Title

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Journal

Journal of the Academy of Nutrition and Dietetics, 123(5)

ISSN

2212-2672

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Publication Date

2023-05-01

DOI

10.1016/j.jand.2022.09.015

Peer reviewed

HHS Public Access

Author manuscript

J Acad Nutr Diet. Author manuscript; available in PMC 2024 May 01.

Published in final edited form as:

J Acad Nutr Diet. 2023 May ; 123(5): 740–750. doi:10.1016/j.jand.2022.09.015.

Environmental and climate impact perceptions in university students: Sustainability motivations and perceptions correspond with lower red meat intake

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Abstract

Background: Red meat production is a leading contributor to food-related greenhouse gas emissions. Decreasing red meat intake can mitigate climate change and lower risk of diet-related diseases.

Objective: The goal of this study is to evaluate university students' perceptions of climate-friendly behaviors, and to assess how these perceptions are associated with the frequency of red meat intake.

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Contributions: CL, JF: conception of study idea, data collection, analysis, critical revisions of the manuscript; JF: perception measures; MS: interpretation of results, writing of the manuscript, critical revisions of the manuscript; JC, AG, JW: review of results, critical revisions of the manuscript

Conflicts of Interest: None

Design: Cross-sectional survey

Setting: A large, public California university and a large, public Michigan university

Participants: Undergraduate students from a California university (n=721) and a Michigan university (n=568).

Main Outcome Measures: Perceptions of climate-friendly behaviors and frequency of red meat intake.

Statistical Analysis: Differences in perceptions by student characteristics were compared using t-tests and one-way ANOVA. Associations between perceptions of climate-friendly behaviors and red meat intake frequency were examined using generalized linear models, adjusted for sociodemographic covariates.

Results: Across both universities, students rated reducing meat intake as less effective than other climate change mitigation behaviors such as recycling and using less plastic. However, students who reported: (1) making food and beverage choices that "are good for the environment," (2) making food and beverage choices that "reduce climate change impact," or (3) agreeing that "eating less meat is an effective way to combat climate change," reported 10–25% lower frequency of red meat intake for each point higher on the agreement scale. In contrast, making food and beverage choices motivated by health was not associated with frequency of red meat intake.

Conclusions: Sustainability motivations and perceptions of meat's climate impact were associated with lower frequency of red meat intake, despite the overall moderate rating of eating less meat as an effective climate change mitigator. This research lends support to behavioral interventions, public education campaigns, and policies aiming to reinforce sustainable dietary patterns in young adults.

Keywords

Red meat; young adults; environmental attitudes; plant-based diets; climate change

Introduction

Climate change, one of the most pressing problems facing the world today, is driven by greenhouse gas emissions (GHGE), resulting in a multitude of threats to the environment, global food systems and human health.[1, 2] Meat production results in GHGE, and although GHGE varies by animal type and livestock practices, bovine meat (and meat from other ruminants) is consistently reported to have higher GHGE per serving than any other food type.[3–6] On average, foods from plants have smaller environmental impacts and lower GHGE per serving than meat and meat products.[3, 6, 7] A shift to plant-rich diets with limited red meat intake could decrease food-related GHGE by up to 70%.[8] Furthermore, healthy plant-based diets with limited red meat, particularly processed red meat intake, have notable human health benefits, such as lower risks of cardiovascular disease, type 2 diabetes, and cancers.[7] Currently, the US Dietary Guidelines for Americans recommends higher intake of vegetables, fruits, and lean proteins, and "lower consumption of red and processed meats" for a healthy dietary pattern.[9] Given the high meat intake in the United

States (US) compared to the global average, US consumer shifts to plant-rich foods can have a significant impact on human and planetary health.[3]

Attitudes of university students towards sustainable eating have been previously evaluated,[10–14] and sustainable eating behaviors in students have been recently reviewed.[15] Barriers to college students consuming sustainable foods include perceived cost, availability, time constraints, convenience, and lack of understanding of sustainable food choices.[14, 15] Students who are women are more likely to eat vegetarian diets and more often report stronger environmental beliefs and more sustainable eating habits than men.[12–16] The relationships between race, ethnicity, and socioeconomic status and sustainable eating habits in young adults are inconsistent.[14, 17, 18] More studies are needed to understand what motivates individuals to consider sustainable food choices,[2] particularly for young adults. Specifically, there is a need to evaluate how sociodemographic characteristics are associated with perceptions of sustainable diets, and how these perceptions translate to dietary choices. While positive environmental attitudes have been linked to higher fruit and vegetable intake[18] and consumption of plant-based meat alternatives[10] in young adults, no known studies have linked environmental and climate impact perceptions to red meat intake in this population.

The university setting, where young adults live away from home and experience autonomy over dietary choices, often for the first time, presents a unique environment for studying dietary behaviors and perceptions. Choices made during young adulthood have the potential to influence future dietary patterns and purchasing decisions,[19, 20] as well as college-level procurement practices and policies,[19] thus affecting the future of global consumer sustainability practices. Therefore, the goal of this study is to evaluate university students' perceptions of climate friendly behaviors, and assess how sustainability perceptions and behaviors translate to frequency of red meat intake. We hypothesize that environmental and health motivations and perceptions may translate to lower frequency of red meat intake in this population.

Methods

Study participants

This study analyzed cross-sectional data from two separate surveys conducted at two large US public universities located in California and Michigan. Researchers at the two universities collaborated on questionnaire design and wording, with the goal of creating comparable questions for parallel comparisons. At the California university, a convenience sample of students was recruited by researchers in university dining commons, via flyers and social media posts. The topic of the study was described as, "college students' eating, sleep, and screen time behaviors and opinions," and only students on a meal plan were recruited because the questionnaire was part of a larger evaluation of a dining hall sugar-sweetened beverage intervention. Data collection occurred from November 2018-February 2019, and students received a $7 Amazon gift card for completing the 15-minute survey. Students could complete the survey on paper or online via Qualtrics. Of the 761 total eligible participants who passed the screener (age 18+ years, undergraduate student, and on a meal plan), 756 took the survey. Those with missing data for the outcomes of the present study

or key sociodemographic characteristics were excluded, leaving an analytic sample of 721 participants.

