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Awareness of and reactions to health and environmental harms of red meat among parents in the United States

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Abstract

Objective: Evidence of the health and environmental harms of red meat is growing, yet little is known about which harms may be most impactful to include in meat reduction messages. This study examined which harms consumers are most aware of and which most discourage them from wanting to eat red meat.

Design: Within-subjects randomized experiment. Participants responded to questions about their awareness of, and perceived discouragement in response to, eight health and eight environmental harms of red meat presented in random order. Discouragement was assessed on a 1-to-5 Likert-type scale.

Setting: Online survey.

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Authorship: AHG, LMJ, CAC, and LST designed and conceptualized the study. AHG, DG, and MGS contributed to data curation. AHG and DG analyzed the data and created data visualizations. AHG drafted the initial manuscript. EBR provided study oversight. All authors provided critical feedback on the manuscript draft and approved the final manuscript.

Conflict of Interest: None

Ethical Standards Disclosure: This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving research study participants were approved by the Harvard Longwood Campus Institutional Review Board. Written informed consent was obtained from all subjects/patients.

Participants: 544 US parents.

Results: A minority of participants reported awareness that red meat contributes to health harms (ranging from 8% awareness for prostate cancer to 28% for heart disease) or environmental harms (ranging from 13% for water shortages and deforestation to 22% for climate change). Among specific harms, heart disease elicited the most discouragement (mean=2.82 out of 5), followed by early death (mean=2.79) and plants and animals going extinct (mean=2.75), though most harms elicited similar discouragement (range of means, 2.60 to 2.82). In multivariable analyses, participants who were younger, identified as Black, identified as politically liberal, had higher general perceptions that red meat is bad for health, and had higher usual red meat consumption reported being more discouraged from wanting to eat red meat in response to health and environmental harms (all $p<0.05$).

Conclusions: Messages about a variety of health and environmental harms of red meat could inform consumers and motivate reductions in red meat consumption.

Keywords

Meat; Environmental sustainability; Messages; Communication; Parents; Food labeling

Introduction

High consumption of meat, particularly red and processed meat, increases risk of cardiovascular disease, diabetes, and some cancers.^(1–8) Further, red meat is a major contributor to environmental harms such as greenhouse gas emissions,^(1,9–13) air and water pollution,^(1,9) biodiversity loss,^(1,14) and deforestation.^(14,15) Reducing red meat consumption is therefore an important strategy for reducing chronic disease risk and mitigating environmental damage.⁽¹⁶⁾

Despite growing recognition of the health and environmental harms of red meat, American adults consume an average of 284 grams/week (about 0.6 pounds) of unprocessed red meat alone (i.e., not including processed red meats such as bacon), nearly three times the maximum level recommended for optimizing human and planetary health.⁽²⁾ More than half of Americans say they are willing to eat less red meat.⁽¹⁷⁾ Yet red meat consumption is projected to increase over the next decade,⁽¹⁸⁾ perhaps in part because many Americans are unaware of the health and environmental harms of red meat.^(17,19) Given this willingness to change, coupled with lack of awareness about red meat's impacts, educating consumers about the harms of red meat could reduce red meat consumption.

A growing body of research has shown that communicating about a products' health harms, for example through product warning labels and mass media campaigns, is an effective strategy for reducing unhealthy behaviors including cigarette smoking,^(20,21) alcohol consumption,⁽²²⁾ and sugary drink consumption.^(22–25) Similarly, a recent systematic review found that providing information about the health effects of meat consumption is an effective strategy for reducing intentions to eat meat as well as meat consumption.⁽²⁶⁾ Emerging literature also suggests the promise of communicating about products' environmental harms as a strategy for changing consumer behavior. For example, a randomized experiment

with undergraduate students in the UK found that sending students two weeks of daily messages about the environmental effects of meat production reduced students' red and processed meat consumption compared to a no-message control group.⁽²⁷⁾ What remains unknown is which specific health and environmental harms hold the most promise for motivating consumers to reduce their red meat intake. Identifying the specific harms that most discourage red meat intake is important because messaging campaigns may not be able to communicate about all harms (e.g., due to space constraints), and because prior studies of tobacco and sugary drink messages suggest advantages to shorter, simpler messages.^(28–32) Also unknown is whether consumers' reactions to health and environmental harms of red meat vary by demographic characteristics, information that could help to tailor messages to specific groups.

