify how recent trends in ecological, economic, human health, and socio-cultural & political dimensions of a sustainable diet were similar or different across diverse US subpopulations from 2019 to 2021, and 3) describe perceived changes among U.S. adults' ecological, economic, human health, and socio-cultural & political dimensions of a sustainable diet within the food environment one year into the COVID-19 pandemic. Results from Aim 1 found that participants' overall PHD score was 4.1 on average on a scale of 0 to 14 with 14 being the most sustainable. While most young adults in the study met the PHD recommended intakes for fruits, vegetables, and added fats, the majority under-consumed whole grains, plant-based proteins, and fish, and overconsumed meat and added sugar. Females, young adults of high socioeconomic status, and those with higher educational attainment consumed diets more aligned with PHD recommendations than their peers. Furthermore, the strongest correlates of meeting the PHD recommendations were greater healthy food availability at home and consuming fast food less often. Results from Aim 2 found that the importance of healthfulness in making food and drink purchasing decisions, purchasing antibiotic-free food, hormone/steroid-free food, and

locally sourced foods declined among a nationally representative sample of Americans. In contrast, consumers' decision to buy foods and beverages based on environmental sustainability and price remained consistent over the years examined and low-income households reported a decrease in the impact of price on buying foods and beverages in 2020 and 2021. Results from Aim 3 found that on average, adults more frequently engaged in behaviors that are supportive of a sustainable diet during the COVID-19 pandemic as compared to before. This is particularly true regarding ecological and economic dimensions, likely in large part due to business closures and social distancing regulations that limited consumer behavior. Looking at the ecological, economic, and human health dimensions through the lens of equity revealed that White and high-income participants were more likely than African American/Black, Hispanic/Latino, or low-income participants to engage in behaviors that are supportive of a sustainable diet with regard to the ecological and economic dimensions during the pandemic, with the exception that African American/Black participants reported large increases in the human health dimension. Overall, this dissertation found that Americans had substandard sustainable diets, particularly with regard to high animal sourced-food (ASF) consumption. Furthermore, low-income participants had a harder time accessing and consuming sustainable diets. Therefore, future research should prioritize determining effective interventions that target high ASF consumers to shift protein intake (e.g., beef) to plant-based proteins and more sustainable ASF (e.g., poultry) with specific attention to low-income households. Additionally, large-scale changes to the food system will help improve the accessibility of sustainable diets to low-income households.

Chapter 1 Introduction

In 2015, the Paris Agreement set the goal to limit global temperature increase to less than 2°C to mitigate the devastating effects of climate change.[1] At present, agriculture is responsible for about 25% of greenhouse gas emissions (GHGE) globally,[2] more than 70% of freshwater use,[3] 80% of deforestation,[4] and is the single largest contributor to biodiversity loss.[5] If these statistics are to be improved in the years to come, it is clear that building and maintaining sustainable food systems will be an integral component to meeting the Paris Agreement goals. A sustainable food system is one that relies on sustainable diets that provide economic, socio-cultural, and political wellbeing along with flourishing human and ecological health.[6]

Sustainable Diets

Sustainability attributes of foods and beverages can be understood through a variety of frameworks, one of which is the food environment framework created by Downs et al.[6] in 2020. It outlined four dimensions of sustainable diets: ecological, economic, human health, and socio-cultural and political. The ecological and economic dimensions support agricultural production systems that promote biodiversity, local and seasonal foods, soil and water conservation, and low GHGE; minimize food loss and waste; and are financially viable for the producer and accessible for the consumer.[6] The human health dimension supports the thriving of human health through plant-based, nutrient-dense foods that meet the macro- and micro-nutrient adequacy of humans.[6] Finally, the socio-cultural and political dimension looks at issues of equity and disparities within the food system.[6] Each of these dimensions is described in more detail in the sections below.

Ecological and Economic Dimension

A review of the literature in combination with Downs et al.'s framework outlines specific behaviors that fit into the ecological and economic dimension. Behaviors that are supportive of a sustainable diet include minimizing grocery store trips, fast-food consumption, ready-made meal consumption, and eating at restaurants.[7–11] More sustainable alternatives include having groceries delivered to the home,[7,8,17,9–16] ordering meal kits,[18] cooking at home,[12–17] shopping for locally grown produce and/or other food,[19,20] shopping at a farmer's market or participating in a CSA (Community Supported Agriculture),[19–21] growing a vegetable garden or participating in a community garden,[19,22–24] making more foods from scratch,[12–17] and decreasing food loss and waste (FLW).[25,26] While evidence supports these behaviors being more sustainable on average, the specific contexts and applications make a difference (e.g., locally grown food may or may not have a smaller GHGEs but they do often provide farmers with greater economic benefit and increase consumer's access to healthy food).

Human Health Dimension

As the prevalence of overweight and obesity has increased beyond two billion globally,[27] another 2 billion individuals remain micronutrient deficient[28] and 821 million individuals are undernourished (habitual insufficient caloric intake).[29] Identifying ways to optimize human health that fit within safe planetary boundaries is imperative both to combat climate change and meet nutritional needs.[30] Globally, nations are working to mitigate climate change and maximize human nutrition by incorporating sustainability into their dietary recommendations. Until recently, there were no universally agreed upon approaches to measure sustainability of the diet,

limiting comparison of diet sustainability across cultures and geography.[31–35] For example, a recent literature review on measurements of sustainable diets found 30 different components of sustainable diets evaluated in research studies.[36] In 2019, the EAT-Lancet Planetary Health Diet (PHD) was created to establish a generalizable metric with which to assess diet sustainability in a manner that simultaneously recognizes the environmental and health impacts of consumption of various food groups (**Figure 1.1**).[37] Overall, as defined by the PHD, sustainable diets are ones that are high in vegetables, fruits, whole grains, legumes, nuts and seeds, and include small amounts of poultry, fish, eggs, and dairy, with little to no added sugar, alcohol, and meat.[37] This metric was developed by experts in the fields of human health, agriculture, political science, and environmental sustainability to help meet the Sustainable Development Goals and Paris Agreement, which allows for feeding an estimated 10 billion people globally by 2050.[37] It was designed to be a culturally adaptable, win-win diet that is healthy for humans and the environment with regards to GHGE, nitrogen and phosphorus application, agricultural water use, biodiversity loss, and cropland use.[38] Notwithstanding, some shortcomings of the diet have been noted; particularly in relation to meeting the nutritional requirements for women of reproductive age in low-to-middle-income countries (LMICs).[39] One proposed solution is to set minimum intake values for all food group categories.[39] Another area of criticism is in relation to the affordability of the PHD. At an average of $2.65 per day, many in LMICs would not be able to afford the PHD.[40] However, for the vast majority of Americans it would be affordable.[40] Even so, many Americans may find the PHD challenging to adopt as it differs from current US dietary patterns.[41]

High-income countries like the US can contribute to reducing GHGE by up to 50% of food-related emissions by changing dietary intake, primarily with regard to animal-sourced food (ASF) consumption.[42] Meat and dairy account for around 15% of global GHGE, thereby reduction and substitution of ASF (particularly ruminant meat) can precipitate substantial positive mitigatory change.[42,43] A recent analysis of the US diet by Rose et al. found that one-fifth of Americans are responsible for 41% of all diet-related GHGE, largely due to greater consumption of meat and dairy.[44] These individuals also had a significantly lower Healthy Eating Index (HEI) score than those in the bottom fifth of GHGE. The HEI is a metric to measure alignment of dietary consumption to the Dietary Guidelines for Americans (DGA). This study highlights the large proportion of GHGE that can be eliminated by reductions in ASF consumption and at the same time make gains in population health. Previous research has also demonstrated the environmental impact of reducing ASF consumption in high-income countries towards vegetarian dietary patterns and found a 35% reduction in GHGE, 42% reduction in land use, 28% reduction in water use, along with population health benefits if omnivores switched to eating a fully vegetarian diet.[45] This is consistent with previous review articles on the topic and further substantiates recommendations for climate change mitigation through reduction in ASF consumption.[46,47]

In 2019, Wang et al. estimated that 25% of premature deaths could be prevented if Americans switched to eating the PHD.[48] This estimate was developed by calculating the Alternate Healthy Eating Index (AHEI) score for the PHD and then calculating the AHEI score for Americans using the Global Burden of Disease data.[48] Thus far, Indian, British, and Mexican samples have all been examined to quantify how their diets compare to the PHD.[49–51] Whereas existing

research has documented that the 2015-2020 DGA fall below recommendations for sustainable dietary intake based on the PHD,[52] no research has examined the actual dietary intake of Americans using the PHD. It is important that the US be evaluated using the PHD as it is the only international metric of sustainable diets to date and addressing climate change requires international cooperation.

Socio-Cultural and Political Dimension

The socio-cultural and political dimension of sustainable diets is important to ensure equitable access to sustainable diets. Over the past 15 years in the US, demand for sustainably produced foods has been growing.[53] In a 2017 survey of over 1,000 U.S. adults, 50% stated that it is important to them that their food is produced in a sustainable manner.[54] Just one year later, 60% of U.S. consumers held this view.[55] The driving forces for this increase were concerns over pesticide use and ensuring an affordable food supply.[55] While consumer preference for sustainable diets is growing,[56–58] relatively little is known about beliefs regarding sustainable food systems among traditionally underserved and nutritionally-vulnerable populations in the U.S. including Black, Hispanic/Latino, rural, and low-income populations.[59] Climate change is often painted as an elitist concern.[60] Yet, marginalized populations comprise a significant proportion of the U.S. population and are more likely to be harmed by unsustainable food systems through unfair agricultural employment practices, limited food access and security, higher prevalence of diet-related illnesses, and agriculture-related environmental hazards.[61] Evidence is mounting that suggests Black, Hispanic, and low-income households care just as much or more that their food is environmentally sustainable than white households and those with high incomes, highlighted by the growing popularity of the food justice movement, which

aims to address these inequities.[59,62] In 2019, the International Food Information Council found that among a nationally representative sample of Americans, 58% of African Americans and 59% of Hispanic Americans believed that it is important that their food is produced in an environmentally sustainable way, while only 41% of non-Hispanic white Americans said the same.[63] Larson et al.,[57] further found that among a sociodemographically diverse sample of young adults (25-36 years old), 35% of people with very low household incomes (making less than $20,000 per year) cared that their food is produced organically, 45% cared that their food is produced without processing, 42% cared that their food is locally grown, and 46% cared that their food is not genetically modified. These preferences are comparable to those of individuals with higher household incomes. It is important to note that although preferences might be similar between income groups, there are more barriers standing in the way of low-income/marginalized populations being able to make food choices in line with these preferences due to budget constraints, food access limitations, etc. Therefore, it is important that we understand not only consumers preferences but also their behaviors and barriers to sustainable diets.

In addition to equity, socio-cultural factors that drive sustainable diet intake can be understood through the framework of Social Cognitive Theory. Social Cognitive Theory is a framework for understanding the determinants of human behavior divided into three categories: personal, behavioral, and social.[64] Having greater sustainable diet values[65] and having a lower BMI[66] are personal factors that have been associated with sustainable diet intake. Being more physically active,[67,68] less fast-food consumption,[57] less heavy alcohol consumption,[66] and better overall diet quality [44,57,66,69] are behavioral factors that have been associated with sustainable diet intake. Food security is one social factor that has been associated with sustainable diet intake.[70]

Additionally, socio-demographic factors that have been correlated with greater sustainable diet intake are obtaining a higher education,[57,65] being female,[44] higher income,[66] younger age,[44] living in urban locations,[66] and being African American.[44]

COVID-19 and Sustainable Diets

In March 2020, the novel coronavirus SARS-CoV-2 (COVID-19) began to spread across the US, growing into a pandemic that has infected around one hundred million people and killed over a million.[71] To help contain the virus, federal and local governments quickly implemented restrictions on citizens to support social distancing including quarantining at home, closing non-essential in-person businesses and schools, and restricting social gatherings. As a result, many lost their jobs or started working from home, there was an upheaval in in-person schooling and childcare, and many experienced psychological distress.[72–76] Consumers' dietary behaviors also changed rapidly because of sheltering in place, working from home, and social distancing. The vast majority of research regarding individuals' COVID-19 pandemic-related dietary changes has focused on the health implications of such changes.[77–81] However, changes in consumer behavior also have implications for sustainable diets.[6]

Preliminary research has shown that since the COVID-19 pandemic, Americans have been consuming more fruits, vegetables, sweets, and alcohol.[77,78] Furthermore, disruption to the meat supply chain in the US resulted in decreased meat consumption and replaced it with more plant-based alternatives,[79,80] although some data suggests that Americans were cooking more meat at home.[81] These changes have been attributed to factors including a desire to eat more healthfully, stress eating or eating due to boredom, and changes in the food supply.[78,82–84] Americans' habits

around where they accessed food and how they prepared it changed as people shopped less frequently in person and did more online shopping and cooked more at home as opposed to getting fast-food, takeout, or ready-made meals.[78,80] Furthermore, in an effort to decrease food costs and the need to purchase food, some households implemented strategies to conserve food and decrease food waste.[85] Many of these changes are in alignment with sustainable diets. However, unemployment and food insecurity were at all-time highs, conditions known to be associated with poorer diet quality and higher GHGE.[70,86,87] The COVID-19 pandemic also disproportionately impacted racial/ethnic minorities along with low-income populations, both in terms of increased unemployment and food insecurity, as well as in the severity of COVID-19 cases.[92,129] As such, the COVID-19 pandemic may have differentially and inequitably changed people's sustainable diet preferences with regard to sociodemographic characteristics.

Dissertation Aims and Hypotheses

The long-term goal of this research is to increase sustainable diets among diverse populations of Americans. The objective of this dissertation is to characterize the ecological, economic, human health, and socio-cultural and political dimensions of a sustainable diet among socio-demographically diverse populations in the US before and during the COVID-19 pandemic. Our central hypothesis is that on average Americans have a substandard human health dimension of a sustainable diet based on the PHD across populations. We also hypothesize that nutritionally vulnerable populations will have equal or better ecological, economic, and human health dimensions of a sustainable diet compared to higher-income and White populations.

The first aim of this dissertation is to describe the human health dimension of sustainable diets among a large, socioeconomically and racially/ethnically diverse population-based sample of young adults from a large metropolitan area of the US through application of the PHD. Young adults hold particular importance since they are at a life stage of increasing independence and are developing habits that may persist throughout their adult lives.[88] Additionally, we identify personal, behavioral, and socio-environmental correlates of young adults' sustainable dietary intake assessed via the PHD. We hypothesize that most young adult participants have substandard sustainable dietary intake based on the PHD and that sustainable dietary intake will correlate with other health-promoting behaviors. The knowledge obtained from this study will provide the first benchmark regarding sustainable dietary intake using the PHD among a U.S. sample and suggest intervention targets that could promote and reduce barriers to sustainable food consumption across diverse communities.

The second aim of this dissertation is to identify how recent trends in ecological, economic, human health, and socio-cultural & political dimensions of a sustainable diet are similar or different across diverse U.S. subpopulations from 2019 to 2021. We hypothesize that sustainable diet preferences will have become stronger throughout time and will have strengthened equivalently or greater for adults from non-White ethnic/racial identification and low-income households. This knowledge will inform initiatives to support consumer education and engagement in strengthening the sustainability of the food system, with targeted attention to subpopulations most in need and potentially accepting of information uptake and implementation.

The third aim of this dissertation is to describe perceived changes among U.S. adults' ecological, economic, human health, and socio-cultural & political dimensions of a sustainable diet within the food environment one year into the COVID-19 pandemic. We hypothesize that behaviors will have become, on average, better aligned with sustainable diets during the COVID-19 pandemic compared to before the pandemic. This knowledge will inform initiatives, with specific attention to demographic groups, to support the continuation of sustainability-promoting behaviors that increased during the COVID-19 pandemic and target behaviors that have not changed or have worsened.

This dissertation will provide insight into sustainable diets, particularly among underserved and nutritionally vulnerable Americans including Black, Hispanic/Latino, rural, and low-income populations. Study findings will identify how ecological, economic, human health, and socio-cultural & political dimensions of a sustainable diet varies across subpopulations and how they have changed across time, including during the COVID-19 pandemic. This knowledge will inform initiatives to reduce barriers to sustainable dietary intake across diverse communities and guide the development of innovative policy and programmatic strategies to expand sustainable food demand and choice. Ultimately, we anticipate that these efforts will culminate in increased production, purchasing, and consumption of sustainable diets in the US, contributing to decreases in GHGE and mitigating climate change.

	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

Figure 1.1 Planetary Health Diet[37]

Chapter 2 Personal, Behavioral, and Socio-environmental Correlates of Young Adults' Sustainable Diets

Introduction

In 2015, the Paris Agreement set the goal to limit the global temperature increase to less than 2°C to mitigate the devastating effects of climate change.[1] Sustainable food systems are essential to meeting the goal of the Paris Agreement because agriculture is responsible for about 25% of greenhouse gas emission (GHGE) globally, more than 70% of freshwater use,[37] 80% of deforestation,[4] and is the single largest contributor to biodiversity loss.[5] A sustainable food system is one that relies on sustainable diets that provide economic, socio-cultural, and political wellbeing along with flourishing human and ecological health.[6] Individuals can support sustainable food systems by consuming a diet comprised of foods that arise from sustainable practices.

There is general agreement that diets are more sustainable when high in vegetables, fruits, whole grains, legumes, nuts and seeds, with only small amounts of poultry, fish, eggs, and dairy, and with little to no added sugar, alcohol, and meat.[37] However, until recently, there were no internationally generalizable approaches to measure sustainability of the diet, limiting comparison of diet sustainability across cultures and geography.[31–35] In 2019, the EAT-Lancet Planetary Health Diet (PHD)[37] was created to establish a generalizable metric with which to assess diet sustainability in a manner that simultaneously recognizes the environmental and health impacts of consumption of various food groups. The PHD was designed to be a culturally

adaptable, win-win diet that is healthy for humans and the environment with regards to GHGE, nitrogen and phosphorus application, agricultural water use, biodiversity loss, and cropland use.[38] Calculated as costing an average of US$2.65 per day in 2011, the PHD is affordable for the vast majority of US population groups[40] and in 2019, Wang et al. estimated that 25% of premature deaths could be prevented if US populations consumed diets that aligned with the PHD.[48] Despite the availability of the PHD, few studies have assessed the extent to which national dietary recommendations and current intake patterns of US populations align with sustainable diet goals as described by the EAT-Lancet Commission. Blackstone and Conrad[52] identified that the 2015-2020 Dietary Guidelines for Americans (DGA) fall below recommendations for sustainable dietary intake based on the PHD and a recent analysis of US school lunches served at elementary, middle, and high schools found that these meals were particularly low in whole grains and vegetables, while high in meat and dairy, when compared to the PHD.[89] These findings suggest that US nutrition programs and actual dietary intake may likely be substandard with respect to diet sustainability, particularly when measured by the PHD for young adults.

Further, the factors that support consumption of sustainable diets have not been rigorously examined. Understanding the personal, behavioral, and socio-environmental correlates of the PHD would identify subgroups of individuals that are consuming more sustainable diets and could suggest policy-based, environmental, and educational levers with the potential to move other groups toward more sustainable intake. A small number of studies have identified that individuals who consume more sustainable diets have a lower body mass index (BMI),[66] engage in more physical activity,[67,68] consume less fast food and alcohol,[57,66] and overall, have better

diet quality.[44,57,66,69] Additionally, some studies show that sustainable diets are more common among higher socioeconomic status groups including those with higher educational attainment, higher income, and food security.[65,70] None of these studies used the PHD as a measure of diet sustainability; thus, there is a need for future research to standardize the operationalization of sustainable dietary intake to allow for comparisons across study samples and cross-culturally.

The objective of the current study is to describe diet sustainability among a large, socioeconomically and racially/ethnically diverse population-based sample of young adults from a large metropolitan area of the US through application of the PHD. Young adults hold particular importance since they are at a life stage of increasing independence and are developing habits that may persist throughout their adult lives.[88] Additionally, we identify personal, behavioral, and socio-environmental correlates of young adults' sustainable dietary intake assessed via the PHD. We hypothesize that most young adult participants have substandard sustainable dietary intake based on the PHD and that sustainable dietary intake correlates with other health-promoting behaviors. The knowledge obtained from this study will provide the first benchmark regarding sustainable dietary intake using the PHD among a US sample and suggest intervention targets that could reduce barriers and promote sustainable food consumption across diverse communities.

Methods

Study Population

The current cross-sectional analysis uses data from the second wave of EAT 2010-2018 (Eating and Activity over Time), a population-based study designed to understand weight-related health

across the life course. EAT 2010 was conducted within the Minneapolis and St. Paul school districts, which serve socioeconomically and racially/ethnically diverse communities.[90] During the 2009-2010 school year, 20 public middle and high schools agreed to participate in the study. Within these 20 schools, students from selected health, physical education, and science classes were invited to participate; 96.3%, (n=2,793) of the students present on the day of data collection had parental consent and provided written assent to participate. The mean age of participants was 14.4 years (SD=2.0).[90] In 2017-2018, a follow-up study of the EAT 2010 participants was conducted online and via mailed surveys; 2,383 EAT 2010 participants were invited to take part in the study (410 were lost to follow-up) and 1,568 completed a survey (mean age=22.0 ± 2.0 years).[90] To account for missing data due to attrition, inverse probability weighting (IPW) was used.[91] The current analysis included only the participants who additionally completed a food frequency questionnaire (FFQ) and excluded those who reported biologically implausible caloric intake (consuming < 400 or > 7,000 kcal/day) (n=175).[92] Participants with missing values for covariates (age, gender, income, education, race, and total caloric intake) were also excluded to ensure comparability among models, resulting in a final sample of 1,308 young adults. See **Figure 2.1** for a flow diagram of the analytic sample.

Assessment of Diet

A semi-quantitative 149-item validated FFQ was administered at the same time as the EAT survey to assess usual dietary intake in the past year.[93] To compare intake to the PHD criteria, participants' intake was categorized into one of the 14 PHD food groups (**Table 2.1**) and conversion factors reported by Blackstone et al.[52] were used to translate from servings per day to grams per day (1 serving fruit=182 g; 1 serving dark green vegetables=118 g; 1 serving red and

orange vegetables=114 g; 1 serving starchy vegetables=134 g; 1 serving other vegetables=140 g; 1 serving whole grains=51 g; 1 serving dairy=149 g; 1 serving meat=31 g; 1 serving poultry=29 g, 1 serving eggs=50 g; 1 serving fish=29 g; 1 serving nuts and seeds=15 g; 1 serving soy=24 g, and 1 serving legumes=44 g). To apply the PHD, a score of 1 was given for each food group when average daily intake fell within the following ranges: whole grains (232–464 g/day), tubers (50-100 g/day), dairy (250-500 g/day), beef, lamb, and pork (14-28 g/day), chicken and other poultry (29-58 g/day), eggs (13-25 g/day), fish (28-100 g/day), dry beans, lentils, peas (50-100 g/day), soy (25-50 g/day), peanuts or tree nuts (25-100 g/day), added fat (20-91.8 g/day), and added sugar (0-31 g/day). A score of 0 was given to those who were outside the PHD with the exception of vegetables and fruits, which were scored in accordance with Knuppel et al.[39] For vegetables and fruits a score of 1 was given to those who met or exceeded the minimum intake ($\geq$200g/day) and ($\geq$100/day), respectively, while a score of 0 was given to those who fell short of the PHD.[50] Minimum intake values used were those suggested by Hanley-Cook et al.[39]

The PHD was developed to align with daily energy intake of 2,500 kcal/day to account for various isocaloric dietary scenarios. To standardize the application of the PHD to the total caloric intake of participants, their intake in grams was scaled to 2,500 kcal/day. A sensitivity analysis (**Tables 2.2-2.4**) was conducted by weighting the PHD to align with a 1,500 kcal/day intake and 2,000 kcal/day intake creating ideal intake goals for three ranges: <1,500 kcal/day, 1,500-2,500 kcal/day, and >2,500 kcal/day. There was no significant difference between the sensitivity analysis and the primary analysis; therefore, the primary analysis was used. An overall PHD score was created by summing points for achieving optimal intake in each of 14 food categories derived from the FFQ, resulting in an index with possible scores ranging from 0 to 14.[50]

Furthermore, percent difference of participant intake from the PHD for each of the food categories was calculated by subtracting the midpoint of the suggested PHD caloric range from the observed participant intake weighted by that participant's ideal intake range.[69]

Assessment of Personal, Behavioral, and Socio-environmental Variables

The EAT 2010-2018 survey was developed to integrate an ecological perspective with Social Cognitive Theory. Personal, behavioral, and socio-environmental variables (**see Table 2.5**) for this analysis were identified based on Social Cognitive Theory and on our existing understanding of predictors that influence sustainable diet intake within each of the Social Cognitive Theory domains.[64] To promote ease of interpretation all variables were standardized to a mean of zero and standard deviation of one.

Sociodemographic Characteristics

Ethnicity/race was determined by asking "Do you think of yourself as White, Black or African American, Hispanic or Latino, Asian American, American Indian or Native American, or Other." Socioeconomic status was classified using participants' highest level of parental education along with eligibility for public assistance, free or reduced-price school lunches, and parental employment status. Gender, educational attainment, birth year, and student status were self-reported.[90]

Statistical Analysis

Descriptive statistics were used to examine PHD scores (overall and for each food group) across participant characteristics, including age, gender, ethnicity/race, educational attainment, SES,

student status, and total energy intake. The author's calculated means and standard deviations of PHD scores, the percent of participants achieving the PHD goals, percent below the PHD goal, and percent exceeding the PHD goal. The differences in mean PHD composite score across sociodemographic groups (gender, ethnicity/race, educational attainment, and socioeconomic status) were compared using ANOVA. Linear regression models were then constructed to allow for separately examining each personal, behavioral, and socio-environmental factor of interest as a predictor of PHD composite score. Crude models were first constructed and then further adjusted for potential confounders, including ethnicity/race, educational attainment, gender, age, SES, and total energy intake. Inverse probability weighting was used to account for missing data due to attrition.[91] A p-value of <.05 was used to indicate statistical significance. Statistical analyses were carried out in SAS version 9.4.

Results

The weighted descriptive characteristics of the study sample in 2018 are presented in **Table 2.6**. The mean age of study participants was 22.1 (SD = 2.0) and just under half (41.8%) were enrolled in college. Over half of participants (59.8%) were of low or low-middle socioeconomic status.

Figure 2.2 shows the average intake of participants for each food group compared to ideal PHD intake. Overall, participants were close to meeting PHD recommendations for potatoes (percent difference from the PHD = 3.9%), dairy (7.7%), and poultry (8.6%). However, on average, participants over-consumed meat (148.5%), eggs (70.0%), and added sugar (83.2%), and under-consumed whole grains (-54.8%), fish (-94.7%), legumes (-121.5%), soy (-146.0%), and nuts (-

175.2%). The mean scaled intake of meat is high at 47.4 (SD = 32.6) g/day with more than 71% of participants consuming above the PHD recommendations. In comparison, the mean scaled intake of fish was 10.0 (SD = 12.8) g/day, and mean scaled intakes of plant-based proteins were 12.2 (SD = 20.4) g/day for legumes, 3.9 (SD = 11.9) g/day for soy, and 3.3 (SD = 7.2) g/day for nuts, with more than 90% of participants having intakes that were below PHD recommendations across all four categories **(Table 2.7)**.

Participants' overall PHD score was 4.1 on average (SD = 1.4), on a scale of 0 to 14 possible, with 14 being the most sustainable **(Table 2.8)**. Participants of low socioeconomic status had significantly lower overall PHD scores (4.1 (SD = 1.4)) than those of high socioeconomic status (4.5 (SD = 1.2)). Likewise, those with only some high school education had significantly lower overall PHD scores (3.9 (SD = 1.5)) than those with a bachelor's, graduate, or professional degree (4.3 (SD = 1.4)).