At the Michigan university, an online (Qualtrics) survey was fielded to students who had previously participated in a sugar-sweetened beverage warning label intervention.[21] The purpose of the study was described to students as "[to] improve our understanding of students' demographics and health behaviors." In total, 804 students were contacted and 609 students responded, yielding a response rate of 76%. Data collection occurred in March-April 2020, and students received a $10 Amazon gift card code for completing the 15-minute survey. Those with missing data for the outcomes of the present study or key sociodemographic characteristics were excluded, leaving an analytic sample of 568 participants. All procedures involving research study participants were approved by the Institutional Review Boards at both universities. Written or digital informed consent was obtained from all participants.

Measures

Motivations for food and beverage choices.—Novel items were developed to assess the extent to which food and beverage choices were motivated by concern for (1) the environment, (2) climate change, and (3) health. These items were based on prior measures of health consciousness[22, 23] and asked "How much do you agree with these statements? I try to make food and beverage choices that…": "Are good for the environment," "Reduce my impact on climate change," and "Are good for my health," with a 7-point response scale ranging from 1="Strongly Disagree" to 7="Strongly Agree" for each item. These questions were identical for surveys administered at both universities.

Perception of climate-friendly behaviors.—Items assessing perceived effectiveness of behaviors for combatting climate change were modified from a scale developed by de Boer and colleagues.[24] The questionnaire for the California university asked, "For each of the following lifestyle-changes, let us know whether you think this is an effective way of combatting climate change" for each of 7 behaviors (presented in random order): "Eat local, seasonal foods", "Eat less meat", "Drive less", "Eat organic foods" (modified from "buy [more] organic foods" because many college students are on a meal plan), "Use less plastic (e.g., bottles and packaging)" (not on the original scale), "Save energy at home (e.g., turn thermostat down, use energy saving bulbs)", "Recycle" (instead of the original "Install solar panels on my house" because most college students do not own homes). The questionnaire for the Michigan university asked, "For each of the lifestyle changes, indicate whether you think this is an effective way of combatting climate change of the same 7 overall behaviors (in this order): "Eat local, seasonal foods", "Eat less meat", "Drive less", "Eat organic foods", "Use less plastic", "Save energy at home", "Recycle". For both questionnaires, response options included 1="Not effective at all," 2="Not very effective," 3="Effective," 4="Highly effective," and "Don't know." Responses of "Don't know" were excluded from the analyses.

Frequency of red meat intake.—Red meat intake frequency at the California university was assessed with a food frequency screener adapted from the Youth/Adolescent

Questionnaire,[25] which asked, “during the fall semester, how often did you eat…” (1) “Beef like hamburgers, steak, ground beef” and (2) “Pork, lamb, or goat” with the following response options for both categories of meat: 4+ per day, 2–3 per day, 1 per day, 5–6 per week, 2–4 per week, 1 per week, 1–3 per month, and <1 per month. Frequencies for (1) beef and (2) pork, lamb, or goat were summed and converted to determine total frequency of red meat consumption per day for the California university. Dietary intake at the Michigan university was assessed using the National Cancer Institute’s Dietary Screener Questionnaire (DSQ). The DSQ includes 26 questions on the intake frequency of foods related to national dietary guidance. For the present study, we focused on the question pertaining to red meat frequency: “During the past month, how often did you eat red meat, such as beef, pork, ham, or sausage?” Nine frequencies were presented: never, one time last month, two-three times last month, one time per week, two times per week, three-four times per week, five-six times per week, one time per day, and two or more times per day. For analysis, response frequencies were converted to a continuous variable indicating times per day. Specifically, for categorical frequency ranges, the mid-point was used to represent frequency, and this number was divided by 7 or 30 to convert weekly or monthly frequency, respectively, to daily frequency.

Sociodemographic covariates.—A goal of this study was to evaluate how sociodemographic characteristics are associated with perceptions of sustainable diets, and how these perceptions translate to dietary choices. Therefore, race and ethnicity, gender, and other sociodemographic data were collected. Students in both studies self-reported their age, gender (man, woman, gender-queer/gender non-conforming/non-binary, other-specify), race and ethnicity (Asian, American Indian/Alaska Native, Black/African American, Hispanic, Middle Eastern/North African (MENA), Pacific Islander/Native Hawaiian, White/Caucasian, Other-specify), parental income, receipt of Pell grant in the current academic year (yes/no), and food security. Federal Pell grants are usually awarded to students with exceptional financial need and are therefore an indicator of income level.

Race and ethnicity categories were provided by researchers, and students self-reported race and ethnicity based on these specified categories. At the California university, students were asked to select all categories that apply, while at the Michigan university, students were given the option of selecting “Multiracial/Multiethnic.” Students at both universities were also given the option to write in race and ethnicity. Race and ethnicity were further classified into Non-Hispanic Asian, Non-Hispanic White, and Other racial and ethnic identities which were combined by researchers for analysis due to small numbers of American Indian/Alaska Native, Black/African American, Hispanic, and Multiracial/Multiethnic participants for stratification analyses. At the Michigan university, MENA students were classified as Other racial/ethnic identities (n=8), while at the California university MENA students (n=24) were classified as White in accordance with the US Census Bureau guidelines.[26] At the California university, food security was assessed using the USDA Six-Item Short Form Food Security Survey Module.[27] At the Michigan university, food security was assessed using the ten-item U.S. Adult Food Security Survey Module.[27] Food security categories (high/marginal, low, and very low for the California sample and high, marginal, low, very low for the Michigan sample) were created according to USDA guidelines.[27]

