Appetite 203 (2024) 107667

Contents lists available at ScienceDirect

Appetite

journal homepage: www.elsevier.com/locate/appet

Sustainability considerations are not influencing meat consumption in the US

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ARTICLE INFO

Keywords:
Food choice
Animal-source food
Consumer preferences
United States
Dietary behaviors

ABSTRACT

The consumption of animal-source foods, and particularly red meat from ruminants, is a major contributor to greenhouse gas emissions, freshwater use, and loss of biodiversity. Reducing red meat consumption has been identified as a key strategy to mitigate climate change; however, little is known about how to effectively intervene to promote its reduction in the United States (US). This study aimed to examine meat (red, unprocessed, and poultry) and seafood consumption patterns, the factors influencing their consumption (including a reduction in their consumption over time), and how these differed based on socioeconomic variables. The study was conducted through an online survey with a representative sample of the US population (n = 1224) in 2021 using KnowledgePanel®. Overall, we found that most participants reported consuming red meat (78%), processed meat (74%), or poultry (79%) 1–4 times per week, with several differences in consumption patterns based on socio-demographic characteristics. A substantial proportion of the population reported reducing their red (70%) and processed meat (64%) consumption over the previous year, which was much higher than those that reported reducing poultry (34%) or seafood (26%). Key factors influencing red meat reduction were health and price, while environmental sustainability and animal welfare were less important, particularly among certain socio-demographic groups. These findings can help provide insight into how best to frame messaging campaigns aimed at shifting red meat consumption in the US to support climate change mitigation. Focusing on the factors that resonate more with consumers is more likely to lead to shifts in consumption patterns.

1. Introduction

Food production is associated with approximately 30% of greenhouse gas emissions (GHGe), 70% of freshwater use, and is the largest contributor to biodiversity losses (Benton, Bieg, Harwatt, Pudasaini, & Wellesley, 2021; Crippa et al., 2021; FAO, 2017, pp. 1–33; Ortiz, Outwaite, Dalin, & Newbold et al., 2021). Animal-source foods, particularly ruminants such as beef and lamb, have the largest impact on GHGe, as compared to plant-based food sources (Clark et al., 2022). The Intergovernmental Panel on Climate Change's Sixth Assessment Report identified reducing meat consumption, particularly meat derived from ruminants, as a key response option for climate change mitigation, given its high environmental footprint (IPCC, 2022).

In addition to growing environmental concerns related to meat production, there are public health concerns related to high levels of red and processed meat consumption. Excessive red meat consumption has been linked to an increased risk of diet-related diseases such as cardiovascular disease, stroke, and some cancers (Battaglia Richi et al., 2015; Kim et al., 2017; McAfee et al., 2010). Moreover, the added salt and preservatives often used in processed meat are associated with a higher risk of heart disease and cancer, especially colon cancer (Battaglia Richi et al., 2015; Kim et al., 2017; McAfee et al., 2010). Based on previous

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https://doi.org/10.1016/j.appet.2024.107667
Received 20 December 2023; Received in revised form 1 August 2024; Accepted 4 September 2024
Available online 6 September 2024

research (Neff et al., 2018), there is a clear need to reduce the consumption of red and processed meat in high-income countries such as the US. The World Cancer Research Fund (WCRF) recommends modest consumption of red meat, defined as three portions (350–500g cooked weight) per week, and little to no consumption of processed meat, defined as "meat that has been transformed through salting, curing, fermentation, smoking or other processes to enhance flavor or improve preservation" such as salami and some sausages (e.g., frankfurters) (Wiseman, 2023). However, beef consumption in the United States, reported by individual consumer surveys, remains above recommended levels (Tonsor & Lusk, 2022; Zeng et al., 2019).

Better understanding of how messaging campaigns should be designed to resonate with consumers is important to shift food choice. There is plenty of evidence indicating the need to reduce red meat consumption, but very little in terms of what works, particularly in a country in which federal policy has largely ignored the impacts of food systems on climate change. Interventions that have focused on providing consumers with information to equip them with the knowledge to shift towards more sustainable food choices, such as environmental labeling, education campaigns, pamphlets, etc., have had mixed (and limited) results (Bianchi, Dorsel, Garnett, Aveyard, & Jebb, 2018; Potter et al., 2021; Ronto et al., 2022).

Dynamic norm messaging (i.e., information that a behavior is increasing in prevalence) and nudge interventions (i.e., change in presentation of choices to an individual to nudge a specific behavior) have led to modest shifts in meat consumption in the food service sectors at point-of-sale (Friis et al., 2017; Gravert & Kurz, 2017; Meier, Andor, Doebbe, Haddaway, & Reisch, 2021; Sparkman, Weitz, Robinson, Malhotra, & Walton, 2020). For example, a dynamic norm messaging experiment in restaurants in the US demonstrated that making consumers aware of the increased popularity of meatless meals within their eatery increased vegetarian orders (Sparkman et al., 2020). In addition, nudge interventions in high-income countries that promoted vegetable consumption in a self-service buffet (Friis et al., 2017), pre-set meatless food orders (Meier et al., 2021), and conscious framing of a menu in favor of climate friendly dishes (Gravert & Kurz, 2017) led to a reduction in meat consumption. These interventions demonstrate that there is a sector of the population willing to change meat consumption behavior, at least in the short-term. However, little is known about what influences the reduction of red meat consumption, as well as what influences the consumption of red meat alternatives with lower environmental footprints such as poultry, seafood, and plant-based meat alternatives, on a day-to-day basis.

To better design interventions to reduce red meat consumption in the US, it is important to better understand the factors that influence food purchase and consumption more broadly, and red meat and its alternatives more specifically. Previous studies have found gender-based differences in meat consumption, with men consuming more meat than women (Clonan, Roberts, & Holdsworth, 2016; Hopwood et al., 2024; Rosenfeld & Tomiyama, 2021), particularly in countries with higher gender equality (Hopwood et al., 2024). Moreover, previous research has found that the factors that influence reductions in meat consumption also differ based on gender (Fantechi, Contini, & Casini, 2024). More specifically, a recent study found that Italian men with better cooking skills had lower intentions to reduce their meat consumption as did Italian women with higher purchasing power (Fantechi et al., 2024). Among women, the availability of meat alternatives within the retail environment was also an important influencer of meat reduction in that study (Fantechi et al., 2024), likely attributed to the role women play in food purchasing within households (Fantechi et al., 2024; Loginova & Mann, 2024). In addition to gender-based differences in meat consumption and the factors driving it, other sociodemographic factors have been associated with differential meat intakes. In a study that examined factors influencing meat consumption in 137 countries globally, per capita income and rate of urbanization were the two most important drivers of meat consumption (Milford, Le Mouël, Bodirsky, & Rolinski, 2019).

While various studies have examined consumer changes in meat consumption in the short-term (Friis et al., 2017; Gravert & Kurz, 2017; Meier et al., 2021; Sparkman et al., 2020), little is known about what influences Americans to consume less red and processed meat in their overall dietary patterns over time. By better understanding these factors, we may be able to identify different approaches to intervening to reduce meat consumption as a way to mitigate future climate change. Our previous qualitative research found that consumers had varied views on both the health and sustainability aspects of meat consumption as well as uncertainty around how to conceptualize alternative plant-based protein foods (Fox, Davis, Downs, McLaren, & Fanzo., 2021). We found only weak consensus of the perceived healthiness of different foods and no consensus on how participants classified foods based on their environmental impact, which presents challenges in terms of how to communicate about healthy and sustainable foods and diets (Fox, Davis, Downs, McLaren, & Fanzo., 2021). Building on that work, this study aimed to examine meat (red meat, processed meat, and poultry) and seafood consumption patterns, the factors driving them, and how these differed based on socioeconomic variables among a representative sample of the US population. Exploring the drivers of meat and seafood consumption, with a focus on red and processed meat, and what influences shifts in consumption among people living in the US can provide valuable insights that can be used to inform interventions and policies aimed at reducing red and processed meat consumption in the US.

Our research was guided by the following exploratory research questions.

- Which sociodemographic characteristics (including gender) influence meat and seafood consumption in the US?
- What are the key factors that people living in the US consider when making meat and seafood purchasing decisions?
- How have people living in the US changed their meat and seafood consumption over time?
- What is the relationship between sociodemographic factors and changes in meat and seafood consumption? and,
- Which factors have influenced changes in meat and seafood consumption among people living in the US?