To inform communication efforts, we examined consumers' responses to health and environmental harms of red meat in an experiment with US parents of young children. Parents are a critical group to study in dietary communication interventions because their behaviors influence both their own health and the dietary habits of their children.⁽³³⁾ Parents of young children (i.e., under age five) are especially important, given that dietary habits in early childhood affect diet and health later in childhood and into adolescence.^(34,35) Moreover, US parents are nearly 40% less likely than non-parents to have reduced their red meat intake compared to three years ago,⁽¹⁹⁾ suggesting red meat reduction campaigns may be especially beneficial for this group. Thus, the specific objectives of this study were to examine which health and environmental harms of red meat parents are aware of and which are most likely to discourage red meat consumption. Additionally, to provide insight on populations that might respond more strongly to messages about red meat's harms, we examined demographic predictors of awareness of health and environmental harms and of the extent to which these harms discouraged participants from wanting to consume red meat.

Methods

Prior to data collection, we pre-registered the sample size, hypotheses, and analysis plan (<https://aspredicted.org/blind.php?x=q4xu3d>). The only deviations from this plan were that we corrected for multiple comparisons using Bonferroni's method rather than Tukey's method because Tukey's method cannot be applied to mixed models, and that we conducted two unplanned exploratory analyses, examining: 1) predictors of awareness of health and environmental harms, and 2) predictors of harm-induced discouragement separately for health versus environmental harms.

Participants

In January 2020, we recruited a convenience sample of 544 US adults using the survey research firm Dynata as part of a study of parents' responses to experimental stimuli and survey questions. Participants were eligible if they were aged 18 years or older and had a child aged six months to five years. Online convenience samples provide efficient and generalizable findings for experiments like the one used in this study.⁽³⁶⁾

Procedures

Participants provided informed consent, completed an online survey programmed in Qualtrics, and received incentives from Dynata (e.g., gift cards, reward points).

Measures

A flow of survey questions is shown in Figure 1. First, participants answered questions about their usual red meat consumption^(19,37) and general perceptions that red meat is bad for health and for the environment (e.g., “How bad or good for your health do you think eating red meat is?”). Next, they responded to questions about their awareness of, and discouragement in response to, specific health and environmental harms of red meat. The order of presentation of health and environmental harms was randomized such that half of participants answered questions about health harms first and half answered questions about environmental harms first.

We assessed awareness of harms using a select-all-that-apply question adapted from previous studies,^(38–40) “Before today, had you ever heard that eating red meat can contribute to the following harms?” Then, we listed the eight health or eight environmental harms, displayed in random order. Participants could also select “I haven’t heard of red meat contributing to any of these harms before;” this option was always displayed last.

Next, we assessed the extent to which each harm discouraged participants from wanting to eat red meat using an item adapted from previous studies,^(38–40) “How much does knowing that eating red meat contributes to these harms discourage you from wanting to eat red meat?” We assessed perceived discouragement because meta-analytic evidence indicates that perceived message effectiveness is predictive of actual message effectiveness.⁽⁴¹⁾ Participants rated perceived discouragement in response to each harm on a 5-point scale, from “Not at all” (coded as 1) to “Very much” (coded as 5).

We selected harms to present based on recent literature linking red meat production and consumption with health and environmental harms (Table 1). The eight health harms were: type 2 diabetes,^(42,43) weight gain,^(43–45) heart disease,^(43,46) stroke,^(47,48) colon cancer,^(43,49,50) prostate cancer,⁽⁴⁹⁾ stomach cancer,⁽⁴⁹⁾ and early death.^(43,51) The eight environmental harms were: climate change,^(14,15) more greenhouse gases,^(1,9–12) water shortages,^(1,11,52) water pollution,⁽¹⁾ air pollution,⁽⁹⁾ plants and animals going extinct,^(1,14) clearing of forests,^(14,15) and worse land quality.^(1,15,53) All participants rated their awareness and discouragement for each of the 8 health harms and each of the 8 environmental harms. Within each type of harm (health vs. environmental), specific harms were presented in random order.

Finally, the survey assessed standard demographics. Survey measures appear in Supplemental Exhibit 1.

Analysis

First, we calculated the proportion of participants who reported they were aware of each harm and the mean discouragement ratings for each harm. We also calculated the proportion of participants who were aware of at least one harm, and the mean number of harms

for which participants indicated awareness, both overall and separately for health and environmental harms. Next, we assessed whether likelihood of reporting awareness of harms was higher for health compared to environmental harms using mixed effects logistic regression, regressing awareness (coded as 0/1 for each harm) on an indicator variable for whether the harm was a health or environmental harm. These models treated the intercept as random to account for repeated measures within participants.

To shed light on the populations who were most aware of red meat's harms, analyses also examined demographic predictors of the total number of harms for which participants indicated awareness (summed across all 16 health and environment harms). These analyses used negative binomial regression with robust standard errors. We regressed the total number of harms for which participants indicated awareness on the following potential predictors: age, gender, race/ethnicity, educational attainment, income, political leaning, and usual red meat consumption. We also used this approach to examine predictors of awareness separately for health harms versus environmental harms.

