
Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Appetite 165 (2021) 105293

Contents lists available at ScienceDirect

Appetite

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

# The effectiveness of COVID-related message framing on public beliefs and behaviors related to plant-based diets

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A B S T R A C T

Shifting the public towards plant-based diets is critical for achieving environmental and public health outcomes. Increasingly news articles and organizations have begun using the saliency of the COVID-19 crisis to highlight the link between animal agriculture, pandemic risks, and other widespread public health threats. Yet, little is known about the effectiveness of this messaging strategy for motivating dietary change. We conducted a randomized trial with an online sample to examine the impact of: (1) a message that uses the saliency of the COVID-19 pandemic to highlight the risk of disease transmission from factory farms, and (2) a message that uses the saliency of the COVID-19 pandemic to highlight the threat to worker's health created by factory farms. We examine whether these messages are more effective at changing beliefs about and behavioral intentions towards plant-based eating, as compared to more traditional messages that highlight the environmental, personal health, or animal welfare implications of factory farmed meat consumption. We find that all messages differentially influenced beliefs about the various negative consequences of meat consumption. However, these altered beliefs did not differentially motivate changes in respondents' intentions to reduce meat consumption and choose plant-based alternatives. This was possibly due to the numerous other barriers to behavior change identified in qualitative survey responses, such as cost, taste, and social factors. We did find that messages that highlight the personal health benefits of reduced meat consumption were more effective at increasing public trust in the message deliverer. Our results suggest that highlighting personal health benefits in messaging and addressing the additional identified barriers to behavior change may be critical for building trust and shifting the public towards plant-based diets.

## 1. Introduction

Reducing public meat and dairy consumption is essential for improving human health and animal welfare and reducing carbon emissions and environmental degradation. Meat, aquaculture, eggs, and dairy (which we here term 'animal products') use more than 80% of the world's farmland and contribute to more than 55% of carbon emissions from food, despite providing only 37% of our protein and 18% of our calories (Poore & Nemecek, 2018). According to the 2019 Intergovernmental Panel on Climate Change (IPCC), shifting the public towards plant-based diets could free up several million square kilometers of land and reduce global $CO_2$ emissions by up to eight billion tons per year by 2050 (Schiermeier, 2019). Because of these significant environmental impacts, non-governmental organizations (NGOs) have listed choosing a plant rich diet as one of the most important behaviors that the public can engage in to meaningfully curb greenhouse gas emissions (Rare & California Environmental Associates, 2019). In addition to animal products' climate impacts, meta-analyses of the health impacts of meat consumption have found that increased long-term consumption of red meat and processed meat is associated with an increased risk of mortality, cardiovascular disease, colorectal cancer and type 2 diabetes (Richi et al., 2015). Furthermore, consumption of animal products contributes to continued animal abuses, particularly on factory farms, such as tight confinement, restriction from engaging in natural behavior, physical alterations without anesthetic, untreated illnesses and injuries, and rough handling (Anomaly, 2015; ASPCA).

Despite these negative environmental, health, and animal welfare impacts, consumption of animal products continues to be a normative practice in many countries (Godfray et al., 2018). In the United States, for example, only 8% of the population is vegan or vegetarian (Rare & California Environmental Associates, 2019). Further, national regulations and policy change on these practices in most countries are slow moving (Selinske et al., 2020). Changing norms around food choices will thus require strategic messaging and behavior change campaigns conducted by NGOs, community organizations, and local governments encouraging vegetarian and vegan food choices (Godfray et al., 2018; Selinske et al., 2020).