Participants' overall adjusted PHD scores were most strongly associated with standardized (mean=0, SD=1) scores indicating higher availability of healthy food at home ($\beta = 0.24$, *P* value < 0.001) and less frequent fast-food consumption ($\beta = -0.26$, *P* value < 0.001) (**Table 2.9**). Other personal characteristics associated with the PHD score were greater self-efficacy for cooking ($\beta = 0.16$, *P* value < 0.001), self-esteem ($\beta = 0.10$, *P* value = 0.009), and overall body satisfaction ($\beta = 0.12$, *P* value = 0.008). Increased hours of physical activity per week ($\beta = 0.15$, *P* value = 0.0002) and number of lifestyle weight management behaviors performed last year ($\beta = 0.11$, *P* value < 0.0001) were behavioral characteristics associated with more sustainable dietary intake. Meanwhile, less frequently eating at a restaurant ($\beta = -0.25$, *P* value < 0.0001), and fewer hours

of screen time (β = -0.16, *P* value < 0.0001) were associated with sustainable dietary intake. Finally, participants reporting greater parental encouragement of healthy eating (β = 0.15, *P* value = 0.0002) experienced higher overall PHD scores on average, while participants experiencing food insecurity had moderately lower PHD scores (β = -0.09, *P* value = 0.02).

Discussion

The objective of the current study was to describe intake of sustainable diets among a large, socioeconomically and ethnically/racially diverse sample of US young adults through application of the PHD. Additionally, we identified personal, behavioral, and socio-environmental correlates of young adults' sustainable dietary intake assessed via the PHD. Overall, as hypothesized, young adults participating in EAT 2018 were not consuming diets that aligned with PHD recommendations. While most young adults met the PHD recommended intakes for fruits, vegetables, and added fats, the majority under-consumed whole grains, plant-based proteins, and fish, and overconsumed meat and added sugar. Young adults of high socioeconomic status and those with higher educational attainment consumed diets more aligned with PHD recommendations than their peers. Furthermore, the strongest correlates of meeting the PHD recommendations were greater healthy food availability at home and less frequently consuming food from fast-food restaurants.

Study findings from this US cohort are consistent with dietary patterns observed in other high-income countries (HICs) and contrast with patterns observed in low-to-middle-income countries (LMICs) with regards to meat and whole-grain consumption. For example, prior research in the United Kingdom (UK) has shown relatively few individuals meet the PHD recommendations for

whole grains (36.1%) and most met (66.6%) or exceeded (33.4%) the recommendations for meat.[50] In India, consumption expenditures, in kcal/day, for urban and rural populations respectively, show that the PHD recommendations were exceeded for whole grains 1029 kcal/day and 1275 kcal/day and fell short of meeting recommendations for meat 3 kcal/day and 5 kcal/day, fish 8 kcal/day and 9 kcal/day, and eggs 6 kcal/day and 10 kcal/day.[49] A primary difference between the study conducted in India and the studies in the US and UK are the discrepancies in animal-source food consumption and whole grains. In the US and UK, the PHD recommendations are widely met or exceeded for animal-sourced foods while in India they fall short of meeting them. Conversely, in India, the PHD recommendation is exceeded for whole grains while in the US and UK they fall short of meeting it. These patterns mirror common dietary patterns among LMICs and HICs globally, which necessitates a shift in consumption in order to meet sustainability goals.[94] In LMICs meeting sustainability goals requires a higher intake of animal-based protein to replace some of the calories they are getting from whole grains while HICs need to reduce meat consumption and supplement it with a greater intake of whole grains and plant-based protein.

In HICs like the US, reducing meat consumption and increasing intake of plant-based sources of protein provides a clear path for making gains in the sustainability of dietary intake. Such a change would also be economically advantageous for consumers. For example, according to the US Bureau of Labor Statistics, the market value of ground beef in September 2022 is $4.86/pound (lb.) compared to beans' $1.68/lb., which translates to a per-serving cost of $1.22 and $0.21 respectively.[95] Despite the high cost of beef compared to other protein sources, in the current study, young adults with the lowest SES consumed the most meat (beef, lamb, and pork)

in comparison to higher SES groups. This pattern is often observed within HICs.[96] One reason that individuals from lower SES households may consume more meat, and thus have lower overall PHD scores, is more frequent fast-food consumption (e.g., burgers). Among young adults in the EAT 2010-2018 study, fast food consumption was one of the strongest correlates of lower diet sustainability. A recent study demonstrated the positive association between income and processed meat consumption; furthermore, it showed an additive interaction between income, neighborhood density of fast-food outlets and the outcome of interest, processed meat consumption.[97] One innovative intervention strategy to improve the sustainability of low SES individuals' diets is encouraging fast food restaurants to showcase plant-based proteins, particularly ones that keep costs low. However, it is important to note that most popular brands have not been shown to be nutritionally superior to meat.[98] In 2021, seven fast-food restaurants (Burger King, Chipotle, Starbucks, KFC, Panera Bread, Pizza Hut, and Taco Bell) were recognized for leading the way in plant-based protein alternatives in alignment with their corporate commitments to reducing meat consumption.[99] The increased visibility of plant-based proteins by familiar, restaurants may even also encourage individuals to purchase and prepare more meat alternatives at home.

Beyond shifts towards plant-based protein in the fast food industry, fiscal policies known to alter the healthfulness of diets would likely also positively impact consumers' diet sustainability.[100] For example, the World Health Organization (WHO) recommends at least a 20% tax on sugar-sweetened beverages (SSBs) and other unhealthy foods to be coupled with comparable subsidies on nutrient-dense foods like fruit, vegetables, whole grains, legumes, and nuts as a method to shift consumption patterns, especially among low-income groups.[101] A case study can be found

in Mexico, back in 2013 the government levied a 10% SSB tax that reduced consumption by almost 10%.[102] Low-income consumers are most likely to be affected by this type of regressive tax; however, the high elasticity of SSB taxes means that lower-income households may see some of the largest declines in SSB purchasing and potentially corresponding gains in diet-related health improvements.[103] In contrast to this approach, the US currently subsidizes commodity crops, like corn and soy, that are frequently used to produce unhealthy foods, many of which are a source of added sugar.[104]

Another important component to help people in the US consume more sustainable diets is ensuring that the Dietary Guidelines for Americans (DGA) consider the shared goals of improving physical and environmental health. This is particularly important as a growing number of people are turning to the DGA for nutritional advice.[80] Notably, the 2015-2020 Dietary Guidelines Advisory Committee recommended that sustainability be considered as part of the DGA, but this recommendation was removed from the final guidelines as it was deemed beyond the scope of the Committee's charge.[105] The most recent iteration of the DGA, 2020-2025, did not revisit the topic and currently,[106] the DGA allows for a much higher consumption of meat, refined grains, and discretionary calories than does the PHD.[52]

While this study had multiple strengths including a large population-based sample and socioeconomically and racially/ethnically diverse participants, an important limitation was the brief assessment of plant-based proteins on the FFQ. This may have led to an underestimation of participants' soy intake, resulting in lower overall PHD scores. Future research focused on assessing sustainable diets should ensure that their measures of dietary intake more

comprehensively capture plant-based protein consumption. Participants were also only drawn from one area in the US, thereby geographically limiting study findings generalizability. Participants may have also over-reported behaviors or characteristics they perceived as socially acceptable and under-reported behaviors or characteristics they perceived as socially unacceptable. This would have the effect of attenuating the correlations of personal, behavioral, and socio-environmental characteristics with the PHD.

The majority of young adults participating in the EAT 2010-2018 study had substandard sustainable dietary intake based on the PHD. This was particularly true for individuals of lower socioeconomic status and educational attainment. Most young adults consumed high amounts of meat, a dietary behavior that is especially harmful to the environment. Reducing meat consumption, especially by substituting plant-based proteins, is an important target for intervention among US young adults. Policy and environmental changes known to improve diet healthfulness, such as taxing SSBs and other unhealthy foods, subsidizing nutrient-dense foods, fast food restaurants committing to reducing meat consumption, and including sustainability into the DGA hold promising potential for shifting diets towards more environmentally sustainable choices.

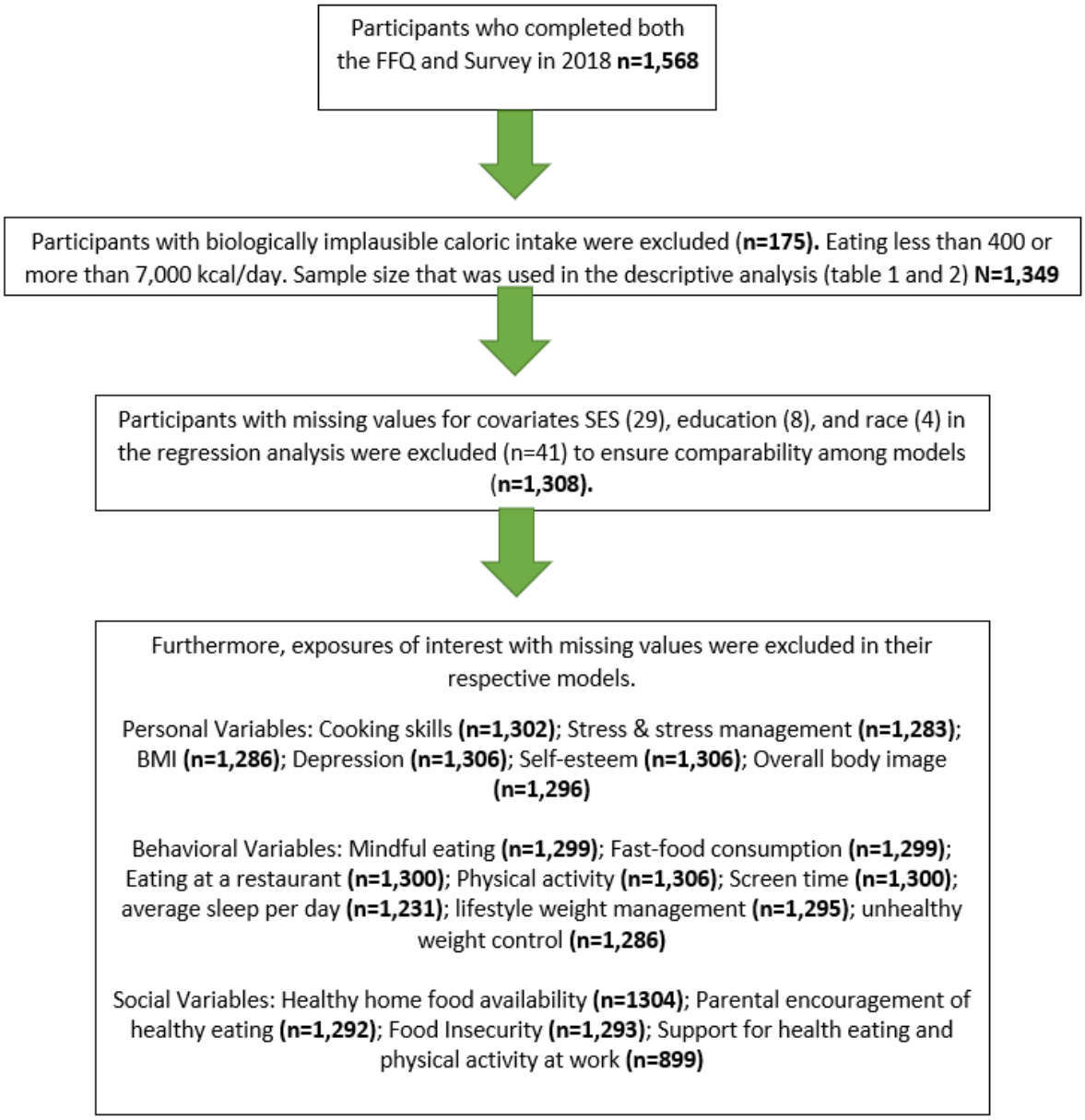

Figure 2.1 Sample Size Flow Chart

Table 2.1 Planetary Health Diet

Dietary Component		Food Item based on the FFQ
1	Whole Grains	Brown rice, whole wheat, brown bread, etc.
2	Potatoes and Cassava	Potatoes and french fries
3	Vegetables	Broccoli, kale, mustard greens, chard, spinach, romaine lettuce, leaf lettuce, bok choy, tomatoes, carrots, yams or sweet potatoes, dark orange winter squash, string beans, cauliflower, cabbage or coleslaw, brussels sprouts, corn, mixed or stir-fry vegetables, eggplant, zucchini or other squash, iceberg or head lettuce, celery, peppers, onions, mushrooms, radish, jicama, hot peppers, asparagus, beets, kimchee, cucumber, bamboo shoots, seaweed, okra, scallions, peapods
4	Fruits	Raisins or grapes, prunes or dried plums, prune juice, bananas, cantaloupe, fresh apples or pears, apple juice or cider, oranges, orange juice, grapefruit or grapefruit juice, other fruit juices, strawberries, blueberries, peaches or plums, apricots, cherries, melon, applesauce, papaya, mango, rhubarb, mixed dried fruit, figs, dates, fruit cocktail, pineapple, pomegranate, rhubarb, watermelon, dried cranberries, plantain, kiwi, raspberries, dried apple
5	Dairy Foods	Milk, yogurt, cheese, etc.
6	Beef, Lamb, and Pork	Hamburger, pork, hotdog, bacon, bologna, etc.
7	Chicken and other poultry	Chicken and turkey
8	Eggs	Eggs
9	Fish	Tuna, dark fish, shrimp, lobster, scallops, other fish
10	Dry beans, lentils, and peas	Beans, peas, hummus
11	Soy	Tofu, soy milk
12	Tree Nuts & Seeds	All nuts and seeds from FFQ
13	Added Fat	Entire FFQ totals
14	Added Sweeteners	Entire FFQ totals

Table 2.2 Planetary Health Diet for Project EAT 2018 Participants: Sensitivity Analysis

Dietary component	Planetary Health Diet Intake Goals in Grams/Day by Energy Intake			Observed Intake in g/day (Mean (SD))	% Achieving PHD	% Below PHD	% Above PHD
	≤1,500 kcal/day	1,500-2,500 kcal/day	≥2,500 kcal/day				
Whole grains	139-278	186-371	232-464	115.6 (124.2)	12.3	85.3	2.4
Potatoes	30-60	40-80	50-100	46.6 (64.9)	15.6	68.9	15.5
Vegetables	≥120	≥160	≥200	359.9 (447.4)	65.5	34.5	N/A
Fruits	≥60	≥80	≥100	433.4 (612.4)	87.7	12.4	N/A
Dairy	150-300	200-400	250-500	238.3 (277.6)	24.2	60.8	15.0
Beef, lamb, pork	8-17	11-22	14-28	41.1 (43.8)	22.5	11.6	65.9
Chicken & other poultry	17-35	23-46	29-58	26.4 (31.6)	25.2	61.3	13.5
Eggs	8-15	10-20	13-25	23.4 (38.0)	15.6	46.4	38.0
Fish	17-60	22-80	28-100	9.7 (18.5)	8.3	90.7	1.0
Beans, lentils, peas	30-60	40-80	50-100	10.9 (22.8)	3.3	95.1	1.6
Soy	15-30	20-40	25-50	3.2 (9.3)	3.0	96.3	0.7
Nuts	15-60	20-80	25-100	3.1 (10.7)	1.5	98.3	0.2
Added Fats							
Added fat	12-55.1	16-73.4	20-91.8	55.2 (39.4)	79.6	3.7	16.7
Added Sugars							
Added sweetener	≤19	≤25	≤31	66.8 (65.3)	18.7	N/A	81.3

Table 2.3 Planetary Health Diet Scores by Sociodemographic Characteristics: Sensitivity Analysis

	Planetary Health Diet Score (Mean (SD))	P-Value
Gender		0.04
Male	3.7 (1.5)[a]	
Female	3.9 (1.3)[b]	
Other	4.0 (1.5)[ab]	
Ethnicity/race		0.01
White	3.8 (1.2)[ab]	
Black or African American	3.7 (1.7)[a]	
Hispanic or Latino	4.0 (1.5)[ab]	
Asian American	3.7 (1.3)[ab]	
American Indian or Native American	3.6 (1.3)[ab]	
Mixed or other	4.1 (1.3)[b]	
Educational Attainment		0.08
Some high school	3.6 (1.5)[a]	
High school graduate or GED	3.7 (1.5)[a]	
Some college	3.8 (1.3)[a]	
Associate degree, vocational, technical, or trade	4.0 (1.3)[a]	
Bachelor's, graduate, or professional degree	3.9 (1.3)[a]	
Socioeconomic Status		0.02
Low	3.7 (1.4)[a]	
Low-middle	3.9 (1.4)[ab]	
Middle	3.8 (1.4)[ab]	
Upper-middle	3.9 (1.3)[ab]	
High	4.1 (1.2)[b]	

Note: Means with common superscript letters do not differ at $p<.05$.

Table 2.4 Associations between Personal, Behavioral, and Socio-environmental Characteristics[1] and Planetary Health Diet Score: Sensitivity Analysis

Characteristics	β (SE)	P-value
Personal		
BMI (kg/m^2)	-0.007 (0.04)	0.85
Cooking skills	0.20 (0.04)	<0.001
Depressive symptoms	-0.06 (0.04)	0.10
Unmanaged stress	-0.08 (0.04)	0.03
Self-esteem	0.12 (0.04)	0.002
Overall body satisfaction	0.06 (0.04)	0.13
Behavioral		
Mindful eating	0.12 (0.04)	0.001
Monthly frequency of fast-food consumption	-0.22 (0.04)	<0.001
Monthly frequency of eating at a restaurant	-0.20 (0.04)	<0.001
Hours of physical activity per week	0.19 (0.04)	<0.001
Alcohol consumption grams per day	-0.009 (0.04)	0.81
Hours of screen time per week	-0.15 (0.04)	<0.001
Hours of sleep per day	-0.03 (0.04)	0.37
Number of lifestyle weight management behaviors performed last year	0.11 (0.02)	<0.001
Number of unhealthy weight control behaviors performed last year	0.03 (0.03)	0.23
Socio-environmental		
Home healthy food availability	0.26 (0.04)	<0.001
Parental encouragement of healthy eating	0.19 (0.04)	<0.001
Support for healthy eating and physical activity at work	0.07 (0.04)	0.12
Food Insecure	-0.08 (0.04)	0.03

[1]Personal, behavioral, and socio-environmental predictors have been standardized to mean = 0, SD = 1 to allow for comparison of estimates across models.
[2]Models adjusted for ethnicity/race, educational attainment, gender, age, SES, and total energy intake

Table 2.5 Assessment of Personal, Behavioral, and Socio-environmental Factors

Variables	Definition
Personal	
Body Mass Index	Self-reported weight and height (kg/m^2)[90]
Cooking self-efficacy	Including asking about people's confidence doing 5 activities: planning meals, following a recipe, preparing a meal from items on hand, using basic cooking techniques, and staying within a food budget, with a range of 5-25[107]
Depressive symptoms	Including feeling too tired to do things; having trouble going to sleep or staying asleep; feeling unhappy, sad, or depressed; feeling hopeless about the future; feeling nervous or tense; worrying too much about things, with a range of 6 to 18[90]
Unmanaged stress	The average level of stress in the past month divided by ability to manage stress in the past month with a range of 0.1-10[108]
Self-esteem	Six items from the Rosenberg Self-esteem Scale, including *I am satisfied with myself; I have a number of good qualities; at times I think that I am no good at all; able to do most things as well as most other people; wish I could have more respect for myself; and I certainly feel useless at times* with a range of 10-24[90]
Body satisfaction	Satisfaction with your height, weight, body shape, waist, hips, thighs, stomach, face, body build, shoulders, muscles, chest, and overall body fat with a range of 13-65[109]
Behavioral	
Mindful eating	Including eating so quickly that I don't taste what I'm eating; snacking without noticing that I am eating; taking a moment to appreciate the colors and smells of my food; tasting every bite of food that I eat with a range of 4-16[110]
Fast-food intake	Number of times you ate fast food (including burger, Mexican, fried chicken, pizza, and Asian) over the past month with a range of 0-140[90]
Eating at a restaurant	Number of times you ate at a restaurant (including all fast-food plus sit-down restaurants) over the past month with a range 0-168[90]
Physical activity	Hours per week engaging in moderate to vigorous activity, ranging from 0-16[90]
Alcohol consumption	Derived from the FFQ in grams per day
Screen time	Average hours of recreational screen time (for example, television, computer, social media, video games, smartphone, or tablet) per week with a range of 7-42 accounting for weekdays and weekends[90]
Sleep hours	Average hours per day derived from asking when do you usually go to bed and get out of bed[90]
Lifestyle weight management behaviors	Number of lifestyle weight management behaviors performed last year including exercise, eating fruits and vegetables, eating less high-fat foods, eating less sweets, drinking less soda pop, drinking more water, watching portion sizes, and other[111]
Unhealthy weight control behaviors	Number of unhealthy weight control behaviors performed last year including fasted, eating very little food, taking diet pills, vomiting, using laxatives, taking diuretics, using food substitutes, skipping meals, and smoking cigarettes[111]
Socio-environmental	
Home healthy food availability	Three items were used to assess whether the following were available at home ("Please think about the apartment, house, dorm room, or other space where you lived for the majority of the time for the past year"): fruits and vegetables were available, vegetables are part of the dinner meal, and whole wheat bread is available with a range of 3-12.[90] Response options were *Never, Sometimes, Usually,* and *Always.*
Parental encouragement of healthy eating	Mother(father) encourages me to eat healthy foods with a range of 4-16[112]
Support for healthy eating and PA at work	Five items were used to assess whether participants could easily be physically active at or around their workplace, coworkers think it is important to be physically active, coworkers care about eating healthy food, easy to buy healthy food at or around the workplace, and employees rarely bring high-calorie foods with a range of 5-20[113]
Household food security	Two items from the US Household Food Security Survey Module: 1) "In the past 12 months did you ever eat less than you felt you should because there wasn't enough money for food?" and 2) "In the past 12 months were you ever hungry but didn't eat because there was not enough money for food?". Response options were *yes, no,* and *I don't know*. If the participant said yes to both household food security questions they were determined to be food insecure.[90]

Table 2.6 Sociodemographic Characteristics of Project EAT 2018 Participants (n=1,349)

	Mean (SD) or %
Age (years)	22.1 (2.0)
Gender	
Male	46.2
Female	53.2
Other	0.6
Ethnicity/race	
White	20.8
Black or African American	26.5
Hispanic or Latino	17.1
Asian American	20.6
American Indian or Native American	3.6
Mixed or other	11.5
Educational Attainment	
Some high school	5.3
High school graduate or GED	29.2
Some college	39.3
Associate degree, vocational, technical, or trade	11.4
Bachelor's, graduate, or professional degree	14.8
Socioeconomic Status	
Low	37.4
Low-middle	22.4
Middle	18.2
Upper-middle	13.8
High	8.3
Student Status	
Not a student	55.0
Student in high school	3.2
Student at a community or technical college	18.9
Student at a four-year college	20.7
Graduate student	2.2
Total Caloric Intake	
≤1,500 kcal/day	37.0
1,500-2,500 kcal/day	32.3
≥2,500kcal/day	30.8

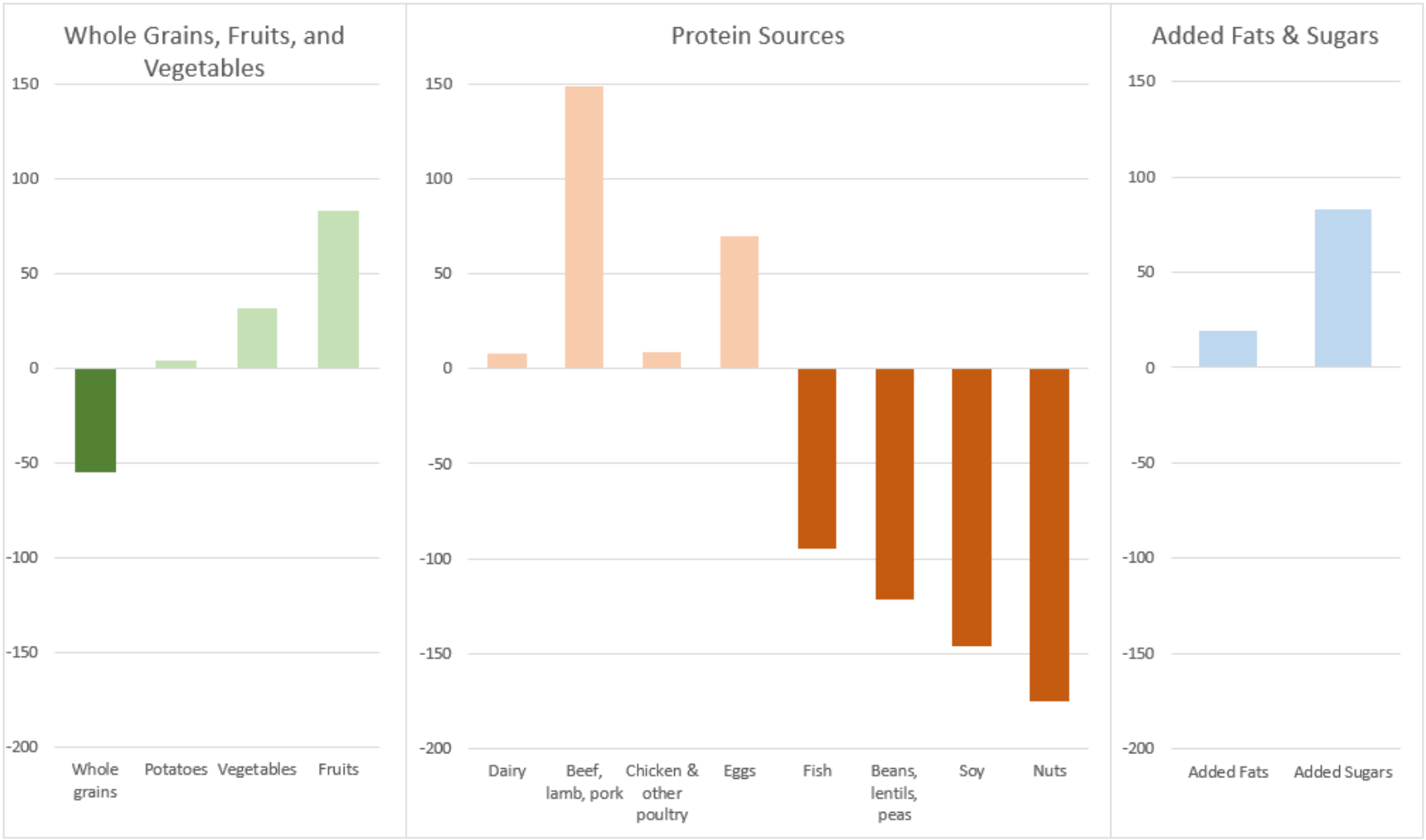

Figure 2.2 Difference of Project EAT 2018 Participant Intake from Planetary Health Diet Targets

Table 2.7 Planetary Health Diet for Project EAT 2018 Participants

Dietary component	Planetary Health Diet Intake Goals in Grams/Day	Observed Intake in g/day (Mean (SD))	Intake in g/day scaled to 2,500 Kcal/day	% Achieving PHD	% Below PHD	% Above PHD
Whole grains	232-464	115.6 (124.2)	132.2 (112.0)	10.5	87.7	1.8
Potatoes	50-100	46.6 (64.9)	52.0 (50.9)	28.5	59.1	12.4
Vegetables	≥200	359.9 (447.4)	412.3 (375.0)	69.7	30.3	N/A
Fruits	≥100	433.4 (612.4)	483.4 (448.9)	89.8	10.2	N/A
Dairy	250-500	238.3 (277.6)	270.1 (229.1)	28.8	58.6	12.6
Beef, lamb, pork	14-28	41.1 (43.8)	47.4 (32.6)	17.8	10.5	71.7
Chicken & other poultry	29-58	26.4 (31.6)	31.6 (27.9)	27.8	58.9	13.3
Eggs	13-25	23.4 (38.0)	27.0 (34.8)	21.1	42.9	36.0
Fish	28-100	9.7 (18.5)	10.0 (12.8)	8.6	91.4	0.0
Beans, lentils, peas	50-100	10.9 (22.8)	12.2 (20.4)	3.8	95.3	0.9
Soy	25-50	3.2 (9.3)	3.9 (11.9)	2.8	96.3	0.9
Nuts	25-100	3.1 (10.7)	3.3 (7.2)	1.2	98.6	0.2
Added Fats						
Added fat	20-91.8	55.2 (39.4)	62.7 (18.2)	94.3	0.9	4.8
Added Sugars						
Added sweetener	≤31	66.8 (65.3)	75.2 (48.3)	12.2	N/A	87.8

Table 2.8 Planetary Health Diet Scores by Sociodemographic Characteristics

	Planetary Health Diet Score (Mean (SD))	P-Value
Gender		0.07
Male	4.1 (1.5)[a]	
Female	4.2 (1.3)[a]	
Other	4.2 (1.0)[a]	
Ethnicity/race		0.01
White	4.3 (1.2)[a]	
Black or African American	4.0 (1.7)[a]	
Hispanic or Latino	4.3 (1.4)[a]	
Asian American	4.0 (1.2)[a]	
American Indian or Native American	4.2 (1.4)[a]	
Mixed or other	4.3 (1.4)[a]	
Educational Attainment		0.007
Some high school	3.9 (1.5)[ab]	
High school graduate or GED	4.0 (1.4)[a]	
Some college	4.2 (1.4)[b]	
Associate degree, vocational, technical, or trade	4.3 (1.4)[ab]	
Bachelor's, graduate, or professional degree	4.3 (1.4)[ab]	
Socioeconomic Status		0.03
Low	4.1 (1.4)[a]	
Low-middle	4.1 (1.4)[ab]	
Middle	4.1 (1.5)[ab]	
Upper-middle	4.2 (1.1)[ab]	
High	4.5 (1.2)[b]	

Note: Means with common superscript letters do not differ at $p<.05$.