Next, analyses assessed whether health or environmental harms were more effective at discouraging participants from wanting to eat red meat. These analyses used a linear mixed model, regressing harm-induced discouragement ratings on an indicator variable for whether the harm was a health or environmental harm, treating the intercept as random. We then assessed the extent to which each specific harm elicited discouragement using a linear mixed model with indicator variables for each of the 16 harms (excluding one as the referent), again treating the intercept as random. We used z-tests to conduct pairwise comparisons of predicted mean discouragement for each harm, applying Bonferroni's method to adjust for multiple comparisons. These comparisons allowed us to determine which of the harms (if any) were more discouraging than the others while adjusting for repeated measures within participants.

To examine which population groups reported more discouragement in response to health and environmental harms of red meat, we also examined demographic predictors of average discouragement from wanting to eat red meat. First, we averaged discouragement ratings across all 16 harms. We then used ordinary least squares linear (OLS) regression to assess predictors of average discouragement. These analyses assessed the same demographic predictors as for awareness, and additionally examined general perceptions that red meat is bad for health and for the environment. Exploratory analyses used the same approach to examine predictors of average harm-induced discouragement separately for health harms versus environmental harms.

Analyses were conducted in 2021 using Stata MP version 16.1 (StataCorp LLC, College Station, TX).

Results

Participants' average age was 33.8 (SD 8.0) years (range: 19, 80). About two-thirds were White (69%), 18% were Latino(a), 8% were another race/ethnicity, and 5% were Black

(Table 2). Slightly more than half (57%) of participants identified as female and 22% had a high school education or less.

For each of the 16 harms, fewer than one-third of participants indicated awareness that red meat contributed to that harm (Table 3). About one-third (33%) of participants were not aware of any of the 16 harms; 46% were not aware of any of the health harms, and 51% were not aware of any of the environmental harms. The specific harms with the highest level of awareness in the sample were heart disease (28% reported awareness), weight gain (27%), climate change (22%), and increased greenhouse gas emissions (21%). Participants were least aware that red meat contributes to stomach cancer (11%) and prostate cancer (8%). In mixed effects logistic regression, participants were similarly likely to report awareness of harms regardless of harm topic (health versus environment, $OR=1.02$, $p=0.77$).

In multivariate analyses examining predictors of the number of harms for which participants reported awareness, participants aged 26–34 years reported awareness of about 0.3 fewer harms of red meat compared to those aged 18–25 years ($B= -0.33$, $p=0.029$, Table 4). Participants who identified as female reported being aware of fewer harms than those who identified as male ($B= -0.26$, $p=0.023$). Likewise, those who identified as politically moderate ($B= -0.31$, $p=0.013$) or conservative ($B= -0.34$, $p=0.011$) reported awareness of fewer harms than those who identified as liberal. Participants who identified as Black reported awareness of more harms than those identifying as White ($B=0.57$, $p=0.006$), but identifying as Latino(a) or as another race/ethnicity (compared to identifying as White) was not associated with awareness. Higher educational attainment and higher income were generally associated with being aware of more harms. Usual red meat consumption was not associated with being aware of more health and environmental harms of red meat ($B=0.04$, $p=0.558$).

In analyses of awareness of health harms only, participants who identified as Black (compared to White) and those who had higher educational attainment reported awareness of a greater number of health harms. By contrast, participants who identified as politically moderate (compared to liberal) reported awareness of fewer harms (Supplemental Table 1). In analyses of awareness of environmental harms only, being age 26–34 years (compared to 18–25), identifying as female (compared to male), and identifying as politically conservative (compared to liberal) were associated with awareness of fewer harms (Supplemental Table 2). Higher education, higher income, and higher usual red meat consumption were associated with awareness of more of the environmental harms of red meat.

In mixed effects regressions of harm-induced discouragement, health harms elicited slightly more discouragement than environmental harms, but the magnitude of the difference was small (mean discouragement 2.73 versus 2.69 on the 1–5 Likert scale; $B=0.04$, $p=0.010$). Harms with higher awareness generally elicited higher discouragement (Figure 2). Among specific harms, heart disease elicited the highest mean discouragement (mean=2.82 on the 1–5 Likert scale), followed by early death (mean=2.79), plants and animals going extinct (mean=2.75), stroke (mean=2.75), and weight gain (mean=2.75) (Table 3). Prostate cancer (mean=2.60) and worse land quality (mean=2.65) elicited the lowest discouragement. After adjusting for multiple comparisons, the only significant differences in discouragement

between harms were that early death was more discouraging than prostate cancer (difference in predicted means=0.20, adjusted $p=0.002$), and heart disease was more discouraging than both prostate cancer (difference=0.23, adjusted $p<0.001$) and worsening land quality (difference=0.17, adjusted $p=0.024$).