2. Methods

2.1. Study overview

This study is part of a larger project examining values and food choices related to animal-source food consumption in the United States, with a focus on red meat (Fox, Davis, Downs, McLaren, & Fanzo, 2021). In this paper, we build on our qualitative data examining the factors influencing meat consumption in the US to quantitatively assess drivers of food choice using a representative sample of the US population. IRB approval for this study was obtained from Johns Hopkins Bloomberg School of Public Health (reference number IRB00008443) and Rutgers School of Public Health (reference number Pro2019000478).

2.2. Study population and recruitment

We conducted an online survey using KnowledgePanel®, a probability-based web panel designed to be representative of the United States population. KnowledgePanel®, uses address-based sampling to recruit panels, allowing it to access hard-to-reach populations. Households without internet connection are provided with a web-enabled device and free internet service to conduct surveys.

In order to recruit participants for this study, randomly selected panel members received an email invitation to complete the survey at their earliest convenience. As is standard with KnowledgePanel surveys, email reminders were sent to non-responders three days after the initial

email invitation and additional reminders were sent to any remaining non-responders after five and then eight days. We included adults aged 18 and older living in the United States in our study sample. Before completing the survey, respondents were asked whether they consented to participating in the study. Overall, the survey was sent to a random sample of 2158 panel members from KnowledgePanel and 1224 completed the survey (56.7% completion rate, which is higher than the average reported in the literature (44.1%)) (Wu, Zhao, & Fils-Aime, 2022).

2.3. Study instrument

We adapted the survey instrument by Neff et al. (2018) for the purposes of this study based on our qualitative findings from the previous phase of this project. The survey instrument included questions related to participants' meat and/or seafood consumption patterns, whether their consumption patterns had changed over the past year and the reasons for those changes, and the factors that they consider when making meat and/or seafood purchasing decisions.

We classified respondents as meat eaters or vegetarians/vegans based on participants' responses about whether they consume meat, seafood, eggs, and dairy. Consumption patterns were ascertained by asking how often the following food groups were consumed over the previous seven days: 1. Red meat, fresh or frozen (beef, pork, lamb, duck, ground red meat (e.g., meat used for hamburgers), etc.); 2. Processed meat (bacon, hot dogs, deli meats, sausages, etc.); 3. Poultry, fresh, frozen or canned/bagged (chicken, turkey, etc.); and 4. Seafood, fresh, frozen or canned/bagged (fish, shrimp, crab, clams, etc.). Food groups were based on the survey by Neff et al. (2018) and response options included consuming "not at all", "1 time", "2–4 times", "5–6 times", "7 times", and "more than 7 times" per week. We subsequently collapsed these into "not at all", "1–4 times", and "5 or more times" in the past 7 days.

We then asked respondents whether they had changed their meat and/or seafood consumption over the past year in order to classify them as meat reducers, as had been done in the prior survey (Neff et al., 2018). For respondents who reported making changes to their meat and/or seafood consumption, we asked how they would describe their consumption of each of the meat/seafood food groups (a lot less than a year ago, slightly less than a year ago, about the same as a year ago, slightly more than a year ago, a lot more than a year ago) as compared to the previous year. We then provided respondents with a list of considerations and asked them to identify which ones explained their changes in consumption. These considerations were based on both the previous survey by Neff et al. (2018) as well as our qualitative findings. Considerations included animal welfare, availability, convenience, environmental sustainability, familiarity, health, price, and taste. If these considerations did not explain the changes, respondents were also able to select "other" and specify the factor that influenced their food choice. Respondents were also asked to rate the importance of these considerations (not at all important, slightly important, somewhat important, very important, extremely important) when they purchase meat and/or seafood.

We collected the following sociodemographic information for the survey respondents: gender (Male/Female); age (18–29, 30–44, 45–59, and 60+); race/Hispanic ethnicity (White/Non-Hispanic, Black/Non-Hispanic, Other/Non-Hispanic, 2+ Races/Non-Hispanic, Hispanic); education (Less than High School, High School, Some College, Bachelor and beyond); census Region (Northeast, Midwest, South, West); household income (under $10k, $10K to <$25k, $25K to <$50k, $50K to <$75k, $75K to <$100k, $100K to <$150k, and $150K+); home ownership status (Own, Rent/Other); metropolitan Area (Yes, No); and Hispanic Origin (Mexican, Puerto Rican, Cuban, Other, Non-Hispanic). In addition, we asked if respondents were pregnant and whether or not they were the primary food shopper for the household.

2.4. Survey implementation

The survey was conducted in English and Spanish using a two-staged approach. The first step involved doing a "soft launch" of the survey with 100 panelists (June 2021) to ensure that the survey length was appropriate and that there were no anomalies in terms of survey responses. These respondents were included in the study sample given that no changes were made to the survey following the soft launch. We then conducted a full launch of the survey in August–September 2021. To prevent biases in survey responses, the way in which the questions were displayed were randomized throughout the survey. For example, the type of meat or seafood was randomly displayed as were the different factors that might influence food choice. For question responses that were sequential (e.g., a lot less, slightly less, about the same, slightly more, a lot more) the response display varied to begin with "a lot less" for some respondents and "a lot more" for others. The median completion time of the survey was 5 min. Upon survey completion, respondents received an entry into the KnowledgePanel sweepstakes as an incentive for completing the survey.

2.5. Data analysis

Sociodemographic characteristics were summarized using percentages and stratified by frequency of consuming unprocessed and processed meat, poultry, and seafood. Multiple logistic regression analyses were conducted to examine the association of covariates (age, income, gender, race/ethnicity, and education level) with the odds of being a reducer of meat, poultry, or seafood. Separate models were conducted for each outcome. For each model, we also adjusted for the frequency of consuming that associated meat category. For example, in the model for 'odds of being a seafood reducer', we adjusted for the frequency of seafood consumption. Chi-squared tests were conducted to determine the associations between socio-demographic variables (e.g., age, income) and frequency of consuming meat, poultry, and seafood (e.g., not at all, 1–4 times in past 7 days). We also used chi-squared tests to examine the relationship between food choice considerations (e.g., price, health, environmental sustainability, etc.) and frequency of consuming meat and seafood. The analyses were conducted using PROC SURVEYLOGISTIC in SAS (version 9.4, SAS Institute Inc, Cary, NC, 2011). Survey weights were utilized to present nationally representative results. For this reason, we have not displayed participant numbers in logistic regression tables, but they are included in the Supplementary Materials File A.

3. Results

Table 1 provides an overview of the respondents' overall sociodemographic characteristics as well as corresponding meat consumption patterns. In total 1224 participants completed the survey. Of the participants, 5% of whom indicated that they did not consume meat and 14% indicated that they did not consume fish or seafood. Most of the participants resided in a metro area (87%) and were white, non-Hispanic (71%).

3.1. Factors influencing meat purchase

Overall, when asked about the importance of different factors that influence meat purchasing (without specifying meat type), most respondents indicated that quality (85%) and taste (84%) were important (see Fig. 1). Animal welfare (28%) and environmental sustainability (29%) were rated as the least important of the factors by participants. We found significant differences in the importance of factors (e.g., price, taste) influencing the purchase of meat between sociodemographic groups (e.g., age, income gender). For example, there were differences in the importance of environmental sustainability and price based on income, gender, race/ethnicity, and education (see Figs. 2 and 3).

Table 1
Socio-demographic characteristics of survey respondents.