A growing body of research has begun examining the types of messages that are most effective at encouraging plant-based food choices (see Harguess et al., 2020 for a review). These studies have found that

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https://doi.org/10.1016/j.appet.2021.105293
Received 10 January 2021; Received in revised form 30 March 2021; Accepted 29 April 2021
Available online 14 May 2021

message framing has the potential to influence attitudes and intentions towards reducing the consumption of animal products as well as people's actual food choices (Harguess et al., 2020; Sparkman & Walton, 2017; Wolstenholme et al., 2020). The majority of existing studies have focused on the effectiveness of providing information about the impact of the consumption of animal products on personal health, the environment, or animal welfare (Carfora et al., 2019; Cordts et al., 2014; Graham & Abrahamse, 2017; Fehrenback 2015). For example, Graham and Abrahamse (2017) found that messaging regarding the climate impacts of meat consumption increased intentions to reduce meat consumption, while Fehrenback (2015) found that participants who watch a video about the impacts of meat consumption on personal health increased intentions to reduce meat consumption. Cordts et al. (2014) provided fictitious newspaper articles to survey participants in Germany describing the effects of meat consumption on personal health, climate change, personal image, and animal welfare, and found that animal welfare and health arguments had the strongest effects on reducing meat consumption. Wolstenholme et al. (2020) found that numerous messages delivered via Facebook messenger focused on the positive impacts of eating less red and processed meat on personal health, the environment, or on both, were effective at reducing self-reported meat consumption.

Since the COVID-19 pandemic began, two new types of health-related message framing have been increasingly used by news media and public health experts. The first links the consumption of animal products with public health threats such as pandemic risks and antibiotic resistance. These messages have used the saliency of the COVID-19 crisis to highlight the need for reducing society's reliance on animal agriculture to prevent future widespread public health crises. News articles, for example, have discussed how formal slaughterhouses and factory farms also have disease risk, just like the wet markets (i.e. informal slaughterhouses) where COVID-19 is suspected to have originated (Heppler & Shank, 2020; Safran Foer & Gross, 2020). These articles draw on public health research, such as Leibler et al. (2009, p. 58), who write that "most zoonotic pathogens of recent concern to human health either originate in, or are transferred to human populations from domesticated animals raised for human consumption." Factory farms may especially increase disease risk because animals are crowded together in close confinement, often indoors without adequate sunlight or ventilation. This can make animals more susceptible to infection, facilitate transmission of infection, and facilitate the survival of viruses (Anomaly, 2015). Indeed, the majority of H5 and H7 novel influenza viruses have been traced back to commercial chicken production systems (Dhingra et al., 2018). At the same time, articles point out (e.g., Perry, 2020) that animal agriculture is increasingly implicated in the growing crisis of antibiotic resistance and resulting threats to human health and food security (Manyi-Loh et al., 2018).

The second message framing focuses on worker health specifically during the COVID-19 pandemic. News articles (e.g., Heppler & Shank, 2020) have discussed the outbreaks of COVID-19 in factory farms (summarized in CDC 2020) due to the difficulties of social distancing in these workplaces, pointing out that these are just the latest example of the threats that slaughterhouse working conditions more generally pose to workers. Many of these articles conclude with a plea to the public to reduce meat consumption or ban factory farming to prevent such public health threats in the future.

Several social psychology theories suggest that these emerging messages highlighting the connections between animal agriculture, pandemics and other widespread public health threats may be particularly effective. Studies on psychological distance, for example, suggest that people are more likely to engage with information when it relates to their immediate day-to-day concerns (rather than concerns far in the future or far away; van der Linden et al., 2015; Scannell & Gifford, 2013). By linking animal agriculture and consumption of animal products to COVID-19 – a global pandemic that has substantially impacted people's lives – this messaging may be reducing the psychological distance associated with the impacts of meat consumption. Such an effect is further suggested by the research reviewed by van der Linden (2015), which suggests that people are often more likely to support policies and change behavior when messages connect an issue to their own personal experiences. Linking consumption of animal products to people's highly salient experiences with COVID-19 may therefore prompt new actions.