Statistical analysis

Given the slight differences in surveys as described above, and inherent differences in the two universities, a parallel approach for statistical analyses was selected. First, descriptive statistics were used to examine students' sociodemographic characteristics at the two institutions. Then, we calculated means and standard deviations of the perception of climate-friendly behaviors by students' sociodemographic characteristics overall and then stratified by these characteristics. Differences in perceptions by student characteristics were compared using t-tests and one-way ANOVA. Associations between perceptions of climate-friendly behaviors and frequency of red meat intake were examined using generalized linear models with robust standard errors, a log link (to allow for interpretation of coefficients as percent difference), and gamma distribution (to account for the skewed distribution of red meat intake frequency). Models were adjusted for student's age, gender, race and ethnicity, food security status, parental income, and Pell grant status. Frequency ratios (FR) were calculated by exponentiating the model coefficients; [1-FR]*100 represents percent lower frequency of red meat consumption for each point on the perception scales. All statistical tests were two-sided, and statistical significance was considered at $P<0.05$. Statistical analyses were performed using StataSE v12.1.

Results

The sociodemographic characteristics of students from the California university (n=721) and the Michigan university (n=568) are shown in Table 1. The mean age and gender of students were similar across universities: 18.6 and 18.2 years of age and 57% and 52% women in the California university and Michigan university samples, respectively. There were larger differences in race and ethnicity between samples – at the California university, compared to the Michigan university, a higher percentage of students identified as non-Hispanic Asian (58% vs 30%), and a lower percentage identified as non-Hispanic White (17% vs 56%), reflecting overall differences in each university's enrollment. At the California university, 29% of students had parental income <$50,000, and at the Michigan university 17% of students reported parental income <$50,000. Low or very low food security was reported for 38% of students at the California university and 17% of students at the Michigan university. Mean student red meat intake frequency was 0.9 (±1.1) times/day at the California university and 0.4 (±0.4) times/day at the Michigan university.

Student attitudes and perceptions towards climate change and health are shown in Table 2. Overall, students at both universities most highly ranked health as a motivation for their food and beverage choices (California mean 5.4 [±1.3]; Michigan mean 5.3 [±1.2]). To a lesser extent, students also reported making food and beverage choices that "are good for the environment" (California mean 3.7 [±1.6]; Michigan mean 4.0 [±1.5]) and "reduce my impact on climate change" (California mean 3.6 [±1.7]; Michigan mean 4.0 [±1.5]). Making dietary choices for the environment and climate change were ranked significantly lower than making choices for health at both universities ($p<0.001$).

When asked to rate the effectiveness of climate change mitigating behaviors, using less plastic was rated as most effective by participants at both universities (California mean 3.6 [±0.6]; Michigan mean 3.6 [±0.7]), followed by saving energy at home, and driving

less. These behaviors were all rated as significantly more effective than eating less meat (p-values<0.001). Eating organic foods was ranked as least effective for combatting climate change at both universities (California mean 2.8 [±0.9]; Michigan mean 2.5 [±0.9]), and significantly less effective than eating less meat (Ps<0.001). Eating less meat fell in the middle in perceived effectiveness. At the California university, recycling was rated as significantly more effective than eating less meat, while at the Michigan university, eating less meat was ranked as significantly more effective than eating local, seasonal foods (Ps <0.001). At both universities, the three behaviors related to food systems had lower ratings of effectiveness for combatting climate change than the other behaviors.

Differences in student health and climate mitigation perceptions by sociodemographic characteristics are shown in Table 3. Compared to men, women at both universities agreed more strongly that the environment and climate change motivate their food and beverage choices. At the California university, non-Hispanic White students (mean 5.6 [±1.2]) were significantly but only marginally more likely than non-Hispanic Asian students (mean 5.5 [±1.3]) and other racial/ethnic groups (mean 5.2 [±1.5]) to report health motivations for dietary choices; however, the majority of students, regardless of race and ethnicity agreed that health motivated their dietary choices. Furthermore, at the California university, non-Hispanic White students (mean 3.9 [±1.8]) were marginally more likely than non-Hispanic Asian students (mean 3.6 [±1.6]) and other racial/ethnic groups (mean 3.5 [±1.7]) to report that climate change motivated their food and beverage choices (p<0.05). No significant differences in dietary behaviors were reported by race and ethnicity at the Michigan university, or by parental income or Pell grant status at either university. Although students with higher food security at both universities were significantly more likely to report making food and beverage choices that are good for their health when compared to students of lower food security (California: high and marginal security mean 5.6 [±1.2], very low security mean 5.0 [±1.7]; Michigan: high security mean 5.5 [±1.1], very low security mean 4.9 [±1.3]), the majority of students reported health as an important motivator for their food and beverage choices, regardless of food security status. Students at the California university with low (mean 3.9 [±1.6]) or very low (mean 3.9 [±1.7]) food security were significantly more likely to report making choices that were good for the environment than students with high or marginal food security (mean 3.5 [±1.6]).

Women more highly rated the effectiveness of all climate change mitigation behaviors when compared to men (Table 3); these differences are consistent across both universities, with the exception of there being no gender difference in perceived impact of eating less meat at the California university. At both universities, students with a higher parental income more highly ranked eating less meat as an effective way of combatting climate change, when compared with students of lower-income parents. Students without Pell grants at the Michigan university were more likely to report that eating less meat is an effective way of combatting climate change. However, students on Pell grants at the California university were more likely to report recycling to be an effective way of combatting climate change. Ranking for the lifestyle behaviors did not vary significantly by race and ethnicity.