Table 2.9 Associations between Personal, Behavioral, and Socio-environmental Characteristics[1] and Planetary Health Diet Score

Characteristics	β (SE)	P-value
Personal		
BMI (kg/m^2)	0.01 (0.04)	0.70
Cooking skills	0.16 (0.04)	<0.0001
Depressive symptoms	-0.05 (0.04)	0.20
Unmanaged stress	-0.07 (0.04)	0.08
Self-esteem	0.10 (0.04)	0.009
Overall body satisfaction	0.12 (0.04)	0.008
Behavioral		
Mindful eating	0.06 (0.04)	0.15
Monthly frequency of fast-food consumption	-0.26 (0.04)	<0.0001
Monthly frequency of eating at a restaurant	-0.25 (0.04)	<0.0001
Hours of physical activity per week	0.15 (0.04)	0.0002
Alcohol consumption grams per day	-0.02 (0.04)	0.56
Hours of screen time per week	-0.16 (0.04)	<0.0001
Hours of sleep per day	-0.05 (0.04)	0.20
Number of lifestyle weight management behaviors performed last year	0.11 (0.02)	<0.0001
Number of unhealthy weight control behaviors performed last year	0.02 (0.03)	0.34
Socio-environmental		
Home healthy food availability	0.24 (0.04)	<0.0001
Parental encouragement of healthy eating	0.15 (0.04)	0.0002
Support for healthy eating and physical activity at work	0.05 (0.05)	0.28
Food Insecure	-0.09 (0.04)	0.02

[1]Personal, behavioral, and socio-environmental predictors have been standardized to mean = 0, SD = 1 to allow for comparison of estimates across models.
[2]Models adjusted for ethnicity/race, educational attainment, gender, age, SES, and total energy intake

Chapter 3 Secular Trends in American's Ecological, Economic, Human Health and Socio-Cultural & Political Dimensions of a Sustainable Diet: 2019 and 2021

Introduction

The US is the second highest producer of greenhouse gas emissions (GHGE) globally.[114] In 2021, in order to help mitigate climate change and meet the Paris Climate Agreement, it set the goal to cut its emissions in half by 2030 with a long-term target of having net-zero emissions by 2050.[115,116] In the US, 11% of GHGE are attributable to the agriculture sector; therefore, finding ways to reduce food system emissions is integral to reaching a zero-emissions economy.[117] Creating a sustainable food system is a promising pathway for reducing GHGE in the agriculture sector.[37] A sustainable food system is one that relies on sustainable diets that provide economic, socio-cultural, and political wellbeing along with flourishing human and ecological health.[6] However, wide-scale consumer demand for sustainable diets is critical to support a sustainable food system supply chain.[36,118]

The demand for eating sustainably produced foods has grown over the past 15 years in the US.[53] In a 2017 survey of over 1,000 U.S. adults, 50% stated that it is important to them that their food is produced in a sustainable manner.[54] In 2018, 60% of U.S. consumers held this view.[55] The driving forces for this increase were concerns over pesticide use and ensuring an affordable food supply.[55] While consumer preference for sustainable diets is growing,[56–58] relatively little is known about beliefs about sustainable food systems among traditionally underserved and nutritionally-vulnerable populations in the U.S. including Black, Hispanic/Latino, rural, and low-

income populations.[59] Climate change is often painted as an elitist concern.[60] Yet, marginalized populations are more likely to be harmed by unsustainable food systems through unfair agricultural employment practices, limited food access and security, higher prevalence of diet-related illnesses, agriculture-related environmental hazards, and climate change.[61] With the growing popularity of the food justice movement, which aims to address these inequities,[62] evidence is mounting that Black, Hispanic, and low-income households care just as much or more than White households and those with a high income that their food is environmentally sustainable.[59] In 2019, the International Food Information Council found that among a nationally representative sample of Americans, 58% of African Americans and 59% of Hispanic Americans believed that it is important that their food is produced in an environmentally sustainable way, while only 41% of non-Hispanic White Americans said the same.[63] Further, Larson et al.,[57] found that among a sociodemographically diverse sample of young adults (25-36 years old), 35% of people with very low household incomes (making less than $20,000 per year) care that their food is produced organically, 45% care that their food is produced without processing, 42% care that their food is locally grown, and 46% care that their food is not genetically modified. These preferences are comparable to those of individuals with higher household incomes. It should be noted that consumer preferences do not always manifest into purchases for a variety of reasons, some of which are competing financial demands, food availability and access, along with time constraints.

Furthermore, the past two years have been punctuated by the onset of the COVID-19 pandemic in March 2020. The pandemic killed over a million Americans, resulted in economic hardship for the country marked by record-high unemployment and food insecurity and created supply chain

disruptions with food shortages and subsequent price increases.[71,76,86,119] The pandemic also changed the way consumers interacted with the food environment overnight. Consumers ate more at home, shopped less in person, were more attentive to reducing food waste, and expressed desires to eat more healthfully, but contrarily reported consuming more sweets.[78,80,82,85] The pandemic also disproportionately impacted racial/ethnic minorities along with low-income populations, in terms of increased unemployment, food insecurity, and severity of COVID-19 cases.[87,120] As such, the COVID-19 pandemic may have differentially and inequitably changed peoples' sustainable diet preferences, possibly due to tighter food budges and a lack of access to food sources.

The aim of this study is to identify how recent trends in ecological, economic, human health, and socio-cultural & political dimensions of a sustainable diet changed across diverse US subpopulations from 2019 to 2021. We hypothesize that sustainable diets have become stronger throughout this time and have strengthened equivalently or greater for adults from non-White ethnic/racial identification and low-income households. This knowledge will inform initiatives to support consumer education and engagement in strengthening the sustainability of the food system, with specific attention to subpopulations.

Methods

Study Population:

Repeated, cross-sectional data from the annual International Food Information Council (IFIC) 2019, 2020, and 2021 Food and Health Surveys were used. Each year, more than 1,000 US residents aged 18 to 80 completed the Food and Health Survey, which was administered online

by Greenwald Research (formerly Greenwald & Associates) via Dynata's consumer panel. Dynata's American consumer panel, the sampling frame for the Food and Health Survey, is recruited through social media platforms, mobile apps, and website advertisements, and consists of 14 million Americans: 65% female, 47% have an associate degree or higher, and 52% have an annual income > $50,000.[121] Respondents received a small financial incentive for participating in Dynata panels. The consumer panel is stratified by sociodemographic variables and then randomly sampled within those strata to make sure that the final sample is nationally representative with respect to age, education, gender, race/ethnicity, and region based on the most recent Current Population Survey from the Census Bureau.[63,80,122] The study was exempt from Institutional Review Board oversight as all information collected was deidentified.

Study Measures:

Sustainable diets were assessed using the four dimensions of a sustainable diet: ecological, economic, human health, and socio-cultural and political, which was created by Downs et al.[6] The framework builds upon the food environment literature and was the first to formally include sustainability parameters into the food environment framework. It conceptualizes the ecological dimension as supporting sustainable agriculture, the economic dimension as promoting fair accessible food, the human health dimension as the flourishing of human health through nutrition, and the socio-cultural and political dimension as equitable food systems.[6]

Ecological, Economic, and Human Health Dimensions

The ecological dimension was assessed by asking "How much of an impact does *environmental sustainability* have on your decision to buy foods and beverages?"[63,80,122] The economic

dimension was assessed by asking “How much of an impact does *price* have on your decision to buy foods and beverages?” The human health dimension was assessed by asking “How much of an impact does *healthfulness* have on your decision to buy foods and beverages?” Response options for these three questions were on a 5-point Likert scale ranging from no impact to a great impact and were asked in 2019, 2020, and 2021.

Additionally, the ecological, economic, and human health dimensions were examined jointly due to the interrelated nature of these items across dimensions. Some of the practices within these dimensions are hard for consumers to independently identify; therefore, food labels such as organic, raised without antibiotics, no added hormones or steroids, etc. are used by consumers to guide purchasing decisions.[123] To assess consumers' use of such labels they were asked “Which of the following if any, do you do on a regular basis (that is, most times when you shop for foods and beverages)? Buy foods and beverages because they are advertised on the label as 1) raised without antibiotics, 2) no added hormones or steroids, 3) locally sourced, or 4) organic”.[63,80,122] Participants could select as many as applied. It is important to note that benefits from locally grown food primarily occur from financial benefits to the farmer and greater access to the consumer rather than decreased GHGE. This question was asked in 2019, 2020, and 2021.

Socio-Cultural and Political Dimension

The socio-cultural and political dimension was evaluated by examining differences across the other three dimensions with respect to race/ethnicity, household income, education, geographic location, age, and gender, thus enabling us to determine if disparities exist. Race/ethnicity was determined by asking, “Which of the following best describes(s) your race or ethnicity (select all that apply)?[63,80,122] Response options were White, Black or African American, Asian or Pacific

Islander, Native Hawaiian, Hispanic/Latino/Spanish descent, or Other.[63,80,122] If participants selected more than one race/ethnicity they were classified in accordance with The National Longitudinal Study of Adolescent to Adult Health.[124] Household income was determined by asking, "How much is your total annual household income?"[63,80,122] Response options were less than $35,000; $35,000 to less than $50,000; $50,000 to less than $75,000; $75,000 to less than $100,000; $100,000 to less than $150,000; $150,000 and above; not sure; or prefer not to answer.[63,80,122] Education level was determined by asking, "What is the highest level of education you have completed?"[63,80,122] Response options were no college, some college (no degree), associate degree or technical or vocational school, bachelor's degree, or graduate/professional degree.[63,80,122] Geographic location was determined by asking, "Which of the following best describes the area in which you live?[63,80,122] Response options were rural, suburban, small town, or urban.[63,80,122] Finally, age and gender were self-reported.[63,80,122]

Statistical Analysis:

Percentages within each sociodemographic characteristic (categories of age, gender, race/ethnicity, educational attainment, categories of household income, and geographic location) were calculated and differences were tested between years. All analyses accounted for the sampling weights. Overall trends in consumers' ecological, economic, and human health dimensions of a sustainable diet across 2019, 2020, and 2021 were tested by linear regression for the impact of consumers' decisions to buy foods and beverages based on environmental sustainability, price, and healthfulness and by logistic regression for reporting that they buy foods and beverages because they are advertised as: raised without antibiotics, no added hormones or steroids, locally sourced, or organic. A crude model was constructed along with an

adjusted analysis for income. Additionally, trends in ecological, economic, and human health dimensions of a sustainable diet across the socio-cultural and political dimension categories were evaluated by testing for linear interactions between socio-cultural and political dimension categories (age, gender, race/ethnicity, educational attainment, household income, and geographic location) and year with ecological, economic, and human health dimensions (impact of consumers' decision to buy foods and beverages based on environmental sustainability, price, and healthfulness) as the outcomes of interest. The probability level at which differences were considered significant was less than or equal to 0.05. Statistical analyses were carried out in SAS version 9.4.

Results

The sociodemographic characteristics of the 2019, 2020, and 2021 Food and Health Survey participants are shown in **Table 3.1**. Half of study participants were 36-65 years old in 2019-2021 and gender was split evenly between male and female. Just over 60%, 11%, 6%, and 16% of the study participants identified their race/ethnicity as White, Black or African American, Asian or Pacific Islander, and Hispanic/Latino/Spanish descent, respectively. Most study participants lived in suburban (44.7%-46.5%) or urban (26.2-28.3%) communities while the remainder (25.2-28.5%), lived in a rural area or small town. Most sociodemographic characteristics were similar across the annual samples; however, the educational attainment and household income distributions of the sample were different between years. Household income shifted from low (less than $35,000) and high (above $150,000) income groups towards middle-income groups ($35,000-$150,000) in 2020 and 2021 in comparison to 2019 while a greater

proportion of participants reported higher levels of educational attainment in 2020 than in 2019 or 2021.

Ecological, Economic, and Human Health Dimensions

The impact of healthfulness on consumers' decision to buy foods and beverages declined significantly between 2019 and 2021 (annual trend (β) = -0.06, P value = 0.03) (**Table 3.2**), while the impact of price on consumers' decision to buy foods and beverages remained constant between 2019 and 2021 (annual trend (β) = -0.002, P value = 0.95). The impact of environmental sustainability on consumers' decision to buy foods and beverages increased but not linearly from 2019 (2.8 (1.2)), 2020 (3.0 (1.2)), to 2021 (2.9 (1.3)) so the linear trend was not statistically significant (annual trend (β) = 0.03, P value = 0.40). Additionally, while in 2019, 32.7% of participants reported purchasing foods and beverages because they were advertised as raised without antibiotics, only 27.3% and 23.4% reported doing so in 2020 and 2021 respectively (annual trend (β) = -0.23, P value = 0.0013). Similar declines in the importance of purchasing foods with no added hormones or steroids, because they were locally sourced, and because they were organic were observed between 2019 and 2021. However, the importance of purchasing foods because they were organic was not a statistically significant decline (annual trend (β) = -0.14, P value = 0.06). Trends in consumers' ecological, economic, and human health dimensions of a sustainable diet did not change when adjusted for income.

Socio-Cultural and Political Dimension

Participants from all racial/ethnic groups, household income categories, age categories, educational attainment, genders, and geographic locations reported similar declines in the impact of healthfulness on their decision to buy foods and beverages from 2019, 2020, and 2021 **(Table 3.3)**. Similarly, few differences in changes in the importance of environmental sustainability were observed across sociodemographic groups. However, changes in the importance of environmental sustainability on consumers' decision to buy foods and beverages did vary by age **(Table 3.4)**. Environmental sustainability became increasingly important for young to middle-aged adults (ages 18-50) between 2019 and 2021, while individuals over 50 reported declines in the importance of environmental sustainability (**Figure 3.1)**. Although not statistically significant, the importance of environmental sustainability increased for men across the time period, while women reported slight declines in importance (male ($\beta = 0.08$), female ($\beta = -0.02$), (P value = 0.05). In contrast, differences in changes in the importance of price were observed across more sociodemographic groups, namely educational attainment, household income, and geographic location **(Table 3.5)**. Price became decreasingly important to those living in rural locations or small towns, with less than $50,000 per year in household income, and people with bachelor's degrees or no college education. Price became increasingly important to those living in suburban or urban locations, with between $50,000 and $150,000 per year in household income, and people with some college (no degree) or a graduate/professional degree. Overall, there were not significant differences in trends observed between non-White and White racial/ethnic groups.

Discussion

The objective of this analysis was to identify recent trends in ecological, economic, human health, and socio-cultural & political dimensions of a sustainable diet across diverse U.S. subpopulations from 2019 to 2021. Contrary to our hypothesis, the importance of healthfulness in making food and drink purchasing decisions declined slightly overall and across most consumer subpopulations. Further, the importance of purchasing antibiotic-free food, hormone/steroid-free food, and locally sourced foods also declined among U.S. consumers during this time period. These trends persisted after accounting for differences in household income among each year's sample. In contrast, the importance of environmental sustainability on purchasing decisions increased marginally, yet this change was not statistically significant. Furthermore, younger individuals (18-50 years old) reported increased importance of environmental sustainability on purchasing decisions between 2019 and 2021, while the impact of environmental sustainability on purchasing decisions declined among individuals over 50. Finally, overall, the importance of price on purchasing decisions stayed constant over the time period. However, price became less important to those living in rural locations, with lower household incomes, and for those with a bachelor's degree or no college education. Conversely, price became more important to those living in more urban locations, in the middle class, and with some college education or a graduate degree.

Trends in consumers' sustainable diet human health dimension along with the importance of purchasing antibiotic-free food, hormone/steroid-free food, and locally sourced foods decreased overall in our study population. With so many stressors from the pandemic, (e.g., shopping less, food supply chain inconsistencies, reduced food procurement options) people may have shifted their priorities to the simple necessity of obtaining food rather than focusing on sourcing it

sustainably.[78,84] Furthermore, the economic hardship that occurred as a result of the COVID-19 pandemic could be driving the observed declines in the importance of healthfulness and products that are raised without antibiotics, no added hormones/steroids, and locally-sourced through responses to changes in income.[76,86] Therefore, we tested the hypothesis that declining income during the COVID-19 pandemic contributed to these declines in importance; however, they were still evident after adjusting for income. Although these declines may not be entirely due to decreased income, there is still reason to believe that they may be a response to the COVID-19 pandemic related stressors mentioned above. These pandemic related stressors do not however explain the consistent priority of environmental sustainability in consumers' preferences throughout the pandemic. The concern for environmental sustainability could be due to the strong connection between the emergence of zoonotic diseases and climate change or may represent the disparity between food choices and consumers' aspirations.[125,126] It could also be due to the increased attention focused on climate change over the past few years. Regardless of its origins, the data showed that climate change continues to be an issue of importance for Americans during the COVID-19 pandemic.

Consumers' stable demand for sourcing environmentally sustainable foods could be a potential marketing opportunity for farmers, retailers, and food manufacturers. It could also incentivize governments to support the transition to environmentally sustainable agricultural management practices, as price consistently ranks a stronger priority for consumers. Farmers can increase environmental sustainability through decreasing fertilizer application, water use, and GHGE along with promoting increased biodiversity. Many of these can be achieved simultaneously through improvements to agricultural management practices.[37,127–133] Government should support

farmers in making the transition towards more sustainable agriculture practices through subsidies and incentives that promote these large-scale management changes, thereby keeping prices affordable for consumers, as cost is often a competing priority when balancing ethical food choices.[134] Currently, the United States Department of Agriculture supports the transition of conventional farmers to organic production. The recent USDA Food System Transformation framework has earmarked an additional $300 million for this express purpose; however,[135] in order to meet US net-zero emissions goal by 2050, the framework needs to be taken further to support and encourage all farmers, especially conventional, to transition to more environmentally sustainable agriculture management practices. The Sustainable Agriculture Research and Education (SARE) program within USDA offers grant opportunities to farmers who are looking to implement these and other sustainable management practices on their farms.[136] One way to support sustainable agriculture for all farmers would be to secure funding increases for SARE in the upcoming 2023 Farm Bill.[137]

Stratification of consumers revealed that the impact of environmental sustainability on the decision to buy food and beverages increased slightly among younger adults and decreased slightly among older adults during this time period. This difference may have been because of the increased stress of COVID-19 for older adults, as age increases the risk of contracting COVID-19, developing severe symptoms, and death.[138] Older adults are also more likely to have underlying medical conditions that pose additional risk factors for severe COVID-19 such as cancer, type two diabetes, cardiovascular disease, kidney disease, liver disease, lung disease, obesity, and disabilities.[139] As such, older adults may have prioritized getting food in a contact-free manner over its environmental sustainability. In addition, older adults may have been

impacted differentially by the economic recession due to the retired population relying on a fixed income for their livelihoods.[140] However, our analysis did not demonstrate a difference in secular trend by age for the impact of price on consumers' decisions to buy foods and beverages. Another reason for the age difference may be the amplification of a trend that has persisted for decades; younger generations have consistently been found to have stronger environmental concerns than older generations.[141] The second difference in secular trends for the impact of environmental sustainability on consumers' decisions to buy foods and beverages was observed by gender. Males expressed a modest increase in impact while females stated a slight decrease. Although the p-value for gender was borderline at 0.05, it is worth noting as interactions are often underpowered. The difference by gender may be due to the fact that women are still often the primary shoppers in their households and therefore, may have been more conscious of availability and price of foods during the pandemic.[142]

In contrast to the stratification of consumers by the impact of healthfulness and environmental sustainability, the trends in the impact of price varied considerably by sociodemographic characteristics; although, the absolute magnitude of the changes were small. The most prominent difference was by income. The impact of price on the decision to buy food and beverages decreased slightly among those with less than $50,000 per year in household income while price became increasingly important to those with between $50,000 and $150,000 per year in household income. Additionally, we saw a decreased impact of price among rural study participants, which may be due to the higher rates of poverty across rural America (15.4%) when compared to urban locations (11.9%) in 2019.[143] The decline of the impact of price on purchasing foods and beverages that lower income and rural households experienced during this

time may have been due to the increased and expanded federal nutrition and unemployment assistance during the COVID-19 pandemic.[144] Supplemental Nutrition Assistance Program (SNAP) increased benefits by 15% during 2020 to relieve financial stress brought about by the COVID-19 Pandemic.[145] Furthermore, benefit increases in Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) raised participants' monthly produce allowance for fruits and vegetables from $9 per child and $11 per adult to $35 per person.[146] The effects of this increase have already been seen through increased consumption of fruits and vegetables by WIC-participating children and are projected to continue increasing during 2022.[146] These federal nutrition programs helped mitigate financial hardship for recipients and likely stabilized the impact of price on food and beverage purchases through 2020 and 2021 in these demographic groups. Continuing the increased federal nutrition programs into the future is an ideal way to help low-income families access healthy foods long-term and support the economic dimension of sustainable diets.

One of the strengths of this study is that the sample is nationally representative with respect to age, gender, education, race/ethnicity, and region and therefore results can be generalized to the US population. Notwithstanding, the study also has some limitations. First, Dynata's consumer panel used only electronic platforms for recruitment (social media platforms, mobile apps, and website advertisements); therefore, adults without access to or knowledge about these technologies would have been excluded. Second, the survey was not weighted by income, so the income level distribution may differ from the data in the most recent Current Population Surveys. Finally, social-desirability bias is also a possibility as participants may have misreported specific beliefs and behaviors, such as concern for environmental sustainability and

healthfulness. To mitigate this issue somewhat, survey data was collected anonymously without an interviewer present to maintain anonymity.

This study found that the importance of purchasing food and drink based on healthfulness, antibiotic-free, hormone/steroid free, and locally sourced declined among a nationally representative sample of Americans. These declines may be due to stressors from the pandemic and changing consumer priorities. In contrast, consumers' decision to buy foods and beverages based on environmental sustainability and price remained consistent over the years examined and low-income households experienced slight decline in the impact of price on buying foods and beverages. This may have been due to the expansion of federal nutrition programs SNAP and WIC during the pandemic, and the continuation of those programs should be encouraged to promote equitable food access and healthy sustainable diets.

Table 3.1 Sociodemographic Characteristics of the Food and Health Survey Participants

	2019 (N=983)	2020 (N=946)	2021 (N=944)	
	Weighted %			P-Value
Age (years)				.98
18-35	32.8	31.9	31.2	
36-50	24.8	24.3	25.4	
51-65	24.8	25.5	26.0	
66-80	17.7	18.3	17.4	
Gender				.71
Male	48.9	49.5	50.7	
Female	51.2	50.5	49.3	
Race/Ethnicity				.91
White	61.1	63.5	63.0	
Black or African American	13.4	11.8	11.6	
Asian or Pacific Islander	6.4	6.5	6.7	
Hispanic/Latino/Spanish descent	17.1	16.3	17.3	
American Indian/Alaska Native or Other	2.0	2.0	1.4	
Educational Attainment				.004
No college	33.0	39.7	36.7	
Some college (no degree)	21.5	16.5	16.1	
Associate degree/technical or vocational school	12.3	10.0	11.6	
Bachelor's degree	20.8	23.6	23.4	
Graduate/professional degree	12.4	10.3	12.2	
Household Income				<.0001
Less than $35,000	28.9	25.5	26.7	
$35,000 to less than $50,000	12.2	14.6	16.0	
$50,000 to less than $75,000	15.0	21.1	21.4	
$75,000 to less than $100,000	13.0	14.1	13.8	
$100,000 to less than $150,000	15.9	15.2	13.1	
$150,000 and above	15.1	9.5	9.1	
Geographic Location				.37
Rural	16.7	15.0	15.9	
Suburban	44.7	46.5	46.5	
Small town	11.8	12.2	9.3	
Urban	26.8	26.2	28.3	

Table 3.2 Trends in Consumers' Ecological, Economic, and Human Health Dimensions of a Sustainable Diet

	2019	2020	2021	Annual Trend	
	Weighted Mean (SD)			Beta (SE)	P-Value
Impact on consumers' decision to buy foods and beverages*					
Healthfulness	3.8 (1.0)	3.8 (1.0)	3.7 (1.1)	-0.06 (0.03)	.03
Environmental sustainability	2.8 (1.2)	3.0 (1.2)	2.9 (1.3)	0.03 (0.03)	.40
Price	3.9 (1.1)	4.0 (1.0)	3.9 (1.1)	-0.002 (0.03)	.95
	Weighted %			Beta (SE)	P-Value
Percentages of consumers who report that they buy foods and beverages because they are advertised as,**					
Raised without antibiotics	32.7	27.3	23.4	-0.23 (0.07)	.0013
No added hormones or steroids	36.1	32.1	26.0	-0.24 (0.07)	.0004
Locally sourced	27.7	25.5	21.7	-0.17 (0.07)	.02
Organic	27.1	28.1	22.5	-0.14 (0.07)	.06
	Income Adjusted Weighted Mean (SE)			Beta (SE)	P-Value
Impact on consumers' decision to buy foods and beverages*					
Healthfulness	3.8 (0.03)	3.8 (3.03)	3.7 (0.03)	-0.06 (0.03)	.05
Environmental sustainability	2.8 (0.04)	3.0 (0.04)	2.9 (0.04)	0.02 (0.03)	.51
Price	3.8 (0.3)	3.9 (0.03)	3.8 (0.03)	-0.02 (0.03)	.51
	Income Adjusted Weighted %			Beta (SE)	P-Value
Percentage of consumers who report that they buy foods and beverages because they are advertised as,**					
Raised without antibiotics	32.7	27.3	23.5	-0.23 (0.07)	.0014
No added hormones or steroids	35.7	31.9	25.9	-0.25 (0.07)	.0003
Locally sourced	27.9	25.5	21.7	-0.16 (0.08)	.03
Organic	27.6	28.2	22.7	-0.1243 (0.07)	.09

*1=No impact, 5=A great impact

**Question was asked of half the sample in 2019 and 2020

Table 3.3 Trends in Human Health Dimension of a Sustainable Diet by Sociodemographic Characteristics