In multivariate analyses examining predictors of average discouragement ratings, older participants generally reported lower discouragement than younger participants (Table 5). Participants who identified as Black reported higher levels of average discouragement compared to White participants ($B= 0.56$, $p=0.019$). Those who identified as politically moderate ($B= -0.40$, $p=0.002$) or conservative ($B= -0.64$, $p<0.001$) were less discouraged by the health and environmental harms of red meat than those who identified as politically liberal. Participants who reported higher general perceptions that red meat is bad for health also reported higher average discouragement ($B=0.18$, $p=0.006$). By contrast, general perceptions that red meat is bad for the environment were not associated with average discouragement ($B=0.07$, $p=0.329$). Finally, participants who reported higher usual red meat consumption reported higher average discouragement ($B=0.36$, $p<0.001$). Gender, education, income, and other race/ethnicities (i.e., Latino(a) and other race/ethnicity) were not associated with average discouragement (all $ps>0.05$). The pattern of results was similar when examining harm-induced discouragement separately for health versus environmental harms (Supplemental Tables 3 and 4).

Discussion

Results of this study suggest that messages describing the health and environmental harms of red meat could be a promising strategy for discouraging red meat consumption among US parents of young children. The majority of respondents were not yet aware of the specific health and environmental harms of red meat assessed in this study, and one-third were not aware of *any* of the 16 harms examined. These results suggest a major opportunity to educate consumers and motivate positive behavior change. Expectancy disconfirmation theory posits that when consumers receive negative information about a product that conflicts with their prior expectations (e.g., being informed about the harms of red meat when they had previously not known these harms), their attitudes toward the product will become more negative.^(54–56) This theory would suggest that correcting consumers' misperceptions about the health and environment risks of red meat could motivate them to reduce their red meat consumption. In line with this prediction, one study found that warning messages about the health harms of sugary drinks led to larger changes in parents' attitudes and purchase intentions when the messages were displayed on beverages parents had perceived as healthier compared to beverages parents already understood to be unhealthy.⁽⁵⁷⁾

Regression analyses revealed that participants who were 26–34 years old (compared to 18–25 years), identified as female (compared to male) and identified as politically moderate or conservative (compared to liberal) reported awareness of fewer harms of red meat. By contrast, participants who identified as Black (compared to White) and those with higher educational attainment and higher income reported being aware of more harms. These results suggest that it may be beneficial to tailor awareness-raising campaigns to particular

groups with lower awareness, such as parents who identify as female, are politically moderate or conservative, or have lower educational attainment or income. However, given that the majority of participants were unaware that red meat contributes to the health and environmental harms assessed in this study, educational efforts are likely to benefit parents from all demographic groups.

Participants' usual red meat consumption was not related to their awareness of red meat's health harms, but higher red meat consumption did predict higher awareness of the environmental harms of red meat. The reason for this association is unclear. One explanation is that higher red meat consumers are more likely to pay attention to information about the environmental consequences of red meat consumption because this information is particularly relevant to them, but have not yet acted on their awareness by reducing their red meat consumption. Regardless of the explanation, this finding highlights that interventions would likely benefit from addressing a variety of factors related to reducing red meat consumption, including increasing the accessibility, availability, and attractiveness of non-meat options.⁽⁵⁸⁾

Several participant characteristics predicted higher discouragement from wanting to eat red meat in response to health and environmental harms. For example, consumers aged 18–25 reported higher discouragement in response to environmental harms of red meat compared to those aged 26–34 and 35–44, perhaps because young adults have stronger interest in environmental sustainability and greater concern about climate change than older adults.^(59–61) Younger adults also reported higher discouragement in response to health harms than older adults. This pattern of results differs somewhat from prior research finding that younger adults were less likely than older adults to report health reasons for not eating meat.⁽⁶²⁾ Our results could potentially reflect a growing openness among young adults towards reducing their red meat consumption or consuming a plant-forward diet,⁽⁶³⁾ regardless of the precise motivation for making dietary changes. Participants who reported higher red meat consumption also reported higher discouragement in response to health and environmental harms of red meat. This finding is encouraging, as it suggests that messages about the harms of red meat might have the greatest impact on those who stand to benefit the most from reducing their red meat intake. Additionally, participants who had stronger general perceptions that red meat is bad for health reported being more discouraged, on average, in response to the specific health and environmental harms examined in this study. By contrast, general perceptions that red meat is bad for the environment were not associated with average discouragement ratings. These findings might suggest that strengthening the public's *general* perception that red meat is bad for health could increase the public's receptivity to messages about *specific* health or environmental harms. However, the observed associations between participants' characteristics and their average discouragement ratings should be interpreted with caution because we cannot rule out the possibility that some demographic groups (such as young adults or those who hold stronger general perceptions that red meat is bad for health) might respond more strongly to *any* type of message presented in an online survey, even messages not about red meat. Studies that experimentally compare red meat messages to control messages are needed to establish whether characteristics like age, meat consumption, and general perceptions about red meat influence the effectiveness of red meat reduction messages on consumer behavior.