Demographic Characteristic	N	Unweighted Percentages	Weighted Percentage
Gender			
Male	602	49.2	48.8
Female	622	50.8	51.7
Age			
18–24	66	5.4	8.9
25–34	179	14.6	19.6
35–44	184	15.0	17.1
45–54	177	14.5	14.7
55–64	278	22.7	19.5
≥65	340	27.8	20.1
Ethnicity/Race			
White, non-Hispanic	870	71.1	63.0
Black, non-Hispanic	113	9.2	11.8
Other, non-Hispanic	57	4.7	6.9
Hispanic	147	12.0	16.5
2 or more races, non-Hispanic	37	3.0	1.8
Highest Level of Education			
No high school diploma or GED	91	7.4	11.2
High school graduate	320	26.1	27.4
Some college or Associate degree	371	30.3	30.0
Bachelor's degree	242	19.8	17.6
Master's degree or above	200	16.3	13.8
Current Employment			
Working full-time	572	46.7	49.0
Working part-time	126	10.3	10.6
Not working	526	43.0	40.3
Annual Household Income			
<$10,000	33	2.7	3.4
$10,000 to $24,999	105	8.6	9.2
$25,000 to $49,999	196	16.0	17.6
$50,000 to $74,999	229	18.7	17.4
≥ $75,000	661	54.0	52.5
Metropolitan Statistical Area Status			
Non-Metro	162	12.2	13.4
Metro	1062	86.8	86.6
Animal-Sourced Protein Consumption			
Meat[a]	1156	94.8	94.6
Fish	1051	86.2	84.9
Eggs	1157	94.9	94.6
Dairy	1181	97.0	96.7

[a] Includes processed meat (e.g., bacon and sausage) and game meat (e.g., venison).

Moreover, we found that Black, non-Hispanic respondents rated the importance of price, health, and environmental sustainability higher than other racial and ethnic groups. More specifically, environmental sustainability was the least important among those in the highest income bracket and those who had the highest educational attainment, were males, and white non-Hispanic. Overall, price was the most important factor among those with an annual income of $25,000-$49,999, were females, Black non-Hispanic, and high school graduates. In addition, there were differences in the importance of health based on gender and race/ethnicity. Health was the most important factor among females and Black non-Hispanics (see Fig. 4).

3.2. Frequency of meat and/or seafood consumption

Overall, most participants reported consuming red meat (78%), processed meat (74%), or poultry (79%) 1–4 times per week. Fourteen percent of respondents reported consuming poultry and/or red meat 5 or more times in the past 7 days. Seafood was consumed the least frequently, with 69% of participants saying they consumed it 1–4 times per week and only 4% consuming it 5 or more times per week.

Table 2 provides an overview of meat and/or seafood consumption frequency based on socio-demographic characteristics. The frequency of consuming all meat and/or seafood types was associated with age. A lower percentage of older respondents reported consuming red meat 5 or more times per week compared to other age groups, whereas the youngest age group had the highest percentage of respondents who reported not consuming red meat at all in the previous week. More respondents aged 18–24 years reported both not consuming seafood at all and consuming it 5 or more times in the past week compared to other age groups. Income was only associated with processed meat consumption with lower income respondents 3 times more likely than the highest income group to consume it 5 or more times in the past 7 days. Gender was associated with consumption of all meat and/or seafood types, except for red meat. A higher percentage of male, compared to female, respondents reported consuming processed meat 5 or more times in the past 7 days whereas the opposite was true for poultry and seafood. Females were almost twice as likely to not consume any processed meat compared to males. Both processed meat and seafood consumption differed significantly across race/ethnicity. A higher percentage of Black non-Hispanic respondents reported consuming processed meat 5 or more times in the past 7 days while a higher percentage of other non-Hispanic respondents reported not consuming processed meat in the past 7 days. Seafood was consumed the least among Hispanic respondents. Education was not significantly associated with the frequency of consuming any type of meat and/or seafood. There were also differences in the frequency of consuming different types of meat and/or seafood based on working status and geographical location, with a higher percentage of non-metro residents consuming red and processed meat 5 or more times in the past 7 days compared to those living in metro areas.

3.3. Changes in meat and/or seafood consumption

In addition to ascertaining the frequency of consuming different types of meat and/or seafood, we also asked participants about whether their consumption patterns had changed over the previous year. Fig. 5 provides an overview of the shifts in consumption. Nearly 70% of respondents indicated that they consumed red meat slightly less or a lot less than the previous year, and 64% reported consuming less processed meat. Far fewer respondents indicated consuming less poultry (34%) or seafood (26%) as compared to the previous year. Of those respondents that reportedly changed their meat consumption over the past year (i.e., either consumed more or less), 67% indicated that they intentionally reduced their consumption and 19% stated that they unintentionally reduced their consumption. A smaller percentage of respondents reported intentionally (10%) or unintentionally increasing (4%) increasing their meat consumption.

Respondents who described changing their meat and/or seafood consumption over the previous year were asked to identify which considerations influenced those changes. Fig. 6 provides an overview of the factors influencing changes in the consumption of the different types of meat. For participants who indicated they were reducing meat, health was the most frequently identified factor influencing its reduction (64.1% red meat; 62.8% processed meat; 53.3% poultry; 55.8% seafood). Price was the second most noted reason for reducing meat consumption (31.7% red meat; 23.0% processed meat; 28.6% poultry; 25.3% seafood). Only 6% reported reducing red meat due to environmental sustainability concerns as compared to 7% for poultry and 9% for seafood.

Using chi-squared tests, we found that availability ($p < 0.0001$), convenience ($p = 0.0024$), familiarity ($p = 0.0138$), health ($p < 0.0001$), price ($p = 0.0161$), and quality ($p = 0.0395$) were significantly associated with changes to red meat consumption. Processed meat changes were significantly associated with convenience ($p < 0.0001$), familiarity ($p = 0.0013$), health ($p < 0.0001$), and taste ($p = 0.0399$). Poultry changes were significantly associated with familiarity ($p = 0.0143$) and health ($p = 0.0011$) whereas seafood changes were significantly associated with health ($p < 0.0001$), price ($p < 0.0001$), and taste ($p =$

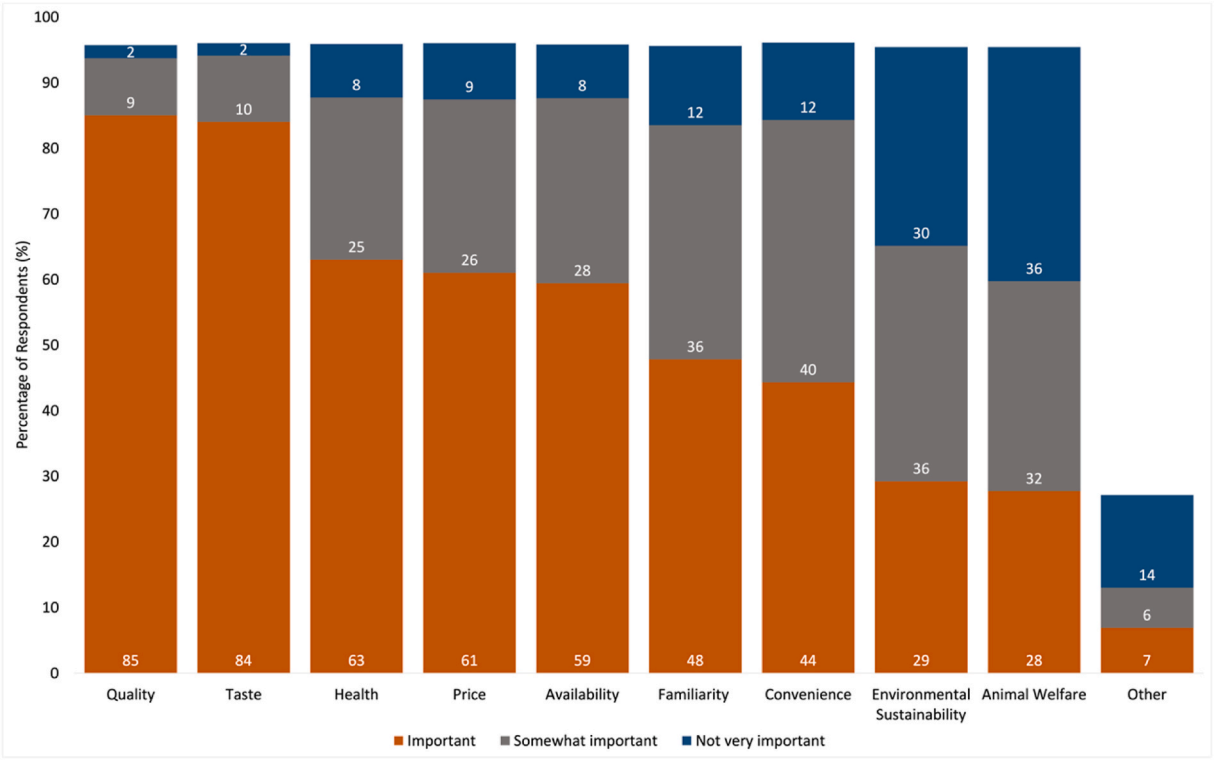

Fig. 1. Level of importance for various factors when purchasing meat (n = 1180).
Data labels within each column represent the percentage of respondents for each respective socio-demographic category and recorded response. We collapsed categories of importance in the figure: Not very important (not at all important and slightly important), somewhat important, and important (very important and extremely important).