Other theories of human behavior, however, suggest that these messaging strategies could have the potential to backfire. Research on psychological reactance, for example, suggests that messages can reduce public support for a cause if recipients of the message perceive that the message poses a threat to their freedom (Brehm, 1966; Reynolds-Tylus, 2019). Reynolds-Tylus (2019) review a variety of different factors that may influence reactance, including message "sensation value," or the degree to which messages elicit affective or arousal responses (which is often influenced by message novelty) and the extent of "freedom threatening language" in the message, or language directing people on exactly how they should behave. Xu et al. (2015) suggests that people are more likely to respond to a message with reactance when the message has high sensation value and high freedom threatening language. Messages that link COVID-19 and meat consumption might fit within this description, as the message is novel, is likely to cause high emotional arousal by reminding people of their negative experiences during the pandemic, and is directing people on exactly how to behave in response to these negative emotions (i.e. what Reynolds-Tylus, 2019 call "freedom-threatening language"). Further, reactance may be more likely because respondents may see the messenger as taking advantage of the human suffering caused by the pandemic to achieve a goal (i.e. reducing meat consumption), which could reduce trust in the messenger.

## 2. Present study

Given the saliency of the COVID-19 pandemic, the pressing need to reduce consumption of animals, and the uncertainty regarding the effectiveness of these different possible messages, we conducted a randomized trial with an online US-based sample to examine the impact of COVID-19 related messages on public intentions to reduce choose plant-based foods. Specifically, we tested: (1) a message that used the saliency of the COVID-19 pandemic to highlight the risk of disease transmission from factory farms, and (2) a message that used the saliency of the COVID-19 pandemic to highlight the threat to worker's safety created by factory farms. We examined whether these messages were more effective at changing behavioral intentions towards plant-based eating, as compared to more traditional messages that highlight the environmental, personal health, or animal welfare implications of factory farmed meat consumption. As a secondary analysis, we also examined how these messages influence public beliefs towards the impacts of animal agriculture and meat consumption (a manipulation check), public trust in the messenger and judgements about animal advocates (measures of potential reactance), and support for a factory farming ban and a global coalition working to transition the food system towards more plant-based eating (all examples of other strategies that NGOs and other groups are using to achieve change on this issue).

We also examined which subgroups various messages might most effectively influence. Literature suggests that the impact of different message framings on behavior may vary by audience (Feinberg & Willer, 2013; Myers et al., 2012; Niemiec, Sekar, et al., 2020). The elaboration likelihood model of persuasion, in particular, suggests that the effectiveness of messaging may vary based on people's prior attitudes or level of engagement with a topic (Petty & Cacioppo, 1986, pp. 1–24). Individuals with lower levels of engagement with the topic may be more affected by numerous, compelling and brief messages (Petty & Cacioppo, 1986, pp. 1–24), whereas highly engaged individuals may be impacted by more in-depth and well-researched arguments. We therefore test whether the effectiveness of message framing is influenced by an individual's prior attitudes toward meat consumption and attitudes

towards government responses to COVID-19.

Finally, we collected qualitative data on respondents' reactions to the messages and the barriers and motivations they face when considering trying plant-based alternatives, reducing meat consumption, and reaching out to others about these causes. The qualitative data is meant to supplement our experimental trial by facilitating a greater understanding of why various messages may or may not have been effective, and what types of additional interventions may be needed for reducing public meat consumption.