Communication interventions such as product warnings and mass media campaigns that describe the health harms of cigarettes,^(20,21) alcohol,⁽²²⁾ and sugary drinks^(22–25) have been shown to generate small but meaningful reductions in purchases and consumption of these products, suggesting that communicating about the harms of red meat could help curb red meat intake. We found that both health and environmental harms elicited similar levels of perceived discouragement. Likewise, a variety of health and environmental harms were similarly discouraging to consumers. These results suggest that message developers have many promising options for topics to address in meat reduction messages. The limited differences in mean discouragement observed between the specific harms also suggests that communication campaigns could easily rotate among these harms, a strategy that could help prevent messages from becoming “stale” and losing efficacy over time.⁽⁶⁴⁾

Strengths of this study include the comprehensive set of health and environmental harms tested and the experimental comparison of how much each harm motivated participants to reduce their red meat consumption. Limitations include the use of a convenience sample of parents and the relatively young age distribution of the sample. Although prior studies indicate that online convenience samples can provide similar experimental results as probability samples,^(36,65,66) future research should confirm our findings with non-parents and with a wider range of ages. Additionally, although we did not query whether participants were vegetarian or vegan, about 13% of our sample reported eating red meat less than 1 time per week during the past 30 days. Future studies may wish to examine awareness and discouragement specifically among non-vegans/vegetarians or among high red meat consumers, for whom messages may be most relevant. Another limitation is that we did not assess whether some consumers believe that red meat is *beneficial* for specific health and environmental outcomes; understanding whether these beliefs are widespread, and who is most likely to hold these beliefs, could help inform messaging campaigns. Additionally, this study focused on health and environmental harms because these are two of the key reasons that US adults report as motivating them to change their diet or reduce their meat consumption.^(19,67) However, consumers might also be motivated by other harms of red meat production. For example, a recent meta-analysis suggested that interventions appealing to animal welfare (e.g., by portraying farm animals) hold promise for reducing meat purchases and consumption.⁽⁶⁸⁾ We also did not assess other potentially important aspects of message design, such as message framing.^(69–71) Finally, while perceived message effectiveness is predictive of behavior change,⁽⁴¹⁾ we did not assess behavioral outcomes. Future studies should experimentally evaluate the extent to which messages describing different types of harms of red meat reduce red meat purchases and consumption.

Conclusions

Reducing meat consumption is critical for mitigating climate change and reducing chronic disease burden.⁽¹⁶⁾ Our study suggests that communication interventions describing how red meat consumption affects both human and planetary health hold promise for informing US consumers and motivating reductions in red meat consumption.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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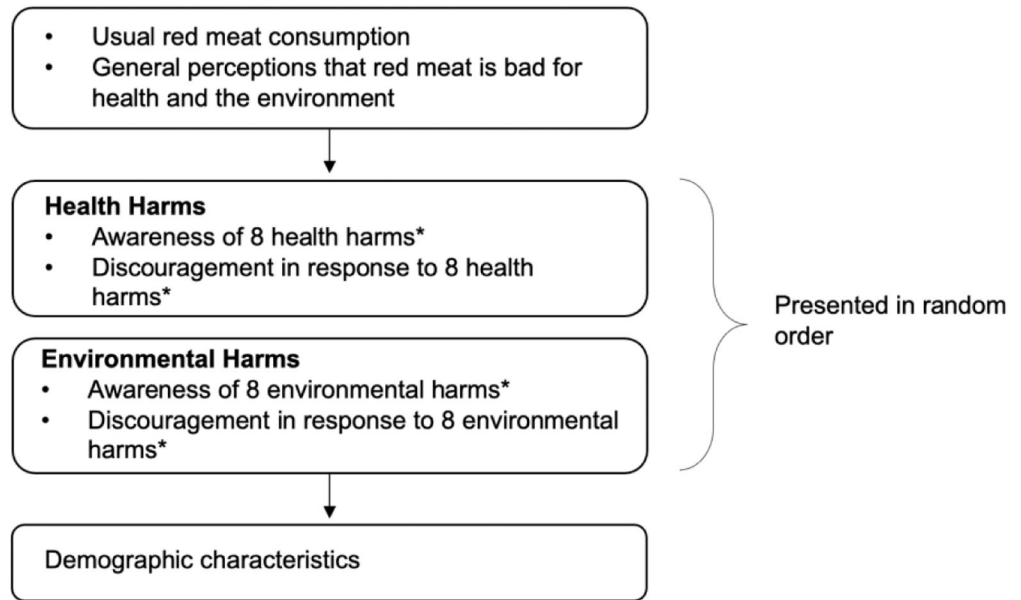
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*The 8 specific harms in each block (health and environmental) were presented in random order. Harms are listed in Table 1.