	How much of an impact does healthfulness have on your decision to buy foods and beverages?				
	2019	2020	2021	Strata specific linear trend	Sociodemographic by year interaction
	Weighted Mean (SD)			Beta (SE)	P-value
Age (years)					.91
18-35	3.7 (1.6)	3.8 (1.1)	3.6 (1.2)	-0.06 (0.05)	
36-50	3.8 (1.1)	3.6 (1.2)	3.6 (1.2)	-0.07 (0.05)	
51-65	3.8 (0.9)	3.9 (0.9)	3.7 (0.9)	-0.06 (0.04)	
66-80	3.9 (0.9)	3.9 (0.8)	3.8 (1.0)	-0.06 (0.05)	
Gender					.90
Male	3.7 (1.0)	3.6 (1.1)	3.6 (1.1)	-0.06 (0.03)	
Female	3.8 (1.0)	3.8 (1.0)	3.8 (1.0)	-0.06 (0.03)	
Race/Ethnicity					.17
White	3.7 (0.9)	3.8 (1.1)	3.6 (1.1)	-0.06 (0.03)	
Black/African American	3.8 (1.2)	3.5 (1.0)	3.9 (1.1)	0.06 (0.07)	
Asian/Pacific Islander	3.9 (0.9)	3.8 (0.6)	3.6 (1.1)	-0.1 (0.08)	
Hispanic/Latino/Spanish descent	3.9 (1.2)	4.0 (1.1)	3.7 (1.1)	-0.1 (0.06)	
American Indian/Alaska Native or Other	4.0 (0.7)	3.8 (0.8)	3.4 (0.9)	-0.3 (0.1)	
Educational Attainment					.17
No college	3.6 (1.4)	3.7 (1.0)	3.6 (1.2)	0.002 (0.04)	
Some college (no degree)	3.8 (1.2)	3.7 (1.3)	3.6 (1.1)	-0.1 (0.06)	
Associate or vocational degree	3.9 (0.8)	3.8 (1.4)	3.5 (1.1)	-0.2 (0.07)	
Bachelor's degree	3.9 (0.9)	3.8 (1.0)	3.8 (0.9)	-0.05 (0.04)	
Graduate/professional degree	4.1 (0.7)	4.1 (0.6)	3.9 (0.9)	-0.08 (0.05)	
Household Income					.61
Less than $35,000	3.6 (1.2)	3.7 (1.1)	3.4 (1.3)	-0.1 (0.05)	
$35,000 to less than $50,000	3.6 (1.2)	3.8 (1.1)	3.6 (1.1)	-0.003 (0.07)	
$50,000 to less than $75,000	3.9 (1.1)	3.7 (1.0)	3.8 (1.0)	-0.08 (0.05)	
$75,000 to less than $100,000	4.0 (1.0)	3.8 (1.0)	3.8 (1.0)	-0.08 (0.06)	
$100,000 to less than $150,000	3.9 (0.8)	3.9 (1.0)	3.7 (0.9)	-0.06 (0.05)	
$150,000 and above	4.0 (0.8)	4.0 (0.8)	4.0 (0.9)	0.04 (0.05)	
Geographic Location					.15
Rural	3.8 (1.0)	3.9 (1.1)	3.7 (1.0)	-0.04 (0.06)	
Suburban	3.9 (0.9)	3.8 (0.9)	3.7 (1.0)	-0.07 (0.03)	
Small town	3.5 (1.2)	3.6 (1.1)	3.6 (1.1)	0.08 (0.08)	
Urban	3.8 (1.2)	3.8 (1.1)	3.6 (1.2)	-0.1 (0.05)	

Table 3.4 Trends in Ecological Dimension of a Sustainable Diet by Sociodemographic Characteristics

	How much of an impact does environmental sustainability have on your decision to buy foods and beverages?				
	2019	2020	2021	Strata specific linear trend	Sociodemographic by year interaction
	Weighed Mean (SD)			Beta (SE)	P-value
Age (years)					.006
18-35	3.0 (1.3)	3.2 (1.2)	3.1 (1.3)	0.09 (0.05)	
36-50	2.7 (1.2)	3.0 (1.4)	3.0 (1.4)	0.13 (0.06)	
51-65	2.8 (1.1)	2.9 (1.2)	2.7 (1.2)	-0.06 (0.05)	
66-80	2.8 (1.1)	2.9 (1.1)	2.6 (1.1)	-0.09 (0.06)	
Gender					.05
Male	2.7 (1.3)	2.9 (1.2)	2.8 (1.3)	0.08 (0.04)	
Female	3.0 (1.1)	3.1 (1.2)	3.0 (1.3)	-0.02 (0.04)	
Race/Ethnicity					.40
White	2.7 (1.1)	2.9 (1.3)	2.8 (1.3)	0.04 (0.03)	
Black/African American	3.1 (1.4)	2.9 (1.1)	3.4 (1.3)	0.1 (0.08)	
Asian/Pacific Islander	3.0 (1.2)	2.9 (0.9)	2.8 (1.1)	-0.06 (0.09)	
Hispanic/Latino/Spanish descent	3.0 (1.5)	3.4 (1.4)	2.9 (1.2)	-0.04 (0.07)	
American Indian/Alaska Native or Other	2.8 (1.0)	3.0 (0.9)	2.8 (1.2)	-0.006 (0.2)	
Educational Attainment					.33
No college	2.7 (1.6)	3.1 (1.1)	2.9 (1.4)	0.1 (0.05)	
Some college (no degree)	2.8 (1.2)	3.1 (1.4)	2.8 (1.2)	-0.02 (0.07)	
Associate or vocational degree	3.0 (1.1)	3.2 (1.8)	2.8 (1.2)	-0.08 (0.09)	
Bachelor's degree	2.9 (1.1)	2.8 (1.2)	3.0 (1.1)	0.03 (0.05)	
Graduate/professional degree	3.0 (1.0)	3.0 (0.9)	3.0 (1.3)	-0.008 (0.07)	
Household Income					.25
Less than $35,000	2.8 (1.3)	3.1 (1.2)	2.8 (1.3)	-0.02 (0.06)	
$35,000 to less than $50,000	3.0 (1.3)	3.1 (1.2)	3.0 (1.3)	0.04 (0.08)	
$50,000 to less than $75,000	2.8 (1.3)	3.0 (1.3)	3.0 (1.2)	0.06 (0.07)	
$75,000 to less than $100,000	2.8 (1.2)	3.0 (1.2)	2.8 (1.3)	0.009 (0.08)	
$100,000 to less than $150,000	2.9 (1.1)	2.8 (1.3)	2.7 (1.1)	-0.07 (0.07)	
$150,000 and above	2.7 (1.1)	3.0 (1.0)	3.0 (1.3)	0.2 (0.07)	
Geographic Location					.83
Rural	2.9 (1.3)	3.1 (1.1)	2.9 (1.3)	-0.01 (0.07)	
Suburban	2.8 (1.1)	2.9 (1.2)	2.8 (1.2)	0.02 (0.04)	
Small town	2.6 (1.2)	3.1 (1.3)	2.7 (1.1)	0.08 (0.09)	
Urban	2.9 (1.3)	3.0 (1.2)	3.0 (1.4)	0.05 (0.06)	

Table 3.5 Trends in Economic Dimension of a Sustainable Diet by Sociodemographic Characteristics

	How much of an impact does price have on your decision to buy foods and beverages?				
	2019	2020	2021	Strata specific linear trend	Sociodemographic by year interaction
	Weighed Mean (SD)			Beta (SE)	P-value
Age (years)					.76
18-35	4.0 (1.0)	3.9 (1.0)	3.9 (1.1)	-0.05 (0.04)	
36-50	3.8 (1.2)	4.1 (1.0)	3.9 (1.1)	0.04 (0.05)	
51-65	3.8 (1.0)	4.0 (0.9)	3.9 (1.0)	0.05 (0.25)	
66-80	3.8 (1.1)	3.9 (1.0)	3.6 (1.2)	-0.06 (0.06)	
Gender					.85
Male	3.8 (1.1)	4.0 (1.0)	3.8 (1.2)	-0.01 (0.04)	
Female	3.9 (1.0)	3.9 (1.0)	3.9 (1.0)	0.00 (0.03)	
Race/Ethnicity					.77
White	3.9 (1.0)	3.9 (1.1)	3.8 (1.1)	-0.02 (0.03)	
Black/African American	4.0 (1.1)	4.1 (0.8)	4.0 (1.1)	0.02 (0.07)	
Asian/Pacific Islander	3.8 (1.0)	3.9 (0.7)	4.0 (0.9)	0.08 (0.07)	
Hispanic/Latino/Spanish descent	3.9 (1.4)	4.0 (1.1)	4.0 (1.0)	0.03 (0.06)	
American Indian/Alaska Native or Other	3.7 (1.3)	3.9 (0.8)	3.8 (0.8)	0.07 (0.17)	
Educational Attainment					.03
No college	4.0 (1.3)	4.0 (0.9)	3.9 (1.3)	-0.06 (0.04)	
Some college (no degree)	3.9 (1.2)	4.0 (1.1)	4.1 (0.9)	0.12 (0.06)	
Associate or vocational degree	3.9 (0.9)	4.1 (1.4)	3.9 (1.1)	0.01 (0.07)	
Bachelor’s degree	3.9 (0.9)	3.9 (1.0)	3.8 (1.1)	-0.07 (0.04)	
Graduate/professional degree	3.6 (0.9)	3.7 (0.8)	3.8 (1.1)	0.10 (0.06)	
Household Income					.04
Less than $35,000	4.3 (1.0)	4.2 (1.0)	4.0 (1.1)	-0.12 (0.04)	
$35,000 to less than $50,000	4.0 (1.0)	4.1 (1.0)	3.9 (1.1)	-0.07 (0.07)	
$50,000 to less than $75,000	4.0 (1.1)	3.9 (0.9)	4.0 (1.0)	0.04 (0.05)	
$75,000 to less than $100,000	3.8 (1.1)	4.0 (0.9)	3.9 (1.0)	0.08 (0.06)	
$100,000 to less than $150,000	3.5 (1.1)	3.8 (1.1)	3.6 (1.0)	0.06 (0.06)	
$150,000 and above	3.5 (0.9)	3.4 (1.0)	3.5 (1.2)	-0.01 (0.07)	
Geographic Location					.02
Rural	4.1 (1.0)	4.0 (1.0)	3.8 (1.1)	-0.14 (0.06)	
Suburban	3.7 (1.0)	3.9 (1.0)	3.9 (1.1)	0.06 (0.03)	
Small town	4.1 (1.1)	4.1 (0.9)	3.9 (1.0)	-0.09 (0.07)	
Urban	3.9 (1.2)	4.0 (1.0)	4.0 (1.1)	0.02 (0.61)	

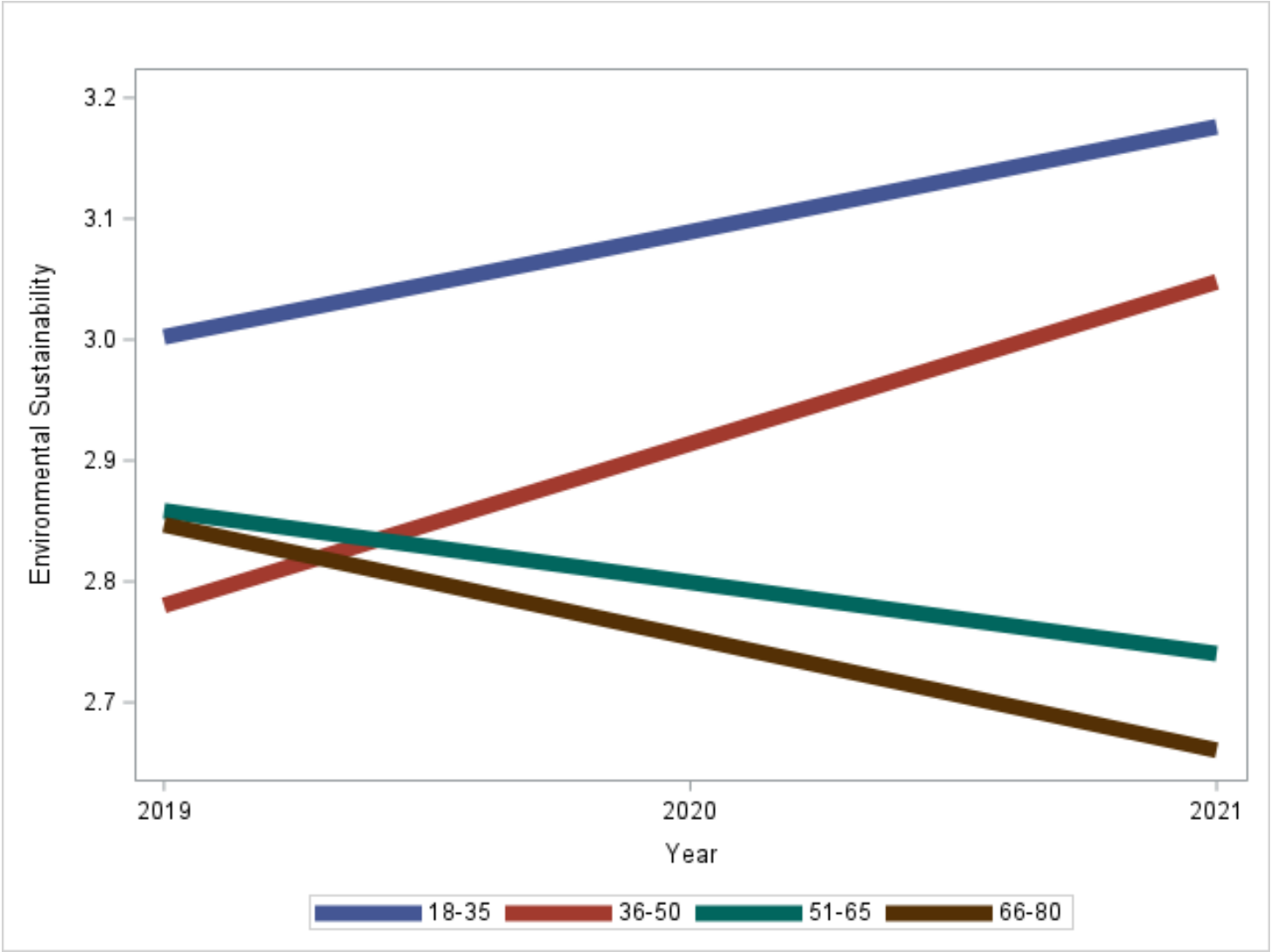

Figure 3.1 Trend in impact of environmental sustainability of consumers' decision to buy foods and beverages by age category

Chapter 4 Changes in Adults' Ecological, Economic, Human Health, and Socio-Cultural & Political Dimensions of a Sustainable Diet Within the Food Environment During the COVID-19 Pandemic

Introduction

In March 2020, the novel coronavirus SARS-CoV-2 (COVID-19) spread across the US, growing into a pandemic that infected nearly 100 million and killed over a million people over the next 2 years.[71] To help contain the virus, federal and local governments quickly implemented restrictions on citizens to support social distancing including quarantining at home, closing non-essential in-person businesses and schools, and restricting social gatherings. As such, many lost their jobs and 2020 became a year of record-high unemployment and food insecurity.[76,86] These conditions were inequitably distributed, disproportionately affecting Black/African American, Hispanic/Latino, and low-income families, and may have contributed to poor diet quality along with the progression of nutrition-related chronic diseases among these populations.[70,87]

The onset of the COVID-19 pandemic in the US also led to rapid changes in how individuals engaged with the food environment. Early evidence suggests that consumption of fruit, vegetables, alcohol, and sweets increased during the early months of the pandemic as compared to pre-pandemic, while meat consumption decreased.[77,78] These changes have been attributed to factors including a desire to eat more healthfully, stress eating or eating due to boredom, and changes in the food supply.[78,82–84] Additionally, Americans shopped less frequently in person,

relied on online shopping to avoid in-person interactions, and cooked more often at home versus purchasing fast food, takeout, or ready-made meals.[78,80] Furthermore, in an effort to decrease food costs and overall food purchasing, some households implemented strategies to conserve food and decrease food waste.[85]

The vast majority of research regarding individuals' COVID-19 pandemic-related dietary changes has focused on the health implications of such changes. However, changes in consumer behavior also have implications for sustainable diets.[6] Sustainable diets have the goal of achieving dual human and ecological health, along with providing optimal economic, socio-cultural, and political wellbeing.[6] Specific behaviors within these dimensions that support a sustainable diet include minimizing grocery store trips,[7–11] the consumption of fast-food or ready-made meals, or eating at restaurants, and in their place having groceries delivered to the home,[7–11] ordering meal kits,[18] cooking at home, shopping for locally grown produce and other food,[6] shopping at a farmer's market or participating in a CSA (Community Supported Agriculture),[6] growing a vegetable garden or participating in a community garden,[6] making more foods from scratch, and decreasing food waste.[25,26] While evidence supports these behaviors being more sustainable on average, the specific contexts and applications make a difference (e.g., locally grown food may or may not have a smaller GHGEs but they do often provide farmers with greater economic benefit and increase consumer's access to healthy food).

The US is the 2nd highest emitter of carbon dioxide globally and food systems account for around one-third of greenhouse gas emissions (GHGE); increasing the sustainability of the American

food environment will go a long way toward combating climate change while at the same time, improving the nutritional status of Americans.[147,148] High-income countries like the US can contribute to reducing GHGE by up to 50% of food-related emissions globally by changing dietary intake, primarily with regard to animal-sourced food (ASF) consumption[42] and decreasing food loss and waste.[25,149] Systematically identifying ways that consumers' behaviors changed during the pandemic will illuminate key areas of positive change with respect to the food environment that can be targeted to help consumers maintain these behavioral alterations in the long term. Furthermore, behaviors during the pandemic that became less supportive of a sustainable diet should be identified as areas that require additional support to improve over time.

The objective of this study is to describe perceived changes among U.S. adults' ecological, economic, human health, and socio-cultural and political dimensions of a sustainable diet within the food environment one year into the COVID-19 pandemic. We hypothesize that behaviors will have become, on average, better aligned with sustainable diets during the COVID-19 pandemic compared to before the pandemic. This knowledge will inform policy initiatives, with specific attention to sub-populations, to support the continuation of sustainability-promoting behaviors that increased during the COVID-19 pandemic and target behaviors that have not changed or have worsened.

Methods

Study Population:

Data were obtained from SUSTAIN; an online survey conducted in April 2021. Potential participants were identified through a query of adult patients who received outpatient care from Michigan Medicine, the University of Michigan's health system, between March 2019 and March 2020. To ensure racial, ethnic, and socioeconomic diversity of the study sample, enrollment quotas were established to ensure that one-third of participants identified as African American/Black, one-third Hispanic/Latino, and one-third White. Additionally, enrollment limits were established to ensure that at least one-third of participants were low-income, identified as being insured by public insurance (Medicaid). To accomplish these goals, all patients between the ages of 18 and 65 who identified as Black/African American (10,547 with public insurance and 15,307 with private insurance) or Hispanic/Latino (2,918 with public insurance and 8,139 with private insurance), and had an email in their electronic health record, were emailed an invitation to participate in the study. Due to the large number of patients between the ages of 18 and 65 identifying as White (253,462), 10,547 White patients with private insurance and 15,307 White patients with public insurance were randomly selected to participate. The participant invitation described the study as seeking to learn more about people's food choices during the COVID-19 pandemic and included a unique link to a Qualtrics-based eligibility screening survey.[150]

The screening survey identified individuals who were, 1) living in the state of Michigan since at least March 2020; 2) involved in food choices/shopping for their household; 3) ages 18 through 65 years old; and 4) fluent in English. Of the 2,625 participants (response rate 4.2%) that completed the screening survey, 2,439 individuals (92.9%) were eligible to participate, and 1,488

completed the study survey. Although eligible, the remaining 951 individuals were not allowed to complete the study survey because enrollment limits had already been met. See **Figure 4.1** for a flow chart of participant enrollment. Study participants who completed at least 85% of the survey questions received the opportunity to enter a lottery for 1 of 10, $100 gift cards as compensation for their participation. The study was determined to be exempt from human subjects research oversight by the University of Michigan Institutional Review Board.

Study Measures:

Survey Development

Development of survey questions was based on sustainability attributes of foods and beverages using the food environment framework created by Downs et al.[6] in 2020, along with a review of existing surveys of the food environment during the COVID-19 pandemic.[151] The framework developed by Downs et al. was the first to formally include sustainability parameters into the food environment framework. It outlines four dimensions of sustainable diets: ecological, economic, human health, and socio-cultural and political, The ecological and economic dimensions support agricultural production systems that promote biodiversity, local and seasonal foods; soil and water conservation; low GHGE; and minimize food loss and waste.[6] The human health dimension supports the thriving of human health and wellbeing through plant-based, nutrient-dense foods that meet macro- and micro-nutrient requirements.[6] Finally, the socio-cultural and political dimension examines issues of equity and disparities within the food system.[6] Initial survey questions that assessed sustainability attributes of foods and beverages

within the sustainable diet dimensions were tested via cognitive interviews among a sociodemographically diverse sample (n=20) and modified based on participant feedback.[152]

Sustainability Attributes of Foods and Beverages: Sustainable Diet Dimensions

1. *Ecological and Economic Dimension*

Ecological and economic dimensions of sustainability were combined in this analysis due to the interrelated nature of the items. To assess these dimensions, participants were asked, "Please indicate how much on average you and your household have done the following?" in response to each of the behaviors listed in **Table 4.1**. The question was asked for two different time periods: 1) over the past year during the COVID-19 pandemic and 2) before the COVID-19 pandemic.[153] Response options were on a 5-point Likert or frequency scale and tailored to the item being assessed. Driving to the grocery store, eating from restaurants, and eating pre-packaged/ready-made meals were reverse coded, and responses to all 13 items were then summed to create an ecological and economic dimension score ranging from 0 to 52 for the two different time points, where higher values represent greater sustainability within the dimension. A change in ecological and economic dimension score was also calculated by subtracting the over the past year score from the before the COVID-19 pandemic score.

2. *Human Health Dimension*

Alignment of participants' diets with the human health dimension of sustainable diets was assessed using the EAT-Lancet Planetary Health Diet (PHD) food group categories.[69] The PHD was created in 2019 to optimize human health through ensuring a diet that meets nutritional

adequacy (both macro- and micro), is primarily plant-based and nutrient-dense, along with operating within safe planetary boundaries (GHGE, nitrogen, phosphorus, water use, biodiversity loss, and land use).[69] Participants were asked, "Please indicate how much on average you have eaten the following foods over the past year during the COVID-19 pandemic (since March 2020) compared to before COVID-19 (before March 2020). I eat _____ [vegetables, fruit, potatoes, whole grains, dairy, eggs, poultry, meat, fish, soy, nuts, legumes, and sweets] now than I did before the COVID pandemic." Response options were on a 5-point Likert scale, "a lot more; more; the same amount; less; a lot less." Response options were then given a point value from -2 to 2, and beef, lamb, or pork; potatoes; dairy; sweets; eggs; chicken and other poultry were reverse coded. The 13 items were summed, using an unweighted score,[50] to create a human health dimension score ranging from -26 to 26, where higher positive values represented greater sustainability.

3. Socio-Cultural and Political Dimension

The socio-cultural and political dimension of sustainable diets was assessed by examining differences across the other dimensions with regard to socioeconomic status and race/ethnicity, thereby allowing us to understand potential disparities. Sociodemographic information including participants' race/ethnicity (White, Black or African American, Hispanic or Latino, Asian American, American Indian or Native American, and Other), income, and number of household members was collected in accordance with the 2020 US Census and NHANES questions.[154,155] Participants that identified as more than one race/ethnicity were categorized in accordance with The National Longitudinal Study of Adolescent to Adult Health.[124] Income to needs ratio (ITN)

was calculated using participants' family income and total household size in accordance with the US Department of Health and Human Services poverty guidelines for 2021 and then stratified into tertiles.[156]

Covariates

Age and gender were collected in accordance with the 2020 US Census questions.[154] Household food security was assessed using the six-item short form of the Food Security Survey recommended by the United States Department of Agriculture.[157]

Statistical Analysis:

Descriptive statistics were calculated for age, gender, household food security, race/ethnicity, and ITN. The mean ecological and economic dimension score, change in mean ecological and economic dimension score, and change in human health dimension, along with their individual components, were also calculated. ANCOVA was used to examine differences in continuous variables (mean ecological and economic dimension score, change in mean ecological and economic dimension score, change in human health dimension, along with their individual components) across the socio-cultural and political dimension categories of race/ethnicity and ITN. Both models were adjusted for education and gender along with ITN and race/ethnicity respectively. If overall tests indicated differences in behaviors by race/ethnicity or ITN, pairwise comparisons between means for individual categories were examined using Tukey's Studentized Range. A minimum sample size of 300 per group was needed to detect small to moderate size differences in sustainable diets before the COVID-19 pandemic and during the COVID-19

pandemic between key sociodemographic groups (Black/African American; Hispanic/Latino descent; White participants; low-income households; middle-income households; and high-income households) participating in the survey. The alpha level at which differences were considered significant was less than .05. Statistical analyses were carried out in SAS version 9.4.

Results

The mean age of study participants was 42.7 (SD = 12.6) years old with 77.4% of participants identifying as female, 22.0% male, and 0.5% identifying as another gender **(Table 4.2)**. The racial/ethnic distribution of the study sample was equally distributed between White, Black/African American, and Hispanic/Latino. More than half (53.9%) of participants reported having a bachelor's degree or higher. Within race/ethnicity 23.9% of Hispanic or Latino, 42.4% of Black or African American, and 36.6% of White individuals were low-income **(Table 4.3)**.

Ecological and Economic Dimension

The ecological and economic dimension of a sustainable diet during the COVID-19 pandemic in comparison to before the COVID-19 pandemic is shown in **Table 4.4**. Overall, participants' ecological and economic sustainable diet dimension score improved (mean effect size=1.2, $p<.0001$). Improvements to the dimension were achieved through large decreases in eating at a restaurant either indoors or outdoors (effect size=-1.0, $p<.0001$), decreases in driving to the grocery store (effect size=-0.6, $p<.0001$), increases in eating foods that were traditionally purchased pre-made but now made at home (effect size=0.4, $p<.0001$), and increases in eating meals that were home-cooked (effect size=0.3, $p<.0001$). However, not all changes to the

dimension were improvements; shopping at a farmer's market or participating in a CSA (effect size=-0.6, $p<.0001$) along with shopping for locally grown produce and/or other food (effect size=-0.3, $p<.0001$) both declined.

Human Health Dimension

On average, alignment of participants' diets with the PHD improved during the COVID-19 pandemic as compared to before the COVID-19 pandemic (**Table 4.5**). Specifically, using a scale of -2 (less sustainable) to 2 (more sustainable) to quantify the degree of change from before COVID, participants reported eating more vegetables 0.4 (1.0), fruit 0.4 (1.0), and nuts 0.2 (0.9) during COVID, as well as less beef, lamb, and pork 0.2 (0.9). However, participants also reported eating less soy food -0.3 (1.0) and more poultry -0.3 (0.9) and eggs -0.2 (0.9).

Socio-Cultural and Political Dimension

The analysis was adequately powered to assess differences by race/ethnicity and income as there were at least 300 people in each category. High-income households and White participants were more likely than other sociodemographic groups to have a higher ecological and economic dimension score for sustainable diets both before and during the COVID-19 pandemic **(Table 4.6).** Individual ecological and economic dimension items varied considerably by income and race/ethnicity. Before COVID, high-income participants more frequently ate at restaurants either indoors or outdoors (2.7 (0.2)), compared to low (2.2 (0.2)) and moderate (2.5 (0.2)) income participants ($p<.0001$) (**Table 4.7**). However, during the COVID-19 pandemic, a large decline in eating at restaurants was seen among all income groups, with the largest declines among high-

income households (low -1.3 (0.2), moderate -1.6 (0.2), and high-1.9 (0.2) (p<.0001)). This decline was countered by an increase in eating meals prepared at home, again with the largest change being for high-income households (p=0.0001). Additionally, high-income households (0.3 (0.1)) increased the amount of food traditionally purchased pre-made that they now made at home more than did low (0.1 (0.1)) or moderate (0.1 (0.1)) income households (p<.0001). On the other hand, low-income households (0.2 (0.3)) slightly increased their consumption of pre-packaged meals such as frozen dinners, canned soup, or ramen noodles in comparison to moderate (0.0 (0.3)) or high (0.0 (0.3)) income households, although this finding was not statistically significant (p=0.44).