0.0386).

3.4. Meat and/or seafood reducers

In addition to examining changes in meat and/or seafood consumption overall, we also assessed meat reducers more specifically based on whether they indicated that they had either intentionally or unintentionally reduced their meat consumption over the past year. Table 3 provides an overview of the odds of being a meat reducer based on sociodemographic variables and meat consumption over the previous 7 days.

There was a trend towards greater odds of being a red meat reducer among participants 65 years of age and older, as compared to those who were 18–24 years (OR 3.15; CI 0.98,10.13; p = 0.054). The odds of being a processed meat reducer were higher among adults 35–44 (OR 4.2; CI 1.35, 13.05; p = 0.013), 55–64 (OR 3.08; CI 1.03, 9.23; p = 0.045) and those 65 years of age and older (OR 3.43; CI 1.15, 10.22; p = 0.027) as compared to those who were 18–24 years of age. In contrast, the odds of being a poultry reducer were significantly lower among participants 65 years of age and older (OR 0.31; CI 0.10, 0.96; p = 0.043) as compared to those who were 18–24 years. We found little influence of income on being a meat reducer with the exception of reducing poultry consumption in which we found higher odds among those reporting an income of between $10,000 and $24,999 (OR 4.34, CI 1.95, 9.70; p = 0.01) and $50,000–74,999 (OR 2.54, CI 1.20, 5.39; p = 0.015) as compared to those earning $75,000 per year or more. With the exception of men having lower odds of being a poultry reducer than women (OR 0.47, CI 0.27, 0.80; p = 0.006), there were no differences in the odds of being a meat reducer based on gender. Moreover, there were few differences in the odds of being a meat reducer based on race and ethnicity with the exception of the 'other, non-Hispanic' group which had higher odds of being a reducer of all meat types as compared to 'white, non-Hispanic participants' (OR 6.29, CI 1.16, 33.99, p = 0.033 for red meat; OR 11.21, CI 2.37, 53.10, p = 0.002 for processed meat; OR 7.21, CI 2.20, 23.57, p = 0.001 for poultry; OR 7.58, CI 2.56, 22.48, p = 0.01 for seafood). In terms of education, those with a bachelor's degree had significantly lower odds of being a red meat (OR 0.34, CI 0.13, 0.94; p = 0.038), processed meat (OR 0.27, CI 0.09, 0.77; p = 0.014), and poultry (OR 0.24, CI 0.08, 0.72; p = 0.011) reducer as compared to participants without a high school diploma or equivalent. Participants who did not report eating red or unprocessed meat at all and those consuming unprocessed meat 1–4 times in the past 7 days had higher odds of being meat reducers compared to those consuming red and processed meat 5 or more times in past 7 days.

4. Discussion

This paper examined the factors influencing meat and seafood consumption among people living in the US. About 5% of respondents indicated that they did not consume any meat, which is aligned with a recent Gallup Poll indicating that 4% of people living in the US were vegetarian (Jones, 2023). Overall, we found that a significant proportion of the population surveyed reported reducing meat consumption as compared to the previous year. At the same time, frequency of consumption remained relatively high. Key factors influencing red meat reduction were health and price, while environmental sustainability and animal welfare were less important, particularly among certain socio-demographic groups. We found that socio-demographic characteristics influenced the way respondents rated the importance of different food choice considerations. In particular, we found that Black, non-Hispanic respondents rated several considerations as being important as compared to other racial and ethnic groups. These findings provide insight into how best to frame messaging campaigns aimed at shifting red meat consumption in the US to support climate change mitigation. In some cases, combining considerations (health, environmental sustainability, and price) into a single campaign may be

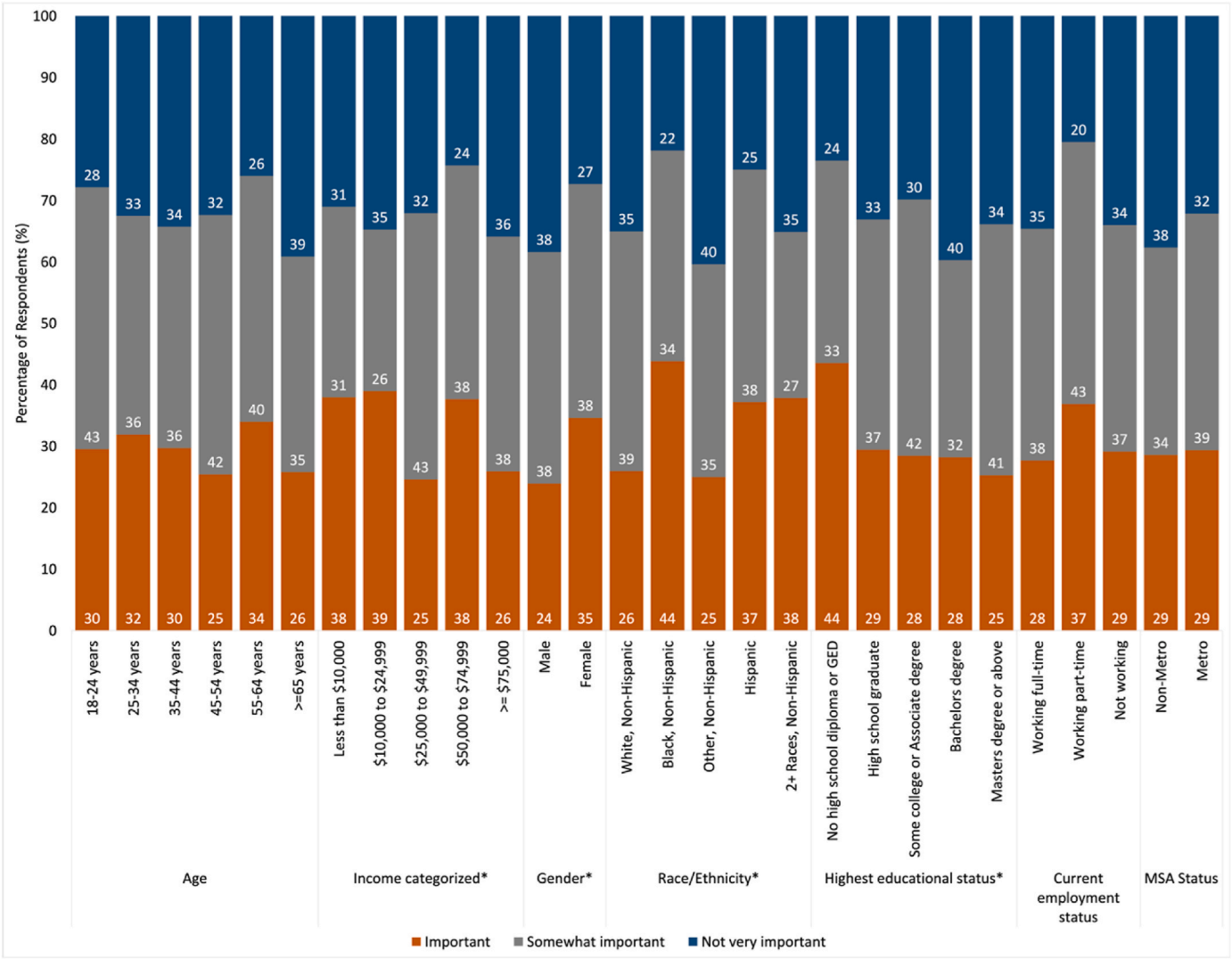

Fig. 2. Differences in the importance of 'environmental sustainability' when purchasing meat and/or seafood by socio-demographic.
Data labels within each column represent the percentage of respondents for each respective socio-demographic category and recorded response.
*When considering sustainability, statistically significant socio-demographic factors that influence the purchase of animal-source protein at $p < 0.05$ (χ^2 test). We collapsed categories of importance in the figure: Not very important (not at all important and slightly important), somewhat important, and important (very important and extremely important).

important to truly resonate with some segments of the population.