Figure 1.
Flow of survey questions

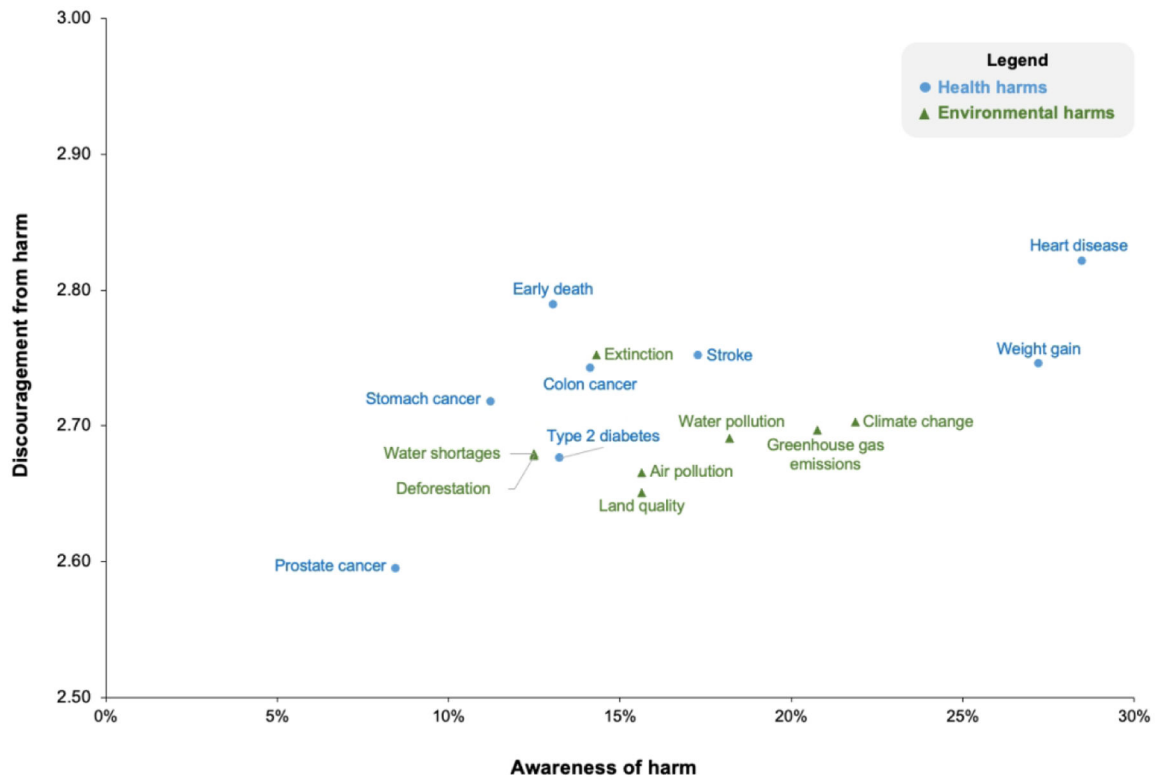


Figure 2. Health and environmental harms of red meat by discouragement and awareness, $n=544$ US parents of young children

Table 1.

Health and environmental harms of red meat shown in experiment and supporting evidence.