Students who reported higher agreement that the environment and climate change motivated their food and beverage choices reported significantly lower frequency of red meat intake

(Table 4). Specifically, for each 1-point higher agreement that the participant made food and beverage choices that "are good for the environment," red meat was consumed 10% less frequently at the California university (Frequency Ratio [FR]: 0.90; 95% CI: 0.84, 0.96; p=0.001) and 25% less frequently at the Michigan university (FR: 0.75; 95% CI: 0.69, 0.81; p<0.001). Similarly, for each 1-point higher agreement that the participant made food choices that reduce [their] impact on climate change, red meat consumption was 10% less frequent at the California university (FR: 0.90; 95% CI: 0.84, 0.96; p=0.001) and 22% less frequent at the Michigan university (FR: 0.78; 95% CI 0.72, 0.85; p<0.001). For each 1-point higher agreement that "eating less meat is an effective way to combat climate change," red meat intake was consumed 13% less frequently at the California university (FR: 0.87; 95% CI 0.79, 0.95; p=0.003) and 20% less frequently at the Michigan university (FR: 0.80; 95% CI 0.72, 0.89; p<0.001). In contrast, the motivator of "[making] food choices that are good for my health" was not significantly associated with frequency of red meat intake at either institution.

Discussion

In this study, we found that undergraduate students at two large, public universities were motivated to make food and beverage choices that are good for their health and planetary health. Students perceived using less plastic, saving energy at home, and driving less as the most effective ways of combatting climate change, followed by eating less meat. Despite moderate ranking of meat reduction as a climate change mitigation strategy by students, being motivated by environmental and climate change concerns when making food and beverage choices translated into a significantly lower frequency of red meat intake. In contrast, making food and beverage choices motivated by health was not associated with frequency of red meat intake.

We observed a significantly lower frequency of red meat intake among young adults motivated to make dietary choices for climate change and the environment. Similarly, another study reported that students at a different midwestern US university were more likely to consume plant-based meat alternatives if they believed them to be better for the environment.[10] At a European university, a higher concern for environmental problems was associated with higher student support for less-meat initiatives at the university.[13] As evident in a recent review, environmental concerns alone may motivate some reduction in meat intake; yet, often health, cultural, and ethical motivators are more significant drivers, particularly for vegan or vegetarian lifestyles.[28] Environmental concerns, however, have potential to be motivators for reducing meat consumption in the US. Approximately half of Americans surveyed recently reported a willingness to eat more plant-based foods if they had more information on the environmental impact of different foods.[29] There is some evidence to suggest that the environment might be a stronger motivator of meat reduction in younger populations,[28] but this speculation warrants further research.

In the current study, it is possible that low awareness of effective environmental actions resulted in participants underestimating the effectiveness of reducing meat intake for climate change. When asked to indicate behaviors effective for mitigating climate change, students ranked "eat less meat" as less effective than "use less plastic" or "recycle", whereas research

has indicated that recycling is four times less effective than eating a completely plant-based diet.[30] Moreover, simply replacing beef intake with poultry in diets of select Americans decreased personal GHGE by 1.38 kg CO_2 equivalents per person per day[31] – a reduction approximately 100 times more effective than eliminating plastic grocery bag use.[30] It has been consistently reported in the literature that consumers underestimate the environmental impact of meat consumption.[5, 28] Such low awareness persists across different countries.[5] Studies involving university students have shown that educational interventions influence sustainable eating habits while simultaneously improving diet quality,[32, 33] and should be considered as a way to increase sustainable eating behaviors.

Counter to what we hypothesized, a health motivation for making food and beverage choices was not significantly associated with lower frequency of red meat intake in this study. This lack of significant association may be due to recent mixed messages in the US about the health benefits and risks of red meat intake[34] and saturated fat,[35] which is concentrated in red meats, as well as the popularity of meat-heavy diets such as the Keto and Paleo diets.[36] It is possible that this is especially true for young adults, who may be receiving health information from a variety of sources, including social media. In a recent survey, Americans age 18–29 were less likely to reduce red meat intake than older participants; furthermore, perception that a healthy diet includes meat was a common reason given for not reducing meat consumption.[37] Our findings suggest that young adults may be confused about the health impacts of red meat consumption. Therefore, this population may benefit from messaging that addresses both health and environmental impacts of red meat consumption.

Women in this study were more likely than men to say they make food and beverage choices that are good for the environment and reduce their impact on climate change. This finding is consistently reported in the literature for both adolescents and adults, and in different parts of the world.[5, 12, 14, 16, 18] Women are also more likely to be vegetarians and to be willing to reduce red meat consumption than men.[5, 37] These blanket gender differences are likely due in part to the association between traditional views of masculinity and meat consumption, which can create obstacles to encouraging reduction of red meat intake in men.[38] However, such gender barriers have potential to shift as masculinity evolves.[39]

The role of race and ethnicity and income in shaping sustainable food perceptions and behaviors is unclear. While some differences in making food choices that “are good for my health” were observed by race and ethnicity at the California university, these were not corroborated at the Michigan university. At both universities, a majority of students in all race and ethnicity groups reported that health and the environment motivated their food choices. However, a recent study which analyzed sustainable food choices of US adults reported that participants identifying as Black, Hispanic, Asian, or “Other” race and ethnicity placed higher value on sustainable food than White participants, as did those with lower incomes and education levels.[40] In the general US population, red and processed meat consumption has been shown to differentiate by race and education, but not family income.[41]

Perceptions of motivations for food behaviors did not appear to be strongly associated with parental income or Pell grant status in our population, demonstrating that these groups have

similar views of sustainable behaviors. However, students whose parents fell into the highest income category (≥$100,000) at both universities, and students who were not on the Pell grant at the Michigan university, were more likely to believe that eating less meat was a successful way to combat climate change than students in the lower income categories.