## 3. Methods

We conducted a survey experiment with 1460 residents representative of the United States population recruited through Prolific survey company, a licensed participant recruitment firm (https://www.prolific.co/). We randomly assigned approximately 300 participants (the maximum number we could recruit with our funding limitations) to each of our 5 message conditions (see Appendix S-2 for full messages). We did not conduct a power analysis because we didn't have a minimal detectable effect of interest based on prior research or estimate of likely variance of the outcomes prior to the experiment; we therefore used similar sample sizes as previous messaging studies on reducing meat consumption (Graham & Abrahamse, 2017; Sparkman & Walton, 2017). Our five treatments included: 1) a message using the saliency of the COVID-19 crisis to highlight the link between animal agriculture and pandemic risks, as well as other public health threats like antibiotic resistance (labeled "COVID/pandemic message," designed based on Heppler & Shank, 2020, Safran Foer & Gross, 2020, and Perry, 2020; n = 304); 2) a message using the saliency of the COVID-19 crisis to highlight the threats to the safety of factory farm workers. Specifically, this message discusses how some of the worst COVID-19 outbreaks have occurred in meatpacking plants as well as other safety threats that workers face (labeled "worker safety message," designed based on the CDC 2020; Heppler & Shank, 2020; n = 273); 3) a message focused on animal welfare, comparing how Americans treat dogs and cats with how they treat factory farm animals (labeled "animal welfare message," designed based on content from Mercy for Animal's website; n = 296); 4) a message focused on the impacts of meat consumption on climate change and environmental degradation (labeled "environment message," designed based on Poore & Nemecek, 2018 and Schiermeier, 2019; n = 281); and 5) a message focused on the impacts of meat consumption on personal health (i.e. mortality risk, cardiovascular disease, colorectal cancer, etc.; labeled "personal health message," designed based on Mayoclinic, 2020, Medawar et al., 2019; Richi et al., 2015; n = 306). The final sample of 281 residents who received the environmental message was collected several days after the rest of the sample, because the original environmental message sample was discarded due to an error in the message. We did not include a control without a message because our objective was to examine the effectiveness of the COVID-related messages compared to more standard messaging approaches.

Each message ended with a moral appeal for respondents to reduce their meat consumption that sought to leverage personal norms by emphasizing respondents' responsibility to do their part to affect the outcome described in the message. Personal norms are people's own behavioral standards that flow from one's values (De Groot & Steg, 2009). These norms are influenced by a person's awareness of the consequences of their actions as well as their ascription of responsibility for the negative consequences of not acting (De Groot & Steg, 2009). We included this appeal given that personal norms are strong predictors of pro-environmental behavior more broadly (Niemiec, Champine, et al., 2020) as well as meat consumption more specifically (Carfora et al., 2020). Our experimental protocol was approved by Colorado State University's IRB (Protocol #20–10317H).

In the first section of the survey, participants completed a series of questions about their attitudes and prior behavior related to the consumption of animal products and plant-based alternatives, as well as their attitudes towards government actions to address the COVID-19 crisis (adapted from the CDC's weekly morbidity and mortality report; see Appendix S-2 for the full survey). These variables were pre-screened as potential covariates (i.e., variables potentially correlated with our outcomes) in our adjusted analysis. We also asked participants several open-ended questions about reasons why they had or had not tried to reduce their own consumption of animal products in the past. We then presented participants with the randomly assigned message condition. We told participants that we were interested in their response to the message and that the message was crafted from recent news articles and scientific papers. Immediately after the message, we asked an open-ended question about what participants thought was surprising, interesting, or concerning about the message. We then asked participants about the extent to which they thought the person who crafted the message was trustworthy, given that trust in messengers has been found to be an important predictor of conservation attitudes and behavior change (Davenport et al., 2007; Vaske et al., 2007). We also asked participants whether they thought activists against factory farming are honest, annoying, truthful, misleading, accurate, or similar to participants in values. These questions were designed to measure any potential backfire effect from the message and were included as secondary outcomes in our analysis.

After these questions about the messenger, we included questions to measure our three primary behavioral outcome variables, which were participants' likelihood of: 1) replacing animal products with plant-based alternatives; 2) reducing overall meat consumption; and 3) encouraging friends or family to try plant-based alternatives over the next month. We included the third variable given recent calls in the scientific literature to examine not only how to motivate personal action but also more collective actions to facilitate the spread of conservation behavior through social networks (Amel et al., 2017; Niemiec, Sekar, et al., 2020). We also included open-ended questions asking why participants would or would not be likely to engage in those behaviors. In addition to the primary outcomes, we then included questions to measure beliefs regarding the impacts of meat consumption on personal health, the environment, pandemics and antibiotic resistance, and worker health. These were included both as secondary outcomes and as a manipulation check to examine whether the messages were indeed altering relevant beliefs. We also included questions about participants' perceived personal responsibility to reduce meat consumption (i.e. personal norms), participants' perceived social norms surrounding meat consumption, and participants' support of a factory farm ban or a global coalition working to develop a food system more focused on plant-based sources. We included these additional beliefs as secondary outcomes given that beliefs may be easier to alter through one-off messaging and changes in beliefs are often a first step towards changes in behavioral intentions.