Red Meat Harms	Supporting evidence
<i>Health Harms</i>	
Type 2 diabetes	<ul style="list-style-type: none"> • Meta-analyses have found that both unprocessed and processed red meat intake are associated with increased risk of type 2 diabetes.^(3,72)
Weight gain	<ul style="list-style-type: none"> • A systematic review⁽⁴⁵⁾ and a meta-analysis⁽⁴⁴⁾ found that red and processed meat intake is associated with weight gain and increased risk of overweight and obesity.
Heart disease	<ul style="list-style-type: none"> • Meta-analyses have found that red meat intake is associated with cardiovascular disease risk factors⁽⁴⁶⁾ and increased risk of coronary heart disease and heart failure.⁽⁷³⁾
Stroke	<ul style="list-style-type: none"> • Meta-analyses have found that red meat intake is associated with increased risk of stroke.^(47,73)
Colon cancer	<ul style="list-style-type: none"> • Meta-analyses have found that red and processed meat intake is associated with increased risk of colorectal cancer.^(4,74,75) Additionally, the International Agency for Research on Cancer (IARC) classifies red meat as probably carcinogenic to humans.⁽⁵⁾
Prostate cancer	<ul style="list-style-type: none"> • A meta-analysis found that red meat intake is associated with increased risk of prostate cancer.⁽⁵⁾ • A pooled analysis of 15 prospective cohorts found that red and processed meat intake is associated with increased risk of advanced prostate cancer.⁽⁷⁶⁾
Stomach cancer	<ul style="list-style-type: none"> • A meta-analysis found that red meat intake is associated with increased risk of gastric (i.e., stomach) cancer.⁽⁷⁷⁾
Early death	<ul style="list-style-type: none"> • A meta-analysis found that red meat intake is associated with increased risk of all-cause mortality.⁽⁷⁸⁾ • A pooled analysis of two prospective cohorts found that red meat intake is associated with increased risk of all-cause mortality.⁽⁷⁹⁾
<i>Environmental Harms</i>	
Climate change	<ul style="list-style-type: none"> • Systematic reviews of life cycle analyses indicate that production of red meat is a major contributor to greenhouse gas emissions,^(9,14) which are a key driver of climate change.⁽⁸⁰⁾
More greenhouse gases	<ul style="list-style-type: none"> • Systematic reviews of life cycle analyses indicate that production of red meat is a major contributor to greenhouse gas emissions.^(9,14) • Ruminant (e.g., cow, goat, sheep) production is a major contributor to methane emissions.^(80,81)
Water shortages	<ul style="list-style-type: none"> • Production of red meat is a major contributor to water use⁽⁸²⁾ and water scarcity (i.e., the relative freshwater availability in a given region).⁽⁸³⁾
Water pollution	<ul style="list-style-type: none"> • Production of red meat is a major contributor to water pollution, including through leaching of fertilizers and pesticides used to grow animal feed⁽⁸²⁾ and through increases in eutrophication⁽⁹⁾ (the process by which water becomes enriched with minerals and nutrients, stimulating algal blooms and other negative ecological effects).
Air pollution	<ul style="list-style-type: none"> • Systematic reviews of life cycle analyses indicate that production of red meat is a major contributor to acidifying emissions (e.g., SO₂, NH₃, and NO_x).⁽⁹⁾
Plants and animals going extinct	<ul style="list-style-type: none"> • Meat production (particularly red meat) contributes to biodiversity loss through habitat destruction (e.g., when land is converted to use for feed production or animal grazing, or due to nutrient pollution).^(1,84,85)

Red Meat Harms	Supporting evidence
Clearing of forests	<ul style="list-style-type: none"> <li data-bbox="451 262 1325 310">Red meat (particularly beef) production is a major contributor to deforestation (e.g., when forests are converted to pasture for cattle).^(14,86)
Worse land quality	<ul style="list-style-type: none"> <li data-bbox="451 346 1325 373">Red meat production contributes to land degradation via overgrazing, compaction, and erosion.^(15,87)

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Table 2.Participant characteristics, *n*=544 US parents of young children

Characteristic	N	%
Age in years		
18–25	91	17%
26–34	209	39%
35–44	204	38%
45+	38	7%
Gender		
Male	227	42%
Female	308	57%
Non-binary	1	0.2%
Race/ethnicity		
Non-Hispanic White	373	69%
Non-Hispanic Black or African American	29	5%
Hispanic	97	18%
Non-Hispanic other	45	8%
Education		
High school or less	120	22%
Some college	85	16%
College degree	224	41%
Graduate degree	114	21%
Annual household income		
Less than \$25,000	90	17%
\$25,000–\$49,999	106	19%
\$50,000–\$74,999	90	17%
\$75,000–\$99,999	115	21%
\$100,000 or more	143	26%
Political party		
Liberal	136	25%
Moderate	218	40%
Conservative	189	35%
General perceptions of how good or bad red meat is to health		
Very bad	29	5%
Somewhat bad	78	14%
Neither good nor bad	221	41%
Somewhat good	135	25%
Very good	80	15%
General perceptions of how good or bad red meat is to the environment		
Very bad	29	5%
Somewhat bad	82	15%
Neither good nor bad	272	50%

Characteristic	N	%
Somewhat good	88	16%
Very good	73	13%
Usual red meat intake (servings/day), mean and SD	0.7	0.8

Note. Missing data ranged from 0.0% to 1.5%.