At the Michigan university, food security status was not associated with sustainable eating choices. At the California university, students with lower food security were more likely to report making choices perceived as good for the environment. Disadvantaged groups are often more likely to observe societal problems through an environmental lens,[42] and this may apply to those affected by food insecurity. It is possible that greater availability of affordable plant-based foods, or fresh fruits and vegetables, made sustainable eating more accessible for the California students. In contrast to findings for environmental motivations, students at both universities with lower food security were less likely to report health as a motivation for their food choices (although health motivation was still rated relatively high across food security categories). These results suggest that students experiencing food-related hardship may view sustainable eating differently than heathy eating, which requires future investigation. Nonetheless, valuation of sustainable food choices persists across different income brackets.

Valuation, however, might not always translate into consumption of these foods. In a recent survey, lower-income American households were more likely than high-income households to report that cost, knowledge of preparation, and access affect purchase and eating of plant-based foods.[29] The price of food is one of the main factors affecting purchasing decisions in low-income households,[43] which would likely affect the ability of some populations to prioritize sustainable eating, even if it is highly valued. Cost has been identified as a reason for reducing red meat intake,[37] yet it has been reported that low-income groups purchase lower-priced, fattier cuts of meat rather than less meat.[43]

Research has shown that US adults underestimate environmental concerns of low-income Americans and Asian, Black, and Latino Americans, and that these stereotypes extend to climate change beliefs.[44] Our findings reiterate that research, policies, interventions, and outreach regarding sustainable diets should ensure that vulnerable populations are equitably included and engaged in these conversations.

Intervention studies involving university students have shown that education has the power to influence sustainable eating habits while simultaneously improving diet quality.[32, 33] In one study, educational interventions were shown to significantly decrease carbon footprints of Generation Z college students by 14%, and significant decreases in ruminant meat and sugar sweetened beverages were also reported.[33] In another study, students enrolled in a food and society course reported increased awareness of the importance of environmental sustainability as well as increased healthy diet scores, increases in vegetable intake, and decreases in high fat dairy and sweets.[32] Lastly, carbon footprint labeling in cafeterias may promote more climate friendly dietary behaviors among university students.[45]

While consumer education and behavior can be important drivers of change towards healthy and sustainable diets, governing bodies as well as intermediary players - such as retailers

and food servicers - must be involved to create lasting change.[7] Efforts should be made in institutional settings, such as university cafeterias, to curate both sustainable and healthy eating options. University campuses continue to work on sustainability problem-solving, with many efforts geared towards operational changes.[46] While campus environmental sustainability interventions have included campus gardens, composting, and portion-size messaging, such interventions are primarily focused on food waste reduction and less on sustainable proteins and reducing red meat intake.[47] Interventions that simultaneously address both health and environmental sustainability are needed.[47] Future studies should evaluate students' receptiveness to sustainable diets, perceptions of red meat and health in young adults, and barriers to reducing red meat consumption in this population.

Limitations and Conclusions

Strengths of the study include large sample sizes from two different public universities in different geographic areas of the US. This study also has some limitations. Dietary data were self-reported frequency data, and therefore do not capture information on absolute intakes; self-reported frequency of intake may be subject to reporting bias if environmentally conscious students are more aware of dietary intake. Different measures were used to assess frequency of red meat intake at the different universities (e.g., frequency during the semester vs frequency in the past month); it is possible that the semester measurement, as used by the California university, was more likely to capture long-term dietary preferences, such as veganism/vegetarianism/pescatarianism.

A limitation of our measure of the perceived effectiveness of eating less meat for climate change is that it assessed "meat" generally and did not specify red meat. Although beef is the most highly consumed red meat amongst adults[41] and adolescents[48] in the US, and all types of meat (poultry, fish, and red meat) generally have a higher climate impact than plant foods[3, 7], it is unclear to what extent the participants equated "meat" with "red meat." Future studies should ask about perceived climate impact of reducing intake of specific types of meat: beef, lamb/goat, pork, poultry, fish and seafood. Future studies should also examine environmental and health attitudes of vegetarian/vegan students versus meat-eating students.

Studies on environmental behaviors can be influenced by social desirability bias.[49] In this study, however, it is unlikely social desirability bias played strongly into results as health seemed to be a primary motivator for making food and beverage choices, and the questionnaires assessed a range of other behaviors and perceptions (e.g., screen time, sleep). Another limitation is that students surveyed may not be representative of the broader young adult population of the US, and globally. This population is comprised of university students at two highly ranked institutions; previous research has shown that education level influences dietary intake, and specifically red meat intake, in the US.[41, 50] Further studies are needed to corroborate these findings in different population subsets of young adults.

In this study, positive perceptions about environmental sustainability and a desire to mitigate climate change were associated with lower frequency of red meat intake, suggesting the possibility that knowledge and motivation can translate into positive and sustainable health behaviors. These associations persisted despite beliefs underestimating the effect of eating

less meat on climate change. These findings underscore the importance of public education campaigns aiming to increase sustainable eating knowledge and habits in young adults, and perhaps young men in particular, while focusing on co-benefits of healthy eating patterns. Such messaging has the potential for positive impacts on eating habits, the global food system, and planetary health.

Funding/Financial Disclosure:

JF and research reported in this publication was supported by the National Institute of Diabetes and Digestive and Kidney Diseases of the National Institutes of Health under Award Number K01DK113068. CWL and research reported in this publication was supported by the Eunice Kennedy Shriver National Institute of Child Health and Human Development (R00HD084758) and a grant from the University of Michigan Office of Research. JAW was supported by the National Institutes of Diabetes and Digestive and Kidney Diseases of the National Institutes of Health (Award #K01DK119166). The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health. The authors have no financial disclosures.