We found that most respondents described themselves as red and/or processed meat reducers (69% and 63%, respectively). This was a substantially higher percentage of red meat reducers as compared to a similar study conducted in 2015, which found 55% of respondents reported reducing processed meat and 41% reduced red meat (Neff et al., 2018). The most important factors influencing red meat reduction in both studies were the same, health and price (Neff et al., 2018). There are several ways in which these factors may have become more prominent between the two study periods (2015 and 2021, respectively). Shortly after the fielding of the 2015 survey, the World Health Organization classified processed meats as a Class 1 carcinogen (Bouvard et al., 2015), which was captured widely in the mainstream media (Zec et al., 2019). Evidence continues to mount regarding the negative health consequences of excessive processed meat consumption (English et al., 2021). Relative to the price of meat, between 2019 and 2020 (a year prior to this survey) there was a significant increase (7%) in the retail price of meat due to the COVID-19 pandemic and the supply chain issues that ensued (Dong, 2022). Also during this time, due in part to restaurant restrictions from the pandemic, there was an increase in the amount of meat US consumers purchased for household consumption (7%) and the overall price paid for meat (15%) (Dong, 2022). The USDA found that the increase in the price of beef was almost double that of poultry (9% and 5%, respectively) (Dong, 2022). This may have contributed to respondents' report of an overall reduction in red and processed meat consumption and an increase in consumption of poultry (24%) and seafood (32%). This trend towards an increased consumption of poultry and seafood, while simultaneously reducing meat consumption, has the potential to lead to reductions in the environmental footprint of diets and contribute positively to climate change mitigation. Complementary to our data, agencies forecast a reduction in beef and an increase in poultry consumption (Valcu-Lisman, 2022). Moreover, despite the increase in meat prices and a rise in food insecurity among certain populations in the US (Coleman-Jensen, Rabbitt, Gregory, & Singh, 2022), a majority of the survey participants (63% or more) reported frequent consumption (1–4 times per week) of all meat types.

While we found that a relatively large proportion of respondents reported reducing red meat consumption, we found that consumption of red and/or processed meat remained relatively high (5 or more times a week) among sub-populations in our study (e.g., aged 25–34 years,

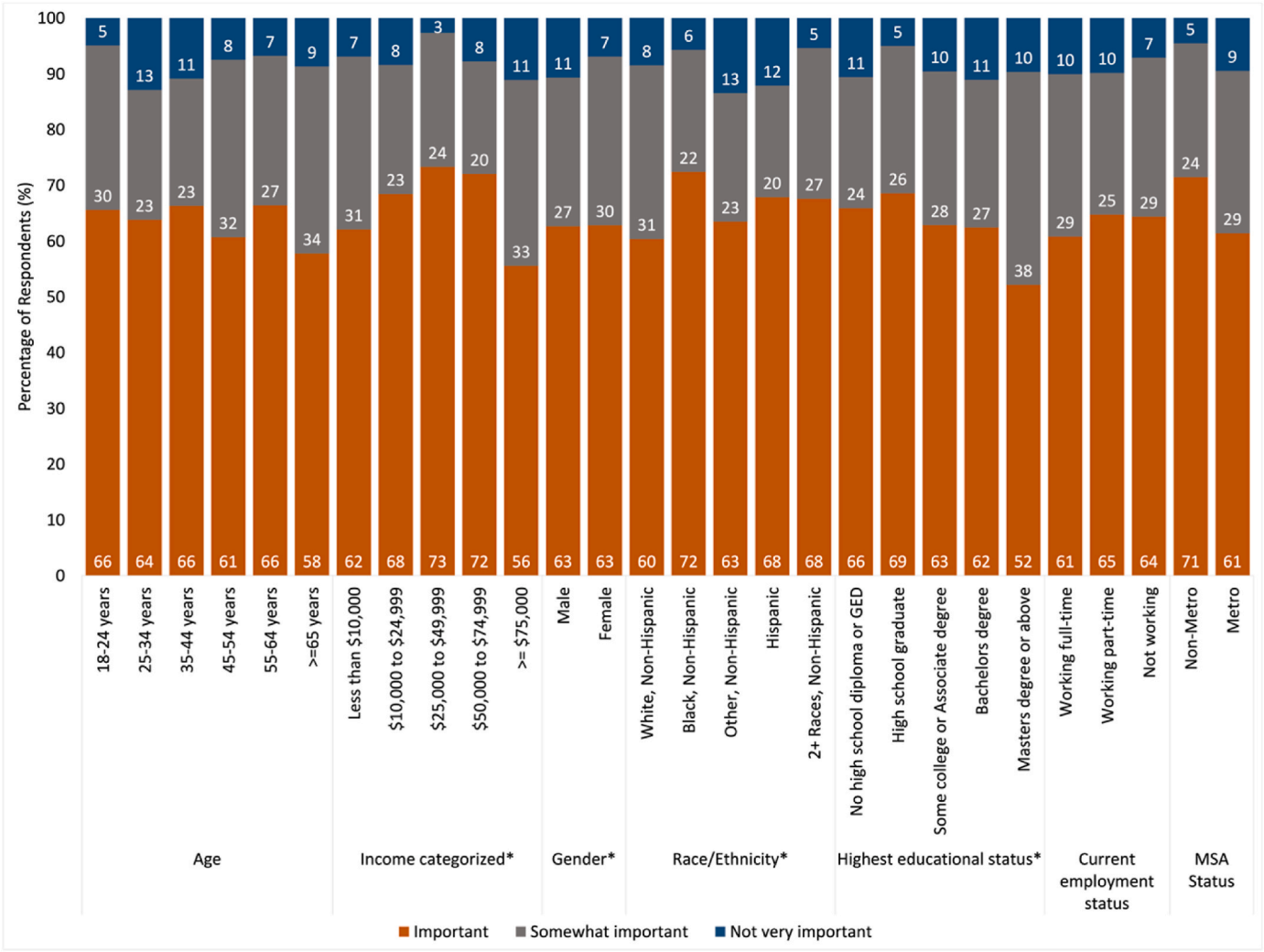

Fig. 3. Differences in the importance of 'price' when purchasing meat and/or seafood by socio-demographics.
Data labels within each column represent the percentage of respondents for each respective socio-demographic category and recorded response.
*When considering price, statistically significant socio-demographic factors that influence the purchase of animal-source protein at $p < 0.05$ (χ^2 test). We collapsed categories of importance in the figure: Not very important (not at all important and slightly important), somewhat important, and important (very important and extremely important).

males, Black non-Hispanics, those working full time and those in a non-metro area) as compared to WCRF recommendation of 3 portions (350–500g cooked weight) per week (Wiseman, 2023) and the EAT--*Lancet* Commission recommendations of 0g/day to 28g/day (Willett et al., 2019). In addition, our study revealed that most respondents (63% or more) consumed processed meat 1–4 times in the past 7 days. While recommendations for processed meat consumption vary by area, many dietary guidelines recommend little to no consumption of processed meat (Wiseman, 2023). Globally, average red meat consumption is trending upward, particularly in low- and middle-income countries with disparities in consumption patterns among sociodemographic groups (WHO, 2023). In high-income countries, red meat consumption patterns are leveling out, although they remain above global recommendations (WHO, 2023). In our survey, nearly a fifth of adults 25–34 years consumed red meat 5 or more times per week. However, consumption was much lower among the oldest respondents (65 years of age or older). Despite this finding, research has shown younger generations are more concerned with environmental and health impacts of consuming meat and are more likely to consider meat alternatives despite maintaining similar consumption patterns to other age groups (Bollani, Bonadonna, & Peira, 2019).