High-income and Black/African American participants reported the greatest increases in the human health dimension of sustainable diets during COVID. With regard to income, these changes were strongly driven by high-income participants eating more fish 0.1 (0.2) during the COVID-19 pandemic as compared to before the COVID-19 pandemic **(Table 4.8).** Meanwhile, Black/African American participants' increases in the human health dimension were due to consuming more vegetables 0.9 (0.2), fruit 0.8 (0.1), and fish 0.2 (0.2), and fewer sweets 0.3 (0.2), than before the COVID-19 pandemic.

Discussion

The goal of this study was to describe perceived changes among U.S. adults' ecological, economic, human health, and socio-cultural and political dimensions of a sustainable diet within the food environment one year into the COVID-19 pandemic. Our hypothesis that behaviors

became on average more supportive of a sustainable diet one year into the COVID-19 pandemic compared to before the COVID-19 pandemic was supported by study findings with regards to ecological, economic, and human health dimensions of sustainable diets. Gains within the ecological and economic domain were likely due to social distancing and prohibitions on indoor dining, which resulted in participants eating at restaurants less frequently and eating home-cooked meals more frequently one year into the COVID-19 pandemic compared to before.[78,80] Furthermore, participants drove to the grocery store less frequently during the COVID-19 pandemic and increased home delivery of groceries, which may have decreased GHGE from fuel use.[158] Additionally, the human health dimension of sustainable diets improved through increased consumption of vegetables, fruits, and nuts, and eating less meat during the COVID-19 pandemic as compared to before.

The COVID-19 pandemic precipitated some positive changes to ecological, economic, and human health dimensions of a sustainable diet – specifically, less frequent trips to the grocery store and increased use of home grocery delivery options. In the US where most consumers drive to the grocery store, having groceries delivered to the home is on average more sustainable,[158] however, it is important to note that the overall frequency of groceries acquired (when done so in a car or van) has a larger impact than on which method consumers use.[10] Therefore, home delivery options could use a minimum item order requirement or a fiscal incentive to lessen the frequency of deliveries per customer. However, as the risk associated with the COVID-19 pandemic lessens, consumers may rebound back to their original shopping habits with regard to both frequency and location.[159] As such, increased access to public transportation would be a

way to incentivize consumers to continue taking fewer trips in their cars to the grocery store. In countries like the US where residents regularly drive to the store, walking or biking instead would result in even lower GHGE compared to online delivery shopping.[158] Consequently, improving access to public transportation (sidewalks, bike lanes, busses, and trains) in urban and peri-urban areas throughout the US could facilitate even greater improvements to the sustainability of acquiring food than having groceries delivered to people's homes in the US.

Another positive change that occurred during the COVID-19 pandemic was an increase in eating home-cooked meals along with greater consumption of vegetables, fruits, and nuts. It is important to encourage the continuation of these habits as they are not only better for the ecological and economic dimensions of a sustainable diet but could also help to support the positive changes to the human health dimension observed in study participants mentioned above.[160] Lack of time and cooking skills are often-cited obstacles to cooking at home.[161] Exploring each of these reasons in turn may help overcome the respective obstacles. Not having enough time to cook could be addressed by reducing the amount of time employees spend commuting each day to and from work. Some companies have offered the continuation of work-from-home options that were required during the early months of the COVID-19 pandemic; however, this is not an option for all occupations, especially for low-income service jobs.[163] Other ways to minimize the time required to cook at home are by cooking food in bulk for the week and portioning food into meals. This strategy has been shown to decrease the overall time spent cooking each week by 43% or from 7 to 4 hours per week.[164] To strengthen the efficacy of bulk cooking and also address a perceived lack of cooking skills, bulk cooking can be coupled

with group cooking classes which have been shown to improve self-efficacy, thereby increasing people's confidence in their cooking skills.[164] Overall, it is important to help support the positive changes to ecological, economic, and human health dimensions of a sustainable diet with a diverse suite of interventions.

When assessed through the socio-cultural and political dimension, the overall improvements in sustainable diet dimensions during the COVID-19 pandemic were not equitably experienced across socioeconomic groups. For example, low-income participants reported significantly fewer improvements in the human health dimension than higher-income participants. These differences can largely be explained by high-income households increasing their fish consumption, while in low-income households, fish consumption declined. The increase in fish consumption among higher-income individuals may have been an approach to maintain protein intake in spite of decreased beef, lamb, and pork consumption. This was seen among all income levels and was likely due to disruptions in the meat supply chain which resulted in higher prices and lower availability.[119] There is, however, marginal room for Americans overall to increase their fish consumption while staying within sustainable parameters.[37] Therefore, in order for low-income households to have improved sustainable diets, other alternative sources of protein must be explored, with particular attention to plant-based proteins. Unfortunately, in our study population, low-income households ate fewer beans and soy during the COVID-19 pandemic than their high-income counterparts. This difference may be due to low-income households in our study population having the lowest declines in fast-food consumption, the highest increases in consumption of pre-packaged meals, and the lowest increases in home-cooked meals

compared to moderate- and high-income households. It is well established that low-income households cook less at home due to limited finances, time, and cooking skills.[172] Therefore, substitution of plant-based proteins into fast-food and pre-packaged meals may help decrease the environmental impact of foods, especially for low-income households.[173] Additionally, plant-based proteins could be promoted to low-income families at the grocery store through the addition of certain types of plant-based proteins in the Double Up Food Bucks program (e.g., beans and other legumes). Double Up Food Bucks currently offers lower-income people who have an EBT/Bridge Card or are on SNAP the opportunity to match their fruit and vegetable purchases up to $20 per day.[174] Together, these interventions could increase low-income households' access to and consumption of legumes. However, it is important to acknowledge that legume consumption is not part of the typical US dietary pattern, which could provide additional barriers for increasing legume consumption.[41]

Further differences in sustainable diets were observed within the socio-cultural and political dimension by race/ethnicity. A notable difference across different racial/ethnic groups was the change in the human health dimension of sustainable diets during the COVID-19 pandemic. When adjusting for household income, White participants reported few changes in the human health dimension during the COVID-19 pandemic while Black/African American participants increased their human health dimension score substantially through increased intake of vegetables, fruit, and fish, as well as decreased intake of sweets. These changes may be due to the fact that Blacks or African Americans were disproportionately affected by the COVID-19 pandemic and were therefore trying to improve their nutrition as a way to prevent falling

severely ill from COVID-19.[175,176] In order to support these positive dietary changes in the future, interventions that address structural racism, as it is in part responsible for the nutrition inequities in the food environment including those that occurred during the COVID-19 pandemic, and take a health equity approach are important. A recent literature review found that nutrition interventions targeted to the African American community have often focused on increasing healthy options and building community capacity through education yet neglected to reduce deterrents (e.g. high density of unhealthy food options) or improve social and economic resources (e.g. disparities in socioeconomic status).[177] In order to promote sustained nutritional change in the African American community, addressing the food environment from a social determinants of health perspective by including policy, structural, and/or environmental changes along with education should be undertaken.[177]

It is worth highlighting one change that occurred across all race/ethnicities: a decline, by about 50%, in local food system engagement (farmer's markets and CSAs). This decline likely occurred for the same reason as trips to the grocery store declined: to minimize social contact. However, unlike grocery stores that may have offered online shopping or home delivery options, many farmers were unable to provide consumers with these options due to a lack of technical resources.[178] Some farmers were able to make the transition to contact-free shopping and offer an example to others for developing innovative systems that allow local farmers to sell to consumers outside of traditional farmer's markets and CSAs, such as providing farm-to-home delivery and online purchasing options which increased access to sustainable agriculture during

times of changing consumer demand.[178] These along with other avenues could be implemented by farmer's markets and CSAs to strengthen the resilience of local food systems.

A noteworthy strength of this study is its large, sociodemographically diverse population-based sample with respect to income and race/ethnicity. However, as Black/African American, Hispanic/Latino, and White individuals were specifically recruited, this study did not capture the experience of other racial or ethnic groups and findings cannot be generalized to these populations. Furthermore, data were collected using convenience sampling, a form of non-probability sampling that relies on self-selected participation. Our sample also consisted of people who received their primary health care at Michigan Medicine. This approach would by nature exclude people who did not seek primary care and may have over-sampled healthier people than the general population.[179] Additionally, this study required that participants had an email address in their medical record and would not have reached people who do not have access to the internet or an active email account. Participant responses may also have been impacted by social-desirability bias, particularly given the highly politically polarized nature of social distancing protocols that were put into place to mitigate the spread of COVID. As such, participants may have under-reported high-risk behaviors or consumption of unhealthy food options (i.e., fast food). For the same reason, participants may have overreported healthy food choices. To mitigate social-desirability bias, survey response data was collected online without an interviewer present and minimal personally identifiable data was collected to maintain anonymity.

This study found that on average, adults engaged in more behaviors that are supportive of a sustainable diet during the COVID-19 pandemic as compared to before the COVID-19 pandemic. This is particularly true regarding ecological and economic dimensions, including, less frequent trips taken to the grocery store, an increased use of home grocery delivery options, increased cooking at home, and greater consumption of healthy foods. In order to support the continuation of these behaviors, policies that increase access to public transportation, limit the frequency with which consumers have groceries delivered to their homes, and increase home cooking should be supported. However, not all behavior changes during the pandemic were positive with respect to sustainability. For example, the use of farmer's markets and CSAs declined from before the COVID-19 pandemic, highlighting the importance of supporting local farmers and food systems to strengthen their resilience to consumers' changing needs. Examining the ecological, economic, and human health dimensions through the lens of equity revealed that White and high-income participants were more likely than African American/Black, Hispanic/Latino, or low-income participants to engage in behaviors that are supportive of a sustainable diet with regard to the ecological and economic dimensions during the pandemic. The exception was that African American/Black participants reported large increases in the human health dimension. Multiple public health policies and interventions will likely be needed to increase the equity of sustainable diets, with particular respect to policies that address structural racism and the social determinants of health.

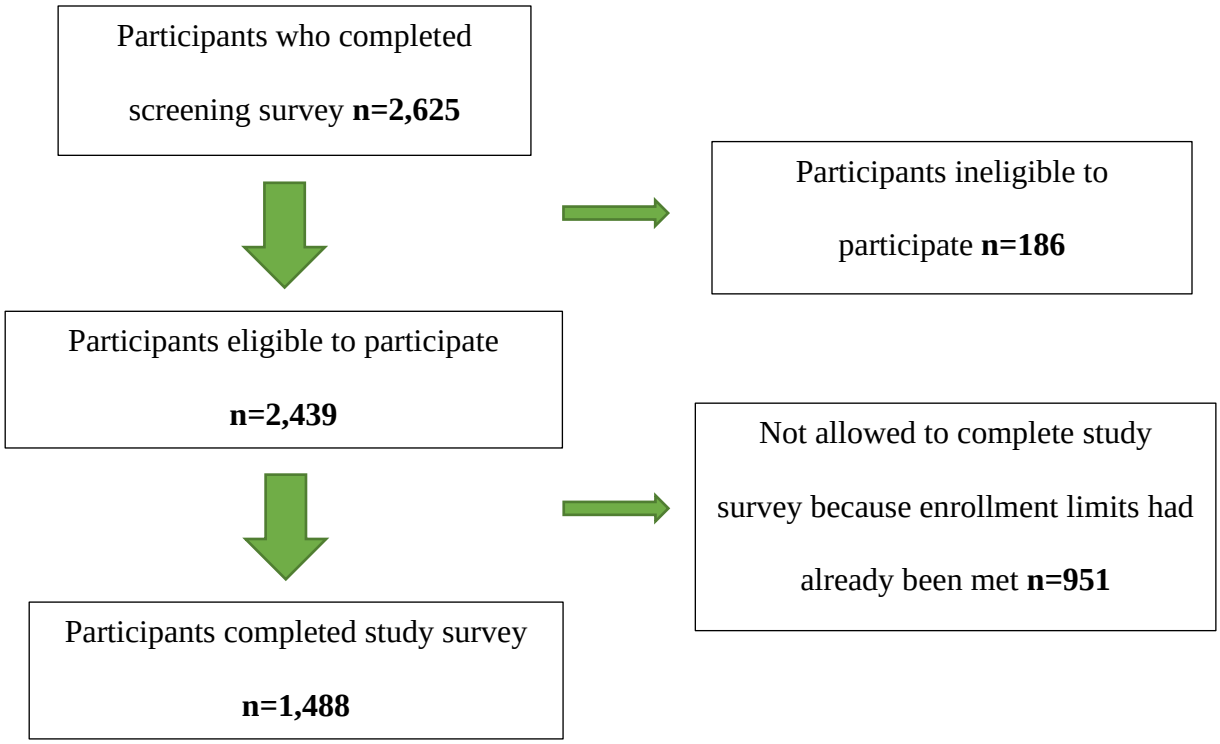

Figure 4.1 Sample Size Flow Chart

Table 4.1 Ecological and Economic Sustainable Diet Dimensions

Survey Items[6]	**Response Options**
• Drive to the grocery store • Have groceries delivered to your home	Never or less than once a month
	1-2 times per month
	3-4 times per month
	2-3 times per week
	1 or more times per day
• Shop for locally grown produce and/or other food • Shop at a farmer's market or participate in a CSA (Community Supported Agriculture) • Grow a vegetable garden or participate in a community garden • Eat foods that someone made at home, that are traditionally purchased pre-made (e.g. bread, muffins, or granola)	Never
	Rarely
	Sometimes
	Frequently
	Always
• Eat something from the following types of restaurants: 1) fast food (include traditional "burgers-and-fries," Mexican, fried chicken, sandwich or sub shop, and pizza); 2) eat at a restaurant in person; and 3) eat take-out/delivery from a restaurant • Eat food that is cooked at home • Eat pre-packaged/ ready-made meals • Order a meal kit delivery	Never or less than one meal per month
	1-4 meals per month
	2-6 meals per week
	1 meal per day
	2 or more meals per day
• Throw away foods (e.g. vegetables, fruit, meat, poultry, fish, and grains)	None
	Very little
	Little
	Some
	Much

Table 4.2 Sociodemographic Characteristics of SUSTAIN Participants (n=1,488)

	Mean (SD) or % (N)
Age (years)	42.7 (12.6)
Gender	
Male	22.0 (328)
Female	77.4 (1152)
Other	0.5 (8)
Race/Ethnicity	
White	36.3 (540)
Black or African American	33.6 (500)
Hispanic or Latino	28.9 (430)
Asian America	0.2 (3)
American Indian or Native American	0.3 (4)
Other	0.7 (11)
Educational Attainment	
Some high school or less	2.9 (41)
Finished high school or got GED	7.7 (108)
Did some college or training after high school	22.3 (314)
Associates degree or completed technical training	13.3 (187)
Bachelor's degree	27.5 (387)
Advanced degree (Master's, Ph.D., MD)	26.4 (372)
Household Income	
Low	34.9 (476)
Moderate	31.6 (431)
High	33.5 (457)
Household food security	
High or marginal food security	70.6 (879)
Low food security	17.3 (215)
Very low food security	12.1 (151)

Table 4.3 Household Income by Race/ethnicity and Education (n=1,348)

	Household Income[1]			**Chi-Square (P-value)**
	Low	Moderate	High	
Race/Ethnicity[2]	**% (N)**			
Hispanic or Latino	23.9 (95)	31.4 (125)	44.7 (178)	
Black or African American	42.4 (191)	32.4 (146)	25.1 (113)	
White	36.6 (183)	31.2 (156)	32.2 (161)	
				46.5 (<.0001)
Educational Attainment				
Some high school or less	86.5 (32)	8.11 (3)	5.4 (2)	
Finished high school or got GED	68.9 (71)	23.3 (24)	7.8 (8)	
Did some college or training after high school	56.6 (171)	26.5 (80)	16.9 (51)	
Associates degree or completed technical training	46.6 (83)	33.7 (60)	19.7 (35)	
Bachelor's degree	20.6 (78)	37.0 (140)	42.3 (160)	
Advanced degree (Master's, Ph.D., MD)	10.7 (39)	34.1 (124)	55.2 (201)	
				333.5 (<.0001)

Table 4.4 Ecological and Economic Dimension Before and During the COVID-19 Pandemic (n=1,488)

	Before COVID	During COVID	Cohen's d	T-statistic (P-value)[1]
	Mean (SD)			
Shop for locally grown produce and/or other food[2]	1.9 (1.1)	1.6 (1.1)	-0.3	-12.43 (<.0001)
Shop at a farmer's market or participate in a CSA[2]	1.5 (1.1)	0.9 (1.0)	-0.6	-20.67 (<.0001)
Grow your own produce[2]	0.9 (1.2)	0.9 (1.2)	-0.0	-0.42 (.68)
Drive to the grocery store[3]	1.8 (1.4)	1.1 (1.1)	-0.6	-20.54 (<.0001)
Have groceries delivered to your home[3]	0.1 (0.6)	0.3 (0.6)	0.2	8.67 (<.0001)
Use a meal kit delivery[3]	0.2 (0.9)	0.4 (1.2)	0.1	3.67 (.0003)
Eat foods that are traditionally purchased pre-made but someone made at home[4]	1.6 (1.1)	1.7 (1.2)	0.4	-4.62 (<.0001)
Eat something from a fast-food restaurant[3]	2.7 (2.0)	2.4 (1.9)	-0.1	-4.99 (<.0001)
Eat take-out or delivery from a restaurant[3]	2.3 (1.8)	2.3 (1.6)	0.0	0.75 (.45)
Eat at a restaurant either indoors or outdoor dining[3]	2.5 (1.4)	0.8 (1.3)	-1.0	-38.03 (<.0001)
Eat meals that are home-cooked[3]	8.4 (5.0)	9.4 (5.1)	0.3	10.53 (<.0001)
Eat pre-packaged meals such as frozen dinners, canned soup, or ramen noodles[3]	2.4 (2.8)	2.7 (3.0)	0.2	5.84 (<.0001)
Throw food away[5]	2.5 (0.9)	2.6 (0.9)	0.1	4.49 (<.0001)
Ecological & economic dimension score (0 to 52)	23.4 (5.9)	24.5 (6.2)	1.2	-13.13 (<.0001)

[1]Paired t-test comparing before and during COVID; Cohen's d calculating effect size.
[2]0-4, where 4=Always and 0=Never
[3]Times per week
[4]0-4, where 0=Always and 4=Never
[5]0-4, where 0=A great deal and 4=None at all

Table 4.5 Human Health Dimension: Change in Food Group Consumption Before to During the COVID-19 Pandemic (n=1,051)

	Mean (SD)[3]
Vegetables[1]	0.4 (1.0)
Fruit[1]	0.4 (1.0)
Nuts[1]	0.2 (0.9)
Beef, lamb, or pork[2]	0.2 (0.9)
Potatoes[2]	0.1 (1.0)
Fish[1]	0.1 (1.0)
Beans, lentils, or peas[1]	0.1 (0.9)
Dairy[2]	0.1 (0.9)
Whole grains[1]	0.1 (0.8)
Sweets[2]	-0.1 (1.1)
Eggs[2]	-0.2 (0.9)
Chicken and other poultry[2]	-0.3 (0.9)
Soy food (including tofu and soy milk)[1]	-0.3 (1.0)
Human health dimension score (-26 to 26)	0.7 (4.9)

[1] -2=A lot less and 2=A lot more

[2] -2=A lot more and 2=A lot less

[3] Positive values are more sustainable and negative values are less sustainable according to the PHD

Table 4.6 Sustainable Diets before and during the COVID-19 Pandemic by Household Income and Race/Ethnicity (n=1,346)

	Household Income[1]			**F-stat**	**P-value**	**Race/Ethnicity**[2]			**F-stat**	**P-value**
	Low	Moderate	High			Hispanic or Latino	Black or African American	White		
Ecological and Economic Dimension (mean (SE))										
Before COVID	22.8 (0.8)[a]	23.4 (0.9)[b]	24.3 (0.9)[c]	15.04	<.0001	23.2 (0.9)[a]	22.5 (0.8)[b]	24.8 (0.8)[c]	20.21	<.0001
Change during COVID	1.0 (0.5)[a]	1.2 (0.5)[ab]	1.6 (0.5)[b]	7.09	.0009	1.4 (0.5)[a]	1.5 (0.5)[a]	0.9 (0.5)[ab]	5.19	.006
Human Health Dimension (mean (SE))										
Change during COVID	0.4 (0.8)[a]	0.6 (0.8)[ab]	0.9 (0.8)[b]	3.41	.03	0.3 (0.8)[a]	1.6 (0.8)[b]	0.0 (0.8)[a]	8.47	.0002

Note: Means with common superscript letters did not differ at p<.05.

[1]Adjusted for education, race, and gender

[2]Adjusted for education, ITN, and gender

Table 4.7 Associations Between Income, Race/ethnicity and Ecological and Economic Dimension (n=1,346)

	Household Income[1]			**P-value**	**Race/Ethnicity**[2]			**P-value**
	Low	Moderate	High		Hispanic or Latino	Black or African American	White	
	Mean (SD)				**Mean (SD)**			
Shop for locally grown produce and/or other food[3]								
Before COVID	2.0 (0.2)[a]	2.1 (0.2)[a]	2.2 (0.2)[a]	.07	2.1 (0.2)[a]	1.9 (0.2)[a]	2.3 (0.2)[b]	<.0001
Change during COVID	-0.5 (0.1)[a]	-0.5 (0.1)[a]	-0.4 (0.1)[a]	.35	-0.5 (0.1)[ab]	-0.4 (0.1)[a]	-0.6 (0.1)[b]	.009
Shop at a farmer's market or participate in a CSA[3]								
Before COVID	1.5 (0.2)[a]	1.7 (0.2)[ab]	1.8 (0.2)[b]	.03	1.6 (0.2)[a]	1.5 (0.2)[a]	1.9 (0.2)[b]	<.0001
Change during COVID	-0.8 (0.2)[a]	-0.9 (0.2)[a]	-0.9 (0.2)[a]	.34	-0.8 (0.2)[a]	-0.7 (0.2)[a]	-1.0 (0.2)[b]	.0002
Grow your own produce[3]								
Before COVID	0.8 (0.2)[a]	0.9 (0.2)[a]	0.9 (0.2)[a]	.35	0.8 (0.2)[a]	0.6 (0.2)[b]	1.2 (0.2)[c]	<.0001
Change during COVID	0.1 (0.1)[a]	0.1 (0.1)[a]	0.2 (0.1)[a]	.11	0.2 (0.1)[a]	0.2 (0.1)[a]	0.1 (0.1)[a]	.08
Drive to the grocery store[4]								
Before COVID	1.5 (0.2)[a]	1.4 (0.2)[a]	1.5 (0.2)[a]	.41	1.3 (0.2)[a]	1.4 (0.2)[a]	1.7 (0.2)[b]	<.0001
Change during COVID	-0.7 (0.2)[a]	-0.6 (0.2)[a]	-0.6 (0.2)[a]	.74	-0.6 (0.2)[a]	-0.5 (0.2)[a]	-0.7 (0.2)[a]	.04
Have groceries delivered to your home[4]								
Before COVID	0.1 (0.1)[a]	0.1 (0.1)[a]	0.0 (0.1)[a]	.20	0.0 (0.1)[a]	0.1 (0.1)[b]	0.0 (0.1)[a]	.002
Change during COVID	0.2 (0.1)[a]	0.1 (0.1)[a]	0.1 (0.1)[a]	.75	0.1 (0.1)[a]	0.1 (0.1)[a]	0.2 (0.1)[a]	.69
Use a meal kit delivery[4]								
Before COVID	0.1 (0.1)[a]	0.1 (0.1)[ab]	0.2 (0.1)[b]	.01	0.1 (0.1)[a]	0.2 (0.1)[a]	0.1 (0.1)[a]	.70
Change during COVID	0.1 (0.2)	-0.0 (0.2)[a]	-0.0 (0.2)[a]	.60	-0.0 (0.2)[a]	0.1 (0.2)[a]	0.0 (0.2)[a]	.61
Eat foods that are traditionally purchased pre-made but someone made at home[5]								
Before COVID	1.4 (0.2)[a]	1.5 (0.2)[a]	1.4 (0.2)[a]	.07	1.4 (0.2)[a]	1.4 (0.2)[a]	1.5 (0.2)[a]	.16

Change during COVID	0.1 (0.1)[a]	0.1 (0.1)[a]	0.3 (0.1)[b]	<.0001	0.2 (0.1)[a]	0.1 (0.1)[b]	0.2 (0.1)[ab]	.003
Eat something from a fast-food restaurant[4]								
Before COVID	2.7 (0.3)[a]	2.8 (0.3)[a]	2.7 (0.3)[a]	.07	2.7 (0.3)[a]	3.0 (0.3)[b]	2.5 (0.3)[a]	.0002
Change during COVID	-0.3 (0.3)[a]	-0.6 (0.3)[a]	-0.7 (0.3)[a]	.21	-0.6 (0.3)[a]	-0.6 (0.3)[a]	-0.4 (0.3)[a]	.16
Eat take-out or delivery from a restaurant[4]								
Before COVID	2.3 (0.2)[a]	2.3 (0.3)[a]	2.3 (0.3)[a]	.39	2.3 (0.3)[a]	2.6 (0.3)[b]	2.1 (0.3)[a]	<.0001
Change during COVID	-0.2 (0.3)[a]	-0.2 (0.3)[a]	-0.2 (0.3)[a]	.28	-0.1 (0.3)[a]	-0.4 (0.3)[b]	-0.1 (0.3)[ab]	.02
Eat at a restaurant either indoors or outdoor dining[4]								
Before COVID	2.2 (0.2)[a]	2.5 (0.2)[b]	2.7 (0.2)[c]	<.0001	2.5 (0.2)[a]	2.4 (0.2)[a]	2.5 (0.2)[a]	.16
Change during COVID	-1.3 (0.2)[a]	-1.6 (0.2)[b]	-1.9 (0.2)[c]	<.0001	-1.6 (0.2)[a]	-1.5 (0.2)[a]	-1.7 (0.2)[a]	.16
Eat meals that are home-cooked[4]								
Before COVID	7.8 (0.7)[a]	7.8 (0.7)[a]	7.5 (0.7)[a]	.50	8.1 (0.7)[a]	6.9 (0.7)[b]	8.0 (0.7)[a]	.0005
Change during COVID	0.4 (0.5)[a]	0.8 (0.5)[ab]	1.2 (0.5)[b]	.0001	0.8 (0.5)[a]	0.8 (0.5)[a]	0.8 (0.5)[a]	.68
Eat pre-packaged meals such as frozen dinners, canned soup, or ramen noodles[4]								
Before COVID	3.3 (0.4)[a]	2.5 (0.4)[b]	2.2 (0.4)[b]	<.0001	2.5 (0.4)[a]	2.4 (0.4)[a]	3.1 (0.4)[b]	<.0001
Change during COVID	0.2 (0.3)[a]	0.0 (0.3)[a]	0.0 (0.3)[a]	.44	0.1 (0.3)[a]	0.0 (0.3)[a]	0.1 (0.3)[a]	.89
Throw food away								
Before COVID	2.6 (0.1)[a]	2.6 (0.1)[a]	2.6 (0.1)[a]	.61	2.7 (0.1)[a]	2.5 (0.1)[b]	2.7 (0.1)[a]	.0001
Change during COVID	0.1 (0.1)[a]	0.1 (0.1)[a]	0.1 (0.1)[a]	.17	0.2 (0.1)[a]	0.1 (0.1)[a]	0.1 (0.1)[a]	0.09

Note: Sustainable diet means with common superscript letters did not differ at p<.05.