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Table 3.

Awareness and discouragement of the health and environmental harms of red meat consumption, $n=544$ US parents of young children

Harm of red meat	Awareness	Discouragement	
	%	Mean	(SD)
<i>Health harms</i>			
Heart disease	28%	2.82	(1.46)
Weight gain	27%	2.75	(1.45)
Stroke	17%	2.75	(1.45)
Colon cancer	14%	2.74	(1.46)
Type 2 diabetes	13%	2.68	(1.44)
Early death	13%	2.79	(1.49)
Stomach cancer	11%	2.72	(1.44)
Prostate cancer	8%	2.60	(1.47)
<i>Environmental harms</i>			
Climate change	22%	2.70	(1.44)
Greenhouse gas emissions	21%	2.70	(1.44)
Water pollution	18%	2.69	(1.42)
Air pollution	16%	2.67	(1.42)
Land quality	16%	2.65	(1.42)
Extinction of plants and animals	14%	2.75	(1.45)
Deforestation	13%	2.68	(1.43)
Water shortages	13%	2.68	(1.45)

Table 4.

Associations between participant characteristics and the total number of health and environmental harms of red meat for which participants reported awareness, $n=544$ US parents of young children

	B	(SE)	P
Age in years			
18–25	Reference	-	-
26–34	-0.33	(0.15)	0.029
35–44	-0.16	(0.16)	0.304
45 or older	-0.03	(0.21)	0.886
Female ^a	-0.26	(0.11)	0.023
Race/ethnicity			
White	Reference	-	-
Black	0.57	(0.21)	0.006
Latino(a)	0.07	(0.14)	0.622
Other race/ethnicity	0.11	(0.14)	0.455
Education			
High school or less	Reference	-	-
Some college	0.29	(0.21)	0.176
College degree	0.51	(0.18)	0.003
Graduate degree	0.52	(0.21)	0.013
Annual household income			
Less than \$25,000	Reference	-	-
\$25,000–\$49,999	0.37	(0.20)	0.062
\$50,000–\$74,999	0.42	(0.19)	0.028
\$75,000–\$99,999	0.40	(0.20)	0.045
\$100,000 or more	0.41	(0.20)	0.046
Political leaning			
Liberal	Reference	-	-
Moderate	-0.31	(0.13)	0.013
Conservative	-0.34	(0.13)	0.011
Red meat consumption, servings per day	0.04	(0.06)	0.558

Note. Bs are unstandardized regression coefficients from negative binomial regressions, regressing the total number of health and environmental harms for which participants reported awareness on participant characteristics. Models estimated robust standard errors. **Bold** coefficients are statistically significant, $p<0.05$.

^aReferent group was male. The one nonbinary participant was excluded from analysis due to small cell size.

Table 5.

Associations between participant characteristics and average discouragement from wanting to eat red meat in response to health and environmental harms of red meat across, $n=544$ US parents of young children

	B	(SE)	P
Age in years			
18–25	Reference	-	-
26–34	-0.40	(0.16)	0.011
35–44	-0.41	(0.16)	0.013
45 or older	-0.26	(0.24)	0.272
Female ^a	-0.04	(0.12)	0.724
Race/ethnicity			
White	Reference	-	-
Black	0.56	(0.24)	0.019
Latino(a)	0.22	(0.14)	0.119
Other race/ethnicity	-0.20	(0.19)	0.281
Education			
High school or less	Reference	-	-
Some college	0.12	(0.17)	0.489
College degree	0.29	(0.16)	0.063
Graduate degree	0.32	(0.20)	0.109
Annual household income			
Less than \$25,000	Reference	-	-
\$25,000–\$49,999	0.09	(0.18)	0.607
\$50,000–\$74,999	0.07	(0.19)	0.702
\$75,000–\$99,999	0.32	(0.20)	0.113
\$100,000 or more	0.07	(0.20)	0.750
Political leaning			
Liberal	Reference	-	-
Moderate	-0.40	(0.13)	0.002
Conservative	-0.64	(0.14)	<0.001
General perceptions that red meat is bad for health	0.18	(0.07)	0.006
General perceptions that red meat is bad for the environment	0.07	(0.07)	0.329
Red meat consumption, servings per day	0.36	(0.08)	<0.001

Note. Bs are unstandardized regression coefficients from ordinary least squares regressions regressing participants' average discouragement ratings (across all 16 health and environmental harms) on participant characteristics. **Bold** coefficients are statistically significant, $p<0.05$.

^aReferent group was male. The one nonbinary participant was excluded from analysis due to small cell size.