Given the negative environmental and health impacts associated with the production and consumption of red and processed meat, and the high consumption levels in the US, reducing the consumption of both should be emphasized by public health messaging campaigns as well as policy. Our study findings show that health and price are important influences, so public health messaging and policy are potential channels to achieve this goal. However, there are many political challenges related to red meat reduction (e.g., governmental subsidies) that together contribute to policy inertia (Sievert, Lawrence, Parker, & Baker, 2020). In the US, vested interests have limited the policy window in this area. For example, experts writing the US dietary guidelines evidence report have previously been restricted from considering the environmental impacts of diets when making their dietary recommendations (Frank, Jaacks, Batis, Vanderlee, & Taillie, 2021). Alternative ways may be needed to promote shifts away from red meat consumption in the US, including messaging campaigns. Our findings show that environmental sustainability and animal welfare were not significant factors influencing purchasing decisions among the majority of respondents, but rather health and price were important influences. These findings align to the findings of experimental studies that have found health messages alone, or those combined with environmental warning messages, to be more effective than solely environmental messages (Dijkstra & Rotelli, 2022; Grummon, Musicus, Salvia, Thorndike, &

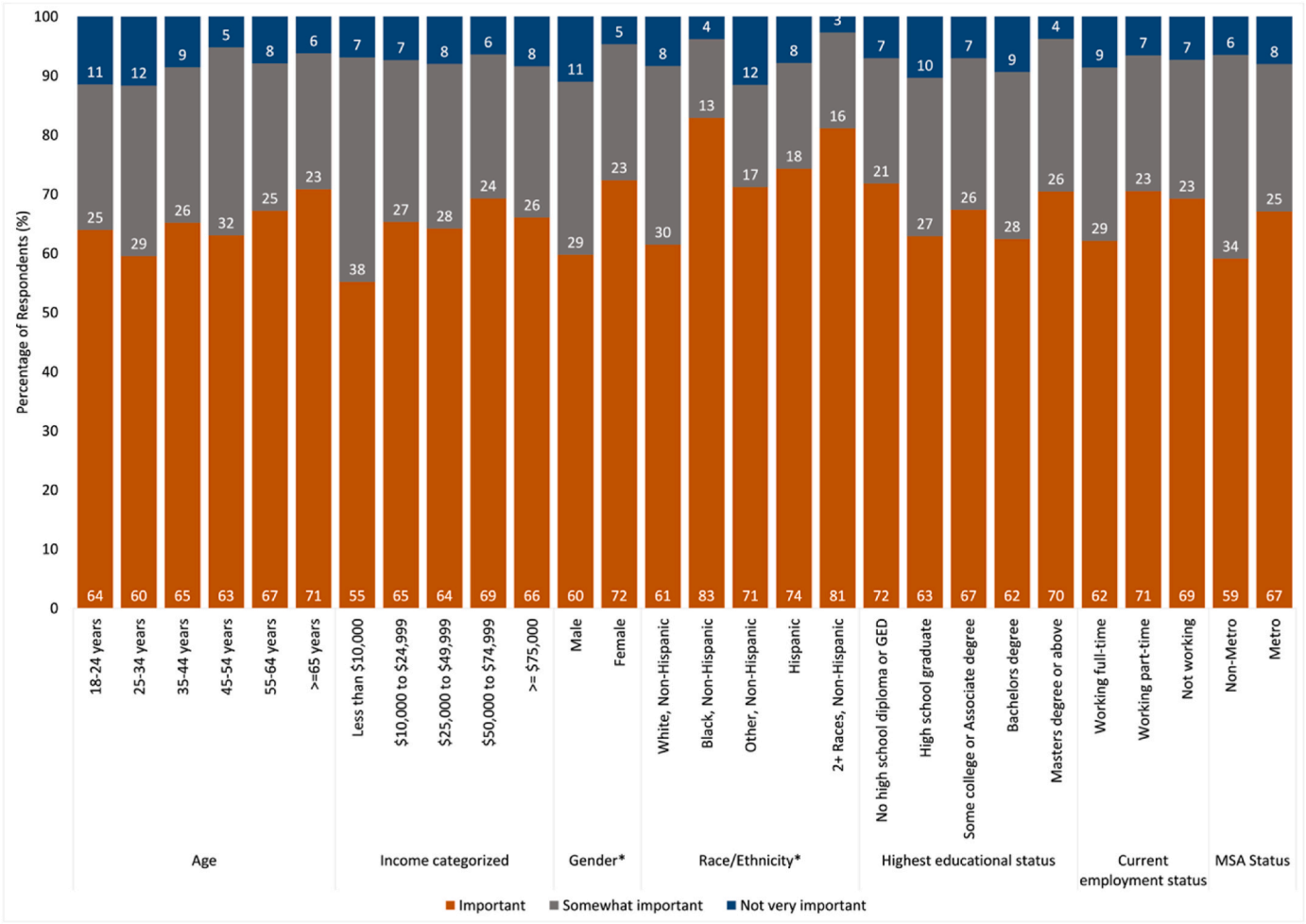

Fig. 4. Differences in the importance of 'health' when purchasing meat and/or seafood by socio-demographics.
Data labels within each column represent the percentage of respondents for each respective socio-demographic category and recorded response. *When considering health, statistically significant socio-demographic factors that influence the purchase of animal-source protein at $p < 0.05$ (χ^2 test). We collapsed categories of importance in the figure: Not very important (not at all important and slightly important), somewhat important, and important (very important and extremely important).

Rimm, 2023; Taillie et al., 2022). Moreover, other studies have found that health and environmental messages that focus on the emotional aspects (i.e., anticipated regret) of decision-making around processed red meat consumption might lead to greater reductions in its intake (Carfora, Bertolotti, & Catellani, 2019).

Messaging campaigns that aim to dissuade consumers from eating red meat will need to be tailored to the key factors that resonate with them (e.g., health and price). A study by Wolfson, Musicus, Leung, Gearhardt, and Falbe (2022) found that high-impact climate messaging influenced consumer choice in a randomized-control trial of fast food purchases. In addition, participants reported a connection between environmental sustainability and health (Wolfson et al., 2022). Another study examining the perceptions of different messages related to the different environmental harms related to red meat consumption (e.g., deforestation, carbon footprint, etc.) found some differences in the responses to the messages by different sociodemographic groups (Wistar, Hall, Bercholz, & Taillie, 2022). It is likely that different messaging might be necessary for different age groups, racial and ethnic groups, as well as genders.

In addition to individual consumption practices, institutions (e.g., schools and hospitals) have the potential to shift dietary patterns among their clients. While, the motivation to reduce meat consumption remains largely underexplored (Hartmann & Siegrist, 2017), we found that health and price were the two biggest motivating factors. One way to make it easier for consumers to shift towards more minimally processed plant-based foods, which is recommended by the WHO to help reduce red meat intakes (WHO, 2023), is to change procurement policies to limit red meat availability within institutions such as hospitals, schools, and other government buildings. For example, NYC public hospitals offer plant-based meals as the default option for dinner in its public hospitals (NYC Health + Hospitals, 2023). Moreover, the city's schools now serve plant-based options every Friday as part of the 'Plant-Powered Meals' initiative within the school lunch program. Moreover, universities that have shifted the default option in dining services to plant-based options have found substantial increases in the selection of plant-based options (Better Food Foundation, 2023).

4.1. Limitations

While our study has several strengths, including the use of a nationally representative sample, it also has limitations. Our survey completion rates were higher than those observed on average (Wu et al., 2022); however, this remains a limitation of the study. In addition, our survey was fielded in summer of 2021, when the COVID-19 pandemic was still impacting the US. This may have influenced consumers' purchasing patterns and responses to the survey questions.

Table 2
Overview of reported meat and/or seafood consumption frequencies by socio-demographic data.