[1]Adjusted for education, race, and gender

[2]Adjusted for education, ITN, and gender

[3]0-4, where 4=Always and 0=Never

[4]Times per week

[5]0-4, where 0=Always and 4=Never

Table 4.8 Associations Between Income, Race/ethnicity and Human Health Dimension (n=1,001)

	Household Income[1]			**P-value**	**Race/Ethnicity**[2]			**P-value**
	Low	Moderate	High		Hispanic or Latino	Black or African American	White	
	Mean (SE)				**Mean (SE)**			
Change in human health dimension before and during COVID								
Vegetables[3]	0.7 (0.2)[a]	0.6 (0.2)[a]	0.7 (0.2)[a]	.49	0.6 (0.2)[a]	0.9 (0.2)[b]	0.5 (0.2)[a]	<.0001
Fruit[3]	0.6 (0.1)[a]	0.5 (0.2)[a]	0.6 (0.2)[a]	.11	*0.6 (0.2)*[a]	0.8 (0.1)[b]	0.4 (0.2)[c]	<.0001
Nuts[3]	-0.2 (0.1)[a]	-0.1 (0.1)[ab]	-0.1 (0.1)[b]	.02	-0.2 (0.1)[a]	-0.1 (0.1)[a]	-0.1 (0.1)[a]	.86
Beef, lamb, or pork[4]	0.4 (0.1)[a]	0.4 (0.1)[a]	0.4 (0.1)[a]	.90	0.5 (0.1)[a]	0.4 (0.1)[a]	0.3 (0.1)[a]	.11
Potatoes[4]	-0.1 (0.2)[a]	-0.1 (0.2)[a]	-0.0 (0.2)[a]	.20	-0.1 (0.2)[a]	-0.0(0.2)[a]	-0.1 (0.2)[a]	.61
Fish[3]	-0.2 (0.2)[a]	0.0 (0.2)[b]	0.1 (0.2)[b]	.0001	-0.1 (0.2)[a]	0.2 (0.2)[b]	-0.1 (0.2)[a]	.0002
Beans, lentils, or peas[3]	-0.2 (0.1)[a]	-0.1 (0.1)[ab]	-0.1 (0.1)[b]	.003	-0.1 (0.1)[a]	-0.2 (0.1)[a]	-0.1 (0.1)[a]	.16
Dairy[4]	0.2 (0.1)[a]	0.1 (0.1)[a]	0.1 (0.1)[a]	.83	0.1 (0.1)[ab]	0.3 (0.1)[a]	0.1 (0.1)[b]	.02
Whole grains[3]	-0.1 (0.1)[a]	-0.1 (0.1)[a]	-0.0 (0.1)[a]	.08	-0.0 (0.1)[a]	-0.0 (0.1)[a]	-0.1 (0.1)[a]	.11
Sweets[4]	0.2 (0.2)[a]	0.1 (0.2)[a]	0.2 (0.2)[a]	.22	0.1 (0.2)[ab]	0.3 (0.2)[a]	0.1 (0.2)[b]	.02
Eggs[4]	-0.2 (0.1)[a]	-0.2 (0.2)[a]	-0.4 (0.2)[b]	.0005	-0.4 (0.1)[a]	-0.1 (0.1)[b]	-0.3 (0.1)[a]	<.0001
Chicken and other poultry[4]	-0.4 (0.1)[ab]	-0.4 (0.1)[a]	-0.5 (0.1)[b]	.03	-0.5 (0.1)[a]	-0.5 (0.1)[a]	-0.4 (0.1)[a]	.24
Soy food (including tofu and soy milk)[3]	-0.4 (0.2)[a]	-0.2 (0.2)[b]	-0.2 (0.2)[b]	<.0001	-0.2 (0.2)[a]	-0.4 (0.2)[b]	-0.2 (0.2)[a]	.005

Note: Food group means with common superscript letters did not differ by income or race/ethnicity at p<.05.

[1]Adjusted for education, race, and gender; analysis was conducted using proc glm lsmeans.

[2]Adjusted for education, ITN, and gender; analysis was conducted using proc glm lsmeans.

[3]-2 to 2, where -2=A lot less and 2=A lot more

[4]-2 to 2, where -2=A lot more and 2=A lot less

Chapter 5: Conclusion

Summary of dissertation findings

The overall objective of this dissertation was to characterize the ecological, economic, human health, and socio-cultural & political dimensions of a sustainable diet among socio-demographically diverse populations in the US before and during the COVID-19 pandemic. Specifically, I used a large, socioeconomically and racially/ethnically diverse population-based sample of young adults to describe the extent to which dietary intake aligns with sustainable diets through the application of the EAT-Lancet Planetary Health Diet (PHD), and identify personal, behavioral, and socio-environmental correlates of the PHD. Additionally, I identified how recent trends in ecological, economic, human health, and socio-cultural & political dimensions of a sustainable diet were similar or different across diverse US subpopulations from 2019 to 2021. Finally, I described perceived changes among U.S. adults' ecological, economic, human health, and socio-cultural & political dimensions of a sustainable diet within the food environment one year into the COVID-19 pandemic.

In **Chapter 2**, I described the extent to which dietary intake of young adults aligns with sustainable diets through the application of the EAT-Lancet Planetary Health Diet (PHD), and identified personal, behavioral, and socio-environmental correlates of sustainable dietary intake. Participants' overall PHD score was low: 4.1 on average (SD = 1.4) on a scale of 0 to 14 with 14 being the most sustainable. The score was slightly higher for females (4.2) than males (4.1). Participants of low socioeconomic status had significantly lower overall PHD scores (4.1 (SD =

1.4)) than those of high socioeconomic status (4.5 (SD = 1.2)). Likewise, those with only some high school education had significantly lower overall PHD scores (3.9 (SD = 1.5)) than those with a bachelor's, graduate, or professional degree (4.3 (SD = 1.4)). Overall, participants were close to meeting PHD recommendations for potatoes (3.9%), dairy (7.7%), and poultry (8.6%). However, on average, participants over-consumed meat (148.5%), eggs (70.0%), and added sugar (83.2%), and under-consumed whole grains (-54.8%), fish (-94.7%), legumes (-121.5%), soy (-146.0%), and nuts (-175.2%). The mean scaled intake of meat was high at 47.4 (SD = 32.6) g/day with more than 71% of participants consuming above the PHD recommendations. In comparison, the mean scaled intake of fish was 10.0 (SD = 12.8) g/day, and mean scaled intakes of plant-based proteins were 12.2 (SD = 20.4) g/day for legumes, 3.9 (SD = 11.9) g/day for soy, and 3.3 (SD = 7.2) g/day for nuts, with more than 90% of participants having intakes that were below PHD recommendations across all four categories. Study findings from this US cohort are consistent with dietary patterns observed in other high-income countries (HICs) and contrast with patterns observed in low-to-middle-income countries (LMICs) with regards to meat and whole-grain consumption. For example, prior research in the United Kingdom (UK) has shown relatively few individuals meet the PHD recommendations for whole grains (36.1%) and most met (66.6%) or exceeded (33.4%) the recommendations for meat.[50] In India, consumption expenditures, in kcal/day, for urban and rural populations respectively, show that the PHD recommendations were exceeded for whole grains (1029 and 1275) and fell short of meeting recommendations for meat (3 and 5), fish (8 and 9), and eggs (6 and 10).[49]

Participants' overall PHD scores were most strongly associated with the standardized (mean=0, SD=1) personal, behavioral, and socio-environmental correlates, availability of healthy food at

home (β = 0.24) and frequency of fast-food consumption (β = -0.26). Other personal characteristics positively associated with PHD score were self-efficacy for cooking (β = 0.16), self-esteem (β = 0.10), and overall body satisfaction (β = 0.12). Hours of physical activity per week (β = 0.15) and number of lifestyle weight management behaviors performed last year (β = 0.11) were behavioral characteristics associated with more sustainable dietary intake. Meanwhile, frequency of eating at a restaurant (β = -0.25), and hours of screen time (β = -0.16) were negatively associated with sustainable dietary intake. Finally, participants reporting greater parental encouragement of healthy eating (β = 0.15) experienced higher overall PHD scores on average, while participants experiencing food insecurity had moderately lower PHD scores (β = -0.09).

As hypothesized, the majority of young adults participating in the EAT 2010-2018 study had substandard sustainable dietary intake based on the PHD. This was particularly true for individuals of lower socioeconomic status and educational attainment. Most young adults consumed high amounts of meat, a dietary behavior that is especially harmful to the environment. Reducing meat consumption, especially by substituting plant-based proteins, is an important target for intervention among US young adults. Policy and environmental changes with the potential to improve diet healthfulness, such as, taxing SSBs and other unhealthy foods, subsidizing nutrient-dense foods, fast food restaurants committing to reducing meat consumption, and considering sustainability in the DGA hold potential for shifting diets towards more environmentally sustainable choices.

In **Chapter 3**, I compared how recent trends in ecological, economic, human health, and socio-cultural & political dimensions of a sustainable diet were similar or different across diverse US subpopulations from 2019 to 2021. Contrary to our hypothesis, the importance of healthfulness in making food and drink purchasing decisions declined overall and across most consumer groups between 2019 and 2021 (annual trend (β) = -0.06). Furthermore, the importance of purchasing antibiotic-free food, hormone/steroid free food, and locally sourced foods also declined among US consumers during this time period. These trends persisted after accounting for differences in household income among each year's sample. In contrast, the importance of environmental sustainability on purchasing decisions increased, yet was not statistically significant (annual trend (β) = 0.03). Younger individuals (18-50 years old) reported increased importance of environmental sustainability between 2019 and 2021, while the impact of environmental sustainability declined among individuals over 50. Finally, the importance of price on purchasing decisions stayed constant over the time period (annual trend (β) = -0.002). Price became decreasingly important to those living in rural locations, with lower household incomes, and for those with a bachelor's degree or no college education. Conversely, price became increasingly important to those living in more urban locations, in the middle-income bracket ($30,000-$150,000), and with some college education or a graduate degree.

This study found that the importance of healthfulness in making food and drink purchasing decisions to consumers, purchasing antibiotic free food, hormone/steroid free food, and locally sourced foods declined among a nationally representative sample of Americans. These declines may be due to stressors from the pandemic and in response to changing consumer priorities. In contrast, consumers' decision to buy foods and beverages based on environmental sustainability

and price remained consistent over the years examined, and low-income households showed a decline in the impact of price on buying foods and beverages. This may have been due to the expansion of federal nutrition programs SNAP and WIC during the pandemic, and the continuation of those programs should be encouraged to promote equitable food access and healthy, sustainable diets. Furthermore, the government should prioritize supporting farmers in the transition to more sustainable agricultural practices to increase consumers' access to affordable, sustainable diets.

In **Chapter 4**, I examined perceived changes among U.S. adults' ecological, economic, human health, and socio-cultural & political dimensions of a sustainable diet within the food environment one year into the COVID-19 pandemic. Our hypothesis that behaviors became on average more supportive of a sustainable diet one year into the COVID-19 pandemic compared to before the COVID-19 pandemic was supported by study findings with regards to ecological, economic, and human health dimensions of sustainable diets. Overall, participants' ecological and economic sustainable diet dimension score improved (mean effect size=1.2). Improvements to the dimension were achieved through large decreases in eating at a restaurant either indoors or outdoors (effect size=-1.0), decreases in driving to the grocery store (effect size=-0.6), increases in eating foods that were traditionally purchased pre-made but now made at home (effect size=0.4), and increases in eating meals that were home-cooked (effect size=0.3). However, not all changes to the dimension were improvements, shopping at a farmer's market or participating in a CSA (effect size=-0.6) along with shopping for locally grown produce and/or other food (effect size=-0.3) both declined. On average, alignment of participants' diets with the PHD improved during the COVID-19 pandemic as compared to before the COVID-19 pandemic.

Specifically, using a scale of -2 (less sustainable) to 2 (more sustainable) to quantify the degree of change from before COVID, participants reported eating more vegetables 0.4, fruit 0.4, and nuts 0.2 during COVID, as well as less beef, lamb, and pork 0.2. However, participants also reported eating less soy food -0.3 and more poultry -0.3 and eggs -0.2.

High-income and Black/African American participants reported the greatest increases in the human health dimension of sustainable diets during COVID. With regard to income, these changes were strongly driven by high-income participants eating more fish during the COVID-19 pandemic as compared to before the COVID-19 pandemic**.** Meanwhile, Black/African American participants' increases in the human health dimension were due to consuming more vegetables, fruit, and fish, and fewer sweets, than before the COVID-19 pandemic. Furthermore, high-income households and White participants were more likely than other sociodemographic groups to have a higher ecological and economic dimension score for sustainable diets both before and during the COVID-19 pandemic**.** Before COVID, high income participants more frequently ate at restaurants either indoors or outdoors (2.7), compared to low (2.2) and moderate (2.5) income participants. However, during the COVID-19 pandemic, a large decline in eating at restaurants was seen among all income groups, with the largest declines among high-income households (low -1.3, moderate -1.6, and high -1.9). This decline was countered by an increase in eating meals prepared at home, again with the largest change being for high-income households. Additionally, high-income households (0.3) increased the amount of food traditionally purchased pre-made that they now made at home more than low (0.1) or moderate (0.1) income households. On the other hand, low-income households (0.2) slightly increased their consumption of pre-packaged meals such as frozen dinners, canned soup, or ramen noodles

in comparison to moderate (0.0) or high (0.0) income households, although the change was not statistically significant.

This study found that on average, adults engaged in more behaviors that are supportive of a sustainable diet during the COVID-19 pandemic as compared to before the COVID-19 pandemic. This is particularly true regarding ecological and economic dimensions, likely in large part due to business closures and social distancing regulations that limited consumer behavior, including less frequent trips taken to the grocery store, an increased use of home grocery delivery options, increased cooking at home, and greater consumption of healthy foods. In order to support the continuation of these behaviors, policies that increase access to public transportation, limit the frequency with which consumers have groceries delivered to their homes, and increase home cooking should be supported. However, not all behavior changes during the pandemic were positive with respect to sustainability. For example, the use of farmer's markets and CSAs declined from before the COVID-19 pandemic, highlighting the importance of supporting local farmers and food systems to strengthen their resilience to consumers' changing needs. Looking at the ecological, economic, and human health dimensions through the lens of equity revealed that White and high-income participants were more likely than African American/Black, Hispanic/Latino, or low-income participants to engage in behaviors that are supportive of a sustainable diet with regard to the ecological and economic dimensions during the pandemic, with the exception that African American/Black participants reported large increases in the human health dimension. Multiple public health policies and interventions such as substitution of plant-based proteins into fast-food and pre-packaged meals along with including plant-based proteins in the Double Up Food Bucks program could increase low-income households' access to

and consumption of environmentally sustainable diets. Additionally, policies that address structural racism and the social determinants of health should be prioritized to increase equity in sustainable diets.

Implications

This dissertation found that low-income participants value consuming a sustainable diet but had a harder time accessing one compared to higher-income participants. Chapter 4 found that sustainable diets were improved during the COVID-19 pandemic across all sociodemographic groups, but that there were inequities between the improvements based on income. I found that low-income households improved their sustainable diets less than those from higher-income households during the COVID-19 pandemic. Therefore, policies that prioritize supporting low-income households' access to foods that support a healthful and sustainable diet should be prioritized. Information from Chapter 3 may provide a promising way to improve access to low-income households as we move into a post-COVID food system. A surprising finding in Chapter 3 was that low-income households experienced a decline in the impact of price on buying foods and beverages during 2020 and 2021 in comparison to 2019. Early on in the COVID-19 pandemic (March 2020), research showed that low-income households experienced increased food insecurity,[180] which was further stressed by increased food costs.[181] However, as the pandemic continued the prevalence of food insecurity remained relatively stable across the US at 10.5%, 10.5%, and 10.2% in 2019, 2020, and 2021 respectively.[182] One study in California even found that very low food security declined among low-income households in 2020 post-COVID-19, from 19.3% to 14.0%.[183] National levels of very low food security also declined slightly from 2019 to 2021, from 4.1% to 3.8%.[183] Our study findings may have occurred due to the provision

of stimulus checks;[184] increased child tax credit,[185] increased unemployment benefits,[144] and/or increased benefits from SNAP and WIC.[145,146] Benefits for SNAP increased by 15% during 2020[145] and WIC increased participants' monthly produce allowance for fruits and vegetables from $9 per child and $11 per adult to $35 per person.[146]An evaluation of WIC households during this time found that children increased their fruit and vegetable intake after the benefits increased, suggesting that low-income parents have the desire to eat healthy diets when they have the opportunity.[146] Other policy changes to SNAP and WIC during this time were waivers that decreased requirements expected of participants to obtain their benefits, such as necessitating in-person appointments and collecting anthropometric data; both of which have been cited as barriers to program participation.[186] Therefore, qualifying households may have been more likely to participate in the programs than before the COVID-19 pandemic, increasing their purchasing power for foods and beverages. Continuing these programs' expanded benefits along with maintaining the decreased participation burden into the future may help improve the accessibility of healthful and sustainable diets to low-income families.

Additionally, other ways to improve the accessibility of sustainable diets to low-income households are to implement fiscal policies known to alter the healthfulness of diets.[100] For example, the World Health Organization (WHO) recommends at least a 20% tax on sugar-sweetened beverages (SSBs) and other unhealthy foods to be coupled with comparable subsidies on nutrient-dense foods like fruit, vegetables, whole grains, legumes, and nuts as a method to shift consumption patterns, especially among low-income groups.[101] The policy is highly cost-effective, with a $0.01/ounce US national SSB tax estimated to provide health care savings of 24 times the cost to implement the tax.[187] Local jurisdictions have implemented such taxes with

promising results in US cities; for example, Berkeley showed a 21% reduction in SSB consumption and Philadelphia showed a 40% decreased odds of consumption.[188,189] These case studies provide compelling evidence that a comparable national tax would be effective. It should be acknowledged that low-income consumers are most likely to be affected by this type of regressive tax. However, the high elasticity of SSB taxes means that lower-income households may see some of the largest declines in SSB purchasing and potentially corresponding gains in diet-related health improvements.[103]

Furthermore, large-scale changes to the food system will help improve the accessibility of sustainable diets to low-income households and should be prioritized. Results from Chapter 3 found that consumers' decisions to buy foods and beverages based on environmental sustainability and price remained consistent from 2019 to 2021. This indicates that even in the midst of a global pandemic and the economic hardship that ensued, consumers continue to state that environmentally sustainable foods are important to them. This being said, other purchasing drivers are in comparison ranked as more important than environmental sustainability, such as taste, price, healthfulness, and convenience. Notwithstanding, a fair amount of public buy-in exists for the government to support strengthening the sustainability of our food system with particular attention to conventional agriculture. They can do this by supporting farmers in making the transition towards greater environmental sustainability through subsidies and incentives that promote large-scale management changes such as no or low till, nitrogen-fixing cover crops, rotational grazing, riparian forests, buffer strips, drip irrigation, permaculture, agroforestry, and polycultures.[37,127–133] This will help to ensure that prices are affordable for consumers as cost is often a competing priority when balancing ethical food choices.[134]

Additionally, results from Chapter 4 showed a decline in consumers' engagement with local food systems during the COVID-19 pandemic. This highlights the need to strengthen the capacity of local agriculture systems to engage consumers and is especially important as small-scale and local food systems were more resilient than large-scale systems to adapt to the COVID-19 pandemic.[190] Three years into the COVID-19 pandemic, the Russian invasion of Ukraine has worsened an already tumultuous food system and threatens global food security.[191] Therefore, as a nation it is important that we work to build local food security.

Dissertation strengths and limitations

This dissertation has multiple strengths. **In Chapter 2,** I used a large population-based sample that was socioeconomically and racially/ethnically diverse. **In Chapter 3,** I used a nationally representative sample with respect to age, gender, education, race/ethnicity, and region; therefore, results can be generalized to the US population. **In Chapter 4,** I used a large, socio-demographically diverse population-based sample with respect to income and race/ethnicity.

However, this dissertation has limitations that must be kept in mind when interpreting study findings. All studies in this dissertation were cross-sectional, thereby limiting the ability to determine causal inference and instead only allowing for the determination of correlation. In **Chapter 2,** an important limitation was the brief assessment of plant-based proteins on the FFQ. This may have led to an underestimation of participants' soy intake, resulting in lower overall PHD scores. Future research focused on assessing sustainable diets should ensure that their measures of dietary intake more comprehensively capture plant-based protein consumption.

FFQs also rely on participants to recall their diet over the past year and studies have consistently shown that people are poor at accurately reporting their past dietary consumption. One alternative to FFQs is using biomarkers to quantitatively determine different components of past dietary consumption; however, this may not be ideal when assessing sustainability as there are not currently agreed upon biomarkers in the field. Participants were also only drawn from one area in the US, thereby geographically limiting study findings' generalizability. Participants may have also over-reported behaviors or characteristics they perceived as socially acceptable and under-reported behaviors or characteristics they perceived as socially unacceptable due to social desirability. This would have the effect of attenuating the correlations of personal, behavioral, and socio-environmental characteristics with the PHD. In **Chapter 3,** Dynata's consumer panel used only electronic platforms for recruitment (social media platforms, mobile apps, and website advertisements); therefore, adults without access to or knowledge about these technologies would have been excluded from the sample. Furthermore, the survey was not weighted by income, so the income level distribution may differ from the data in the most recent Current Population Surveys available at the time. Finally, social-desirability bias is also a possibility as participants may have overreported specific beliefs and behaviors, such as concern for environmental sustainability and healthfulness. To mitigate this issue, survey data was collected anonymously without an interviewer present to maintain anonymity. **In Chapter 4,** only Black/African American, Hispanic/Latino, and White individuals were specifically recruited, thereby limiting study findings from being generalized to other racial or ethnic groups. Furthermore, data were collected using convenience sampling, a form of non-probability sampling, that relies on self-selected participation. Our sample also consisted of people who received their primary health care at Michigan Medicine. This approach would by nature exclude

people who did not seek primary care and may have over-sampled healthier people than the general population.[179] Additionally, this study required that participants had an email address in their medical records and would not have reached people who do not have access to the internet or an active email account. Participant responses may also have been impacted by social-desirability bias, particularly given the highly politically polarized nature of social distancing protocols that were put into place to mitigate the spread of COVID. As such, participants may have under-reported high-risk behaviors like eating in person at a restaurant. Additionally, social-desirability bias could be present due to our recruitment method which advertised the study as being about food choice during COVID, participants may have under-reported unhealthy (i.e., fast food) and overreported healthy (i.e., vegetable consumption) food choice behavior. To mitigate social-desirability bias, survey response data was collected online without an interviewer present and minimal personally identifiable data was collected to maintain anonymity.

Future research

In Chapter 2, I found that Americans fell short of meeting sustainable diet recommendations, particularly among low-income families. This was especially true in regards to high levels of meat consumption and other ASFs. Therefore, future research should prioritize identifying effective interventions that target high ASF consumers to shift protein intake (e.g., beef) to plant-based proteins and more sustainable ASF (e.g., poultry) with specific attention to low-income households. Previous interventions that have effectively demonstrated their ability to promote health-related behavior change hold potential for shifting consumers' ASF consumption and should be tested. Examples of effective health behavior change interventions that should be

tested for efficacy to change ASF consumption include Choice architecture (e.g., front-of-package carbon labels, taste-focused labeling of non-ASFs, defaults that make ASFs an opt-in option, and environmental change to the location of ASFs to less visible or traversed locations) and public communications (e.g. Dietary Guidelines for Americans) along with national policy (decreasing ASFs, particularly beef, in the National School Lunch Program and shifting national ASF subsidies to plant-based foods).[170,171,192,193]

Furthermore, in chapters 2 and 4, I found that more frequent fast-food consumption was correlated with eating a less sustainable diet and that fast food and prepackaged meals were consumed more frequently by low-income families. With the increasing popularity of plant-based meat,[194] many fast food restaurants have begun to incorporate plant-based protein alternatives into their menus.[99] The addition of these menu items has not yet been evaluated to determine the impact on meat consumption and should be conducted with particular attention to the impact on low-income families. Furthermore, future studies should investigate the effectiveness of interventions that decrease ASFs in prepackaged meals as another way to increase the accessibility of environmentally sustainable diets to low-income households. There are significant challenges ahead, but this research can help inform strategies for improving human and planetary health.

Appendices

Appendix A: Pilot Protocol

RECRUITMENT

Convenience and snowball sampling methods will be used to recruit 20 participants. This can be friends, neighbors, family, coworkers. At least 10 of which need to be outside the school of public health and 15 of which need to be outside the field of nutrition.

Eligibility criteria:

a. Aged 18 - 65 years
b. Lives in the state of Michigan since March 10th, 2020
c. Must be able to complete survey in English

Once a Participant has expressed interest in participating in the SUSTAIN Pilot Study:

Research staff will call participants to confirm eligibility and to provide information about the study. If participant is eligible and interested, they will be asked to schedule a zoom interview.

Script for call:

(If not eligible) At this time, you are not eligible to participate in this study. Thank you for your time and interest!

(If eligible) Based on that information, it looks like you are eligible to participate in our study. If you decide to participate in this study, you will participate in a 30 min zoom interview with a member of our research study staff. You will be compensated $10 for your time. What questions do you have any questions for me? *(Answer any questions)*

Does the study sound like something you are interested in? (*If yes, proceed with scheduling*)

(If no) Thank you for your time, I really appreciate you speaking with me this morning. Have a great rest of your day.

(If yes) Okay, great. The next step would be to set up a time for you participate in a zoom interview. Is there a day of the week that works best for you? *(Pull up google calendar and schedule)*

I will send you an email with the zoom link and password for the interview on the *insert date*. The email address I have on file is XX, is that correct?

(*If incorrect, get email)*

(If correct) I will go ahead and send that email once we get off the phone. We also would like to remind participants of their appointments a few days in advance. Would you prefer that we call, email, or text to remind you? *(Note preference)* Okay, so do you have any questions for me before we get off the phone today?

(Answer any questions)

Once Off the Phone Make Sure to Schedule a Zoom Cognitive Interview:

Once a time has been confirmed by the participant schedule a zoom meeting.

1. To schedule a zoom meeting open the Zoom application on the laptop.
2. Click on Schedule a meeting.
3. Name the Meeting "SUSTAIN Pilot Study Interview_ID#"
4. Schedule the day and time that the participant is available with a duration of 30 min.
5. Ensure that a passcode is generated
6. Click on Advanced Options
7. Check off "Automatically record meeting"
8. Click "save" to generate the zoom meeting.
9. Then using google calendar open the scheduled zoom meeting

10. Using the “Add guest” text box add the participant's email and click save.
11. “Would you like to send invitation emails to Google Calendar guests?” Click send. If the guest is outside of your organization, click “invite external guests.”
12. If you need technical help with this process please refer to zoom support.

Right After Study Visit is Scheduled Email Appointment Confirmation:

Subject: SUSTAIN Pilot Study – Appointment Confirmation

Hi XXX,

Thank you for participating in the SUSTAIN Pilot Study. This email is to confirm that you have an appointment with us for INSERT DATE AND TIME on Zoom. Here is the Zoom link INSERT ZOOM LINK and passcode INSERT ZOOM PASSCODE to join the call.

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

Thank you,
Liz Ludwig-Borycz

Day of reminder email:

Subject: SUSTAIN Pilot Study – Appointment Reminder

Hi XXX,

This is just a reminder that you have an Zoom call with the SUSTAIN Pilot Study today at INSERT DATE AND TIME

Here is the Zoom link INSERT ZOOM LINK and passcode INSERT ZOOM PASSCODE to join the call.

The appointment will last about 30min.

I look forward to seeing later today!

Liz

STUDY VISIT TIMELINE

Time	Activity	Audio-recorded
5 minutes	Review study consent form and obtain participant consent	
20 minutes	Participants engage in Cognitive Interviewing to pilot test quantitative measure	X
2 minutes	HSIP Payment	

Study Visit Prep:

15 minutes prior to study visit start time, make sure equipment is working well on Zoom by logging into the call ahead of time. Make sure that Zoom is set to enable audio transcription and recording using the cloud recording. If need to troubleshoot you can use zoom support. 5 min prior to study visit log into Zoom call. Have study visit questions pulled up on the screen ready to share with participant over Zoom.

COGNITIVE INTERVIEWING PROTOCOL

"As explained during the consent form, this zoom call is audio-recorded. I will go ahead and turn on the audio-recorder."

- Don't sound apologetic
- Focus on cognitions, not feelings. Feelings will imply that they are supposed to feel a certain way
- Try to ask in the most neutral way possible

Script

"The goal of this interview is to understand if the following questions capture your experiences as a consumer. I'm going to walk you through three pages of questions that have been adapted from other surveys, and I'd like for you to tell me your impressions.