We also asked participants demographic questions about their age, education, income, area of residence (urban vs rural), gender, pet ownership, and political affiliation. These were included as potential confounders to adjust for in our analysis. Throughout the survey, we also included two attention checks asking participants to select a particular response option. Participants who failed both attention checks were removed from the sample and were not paid through Prolific (n = 5).

Our analysis plan was pre-registered on Open Science Framework (https://osf.io/7b8r3/) prior to beginning the experiment. We used linear regressions (and ordinal logistic regression, as a sensitivity analysis) to examine the impact of message condition on the outcomes described above, both adjusted and unadjusted for demographic and pre-message attitudinal and behavioral covariates (Hernandez et al., 2004). Each potential covariate was pre-screened using a bivariate likelihood ratio test with the outcome. If the p-value was less than 0.20 the covariate was included in the model. We controlled for multiple comparisons (Vickerstaff et al., 2019) when interpreting primary outcomes using a Bonferroni correction (i.e. multiplying the p-value by three, the number of primary outcomes). We report both corrected and

uncorrected p-values for the primary outcomes, particularly since corrected p-values are likely a conservative estimate. We do not correct for multiple comparisons for our exploratory outcomes (Feise, 2002).

We also examined whether participants' attitudes towards COVID-19 and prior attitudes towards plant-based alternatives were potential moderators of message effects. Participants' responses to the attitudes towards COVID-19 scale were combined into a single metric to be used as a moderator and potential adjustment covariate. To determine moderation, we added an interaction term between the hypothesized moderators and the message condition to the regression analyses. We then conducted a likelihood ratio test to examine whether adding the interaction terms between these binary attitude variables and message condition significantly improved the model fit.

Finally, we used thematic content analysis (Braun & Clarke, 2014) to examine respondents' reactions to messages as well as their self-reported barriers and motivations to reducing meat consumption and reaching out to others about plant-based alternatives. We used an iterative approach to develop and categorize participant responses into thematic codes: first, we created a codebook of deductive (a priori) themes that reflected quantitative constructs of motivations and barriers previously identified in the literature; second, M.S.J. coded all qualitative responses line-by-line using the deductive codebook and adding inductive (emergent from the data) themes to capture unforeseen barriers and motivations reflected in respondents' answers; third, we finalized the definitions for inductive themes through integration of behavioral scientific concepts from existing research. Finally, M.S.J. recoded all

**Table 1**
Mean and medians for demographics as well as baseline attitudes and behavioral intentions related to plant-based alternatives, meat consumption, and government attitudes by message condition (prior to receiving message condition).