Socio-Demographic Characteristic	Frequency of Consumption (%)											
	Red Meat			Processed Meat			Poultry			Seafood		
	Not at all	1-4 times in past 7 days	≥ 5 times in past 7 day	Not at all	1-4 times in past 7 days	≥ 5 times in past 7 day	Not at all	1-4 times in past 7 days	≥ 5 times in past 7 day	Not at all	1-4 times in past 7 days	≥ 5 times in past 7 day
Age												
18–24 years	14.0	72.1	14.0	20.9	67.4	11.6	11.6	74.4	14.0	34.9	53.5	11.6
25–34 years	5.7	75.2	19.2	10.6	75.2	14.2	4.3	78.0	17.7	22.7	72.3	5.0
35–44 years	5.6	83.9	10.5	11.2	81.8	7.0	4.9	79.0	16.1	26.6	72.0	1.4
45–54 years	6.8	75.5	17.7	15.0	72.1	12.9	4.8	76.2	19.1	33.3	59.9	6.8
55–64 years	9.1	78.5	12.5	16.8	72.0	11.2	9.9	79.3	10.8	26.7	71.6	1.7
≥65 years	10.7	82.3	7.1	20.7	73.2	6.1	2.9	89.0	8.1	25.8	71.6	2.6
p-value	0.0027[b]			0.0313[a]			0.0024[a]			0.0015[a]		
Income												
Less than $10,000	13.6	68.2	18.2	13.6	63.6	22.7	22.7	63.6	13.6	27.3	63.6	9.1
$10,000 to $24,999	12.8	74.4	12.8	20.5	68.0	11.5	2.6	87.2	10.3	32.1	64.1	3.9
$25,000 to $49,999	8.1	79.7	12.2	14.0	72.7	13.4	6.4	80.2	13.4	29.7	66.3	4.1
$50,000 to $74,999	8.6	79.6	11.8	15.1	75.3	9.7	5.4	83.9	10.8	32.3	63.4	4.3
≥ $75,000	7.7	80.1	12.2	16.9	75.3	7.9	5.2	80.8	14.0	24.0	73.1	2.9
p-value	0.6884			0.0176[a]			0.3158			0.3493		
Gender												
Male	6.8	78.8	14.4	12.5	76.4	11.1	4.5	84.2	11.3	24.4	72.9	2.7
Female	10.1	79.7	10.1	20.1	71.6	8.4	6.8	78.5	14.7	30.0	65.6	4.4
p-value	0.0769			0.0025[a]			0.0215[a]			0.0263[a]		
Race/Ethnicity												
White, Non-Hispanic	8.2	79.1	12.7	14.1	75.7	10.2	5.2	81.8	13.0	29.4	67.9	2.7
Black, Non-Hispanic	14.6	71.8	13.6	21.4	63.1	15.5	5.8	78.6	15.5	18.5	70.9	10.7
Other, Non-Hispanic	4.2	83.3	12.5	29.2	66.7	4.2	4.2	85.4	10.4	14.6	81.3	4.2
Hispanic	6.3	85.2	8.6	19.5	75.8	4.7	7.0	80.5	12.5	28.1	68.8	3.1
2+ Races, Non-Hispanic	10.0	76.7	13.3	13.3	76.7	10.0	10.0	80.0	10.0	20.0	80.0	.
p-value	0.3587			0.001[b]			0.737			0.0001[b]		
Highest level of education												
No high school diploma or GED	6.6	77.6	15.8	13.2	72.4	14.5	9.2	82.9	7.9	26.3	71.1	2.6
High school graduate	8.9	78.9	12.3	16.2	73.5	10.4	5.4	83.1	11.5	29.2	68.1	2.7
Some college or Associate degree	8.6	78.3	13.1	13.1	78.3	8.6	6.4	82.8	10.9	30.0	66.1	3.8
Bachelor's degree	5.5	84.1	10.5	18.4	72.6	9.0	6.0	78.1	15.9	24.9	71.1	4.0
Master's degree or above	12.1	76.5	11.5	21.1	69.3	9.6	2.4	79.5	18.1	21.7	74.1	4.2
p-value	0.4662			0.3232			0.09			0.3712		
Current employment status												
Working full-time	7.5	76.6	16.0	13.4	75.5	11.1	5.8	77.4	16.8	26.2	69.1	4.7
Working part-time	10.8	80.4	8.8	19.6	75.5	4.9	4.9	88.2	6.9	35.3	63.7	1.0
Not working	9.0	81.8	9.2	18.4	72.1	9.4	5.6	84.0	10.3	26.3	70.8	2.9
p-value	0.0423[a]			0.1374			0.0296[a]			0.017[a]		
MSA Status												
Non-Metro	4.5	78.2	17.3	13.5	69.2	17.3	7.5	82.7	9.8	31.6	66.2	2.3
Metro	9.1	79.4	11.6	16.7	74.8	8.6	5.3	81.2	13.5	26.5	69.8	3.7
p-value	0.0388[a]			0.0175[a]			0.3844			0.1853		

A chi-squared test was used to determine the statistical differences between socio-demographic variables (e.g., age, income) and consumption frequencies (e.g., not at all, 1–4 times in past 7 days).
[a] $p < 0.05$.
[b] $p < 0.00$.

5. Conclusions

Overall, we found that while people living in the US continue to consume red meat frequently, many of them are reducing their intake. We found a small number of differences in the odds ratio of being a red meat reducer across sociodemographic characteristics. While health and price were key factors influencing meat reduction, environmental sustainability and animal welfare were not. Messaging campaigns aimed at shifting consumer behavior towards red meat reduction will need to be grounded in the factors that drive U.S consumer decision-making to be more effective.

Funding sources

This work was supported by the Stravros Niarchos' Foundation GFEPP Project 6 No. 90074610. The funding source did not play a part in study design; in the collection, analysis and interpretation of data; in the writing of the manuscript; and in the decision to submit the article for publication.

Ethical statement

IRB approval for this study was obtained from Johns Hopkins Bloomberg School of Public Health (reference number IRB00008443)

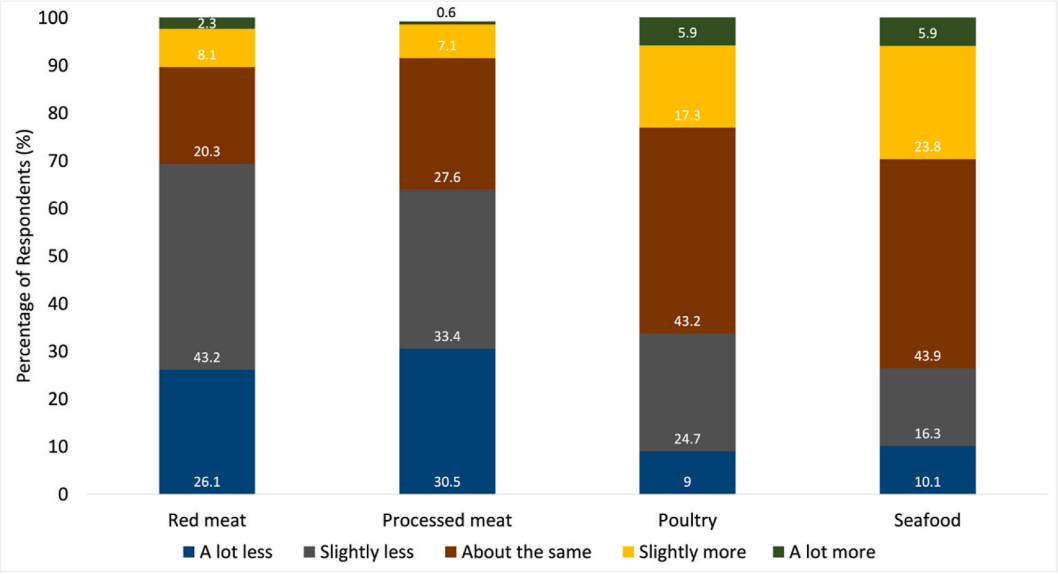

Fig. 5. Consumption frequencies of different meat and/or seafood compared to one year prior.