"Here's the first set of questions. Please take a moment to look over this page." *(Share screens with participant and open first set of questions. Give them a minute to read through*

General Probes:
Please tell me your impressions of what you see.
Please tell me your thoughts about what you see.
Tell me your thoughts about the questions.
Are there any questions that would give you pause?
Are there any questions you would not answer?

Probes to use with items that have been specifically addressed:
What do you think of this question?
What does this question mean to you?

"Thank you for sharing. Now we'll move on to the second set of questions. Please take a moment to look over them."

General Probes:
Please tell me your impressions of what you see.
Please tell me your thoughts about what you see.
Tell me your thoughts about the questions.

Are there any questions that would give you pause?
Are there any questions you would not answer?

Probes to use with items that have been specifically addressed:
What do you think of this question?
What does this question mean to you?

"Thank you for sharing. Here is the third set of questions. Please take a moment to look over them."

General Probes:
Please tell me your impressions of what you see.
Please tell me your thoughts about what you see.
Tell me your thoughts about the questions.
Are there any questions that would give you pause?
Are there any questions you would not answer?

Probes to use with items that have been specifically addressed:
What do you think of this question?
What does this question mean to you?

AFTER STUDY VISIT PROTOCOL

Upload audio & video files:

1. Log into umich google email on laptop.
2. Look for two emails sent by Zoom. The first will contain the link to the cloud video recording and the second will contain the link to the audio transcription. (*Note it may take a few minutes after the video interview has concluded to upload to the cloud and be available for download.)*
3. Open the second email labeled audio transcription.
4. Click on the link that is labeled "These files are available to view, download, and edit on the recording detail page:"
5. This will open a new tab at umich Zoom.
6. Download the mp4 video file.
7. Download the audio transcript vtt file.
8. Drag the Cognitive Interviewing audio and video files to the cognitive interview folder on the server (SPH > NS > Labs> Bauer Lab > Projects > SUSTAIN Study > SUSTAIN Pilot Study > Cognitive Interview > Raw Data) and rename as "ID#_CognitiveInterview_transcript.VTT" and "ID#_CognitiveInterview_video.mp4" respectively.
9. Delete the audio and video files from your laptop downloads.
10. Go into trash and delete the audio and video files from the trash.

Edit Transcription of Cognitive Interview:

1. Open both the transcription and video of the cognitive interview. *(Notepad will open the transcript VTT files on window.)*
2. Copy the text from the transcription in the VTT file and paste it into a new word doc.
3. Save the word doc in the same folder as the transcription and videos on the server labeled "ID#_CognitiveInterview_transcript.docx"
4. Read through the transcript in the word doc to make sure that it recorded the words correctly.
5. If there are errors, use the video to listen to the participant and make corrections in the word document to the text. *(for example, the last name, Ludwig-Borycz, gets transcribed as "Ludwig ports" this would need to be corrected to "Ludwig-Borycz".)*

MODIFICATION OF SURVEY QUESTIONS

Modifying cognitive interviews

1. Conduct 10 cognitive interviews
2. Then modify, clarify, or augment survey questions based on participant's feedback to ensure:
    a. questions produce the intended data
    b. questions that are confusing to participants are identified and improved for clarity
    c. problematic questions or questions that are difficult to answer are identified
    d. response options are appropriate and adequate
    e. it reveals the thought process of participants on domain items
    f. it can indicate problematic question order
3. Then conduct 10 more cognitive interviews.
4. Repeat step 2 "modify, clarify, or augment survey questions based on participant's feedback".

Appendix B: Pilot Survey

SURVEY INSTRUMENT

Construct	Question	Response	Type
Screening Questions	Thank you for your interest in the SUSTAIN study (IRB# HUM00191932). We invite you to participate in a research study to learn more about your food choices during COVID-19. Eligible adults will be asked to complete a 20-minute survey. Those completing the survey will be mailed a $10 Mastercard gift card as a thank you. If you have any questions about SUSTAIN, please contact Elizabeth Ludwig-Borycz, Principal Investigator at SUSTAIN@umich.edu. Please answer the following questions to see if you are eligible to participate.		Note
	Are you able to complete this survey in English?	Yes	Select one
		No	
	How old are you?		Numeric
	Do you live in the State of Michigan?	Yes	Select one
		No	
	Have you lived in Michigan since at least March 10th, 2020?	Yes	Select one
		No	
Eligibility	**If they are not eligible:** Thank you for your interest in our study. Unfortunately, you are not eligible to participate.		Note
	If they are eligible: Thank you for your interest in our study. You are eligible to complete the survey! Please click the Next button to continue.		
Consent	The purpose of SUSTAIN is to learn more about your food choices during COVID-19. This study is being conducted by Liz Ludwig-Borycz at the University of Michigan (IRB# HUM00191932). If you agree to be part of this study, you will be asked questions about yourself and your family. In order to collect the best quality data, we ask that you complete the survey in a quiet place and that you complete all questions without taking a break. We appreciate you taking the time to carefully read the questions and provide thoughtful answers. Participating in this study is completely voluntary. Even if you decide to participate now, you may change your mind and stop at any time. You may choose not to answer questions for any reason. The University of		Note

	Michigan Institutional Review Board Health Sciences and Behavioral Sciences has determined that this study is exempt from IRB oversight. All of your responses will remain confidential. Only qualified research staff will have access to your survey data. This survey takes about 20 minutes to complete. We ask you to please answer as many questions as possible. Your responses are very important to us. If you have any questions about SUSTAIN please email us at SUSTAIN@umich.edu. Thank you for your help! By continuing with the survey, you are consenting to participate in the SUSTAIN study.		
Sociodemographics - age	What is your Age?		Numeric
Sociodemographics - race/ethnicity	How would you best describe YOUR race or ethnicity? Check all that apply. *White; Black or African American; American Indian or Alaska Native; Chinese; Filipino; Asian Indian; Vietnamese; Korean; Japanese; other Asian; Native Hawaiian; Samoan; Chamorro; other Pacific Islander; some other race.*	Black or African American Hispanic and/or Latinex American Indian or Alaska Native Asian or Pacific Islander White Other Refused	Select all that apply
Sociodemographics - sex	What is your sex?	Male Female	Select One
Sociodemographics – household income level	How many people live or stay in your house, apartment, or mobile home? *Here, you counted everyone living and sleeping in your home most of the time, including young children, roommates, and friends and family members who are living with you, even temporarily.*	(XX)	Numeric

Sociodemographics - proxy for household income	Were you or were any children in your home enrolled in any of the following during the past year because of your household income? Check all that apply.	Food Stamps/SNAP/EBT	Select all that apply
		Medicaid	
		Free lunch or reduced lunch at school	
		Head Start	
		WIC	
		Pick-up school provided meals	
Sociodemographics - household income	Think about your income and the income of everyone who lived with you in the past year. Please select which option best describes your total household income before taxes. *Note: including income from jobs, public assistance or welfare, unemployment insurance, workmen's compensation, disability, social security benefits, child support or alimony, and any income any member of your household received from family/friends.*	Less than $20,000	Select one
		$20,000 to $34,999	
		$35,000 to $49,999	
		$50,000 to $74,999	
		$75,000 to $99,999	
		$100,000 to $124,999	
		$125,000 to $149,999	
		$150,000 or More	
Access	Thinking back over the past year, please indicate how much on average you do the following?		Note
Access	Growing a vegetable garden or participating in a community garden	1: Never do this	Select one
		2: Rarely do this	
		3: Sometimes do this	
		4: Frequently do this	
		5: Always do this	
	Please indicate if this is different than before March 10th, 2020, when COVID-19 began?	1: Much Less	Select one
		2: Less	
		3: Same	
		4: More	
		5: Much More	
Access	shopping local for produce and/or other food	1: Never do this	Select one
		2: Rarely do this	
		3: Sometimes do this	
		4: Frequently do this	
		5: Always do this	

	Please indicate if this is different than before March 10th, 2020, when COVID-19 began?	1: Much Less	Select one
		2: Less	
		3: Same	
		4: More	
		5: Much More	
Access	shopping at a farmer's market or CSA (Community Supported Agriculture)	1: Never do this	Select one
		2: Rarely do this	
		3: Sometimes do this	
		4: Frequently do this	
		5: Always do this	
	Please indicate if this is different than before March 10th, 2020, when COVID-19 began?	1: Much Less	Select one
		2: Less	
		3: Same	
		4: More	
		5: Much More	
Access	Ordering a meal kit delivery	1: Never do this	Select one
		2: Rarely do this	
		3: Sometimes do this	
		4: Frequently do this	
		5: Always do this	
	Please indicate if this is different than before March 10th, 2020, when COVID-19 began?	1: Much Less	Select one
		2: Less	
		3: Same	
		4: More	
		5: Much More	
Access	Going to the grocery store	1: Never do this	Select one
		2: A few times per month	
		3: Once a week	
		4: A few times per week	
		5: Every day or more	
		1: Much Less	Select one

	Please indicate if this is different than before March 10th, 2020, when COVID-19 began?	2: Less	
		3: Same	
		4: More	
		5: Much More	
Access	Online delivery grocery shopping	1: Never do this	Select one
		2: A few times per month	
		3: Once a week	
		4: A few times per week	
		5: Every day or more	
	Please indicate if this is different than before March 10th, 2020, when COVID-19 began?	1: Much Less	Select one
		2: Less	
		3: Same	
		4: More	
		5: Much More	
Access	Why did you make this change?	I am afraid of getting COVID-19	Select all that apply
		I don't have enough money	
		Businesses are closed	
		Stay at home order	
		Boredom	
		Want to try something new	
		Lonely	
		Social interaction	
		Loss of transportation	
		Loss of childcare	
		To save money	
		It makes me feel happy	
		If makes me feel safe	
		Other "fill in the blank"	
Access	On a scale of 1 to 10, with 1 being not at all and 10 being definitely, please rate how likely it is that you will continue [doing behavior] once the COVID-19 pandemic is over?"	1, 2, 3, 4, 5, 6, 7, 8, 9, 10	Select one

Preparation	Thinking back over the past year, please indicate how much on average you do the following?		Note
Preparation	Ordering meals that are delivered/take-out from a restaurant	1: Never do this	Select one
		2: A few times per month	
		3: Once a week	
		4: A few times per week	
		5: Every day or more	
	Please indicate if this is different than before March 10th, 2020, when COVID-19 began?	1: Much Less	Select one
		2: Less	
		3: Same	
		4: More	
		5: Much More	
Preparation	Buying fast-food	1: Never do this	Select one
		2: A few times per month	
		3: Once a week	
		4: A few times per week	
		5: Every day or more	
	Please indicate if this is different than before March 10th, 2020, when COVID-19 began?	1: Much Less	Select one
		2: Less	
		3: Same	
		4: More	
		5: Much More	
Preparation	Cooking at home	1: Never do this	Select one
		2: A few times per month	
		3: Once a week	
		4: A few times per week	
		5: Every day or more	
	Please indicate if this is different than before March 10th, 2020, when COVID-19 began?	1: Much Less	Select one
		2: Less	
		3: Same	
		4: More	
		5: Much More	

Preparation	Eating out at a restaurant in person	1: Never do this	Select one
		2: A few times per month	
		3: Once a week	
		4: A few times per week	
		5: Every day or more	
	Please indicate if this is different than before March 10th, 2020, when COVID-19 began?	1: Much Less	Select one
		2: Less	
		3: Same	
		4: More	
		5: Much More	
Preparation	Making foods at home that you traditionally purchased pre-made (e.g. bread, granola, muffins)	1: Never do this	Select one
		2: A few times per month	
		3: Once a week	
		4: A few times per week	
		5: Every day or more	
	Please indicate if this is different than before March 10th, 2020, when COVID-19 began?	1: Much Less	Select one
		2: Less	
		3: Same	
		4: More	
		5: Much More	
Preparation	Making ready-made meals from my pantry or freezer	1: Never do this	Select one
		2: A few times per month	
		3: Once a week	
		4: A few times per week	
		5: Every day or more	
	Please indicate if this is different than before March 10th, 2020, when COVID-19 began?	1: Much Less	Select one
		2: Less	
		3: Same	
		4: More	
		5: Much More	
Preparation	Why did you make this change?	I am afraid of getting COVID-19	

		I don't have enough money	Select all that apply
		Businesses are closed	
		Stay at home order	
		Boredom	
		Want to try something new	
		Lonely	
		Social interaction	
		Loss of transportation	
		Loss of childcare	
		To save money	
		It makes me feel happy	
		If makes me feel safe	
		Other "fill in the blank"	
Preparation	On a scale of 1 to 10, with 1 being not at all and 10 being definitely, please rate how likely it is that you will continue [doing behavior] once the COVID-19 pandemic is over?"	1, 2, 3, 4, 5, 6, 7, 8, 9, 10	Select one
Preparation	Please explain your previous answer to the question "Do you think this change will continue in the future?"	Open-ended	Open-ended
Consumption: 135-item validated semi-quantitative food frequency questionnaire (FFQ)	For each food listed, please estimate the frequency of consumption <u>on average</u> since March 10th, 2020.		Note
Consumption: FFQ	Please indicate if this is different than before March 10th, 2020, when COVID-19 began?	1) Eat much less now	Select one
		2) Eat less now	
		3) Eat the same now	

		4) Eat more now	
		5) much more now	
Consumption	Why did you make this change?	I am afraid of getting COVID-19	Select all that apply
		I don't have enough money	
		Businesses are closed	
		Stay at home order	
		Boredom	
		Want to try something new	
		Lonely	
		Social interaction	
		Loss of transportation	
		Loss of childcare	
		To save money	
		It makes me feel happy	
		If makes me feel safe	
		Other " fill in the blank"	
Consumption	On a scale of 1 to 10, with 1 being not at all and 10 being definitely, please rate how likely it is that you will continue [doing behavior] once the COVID-19 pandemic is over?"	1, 2, 3, 4, 5, 6, 7, 8, 9, 10	Select one
Food Waste	Over the last week, how much of the following foods (e.g. vegetables, fruit, meat, poultry, fish, and grains) have you thrown away?" *Excluding inedible food parts (apple cores, peels, ect.)*	1) none	Select one
		2) very little	
		3) little	
		4) some	
		5) much	
Food Waste	Please indicate if this is different than before March 10th, 2020, when COVID-19 began?	1: Much Less waste now	Select one
		2: Less waste now	
		3: Same waste now	
		4: More waste now	
		5: Much More waste now	
	What is the highest level of education you have completed?	Some high school or less	Select one
		Finished high school or got GED	

Sociodemographics - education		Did some college or training after high school	
		Associates degree or completed technical training	
		Bachelor's degree	
		Advanced degree (e.g., Master's Degree, Ph.D., MD)	
Household food security	*Below are several statements that people have made about their food situation.* *Please indicate whether the statement was <u>often</u> true, <u>sometimes</u> true, or <u>never</u> true for (you/your household) <u>in the last 12 months</u>.*		Note
Household food security-1	The food that (I/we) bought just didn't last, and (I/we) didn't have money to get more.	Often true	Select one
		Sometimes true	
		Never true	
Household food security-2	(I/We) couldn't afford to eat balanced meals.	Often true	Select one
		Sometimes true	
		Never true	
Household food security-3	In the last 12 months did you or other adults in your household ever cut the size of your meals or skip meals because there wasn't enough money for food?	Yes, almost every month	Select one
		Yes, some months but not every month	
		Yes, only 1 or 2 months	
		No	
Household food security-4	In the last 12 months, did you ever eat less than you felt you should because there wasn't enough money for food?	Yes	Select one
		No	
Household food security-5	In the last 12 months, were you ever hungry but didn't eat because there wasn't enough money for food?	Yes	Select one
		No	
Sociodemographics - employment	What was your employment status before COVID-19 (before March 10th, 2020)?	Employed full-time (in person)	Select all that apply
		Employed part-time (in person)	
		Employed full-time (remotely)	
		Employed part-time (remotely)	

		Unemployed, and currently looking for work	
		Unemployed, and currently taking care of house and or family	
		Full-time student (in person)	
		Full-time student (remotely)	
		Part-time student (in person)	
		Part-time student (remotely)	
		Other: _____	
Sociodemographics - employment	Please indicate which of the following describes you best after COVID-19 (after March 10th, 2020).	Employed full-time (in person)	Select all that apply
		Employed part-time (in person)	
		Employed full-time (remotely)	
		Employed part-time (remotely)	
		Unemployed, and currently looking for work	
		Unemployed, and currently taking care of house and or family	
		Full-time student (in person)	
		Full-time student (remotely)	
		Part-time student (in person)	
		Part-time student (remotely)	
		Other: _____	
COVID-19 Family Stress Screener (FSS)	The current coronavirus (COVID-19) outbreak is causing extra stress for many people, including families with children of all ages. We would like to know how things are going for you and your family related to this situation. Please answer the following questions about your experiences and feelings over the last few weeks, using the following scale. **Because of COVID-19 related events and changes, I have felt increased stress about:**		Note
COVID-19 FSS	Food running out or being unavailable	1: Strongly Disagree	Select One
		2: Somewhat Disagree	
		3: Neither Agree nor Disagree	
		4: Somewhat Agree	

		5: Strongly Agree	
COVID-19 FSS	Losing a job or decrease in family income	1: Strongly Disagree	Select One
		2: Somewhat Disagree	
		3: Neither Agree nor Disagree	
		4: Somewhat Agree	
		5: Strongly Agree	
COVID-19 FSS	Housing or utilities	1: Strongly Disagree	Select One
		2: Somewhat Disagree	
		3: Neither Agree nor Disagree	
		4: Somewhat Agree	
		5: Strongly Agree	
COVID-19 FSS	Loss of or limited childcare	1: Strongly Disagree	Select One
		2: Somewhat Disagree	
		3: Neither Agree nor Disagree	
		4: Somewhat Agree	
		5: Strongly Agree	
COVID-19 FSS	Taking care of children, including those who are normally in school	1: Strongly Disagree	Select One
		2: Somewhat Disagree	
		3: Neither Agree nor Disagree	
		4: Somewhat Agree	
		5: Strongly Agree	
COVID-19 FSS	Tension or conflict between household members	1: Strongly Disagree	Select One
		2: Somewhat Disagree	
		3: Neither Agree nor Disagree	
		4: Somewhat Agree	
		5: Strongly Agree	
COVID-19 FSS	Physical health concerns for me or a family member	1: Strongly Disagree	Select One
		2: Somewhat Disagree	
		3: Neither Agree nor Disagree	
		4: Somewhat Agree	
		5: Strongly Agree	

COVID-19 FSS	Increased anxiety or depression	1: Strongly Disagree	Select One
		2: Somewhat Disagree	
		3: Neither Agree nor Disagree	
		4: Somewhat Agree	
		5: Strongly Agree	
COVID-19 FSS	Reminders of past stressful/traumatic events	1: Strongly Disagree	Select One
		2: Somewhat Disagree	
		3: Neither Agree nor Disagree	
		4: Somewhat Agree	
		5: Strongly Agree	
COVID-19 FSS	Loss of social connections, social isolation	1: Strongly Disagree	Select One
		2: Somewhat Disagree	
		3: Neither Agree nor Disagree	
		4: Somewhat Agree	
		5: Strongly Agree	
COVID-19 FSS	Access to medical and/or mental health care	1: Strongly Disagree	Select One
		2: Somewhat Disagree	
		3: Neither Agree nor Disagree	
		4: Somewhat Agree	
		5: Strongly Agree	
Values Sustainable Diet Practices	How important is it to you that your food is **produced as organic**?	1: Not at all	Select One
		2: A little	
		3: Somewhat	
		4: Very important	
Values Sustainable Diet Practices	How important is it to you that your food is **not processed**?	1: Not at all	Select One
		2: A little	
		3: Somewhat	
		4: Very important	
Values Sustainable Diet Practices	How important is it to you that your food is **locally grown**?	1: Not at all	Select One
		2: A little	
		3: Somewhat	

		4: Very important	
Values Sustainable Diet Practices	How important is it to you that your food is **not genetically modified**?	1: Not at all	Select One
		2: A little	
		3: Somewhat	
		4: Very important	
Purchase Drivers	How much of an impact do the following have on your decision to buy foods and beverages on a scale of 1 to 5? (1=No Impact and 5=A Great Impact)		Note
	Convenience	1, 2, 3, 4, 5	Select One
	Healthfulness	1, 2, 3, 4, 5	Select One
	Price	1, 2, 3, 4, 5	Select One
	Taste	1, 2, 3, 4, 5	Select One
	Environmental Sustainability	1, 2, 3, 4, 5	Select One
Cooking Ability	Please rate your cooking skills on a scale of 1 to 5. (1=no skills at all and 5=Expert)	1: No skills at all	Select One
		2:	
		3: Basic	
		4:	
		5: Expert	
Final page	**Thank you for participating in our study!**		Note

Appendix C: SUSTAIN Protocol

HUM00191932 Online Survey Protocol

1. Recruitment Methods (target recruitment=1,200)
    a. DOCTR
        i. To contact research participants and meet enrollment numbers, we will work with the Data Office of Clinical and Translational Research (DOCTR) data team to query contact information (names and emails) for the following groups:
            1. Adults between the ages of 18-65 years old; alive, receiving care at any Michigan Medicine outpatient clinic with a Michigan home zip code from March 1, 2017- March 1, 2020; who identify as African American/black
                a. Insurance status = Medicaid (Recruitment target=133)
                b. Insurance status does not = Medicaid (Recruitment target=267)
            2. Adults between the ages of 18-65 years old; alive, receiving care at any Michigan Medicine outpatient clinic with a Michigan home zip code from March 1, 2017- March 1, 2020; who identify as Hispanic/Latino(a)/Spanish descent
                a. Insurance status = Medicaid (Recruitment target=133)
                b. Insurance status does not = Medicaid (Recruitment target=267)

3. Adults between the ages of 18-65 years old; alive, receiving care at any Michigan Medicine outpatient clinic with a Michigan home zip code from March 1, 2017- March 1, 2020; who identify as non-Hispanic caucasian
    a. Insurance status = Medicaid (Recruitment target=133)
    b. Insurance status does not = Medicaid (Recruitment target=267)

ii. DOCTR identified participant contact:

1. Individuals will be contacted by email developed by the study team and sent by DOCTR to potential participants that have an email on file; our study staff will never have access to PHI.

iii. Recruitment material: Email template is included in Section 12.

b. Paid social media ads

i. Recruitment materials will direct participants to SUSTAINStudy.org, which will include basic study information and link to Qualtrics-based screening survey.

c. UM Health Research

i. Recruitment materials will include basic study information and direct participants to a Qualtrics-based screening survey.

2. Participant screening and enrollment:

a. Eligibility criteria:

i. Aged 18 - 65 years

ii. Lives in the state of Michigan since at least March 2020

iii. Involved in food choices/shopping in your household

iv. Must be able to complete the survey in English

b. Screening procedures:

i. Participants that are recruited through social media and UM Health Research will undergo an additional screening step.

1. Qualtrics-based screening survey
2. If determined that participants may be eligible, RA will send participants an email with a unique, one-time-use URL that directs the participant to take the eligibility screener.
3. Recruitment materials: Email template is included in Section 12.

ii. Participants recruited through DOCTR will receive an email with a unique, one-time-use URL for each person contacted.

iii. All participants recruited through social media, UM Health Research, and DOCTR will take the unique one-time-use URL eligibility screening survey.

1. Participants will complete the screening survey, which will automatically determine their eligibility.
2. If participants are ineligible, they will receive a message thanking them and explaining they are ineligible.
3. If participants are eligible, they will be directed to the study consent form followed by the study survey.

3. Survey completion and participant compensation:

a. Survey completion and participant compensation will occur once all data has been collected by doing a drawing among the 1,200 participants to randomly select 10 winners of a $100 Mastercard gift card. The survey data is collected separately from compensation data so that participants' contact information is not linked to their survey responses.
b. Participants must complete 85% of the qualtrics survey questions to be eligible to enter the drawing.
c. Upon survey completion participants who completed <85% of the qualtrics survey questions will be notified that they did not complete enough of the survey to be eligible to enter the drawing.
d. Participants who completed >=85% of the qualtrics survey questions will be automatically redirected to a separate gift card survey if they would like to enter the drawing to win a $100 Mastercard gift card. The gift card survey will ask participants to provide their email addresses and a verifiable residential mailing address in the state of Michigan.
e. If randomly selected for one of the Mastercard gift cards the participant will be mailed a $100 gift card though the UM HSIP office.
f. Participant mailing addresses will be checked on the USPS website to ensure correct mailing addresses. If there is a discrepancy then it will be reconciled by emailing participants to confirm their correct mailing address and giving them 48 hours to respond.

Appendix D: SUSTAIN Recruitment Email

Subject Line: Participate in an online study for the University of Michigan: *SUSTAIN*

Greetings!

We are inviting adults to participate in a research study from the University of Michigan to learn more about their food choices during COVID-19.

Individuals eligible to participate in the study will complete a 20-minute survey. Those completing the survey will have the opportunity to submit their email to be enrolled in a drawing for 1 of 10, $100 Mastercard gift cards as a thank you.

To learn more about *SUSTAIN* and see if you are eligible to participate, please click the following one-time use link or copy and paste the URL into your internet browser on **your computer (cell phone is not recommended)**: {unique URL}

The survey can only be completed once, so please do not share this email or the one-time use survey link with others.

SUSTAIN is led by Liz Ludwig-Borycz at the University of Michigan. If you have any questions about *SUSTAIN* please email us at SUSTAIN@umich.edu.