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Research Snapshot

Research Question:

How do environmental perceptions and dietary motivations predict the frequency of red meat intake among university students?

Key Findings:

In this cross-sectional study, 1,289 students interviewed at two large, public universities rated reducing meat intake as significantly less effective than other climate change mitigation behaviors such as recycling and using less plastic. However, despite moderate rating of eating less meat as an effective climate change mitigator, higher environmental motivation for food and beverage choices was associated with 10–25% lower frequency of red meat intake (Ps<0.01).

Table 1.

Sociodemographic data for undergraduate students completing written and online health behavior surveys at universities in California (CA) (n=721) and Michigan (MI) (n=568)

	University in CA (n=721[a])		University in MI (n=568[a])	
Age	**Mean**	**SD**	**Mean**	**SD**
	18.6	1.2	18.2	0.6
Gender	**n**	**%**	**n**	**%**
Woman	413	57	297	52
Man	291	40	271	48
Other/nonconforming/nonbinary[b]	17	2	-	-
Race and Ethnicity [c]	**n**	**%**	**n**	**%**
Asian	420	58	172	30
Other	175	24	78	14
White	126	17	318	56
Food security [d]	**n**	**%**	**n**	**%**
High	443	61	386	68
Marginal	-	-	83	15
Low	176	24	59	10
Very low	102	14	40	7
Pell grant	**n**	**%**	**n**	**%**
No	655	91	434	76
Yes	66	9	134	24
Parental income [e]	**n**	**%**	**n**	**%**
<$50,000	177	29	98	17
$50,000–<$100,000	179	29	128	23
≥$100,000	254	42	340	60
	Mean	**SD**	**Mean**	**SD**
Reported red meat intake (times per day)	0.9	1.1	0.4	0.4

[a] Participants missing red meat consumption and dietary motivation questions were excluded from sample.

[b] Removed from analytic sample for the university in MI due to small numbers; included in the university in CA analyses except where noted.

[c] Asian and White categories were non-Hispanic students. Students classified as Other races and ethnicities included American Indian/Alaska Native, Black/African American, Hispanic, and Multiracial/Multiethnic participants. MENA students were classified as White at the university in CA (n=24) and Other at the university in MI (n=8).

[d] Food security was measured by the U.S. Household Food Security Survey Module: Six-Item Short Form at the CA university, and by the 10-item Adult FSSM at the MI university.

[e] Parental income for the CA university was categorized as <$50,000, $50,000-<$110,000, and ≥$110,000. Responses of “Don’t know” or missing were excluded from calculations of percentages.

Table 2.

Climate change and health perception and behavior ranking for undergraduate students surveyed at universities in California (CA) (n=721) and Michigan (MI) (n=568)

	University in CA				University in MI			
I try to make food and beverage choices that[a]…	**n**	**Mean (SD)**	**p-value[b]**	**% Agree[c]**	**n**	**Mean (SD)**	**p-value[b]**	**% Agree[c]**
Are good for the environment	721	**3.7 (1.6)**	**<0.001**	30.4	568	**4.0 (1.5)**	**<0.001**	34.7
Reduce my impact on climate change	721	**3.6 (1.7)**	**<0.001**	29.4	568	**4.0 (1.5)**	**<0.001**	34.9
Are good for my health	721	5.4 (1.3)	(ref)	78.6	568	5.3 (1.2)	(ref)	79.8
This is an effective way of combatting climate change[d]:	**n**	**Mean (SD)**	**p-value[b]**	**% Effective[e]**	**n**	**Mean (SD)**	**p-value[b]**	**% Effective[e]**
Eat local, seasonal foods	665	3.1 (0.8)	0.15	81.4	517	**3.2 (0.8)**	**<0.001**	84.5
Drive less	710	**3.4 (0.7)**	**<0.001**	93.0	559	**3.5 (0.8)**	**<0.001**	87.8
Eat organic foods	651	**2.8 (0.9)**	**<0.001**	61.6	503	**2.5 (0.9)**	**<0.001**	50.1
Use less plastic	707	**3.6 (0.6)**	**<0.001**	95.1	556	**3.6 (0.7)**	**<0.001**	92.2
Save energy at home	708	**3.4 (0.7)**	**<0.001**	91.2	554	**3.5 (0.7)**	**<0.001**	90.6
Recycle	706	**3.4 (0.7)**	**<0.001**	91.8	556	3.3 (0.8)	0.68	84.4
Eat less meat	669	3.2 (0.9)	(ref)	75.6	545	3.3 (0.9)	(ref)	81.3

[a] Students were asked how much they agree with the statement "I try to make food and beverage choices that… are good for the environment, reduce my impact on climate change, are good for my health". Scale of 1–7, 1=strongly disagree to 7=strongly agree

[b] p-value indicates statistical significance of within-person comparison of perceptions compared to the reference category using paired t-tests

[c] Percentage of students responding as agree or highly agree

[d] Students were asked "For each of the lifestyle changes, indicate whether you think this is an effective way of combatting climate change: eat local, seasonal foods; eat less meat; drive less; eat organic foods; use less plastic; save energy at home; recycle". Scale of 1–4, 1= not effective at all to 4=highly effective

[e] Percentage of students reporting behavior as effective or highly effective

Table 3.