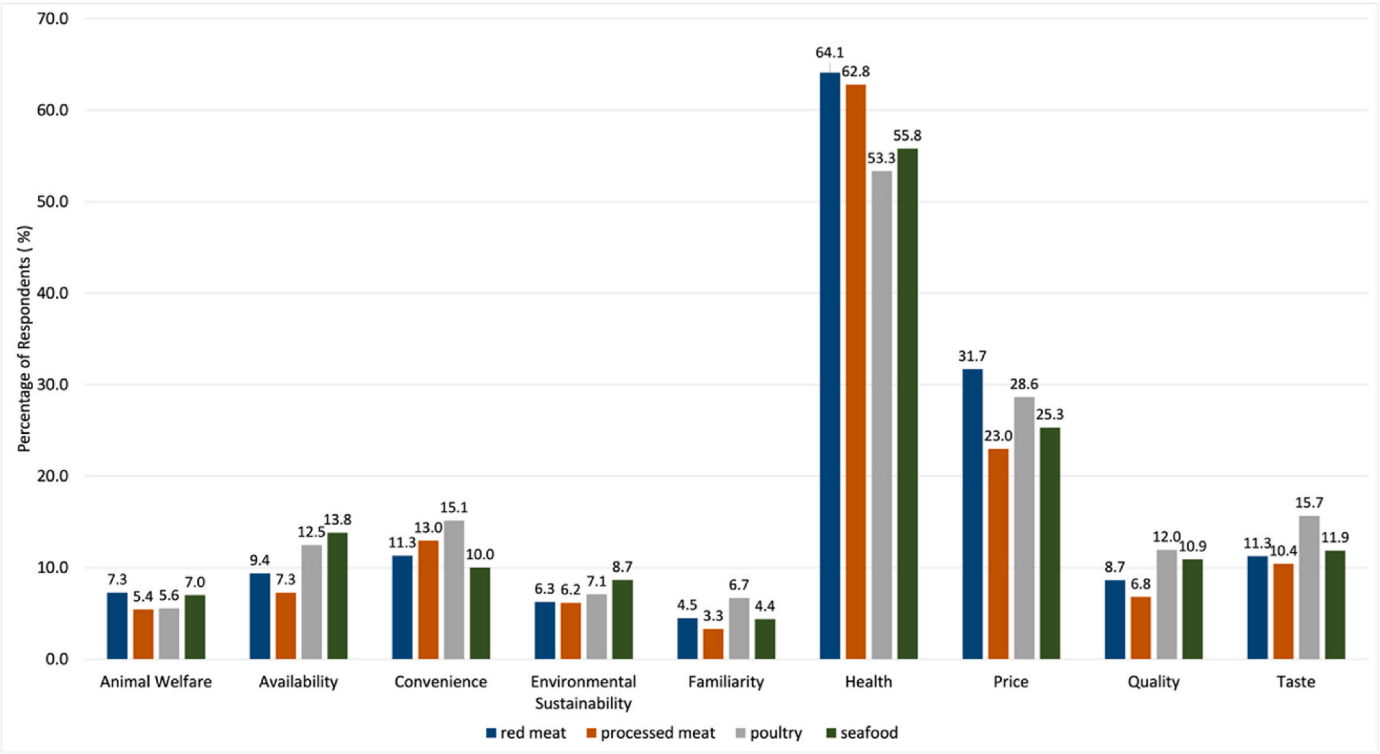

Fig. 6. Factors influencing meat and seafood reducers' changes in consumption.
Note: We only include meat and seafood reducers in this figure. This includes, 70% of respondents for red meat, 64% of respondents for processed meat, 34% of respondents for poultry, and 26% of respondents for seafood.

and Rutgers School of Public Health (reference number Pro2019000478). Written, informed consent was collected from all participants.

CRediT authorship contribution statement

Shauna M. Downs: Writing – review & editing, Writing – original draft, Project administration, Methodology, Formal analysis, Conceptualization. **Emily V. Merchant:** Writing – review & editing, Writing – original draft, Formal analysis. **Joachim Sackey:** Writing – review & editing, Formal analysis. **Elizabeth L. Fox:** Writing – review & editing, Project administration, Methodology, Conceptualization. **Claire Davis:** Writing – review & editing, Project administration, Methodology, Conceptualization. **Jessica Fanzo:** Writing – review & editing, Project administration, Funding acquisition, Conceptualization.

Table 3
Odds **ratio** of being a meat and/or seafood reducer based on sociodemographic variables and consumption patterns over the previous 7 days.

Covariate	Odds ratio of being a red meat reducer			Odds ratio of being a processed meat reducer			Odds ratio of being a poultry reducer			Odds ratio of being a seafood reducer		
	OR	95% CI	P value	OR	95% CI	P value	OR	95% CI	P value	OR	95% CI	P value
Age [ref = 18–24 years]												
25–34 years	1.68	0.48, 5.91	0.417	1.73	0.54, 5.50	0.353	0.68	0.21, 2.22	0.525	4.86	1.13, 20.97	0.034[b]
35–44 years	2.39	0.72, 7.95	0.156	4.2	1.35, 13.05	0.013[b]	2	0.64, 6.24	0.231	1.87	0.45, 7.81	0.392
45–54 years	2.27	0.66, 6.53	0.191	2.13	0.70, 6.44	0.181	0.5	0.16, 1.56	0.233	1.38	0.33, 5.88	0.661
55–64 years	1.98	0.60, 6.53	0.259	3.08	1.03, 9.23	0.045[b]	0.42	0.14, 1.28	0.128	1.28	0.32, 5.11	0.731
≥65 years	3.15	0.98, 10.13	0.054	3.43	1.15, 10.22	0.027[b]	0.31	0.10, 0.96	0.043[b]	1.25	0.33, 4.78	0.747
Income [ref = ≥ $75,000]												
Less than $10,000	0.25	0.05, 1.19	0.081	0.26	0.05, 1.32	0.103	1.23	0.24, 6.23	0.8	0.68	0.07, 6.76	0.742
$10,000 to $24,999	0.68	0.31, 1.52	0.347	0.7	0.31, 1.59	0.398	4.34	1.95, 9.70	0.01[b]	1.68	0.65, 4.33	0.281
$25,000 to $49,999	0.95	0.45, 2.01	0.895	0.77	0.39, 1.53	0.462	1.56	0.76, 3.23	0.228	0.93	0.43, 1.97	0.84
$50,000 to $74,999	0.71	0.37, 1.37	0.309	0.93	0.48, 1.82	0.835	2.54	1.20, 5.39	0.015[b]	1.69	0.78, 3.68	0.182
Gender [ref = female]												
Male	0.67	0.41, 1.11	0.121	0.68	0.43, 1.09	0.111	0.47	0.27, 0.80	0.006[b]	0.81	0.47, 1.41	0.456
Race/Ethnicity [ref = White, Non-Hispanic]												
Black, non-Hispanic	0.85	0.41, 1.74	0.65	0.93	0.46, 1.87	0.829	1.88	0.89, 3.95	0.096	1.34	0.59, 3.08	0.484
Other, non-Hispanic	6.29	1.16, 33.99	0.033[b]	11.21	2.37, 53.10	0.002[b]	7.21	2.20, 23.57	0.001[b]	7.58	2.56, 22.48	0.01[b]
Hispanic	1.06	0.54, 2.08	0.868	1.07	0.55, 2.10	0.843	0.77	0.37, 1.61	0.493	1.43	0.68, 3.00	0.342
2+ Races, Non-Hispanic	0.94	0.26, 3.36	0.923	0.96	0.26, 3.54	0.954	0.68	0.15, 3.03	0.608	0.5	0.06, 4.07	0.517
Education [ref = No high school diploma or GED]												
High school graduate	0.52	0.20, 1.36	0.165	0.6	0.23, 1.55	0.291	0.69	0.29, 1.65	0.4	1.08	0.37, 3.13	0.891
Some college or Associate degree	0.64	0.24, 1.69	0.367	0.61	0.23, 1.60	0.312	0.4	0.16, 1.01	0.053	0.71	0.25, 2.05	0.527
Bachelors degree	0.34	0.13, 0.94	0.038[b]	0.27	0.09, 0.77	0.014[b]	0.24	0.08, 0.72	0.011[b]	0.66	0.19, 2.34	0.519
Masters degree or above	0.54	0.19, 1.55	0.247	0.55	0.18, 1.70	0.298	1.12	0.40, 3.17	0.828	0.83	0.23, 3.03	0.782
Frequency red meat consumption [ref = ≥5 times in past 7 days][a]												
Not at all	8.89	2.57, 30.83	0.001[b]									
1-4 times in past 7 days	4.26	1.66, 10.93	0.003[b]									
Frequency processed meat consumption [ref = ≥5 times in past 7days][a]												
Not at all				3.04	1.10, 8.39	0.032[b]						
1-4 times in past 7 days				1.77	0.73, 4.30	0.204						
Frequency poultry consumption [ref = ≥5 times in past 7 days][a]												
Not at all							11.25	3.36, 37.72	<0.0001[c]			
1-4 times in past 7 days							1.42	0.63, 3.19	0.394			
Frequency seafood consumption [ref = ≥5 times in past 7 days][a]												
Not at all										6.95	0.91, 53.43	0.062
1-4 times in past 7 days										3.13	0.44, 22.19	0.254

[a] Only for reducers of each respective category.
[b] $p < 0.05$.
[c] $p < 0.001$.

Declaration of competing interest

The authors have no disclosures to report.

Data availability

Data will be made available on request.

Acknowledgements

No disclosures to report or other acknowledgements.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.appet.2024.107667.

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