| | Worker health (N = 272) | COVID/pandemic (N = 302) | Animal welfare (N = 295) | Environment (N = 281) | Personal health (N = 306) | Overall (N = 1456) |
|---|---|---|---|---|---|---|
| **Average Attitudes towards COVID-19** | | | | | | |
| Mean (SD) | 5.67 (1.60) | 5.56 (1.63) | 5.75 (1.53) | 5.64 (1.56) | 5.62 (1.65) | 5.65 (1.59) |
| Median [Min, Max] | 6.00 [1.00, 7.00] | 6.00 [1.00, 7.00] | 6.00 [1.00, 7.00] | 6.00 [1.00, 7.00] | 6.00 [1.00, 7.00] | 6.00 [1.00, 7.00] |
| Missing | 0 (0%) | 1 (0.3%) | 2 (0.7%) | 0 (0%) | 0 (0%) | 3 (0.2%) |
| **Attitudes towards Plant-Based Alternatives (pre message)** | | | | | | |
| Mean (SD) | 4.76 (1.69) | 4.85 (1.60) | 4.65 (1.61) | 4.72 (1.62) | 4.85 (1.61) | 4.77 (1.62) |
| Median [Min, Max] | 5.00 [1.00, 7.00] | 5.00 [1.00, 7.00] | 4.00 [1.00, 7.00] | 5.00 [1.00, 7.00] | 5.00 [1.00, 7.00] | 5.00 [1.00, 7.00] |
| **Intentions to Reduce Meat Consumption (pre message)** | | | | | | |
| Mean (SD) | 0.493 (0.501) | 0.568 (0.496) | 0.431 (0.496) | 0.473 (0.500) | 0.548 (0.499) | 0.503 (0.500) |
| Median [Min, Max] | 0 [0, 1.00] | 1.00 [0, 1.00] | 0 [0, 1.00] | 0 [0, 1.00] | 1.00 [0, 1.00] | 1.00 [0, 1.00] |
| Missing | 0 (0%) | 1 (0.3%) | 0 (0%) | 0 (0%) | 1 (0.3%) | 2 (0.1%) |
| **Age** | | | | | | |
| Mean (SD) | 7.70 (1.59) | 7.52 (1.60) | 7.66 (1.64) | 7.08 (1.57) | 7.63 (1.59) | 7.52 (1.61) |
| Median [Min, Max] | 8.00 [5.00, 11.0] | 8.00 [5.00, 11.0] | 8.00 [5.00, 11.0] | 7.00 [5.00, 11.0] | 8.00 [5.00, 11.0] | 8.00 [5.00, 11.0] |
| Missing | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) | 1 (0.3%) | 1 (0.1%) |
| **Gender** | | | | | | |
| Male | 129 (47.4%) | 155 (51.3%) | 136 (46.1%) | 131 (46.6%) | 135 (44.1%) | 686 (47.1%) |
| Female | 140 (51.5%) | 144 (47.7%) | 154 (52.2%) | 147 (52.3%) | 169 (55.2%) | 754 (51.8%) |
| Non-binary/third gender/prefer not to answer/prefer to self describe | 3 (1.1%) | 3 (1.0%) | 5 (1.7%) | 3 (1.1%) | 2 (0.7%) | 16 (1.1%) |
| **Race** | | | | | | |
| Black or African American | 37 (13.6%) | 32 (10.6%) | 28 (9.5%) | 40 (14.2%) | 47 (15.4%) | 184 (12.6%) |
| White | 206 (75.7%) | 217 (71.9%) | 232 (78.6%) | 188 (66.9%) | 210 (68.6%) | 1053 (72.3%) |
| Other (Hispanic or Latino, Asian, American Indian or Alaska Native, Native Hawaiianor Other Pacific Islander, Other) | 29 (10.7%) | 53 (17.5%) | 35 (11.9%) | 53 (18.9%) | 49 (16.0%) | 219 (15.0%) |
| **Education** | | | | | | |
| Mean (SD) | 4.23 (1.33) | 4.18 (1.34) | 4.25 (1.33) | 4.14 (1.33) | 4.26 (1.30) | 4.21 (1.32) |
| Median [Min, Max] | 5.00 [1.00, 6.00] | 5.00 [1.00, 6.00] | 5.00 [1.00, 6.00] | 4.00 [1.00, 6.00] | 5.00 [1.00, 6.00] | 5.00 [1.00, 6.00] |
| Missing | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) | 1 (0.3%) | 1 (0.1%) |
| **Income** | | | | | | |
| Mean (SD) | 3.45 (1.21) | 3.50 (1.16) | 3.48 (1.16) | 3.48 (1.28) | 3.55 (1.22) | 3.49 (1.20) |
| Median [Min, Max] | 4.00 [1.00, 6.00] | 4.00 [1.00, 6.00] | 4.00 [1.00, 6.00] | 4.00 [1.00, 6.00] | 4.00 [1.00, 6.00] | 4.00 [1.00, 6.00] |
| Missing | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) | 1 (0.3%) | 1 (0.1%) |
| **Area of Residence (urban to rural)** | | | | | | |
| Mean (SD) | 3.01 (1.06) | 3.12 (0.956) | 3.11 (1.01) | 3.06 (1.08) | 2.99 (0.951) | 3.06 (1.01) |
| Median [Min, Max] | 3.00 [1.00, 5.00] | 3.00 [1.00, 5.00] | 3.00 [1.00, 5.00] | 3.00 [1.00, 5.00] | 3.00 [1.00, 5.00] | 3.00 [1.00, 5.00] |
| Missing | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) | 1 (0.3%) | 1 (0.1%) |
| **Political Affiliation** | | | | | | |
| Democrat | 127 (46.7%) | 144 (47.7%) | 145 (49.2%) | 129 (45.9%) | 140 (45.8%) | 685 (47.0%) |
| Republication | 58 (21.3%) | 50 (16.6%) | 53 (18.0%) | 56 (19.9%) | 53 (17.3%) | 270 (18.5%) |
| Independent | 87 (32.0%) | 108 (35.8%) | 97 (32.9%) | 96 (34.2%) | 113 (36.9%) | 501 (34.4%) |
| **Pet Ownership** | | | | | | |
| Mean (SD) | 0.676 (0.469) | 0.649 (0.478) | 0.664 (0.473) | 0.662 (0.474) | 0.608 (0.489) | 0.651 (0.477) |
| Median [Min, Max] | 1.00 [0, 1.00] | 1.00 [0, 1.00] | 1.00 [0, 1.00] | 1.00 [0, 1.00] | 1.00 [0, 1.00] | 1.00 [0, 1.00] |