Mean (SD) student environmental and health behavior and perception scores, stratified by sociodemographic characteristics, for undergraduate students surveyed at universities in California (CA) (n=721) and Michigan (MI) (n=568)

University in CA		Gender[a]			Race and Ethnicity[b]				Parental Income				Pell Grant			Food Security Status		
I try to make food and beverage choices that[c]…	**n**	**Man**	**Woman**	**n**	**Asian**	**Other**	**White**	**n**	**<$50,000**	**$50–110,000**	**≥$110,000**	**n**	**Yes**	**No**	**n**	**High & Marginal**	**Low**	**Very Low**
Are good for the environment	704	3.5 * (1.6)	3.8 * (1.7)	721	3.7 (1.6)	3.6 (1.7)	3.9 (1.8)	610	3.7 (1.6)	3.7 (1.6)	3.6 (1.7)	721	3.5 (1.6)	3.7 (1.6)	721	3.5 * (1.6)	3.9 * (1.6)	3.9 * (1.7)
Reduce my impact on climate change	704	3.4 ** (1.6)	3.8 ** (1.7)	721	3.6 * (1.6)	3.5 * (1.7)	3.9 * (1.8)	610	3.6 (1.6)	3.6 (1.6)	3.6 (1.7)	721	3.5 (1.7)	3.7 (1.7)	721	3.5 (1.6)	3.8 (1.6)	3.8 (1.8)
Are good for my health	704	5.4 (1.2)	5.4 (1.4)	721	5.5 * (1.3)	5.2 * (1.5)	5.6 * (1.2)	610	5.3 (1.4)	5.4 (1.2)	5.6 (1.3)	721	5.2 (1.6)	5.5 (1.3)	721	5.6 *** (1.2)	5.2 *** (1.4)	5.0 *** (1.7)
Effective way of combatting climate change[d]:	**n**	**Man**	**Woman**	**n**	**Asian**	**Other**	**White**	**n**	**<$50,000**	**$50–110,000**	**≥$110,000**	**n**	**Yes**	**No**	**n**	**High & Marginal**	**Low**	**Very Low**
Eat local, seasonal foods	649	2.9 *** (0.8)	3.2 *** (0.7)	665	3.1 (0.7)	3.1 (0.8)	3.2 (0.7)	564	3.1 (0.8)	3.1 (0.7)	3.1 (0.7)	665	2.9 (0.9)	3.1 (0.7)	665	3.1 (0.7)	3.0 (0.8)	3.2 (0.8)
Drive less	694	3.3 *** (0.7)	3.5 *** (0.6)	710	3.4 (0.7)	3.5 (0.7)	3.5 (0.6)	601	3.4 (0.7)	3.5 (0.6)	3.4 (0.6)	710	3.5 (0.7)	3.4 (0.7)	710	3.5 (0.6)	3.3 (0.7)	3.5 (0.8)
Eat organic foods	637	2.6 *** (0.9)	2.9 *** (0.8)	651	2.7 (0.9)	2.8 (0.9)	2.8 (0.9)	553	2.8 0.9)	2.8 (0.9)	2.7 (0.9)	651	2.9 (0.9)	2.7 (0.9)	651	2.7 (0.9)	2.8 (0.9)	3.0 (0.9)
Use less plastic	691	3.4 *** (0.7)	3.7 *** (0.6)	707	3.5 (0.6)	3.5 (0.7)	3.6 (0.6)	599	3.6 (0.7)	3.6 (0.6)	3.5 (0.6)	707	3.7 (0.7)	3.5 (0.6)	707	3.6 (0.6)	3.5 (0.7)	3.6 (0.7)
Save energy at home	692	3.4 ** (0.7)	3.5 ** (0.6)	708	3.5 (0.7)	3.5 (0.8)	3.4 (0.7)	599	3.4 (0.7)	3.5 (0.6)	3.4 (0.7)	708	3.5 (0.8)	3.4 (0.7)	708	3.5 (0.7)	3.4 (0.8)	3.5 (0.7)
Recycle	690	3.3 ** (0.7)	3.5 ** (0.7)	706	3.4 (0.7)	3.4 (0.7)	3.4 (0.7)	598	3.5 (0.7)	3.5 (0.6)	3.4 (0.7)	706	3.6 * (0.7)	3.4 * (0.7)	706	3.4 (0.6)	3.4 (0.8)	3.5 (0.7)
Eat less meat	653	3.1 (0.9)	3.2 (0.9)	669	3.1 (0.9)	3.2 (1.0)	3.3 (0.8)	566	3.1 ** (1.0)	3.0 ** (0.9)	3.3 ** (0.8)	669	3.1 (1.0)	3.2 (0.9)	669	3.2 (0.9)	3.1 (0.9)	3.1 (1.0)