Regards,

Liz Ludwig-Borycz
Principal Investigator
IRB# HUM00191932

Appendix E: SUSTAIN Survey

Construct	Question	Response	Type	Source
Eligibility Block				
Screening Questions: Eligible if able to complete study in English; 18-65 years old; Lives in Michigan AND (1-3 years OR 3 years or more); and is involved in grocery shopping/food choices in your household.	Thank you for your interest in the SUSTAIN study (IRB# HUM00191932). We invite you to participate in a research study to learn more about your food choices during COVID-19. If you are eligible to participate in SUSTAIN, you will be asked to complete a 20-minute survey. People who complete the survey can enter a drawing for 1 of 10, $100 Mastercard gift cards as a thank you. If you have any questions about SUSTAIN, please contact Liz Ludwig-Borycz, Principal Investigator at SUSTAINstudy@umich.edu. Please answer the following questions to see if you are eligible to participate.		Note	
	If you are interested in participating in the SUSTAIN study please click "true."	True False	Select one ***Force response***	robot protection
	Are you able to complete this survey in English?	Yes No	Select one ***Force response***	
	How old are you (in years)?		Numeric ***Force response***	DSQ
	What is your gender?	Male Female Do not identify as male or female	Select one ***Force response***	Adapted from Project EAT 2018

	What state do you live in?	(list of all states)	Select one ***Force response***	
	What is your home zip code?		Numeric ***Force response***	
	How long have you lived in (chosen state)?	less than 1 year 1 - 3 years 3 years or more	Select one ***Force response***	
	Are you involved in the grocery shopping or food choices in your household?	Yes No	Select one ***Force response***	
Race/ethnicity	How would you best describe your race/ethnicity? Check all that apply.	Black or African American Hispanic/Latino(a)/Spanish descent Asian or Pacific Islander American Indian or Alaska Native White Other (please describe below)	Select all that apply (make this a required question) ***Force response***	IFIC 2019 Quota at: Hispanic/Latino(a)/Spanish descent =400 AND Gift Card eligible Non-Hispanic Black or African American = 400 AND Gift Card eligible Non-Hispanic White =400 AND Gift Card eligible
Income quota	Were you or your household enrolled in any of the following	Yes No	Select one ***Force response***	Quota at: no=800 AND Gift Card eligible

	during the past year because of your household income? ● Food Stamps/SNAP/EBT ● Medicaid/WIC ● Head Start ● Free lunch or reduced lunch at school			
Captcha	Please click the box below to prove you are human.	I'm not a robot		robot protection
Eligibility	**If they are not eligible:** Thank you for your interest in our study. Unfortunately, you are not eligible to participate.		Note	
	If they are eligible: Thank you for your interest in our study. You are eligible to complete the survey! Please click the Next button to continue.			
Consent Block				
Consent	The purpose of SUSTAIN is to learn more about your food choices during COVID-19. This study is being conducted by Liz Ludwig-Borycz at the University of Michigan (IRB# HUM00191932). We expect that approximately 1,200 people will participate in the study. If you agree to be part of this study, you will be asked questions about yourself and your family. We ask that you complete the survey in a quiet place and that you complete all questions without taking a break. We appreciate you taking the time to carefully read the questions and provide thoughtful answers. Participating in this study is completely voluntary. Even if you decide to participate now, you may change your mind and stop at		Note	

	any time. You may choose not to answer questions for any reason. The University of Michigan Institutional Review Board Health Sciences and Behavioral Sciences has determined that this study is exempt from IRB oversight. All of your responses will remain confidential. Only qualified research staff will have access to your survey data. To thank you for taking part in our study, we are giving all participants who respond to at least 85% of the questions the opportunity to enter a drawing for 1 of 10, $100 Mastercard gift cards. We will also be implementing methods to identify fraudulent responses. Participants identified as fraudulent will not be eligible to enter the gift card drawing. This survey takes about 20 minutes to complete. We ask you to please answer as many questions as possible. Your responses are very important to us. If you have any questions about SUSTAIN please email us at SUSTAINstudy@umich.edu. Thank you for your help! By continuing with the survey, you are consenting to participate in the SUSTAIN study.			
Sociodemographic Block				
We'd like to start by asking some questions about you and your household.			Note	
Sociodemographics –household income level	Including yourself, how many people live in your home?		Numeric (make this a required group)	2020 Census

Gender	What is your gender?	Male Female Do not identify as male or female	Select one ***Force response***	robot protection
Sociodemographics - household income	Think about your income and the income of everyone who lives with you. Please select which option best describes your total household income before taxes in the past 12 months. *Note: include income from jobs, public assistance or welfare, unemployment insurance, workmen's compensation, disability, social security benefits, child support or alimony, and any income any member of your household received from family/friends.*	Less than $10,000 $10,000 to $19,999 $20,000 to $34,999 $35,000 to $49,999 $50,000 to $74,999 $75,000 to $99,999 $100,000 to $124,999 $125,000 to $149,999 $150,000 or More Don't know	Select one (make this a required question)	Adapted from SPROUT Study and NHANES
Sociodemographics - education	What is the highest level of education you have completed?	Some high school or less Finished high school or got GED Did some college or training after high school Associates degree or completed technical training Bachelor's degree Advanced degree (e.g., Master's Degree, Ph.D., MD)	Select one	NHANES
	Please indicate which of the following describe you best	Employed full-time (in person)	Select all that apply	"Taking care of house or family"

Sociodemographics - employment	• *Before COVID-19 (before March 2020)* • *Over the past year during COVID-19 (since March 2020)*	Employed part-time (in person) Employed full-time (remotely) Employed part-time (remotely) Unemployed and looking for work Unemployed and taking care of house and/or family Full-time student (in person) Full-time student (remotely) Part-time student (in person) Part-time student (remotely) Other (please describe below)		comes from NHANES 2017/2018
COVID risk: Part A	Do you consider yourself to be at high risk of COVID-19 infection?	Yes No Don't know	Select one	VA COVID-19 Provider Social Risks Screening Questions
COVID vaccination	Have you been fully vaccinated against COVID-19? *People are considered fully vaccinated:* • *2 weeks after their second dose in a 2-dose series, like the Pfizer or Moderna vaccines* • *2 weeks after a single-dose vaccine, like Johnson & Johnson's Janssen vaccine*	Yes No	Select one	CDC

COVID risk: Part B	Do you have any of the following medical conditions associated with increased risk of severe illness from COVID-19? ● Cancer ● Chronic kidney disease ● COPD (chronic obstructive pulmonary disease) ● Down Syndrome ● Heart conditions, such as heart failure, coronary artery disease, or cardiomyopathies ● Immunocompromised state (weakened immune system) from solid organ transplant ● Obesity, BMI (body mass index) of 30 or higher ● Pregnancy ● Sickle cell disease ● Smoking ● Type 2 diabetes mellitus	Yes No	Select one	CDC

Food Access and Preparation Block				
The following questions will ask you about things you did before COVID-19, have been doing over the past year during COVID-19, and will do once the COVID-19 pandemic is over. *For the following questions,* *"**Before COVID-19"** refers to before March 2020* *"**Over the past year during COVID-19"** refers to since March 2020* ***"Once the COVID-19 pandemic is over"** refers to 2022 or after*			Note	
Access	Please indicate how much on average you and your household have done (will do) the following? ● Before COVID-19 ● Over the past year during COVID-19 ● Once the COVID-19 pandemic is over		Note	
	Drive to the grocery store	Never or less than once a month	Select one	Mangiaracina R, Marchet G, Perotti S, Tumino A. A review of the environmental implications of B2C e-commerce: a logistics perspective. Int J Phys Distrib Logist Manag. 2015;45(6):565–91.
		1-2 times per month		
		3-4 times per month		
		2-3 times per week		
		1 or more times per day		
	Have groceries delivered to your home	Never or less than once a month	Select one	
		1-2 times per month		
		3-4 times per month		
		2-3 times per week		

		1 or more times per day		United States Environmental Protection Agency. What You Can Do to Reduce Pollution from Vehicles and Engines | Transportation, Air Pollution, and Climate Change | US EPA [Internet]. [cited 2020 Sep 28]. Available from: https://www.epa.gov/transportation-air-pollution-and-climate-change/what-you-can-do-reduce-pollution-vehicles-and-engines Siikavirta H, Punakivi M, Kärkkäinen M, Linnanen L. Effects of e-commerce on greenhouse gas emissions: A case study of grocery home delivery in Finland. J Ind Ecol. 2002;6(2):83–97.

				Edwards JB, McKinnon AC, Cullinane SL. Comparative analysis of the carbon footprints of conventional and online retailing: A "last mile" perspective. Int J Phys Distrib Logist Manag. 2010;40(1–2):103–23. Durand B, Gonzalez-Feliu J. Urban Logistics and E-Grocery: Have Proximity Delivery Services a Positive Impact on Shopping Trips? Procedia - Soc Behav Sci.
	Shop for locally-grown produce and/or other food	Never Rarely Sometimes Frequently Always	Select one	Yang Y, Campbell JE. Improving attributional life cycle assessment for decision support: The case of local food in sustainable design. J Clean Prod [Internet]. 2017;145:361–6.
	Shop at a farmer's market or participate in a CSA (Community Supported Agriculture)	Never Rarely Sometimes Frequently Always	Select one	

	Grow your own produce	Never Rarely Sometimes Frequently Always	Select one	Available from: http://dx.doi.org/10.1016/j.jclepro.2017.01.020 Center for Sustainable Systems University of Michigan. U.S. Food System Factsheet. Pub. No. CSS01-:06.
	Use a meal kit delivery (e.g., Blue Apron, Hello Fresh)	Never or less than one meal per month 1-4 meals per month 2-6 meals per week 1 meal per day 2 or more meals per day	Select one	Heard BR, Bandekar M, Vassar B, Miller SA. Comparison of life cycle environmental impacts from meal kits and grocery store meals. Resour Conserv Recycl [Internet]. 2019;147(November 2018):189–200. Available from: https://doi.org/10.1016/j.resconrec.2019.04.008
Preparation	• Eat something from a fast-food restaurant (including traditional "burgers-and-fries" restaurants, Mexican fast food, fried chicken such	Never or less than one meal per month 1-4 meals per month 2-6 meals per week 1 meal per day 2 or more meals per day	Select one	Project EAT

	as KFC, sandwich or sub shops, and pizza places) • Eat take-out or delivery from a restaurant (not including fast food) • Eat at a restaurant either indoors or outdoor dining (not including fast food)			
	Eat meals that are home-cooked (not counting pre-packaged meals like frozen dinners, canned soup, ramen noodles)	Never or less than one meal per month 1-4 meals per month 2-6 meals per week 1 meal per day 2 or more meals per day	Select one	Schmidt Rivera XC, Espinoza Orias N, Azapagic A. Life cycle environmental impacts of convenience food: Comparison of ready and home-made meals. J Clean Prod [Internet]. 2014;73(2014):294–309. Available from: http://dx.doi.org/10.1016/j.jclepro.2014.01.008 Fertig AR, Loth K, Trofholz AC, Tate AD, Miner M, Neumark-Sztainer D, et al. Compared to pre-prepared meals, fully and partially home-cooked meals

				in diverse families with young children are more likely to include nutritious ingredients. J Acad Nutr Diet. 2018;119(5):818–30 NHANES pg 13-15
	Eat pre-packaged meals such as frozen dinners, canned soup, or ramen noodles (NOT counting meals that are home-cooked)	Never or less than one meal per month 1-4 meals per month 2-6 meals per week 1 meal per day 2 or more meals per day	Select one	Schmidt Rivera XC, Espinoza Orias N, Azapagic A. Life cycle environmental impacts of convenience food: Comparison of ready and home-made meals. J Clean Prod [Internet]. 2014;73(2014):294–309. Available from: http://dx.doi.org/10.1016/j.jclepro.2014.01.008 Food and Agriculture Organization of the United Nations, Food Climate Research Network. Plates, pyramids, planet: Developments in national healthy and

				sustainable dietary guidelines. 2016. NHANES pg 13-15
	Eat foods that are traditionally purchased pre-made but someone made at home (e.g. bread, muffins, or granola)	Never Rarely Sometimes Frequently Always	Select one	Monteiro CA, Cannon G, Moubarac JC, Levy RB, Louzada MLC, Jaime PC. The un Decade of Nutrition, the NOVA food classification and the trouble with ultra-processing. Public Health Nutr. 2018;21(1):5–17. Food and Agriculture Organization of the United Nations, Food Climate Research Network. Plates, pyramids, planet: Developments in national healthy and sustainable dietary guidelines. 2016.
Access & Preparation	What is the main reason you made this change? (Referring to *"access/preparation item")*	Safety during COVID-19 Healthier Less expensive Tastes better Convenience	Select one	IFIC 2020

	(Ask for each item in access and preparation only if *Over the past year during COVID-19* & *Before COVID-19* don't match)	Other (please describe below)		
Consumption Block				
These questions are about foods you ate or drank during the past month, that is, the past 30 days. When answering, please include meals and snacks eaten at home, at work or school, in restaurants, and anyplace else.			Note	DSQ from NHANES: 26-item dietary screener questionnaire (DSQ)
dsq_010	During the past month, how often did you eat **hot or cold cereals**?	Never	Select one	
		1 time last month		
		2--3 times last month		
		1 time per week		
		2 times per week		
		3--4 times per week		
		5--6 times per week		
		1 time per day		
		2 or more times per day		
dsq_020	During the past month, what kind of cereal did you usually eat? Search (type cereal name and/or scroll to select)		Drop Down	
dsq_020_oth	If other kind of cereal please describe below		Text box	

dsq_xx3	If there was another kind of cereal that you usually ate during the past month, what kind was it? If none leave blank. Search (type cereal name and/or scroll to select)		Drop Down	
dsq_xx3_oth	If other kind of cereal please describe below		Text box	
dsq_030	During the past month, how often did you have any **milk** (either to drink or on cereal)? Include regular milks, chocolate or other flavored milks, lactose-free milk, buttermilk. Please do **not** include small amounts of milk in coffee or tea or plant-based milks such as oat milk, soy milk, and almond milk.	Never	Select one	
		1 time last month		
		2--3 times last month		
		1 time per week		
		2 times per week		
		3--4 times per week		
		5--6 times per week		
		1 time per day		
		2-3 times per day		
		4-5 times per day		
		6 or more times per day		
dsq_xx4 dsq_xx4os	During the past month, what kind of milk did you usually drink?	Whole or regular milk	Select one	
		2% fat or reduced-fat milk		
		1%, ½%, or low--fat milk		
		Fat--free, skim or nonfat milk		
		Other kind of milk (please describe below)		

dsq_030p	During the past month, how often did you have any **plant-based milks** such as soy, almond, coconut, oat, rice, or others (either to drink or on cereal)? Please do **not** include small amounts of milk in coffee or tea.	Never	Select one	
		1 time last month		
		2--3 times last month		
		1 time per week		
		2 times per week		
		3--4 times per week		
		5--6 times per week		
		1 time per day		
		2-3 times per day		
		4-5 times per day		
		6 or more times per day		
dsq_xx4p dsq_xx4osp	During the past month, what kind of plant-based milk did you usually drink?	Soy milk	Select one	
		Almond milk		
		Coconut milk		
		Oat milk		
		Rice milk		
		Other kind of plant-based milk (please describe below)		
dsq_040	During the past month, how often did you drink **regular soda or pop** that contains sugar? Do **not** include diet soda.	Never	Select one	
		1 time last month		
		2--3 times last month		
		1 time per week		
		2 times per week		
		3--4 times per week		
		5--6 times per week		
		1 time per day		

		2-3 times per day		
		4-5 times per day		
		6 or more times per day		
dsq_050	During the past month, how often did you drink **100% pure fruit juices** such as orange, mango, apple, grape and pineapple juices? Do **not** include fruit flavored drinks with added sugar or fruit juice you made at home and added sugar to.	Never	Select one	
		1 time last month		
		2--3 times last month		
		1 time per week		
		2 times per week		
		3--4 times per week		
		5--6 times per week		
		1 time per day		
		2-3 times per day		
		4-5 times per day		
		6 or more times per day		
dsq_060	During the past month, how often did you drink coffee or tea that had **sugar** or **honey** added to it? Include coffee and tea you sweetened yourself and presweetened tea and coffee drinks such as Arizona Iced Tea and Frappuccino. Do **not** include artificially sweetened coffee or diet tea.	Never	Select one	
		1 time last month		
		2--3 times last month		
		1 time per week		
		2 times per week		
		3--4 times per week		
		5--6 times per week		
		1 time per day		
		2-3 times per day		
		4-5 times per day		
		6 or more times per day		
dsq_070		Never	Select one	

	During the past month, how often did you drink **sweetened** fruit drinks, sports or energy drinks, such as Kool-Aid, lemonade, Hi-C, cranberry drink, Gatorade, Red Bull or Vitamin Water? Include fruit juices you made at home and added sugar to. Do not include diet drinks or artificially sweetened drinks.	1 time last month		
		2--3 times last month		
		1 time per week		
		2 times per week		
		3--4 times per week		
		5--6 times per week		
		1 time per day		
		2-3 times per day		
		4-5 times per day		
		6 or more times per day		
dsq_080	During the past month, how often did you eat **fruit**? Include fresh, frozen or canned fruit. Do **not** include juices.	Never	Select one	
		1 time last month		
		2--3 times last month		
		1 time per week		
		2 times per week		
		3--4 times per week		
		5--6 times per week		
		1 time per day		
		2 or more times per day		
dsq_090	During the past month, how often did you eat a green leafy or lettuce **salad,** with or without other vegetables?	Never	Select one	
		1 time last month		
		2--3 times last month		
		1 time per week		
		2 times per week		
		3--4 times per week		
		5--6 times per week		

		1 time per day		
		2 or more times per day		
dsq_100	During the past month, how often did you eat any kind of fried potatoes, including french fries, home fries, or hash brown potatoes?	Never	Select one	
		1 time last month		
		2--3 times last month		
		1 time per week		
		2 times per week		
		3--4 times per week		
		5--6 times per week		
		1 time per day		
		2 or more times per day		
dsq_110	During the past month, how often did you eat any **other kind of potatoes**, such as baked, boiled, mashed potatoes, sweet potatoes, or potato salad?	Never	Select one	
		1 time last month		
		2--3 times last month		
		1 time per week		
		2 times per week		
		3--4 times per week		
		5--6 times per week		
		1 time per day		
		2 or more times per day		
dsq_120	During the past month, how often did you eat refried beans, baked beans, beans in soup, pork and beans or any other type of cooked dried beans? Do **not** include green beans.	Never	Select one	
		1 time last month		
		2--3 times last month		
		1 time per week		
		2 times per week		
		3--4 times per week		
		5--6 times per week		
		1 time per day		

		2 or more times per day		
dsq_210	During the past month, how often did you eat **brown rice** or other cooked whole grains, such as bulgur, cracked wheat, or millet? Do **not** include white rice.	Never	Select one	
		1 time last month		
		2--3 times last month		
		1 time per week		
		2 times per week		
		3--4 times per week		
		5--6 times per week		
		1 time per day		
		2 or more times per day		
dsq_130	During the past month, not including what you just told me about (green salads, potatoes, cooked dried beans), how often did you eat **other vegetables?**	Never	Select one	
		1 time last month		
		2--3 times last month		
		1 time per week		
		2 times per week		
		3--4 times per week		
		5--6 times per week		
		1 time per day		
		2 or more times per day		
dsq_150	During the past month, how often did you have Mexican--type **salsa** made with tomato?	Never	Select one	
		1 time last month		
		2--3 times last month		
		1 time per week		
		2 times per week		
		3--4 times per week		
		5--6 times per week		
		1 time per day		
		2 or more times per day		
dsq_140	During the past month, how often did you eat **pizza**? Include frozen	Never	Select one	
		1 time last month		
		2--3 times last month		

	pizza, fast food pizza, and homemade pizza.	1 time per week		
		2 times per week		
		3--4 times per week		
		5--6 times per week		
		1 time per day		
		2 or more times per day		
dsq_160	During the past month, how often did you have **tomato sauces** such as with spaghetti or noodles or mixed into foods such as lasagna? Do not include tomato sauce on pizza.	Never	Select one	
		1 time last month		
		2--3 times last month		
		1 time per week		
		2 times per week		
		3--4 times per week		
		5--6 times per week		
		1 time per day		
		2 or more times per day		
dsq_190	During the past month, how often did you eat any kind of **cheese**? Include cheese as a snack, cheese on burgers, sandwiches, and cheese in foods such as lasagna, quesadillas, or casseroles. Do **not** include cheese on pizza.	Never	Select one	
		1 time last month		
		2--3 times last month		
		1 time per week		
		2 times per week		
		3--4 times per week		
		5--6 times per week		
		1 time per day		
		2 or more times per day		
dsq_170	During the past month, how often did you eat **red meat**, such as beef, pork, ham, or sausage? Do **not** include chicken, turkey or seafood. Include red meat you had in sandwiches, lasagna, stew, and other mixtures. Red meats may	Never	Select one	
		1 time last month		
		2--3 times last month		
		1 time per week		
		2 times per week		
		3--4 times per week		
		5--6 times per week		

	also include veal, lamb, and any lunch meats made with these meats.	1 time per day 2 or more times per day		
dsq_180	During the past month, how often did you eat any **processed meat**, such as bacon, lunch meats, or hot dogs? Include processed meats you had in sandwiches, soups, pizza, casseroles, and other mixtures. *Processed meats are those preserved by smoking, curing, or salting, or by the addition of preservatives. Examples are: ham, bacon, pastrami, salami, sausages, bratwursts, frankfurters, hot dogs, and spam.*	Never 1 time last month 2--3 times last month 1 time per week 2 times per week 3--4 times per week 5--6 times per week 1 time per day 2 or more times per day	Select one	
dsq_200	During the past month, how often did you eat **whole grain bread** including toast, rolls and in sandwiches? Whole grain breads include whole wheat, rye, oatmeal and pumpernickel. Do not include white bread.	Never 1 time last month 2--3 times last month 1 time per week 2 times per week 3--4 times per week 5--6 times per week 1 time per day 2 or more times per day	Select one	
dsq_220	During the past month, how often did you eat **chocolate** or any other types of candy? Do **not** include sugar-free candy.	Never 1 time last month 2--3 times last month 1 time per week 2 times per week	Select one	

		3--4 times per week		
		5--6 times per week		
		1 time per day		
		2 or more times per day		
dsq_230	During the past month, how often did you eat **doughnuts**, sweet rolls, Danish, muffins, pan dulce, or pop-tarts? Do **not** include sugar-free items.	Never	Select one	
		1 time last month		
		2--3 times last month		
		1 time per week		
		2 times per week		
		3--4 times per week		
		5--6 times per week		
		1 time per day		
		2 or more times per day		
dsq_240	During the past month, how often did you eat **cookies, cake, pie or brownies**? Do **not** include sugar--free kinds.	Never	Select one	
		1 time last month		
		2--3 times last month		
		1 time per week		
		2 times per week		
		3--4 times per week		
		5--6 times per week		
		1 time per day		
		2 or more times per day		
dsq_250	During the past month, how often did you eat **ice cream or other frozen desserts**? Do **not** include sugar--free kinds.	Never	Select one	
		1 time last month		
		2--3 times last month		
		1 time per week		
		2 times per week		
		3--4 times per week		
		5--6 times per week		
		1 time per day		
		2 or more times per day		

dsq_260	During the past month, how often did you eat **popcorn**?	Never 1 time last month 2--3 times last month 1 time per week 2 times per week 3--4 times per week 5--6 times per week 1 time per day 2 or more times per day	Select one	
End of DSQ				
	How likely are you to **keep eating** the way you are **now**?	Extremely likely Somewhat likely Neither likely nor unlikely Somewhat unlikely Extremely unlikely	Select one	Eccles, M. P.; Hrisos, S.; Francis, J.; Kaner, E. F.; Dickinson, H. O.; Beyer, F.; Johnston, M. Do Self- Reported Intentions Predict Clinicians' Behaviour: A Systematic Review. Implement. Sci. 2006, 1 (1). https://doi.org/10.1186/1748-5908-1-28.
	Has your diet changed over the past year during the COVID-19 Pandemic (since March 2020) compared to before COVID-19 (before March 2020)?	Yes Somewhat No *(if no then skip the rest of the consumption block to the next block, Food waste)*	Select one	
	Please indicate how much on average you have eaten the	a lot more more	Select one	Adapted from Food in the Anthropocene

	following foods over the past year during the COVID-19 Pandemic (since March 2020) compared to before COVID-19 (before March 2020). 1) I eat_____ **vegetables** now than I did before the COVID Pandemic. 2) I eat_____ **potatoes** now than I did before the COVID Pandemic. 3) I eat_____ **fruit** now than I did before the COVID Pandemic. 4) I eat_____**whole grains** now than I did before the COVID Pandemic. 5) I eat_____ **dairy** now than I did before the COVID Pandemic. 6) I eat_____ **beef, lamb, or pork** now than I did before the COVID Pandemic. 7) I eat_____ **chicken and other poultry** now	the same amount of less a lot less		IFIC 2020

	than I did before the COVID Pandemic. 8) I eat_____ **eggs** now than I did before the COVID Pandemic. 9) I eat_____ **fish** now than I did before the COVID Pandemic. 10) I eat_____ **beans, lentils, or peas** now than I did before the COVID Pandemic. 11) I eat_____ **soy foods (including tofu, soy milk, etc.)** now than I did before the COVID Pandemic. 12) I eat_____ **nuts** now than I did before the COVID Pandemic. 13) I eat_____ **sweets** now than I did before the COVID Pandemic.			
	What is the main reason you changed your diet over the past year? (this question is only asked once, not 13 seperate times for each food group)	Safety during COVID-19 Healthier Less expensive Tastes better Convenience	Select one	IFIC 2020

		Other (please describe below)		
Food Waste Block				
Food Waste	Please indicate how much on average you and your household have thrown (will throw) food away? ● Before COVID-19 (before March 2020) ● Over the past year during COVID-19 (since March 2020) ● Once the COVID-19 pandemic is over (2022 or after)	A great deal A lot A moderate amount A little None at all	Select one	Elimelech E, Ert E, Ayalon O. Exploring the drivers behind self-reported and measured food wastage. Sustain. 2019;11(20):1–19 First study to look at the association between self-reported food wasit and measured food waste. They are correlated, albeit weakly.
	What is the main reason you made this change? (Referring to *"throw food away")* (Ask only if *Over the past year during COVID-19* & *Before COVID-19* don't match)	Safety during COVID-19 Healthier Less expensive Tastes better Convenience Other (please describe below)	Select one	IFIC 2020
Covariates				
Cooking Skills	Please rate your cooking skills ● Now	Extremely good Somewhat good Neither good nor bad	Select one	

	• Before COVID-19 (before March 2020)	Somewhat bad Extremely bad		
Values Sustainable Diet Practices	How important is it to you that your food is 1) produced as organic? 2) non-processed? 3) locally grown?	Extremely important Very important Moderately important Slightly important Not at all important	Select One	Larson, N.; Laska, M. N.; Neumark-sztainer, D. Do Young Adults Value Sustainable Diet Practices? Continuity in Values from Adolescence to Adulthood and Linkages to Dietary Behaviour. *Public Health Nutr.* **2019**.
Purchase Drivers	How much of an impact do the following have on your decision to buy foods and beverages? 1) Convenience 2) Healthfulness 3) Price 4) Taste 5) Environmental Sustainability	A great deal A lot A moderate amount A little None at all	Select One	IFIC 2020
Household Food Security Block				
Below are several statements that people have made about their food situation.			Note	Blumberg, S. J.; Bialostosky, K.; Hamilton, W. L.;

Please indicate whether the statement was <u>often</u> true, <u>sometimes</u> true, or <u>never</u> true for you and your household <u>in the last 12 months</u>.				Briefel, R. R. The Effectiveness of a Short Form of the Household Food Security Scale. *Am. J. Public Health* **1999**, *89* (8), 1231–1234. https://doi.org/10.2105/AJPH.89.8.1231
Household food security-1	The food that I bought just didn't last, and I didn't have money to get more.	Often true Sometimes true Never true	Select one	
Household food security-2	I couldn't afford to eat balanced meals.	Often true Sometimes true Never true	Select one	
Household food security-3	In the last 12 months did you or other adults in your household ever cut the size of your meals or skip meals because there wasn't enough money for food?	Yes, almost every month Yes, some months but not every month Yes, only 1 or 2 months No	Select one	
Household food security-4	In the last 12 months, did you ever eat less than you felt you should because there wasn't enough money for food?	Yes No	Select one	
Household food security-5	In the last 12 months, were you ever hungry but didn't eat because there wasn't enough money for food?	Yes No	Select one	
COVID-19 Family Stress Screener Block				
COVID-19 Family Stress Screener (FSS)	COVID-19 is causing extra stress for many people. We would like to know how things are going for you and your family related to this situation. Please answer the following questions about your	Strongly agree Somewhat agree Neither agree nor disagree Somewhat disagree Strongly disagree	Select one	Huth-Bocks, A. COVID-19 Family Stress Screener; Cleveland, Ohio: Case Western, 2020.

	experiences and feelings over the last few weeks, using the following scale. **Because of COVID-19 related events and changes, I have felt increased stress about:** 1) Food running out or being unavailable 2) Losing a job or decrease in family income 3) Housing or utilities 4) Loss of or limited childcare 5) Taking care of children, including those who are normally in school 6) Tension or conflict between household members 7) Physical health concerns for me or a family member 8) Increased anxiety or depression 9) Reminders of past stressful/traumatic events	Not Applicable		

	10) Loss of social connections, social isolation 11) Access to medical and/or mental health care			
Final Page Gift Card Block				
Final page	**If didn't answer enough questions:** Thank you for participating! Unfortunately, you didn't answer enough questions to be enrolled in the gift card drawing.		Note	
	If answered enough questions: Thank you for participating in our study! Would you like to enter a drawing for 1 of 10, $100 Mastercard gift cards?		Yes (automatically redirect to the Gift Card Survey) No (End Survey)	

Gift card survey	Please fill out your name, address, and email below to enter the drawing for 1 of 10, $100 Mastercard gift cards. Winners will be drawn on June 15, 2021. If selected, the winners will be notified by email and the gift card will be mailed to your address.		Note
	Name (First and Last)		Text
	Address line 1		Text
	Address line 2		Text
	City		Text
	State		Text
	Zip Code		Number
	Please enter your email address *[Study team will notify winners by email to expect the gift card in the mail]*		Email
	Please confirm your email address: *(Ensure the emails match)*		Email
	Thank you again for your time!		Note

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