University in MI		Gender[a]		Race and Ethnicity[b]				Parental Income				Pell Grant			Food Security Status			
I try to make food and beverage choices that[c]…	**n**	**Man**	**Woman**	**n**	**Asian**	**Other**	**White**	**n**	**<$50,000**	**$50–100,000**	**≥$100,000**	**n**	**Yes**	**No**	**n**	**High**	**Marg.**	**Low**	**Very Low**
Are good for the environment	568	3.7*** (1.5)	4.2*** (1.4)	568	4.0 (1.4)	3.8 (1.5)	4.0 (1.5)	566	4.0 (1.6)	3.9 (1.4)	4.0 (1.5)	568	3.9 (1.6)	4.0 (1.5)	568	3.9 (1.4)	4.2 (1.6)	4.0 (1.6)	3.7 (1.6)
Reduce my impact on climate change	568	3.6*** (1.6)	4.2*** (1.5)	568	3.9 (1.5)	3.8 (1.6)	4.0 (1.6)	566	4.0 (1.7)	3.9 (1.4)	3.9 (1.5)	568	3.9 (1.7)	3.9 (1.5)	568	3.9 (1.5)	4.2 (1.7)	3.9 (1.5)	3.8 (1.8)
Are good for my health	568	5.3* (1.2)	5.4* (1.1)	568	5.3 (1.1)	5.4 (1.2)	5.3 (1.2)	566	5.3 (1.3)	5.1 (1.2)	5.4 (1.1)	568	5.3 (1.2)	5.4 (1.2)	568	5.5* (1.1)	5.2* (1.3)	5.2* (1.2)	4.9* (1.3)
Effective way of combatting climate change[d]:	**n**	**Man**	**Woman**	**n**	**Asian**	**Other**	**White**	**n**	**<$50,000**	**$50–100,000**	**≥$100,000**	**n**	**Yes**	**No**	**n**	**High**	**Marg.**	**Low**	**Very Low**
Eat local, seasonal foods	517	3.1*** (0.8)	3.3*** (0.7)	517	3.2 (0.8)	3.1 (0.8)	3.2 (0.8)	516	3.1 (0.8)	3.2 (0.8)	3.2 (0.7)	517	3.1 (0.8)	3.2 (0.7)	517	3.2 (0.7)	3.2 (0.8)	3.1 (0.8)	3.1 (0.9)
Drive less	559	3.3*** (0.9)	3.6*** (0.7)	559	3.5 (0.8)	3.5 (0.9)	3.4 (0.8)	558	3.4 (0.9)	3.4 (0.8)	3.5 (0.8)	559	3.4 (0.9)	3.5 (0.8)	559	3.5* (0.7)	3.4* (0.8)	3.2* (1.0)	3.6* (0.7)
Eat organic foods	503	2.4** (1.0)	2.6** (0.9)	503	2.6 (0.9)	2.6 (0.9)	2.5 (0.9)	502	2.5 (1.0)	2.6 (0.9)	2.5 (0.9)	503	2.4 (1.0)	2.5 (0.9)	503	2.5 (0.9)	2.5 (0.9)	2.6 (0.8)	2.8 (0.9)
Use less plastic	556	3.5*** (0.8)	3.7*** (0.6)	556	3.6 (0.7)	3.6 (0.7)	3.6 (0.7)	554	3.6 (0.8)	3.6 (0.7)	3.6 (0.7)	556	3.6 (0.8)	3.6 (0.7)	556	3.6 (0.7)	3.6 (0.8)	3.5 (0.8)	3.6 (0.7)
Save energy at home	554	3.4***(0.8)	3.6***(0.6)	554	3.5 (0.7)	3.6 (0.7)	3.5 (0.7)	552	3.5 (0.7)	3.5 (0.7)	3.5 (0.7)	554	3.5 (0.7)	3.5 (0.7)	554	3.5 (0.7)	3.5 (0.7)	3.5 (0.8)	3.7 (0.7)
Recycle	556	3.2 (0.9)	3.4 (0.7)	556	3.3 (0.8)	3.4 (0.7)	3.3 (0.8)	554	3.4 (0.8)	3.3 (0.8)	3.3 (0.8)	556	3.3 (0.8)	3.3 (0.8)	556	3.3 (0.8)	3.3 (0.8)	3.3 (0.8)	3.5 (0.8)
Eat less meat	545	3.1***(1.0)	3.5***(0.8)	545	3.2 (0.9)	3.4 (0.9)	3.3 (0.9)	544	3.1** (1.1)	3.3** (0.9)	3.4** (0.9)	545	3.2* (1.1)	3.3* (0.9)	545	3.3 (0.9)	3.3 (0.9)	3.1 (1.0)	3.3 (1.1)

*P-value <0.05,

**P<0.01,

***P<0.001 for comparison between groups using two-sample t-tests and one-way ANOVA

[a] Other/nonconforming/nonbinary removed from analysis for comparison between universities

[b] Asian and White categories were non-Hispanic students. Students classified as Other races and ethnicities included American Indian/Alaska Native, Black/African American, Hispanic, and Multiracial/ Multiethnic participants. MENA students were classified as White at the university in CA (n=24) and Other at the university in MI (n=8).

[c] Scale of 1–7, 1=strongly disagree to 7=strongly agree. Statements are paraphrased from questionnaire.

[d] Scale of 1–4, 1= not effective at all to 4=highly effective. Statements are paraphrased from questionnaire.

J Acad Nutr Diet. Author manuscript; available in PMC 2024 May 01.

Table 4.

Environmental perceptions and dietary motivations as predictors of red meat intake for undergraduate students completing written and online health behavior surveys at universities in California (CA) (n=721) and Michigan (MI) (n=566)

Survey Question	University in CA				University in MI			
	n	FR[a]	95% CI	P-value	n	FR[a]	95% CI	P-value
"I try to make food and beverage choices that are good for the environment"[b]	721	**0.90**	**(0.84, 0.96)**	**0.001**	566	**0.75**	**(0.69, 0.81)**	**<0.001**
"I try to make food and beverage choices that reduce my impact on climate change"[b]	721	**0.90**	**(0.84, 0.96)**	**0.001**	566	**0.78**	**(0.72, 0.85)**	**<0.001**
"I try to make food and beverage choices that are good for my health"[c]	721	0.93	(0.87, 1.00)	0.06	566	0.97	(0.88, 2.13)	0.6
Eating less meat is an effective way to combat climate change[d]	669	**0.87**	**(0.79, 0.95)**	**0.003**	544	**0.80**	**(0.72, 0.89)**	**<0.001**

[a] FR: Frequency ratio. 100(1-FR) = % lower frequency of red meat consumption for each point on scale

[b] Question as worded in survey with a response scale of 1–7, 1=strongly disagree to 7=strongly agree. Model adjusted for age, gender, race and ethnicity, food security, parental income, Pell grant status, and health attitudes

[c] Question as worded in survey with a response scale of 1–7, 1=strongly disagree to 7=strongly agree. Model adjusted for age, gender, race and ethnicity, food security, parental income, Pell grant status, and environmental attitudes

[d] Statement paraphrased from survey. Students were asked to "indicate whether [eat less meat] is an effective way of combatting climate change" with a response scale of 1–4, 1= not effective at all to 4=highly effective. Adjusted for age, gender, race and ethnicity, food security, parental income, Pell grant status, and health attitudes