responses using the full codebook (see Table S-1 in the appendices for the full codebook). We then counted the most common themes in respondents' answers overall and by messaging condition.

## 4. Results

### 4.1. Sample characteristics

Our sample was 90% omnivore, 7% vegetarian, and 3% vegan. This distribution of eating habits is reflective of the broader US population, which recent surveys suggest is 8% vegetarian or vegan (Rare & California Environmental Associates, 2019). Approximately 50% of the sample indicated that they had tried to reduce their consumption of animal products in the past five years, and 53% of the sample had somewhat to very positive attitudes towards plant-based alternatives prior to receiving the message condition. Randomization appeared to achieve relative balance in demographics, pre-message attitudes, and behavioral intentions across message conditions (Table 1). However, there were some differences between message conditions in key covariates that might impact our primary outcomes, suggesting the need for covariate adjustment. For example, individuals who received the COVID/pandemic message on average had slightly more positive attitudes towards plant-based alternatives and were more likely to have tried to reduce their meat consumption over the past five years than those who received the environment and animal welfare messages (Table 1).

### 4.2. Primary outcomes

In the unadjusted analysis, there was a trend indicating that the COVID/pandemic message and the personal health message led to the highest intentions to try plant-based alternatives, reduce meat consumption, and encourage others to reduce meat consumption (see Figure S-1 for unadjusted means). In the unadjusted analysis, the COVID/pandemic message led to significantly higher intentions to reduce meat consumption compared to the environmental message (estimate = 0.318, uncorrected p-value = .006, corrected p-value = .019). However, this difference was not significant when adjusting for covariates (estimate = 0.154, uncorrected p-value = .065, corrected p-value = .195). When adjusting for covariates, there were also no other significant differences or near significant differences in primary outcomes between any other message conditions (Fig. 1). Regression results indicated that this difference in the unadjusted and adjusted analysis was likely due to the imbalance between message conditions in pre-message intentions to reduce meat consumption and attitudes towards plant-based alternatives (Tables S–2). The mean of these variables was slightly higher in the sample of residents who received the COVID/pandemic message, and

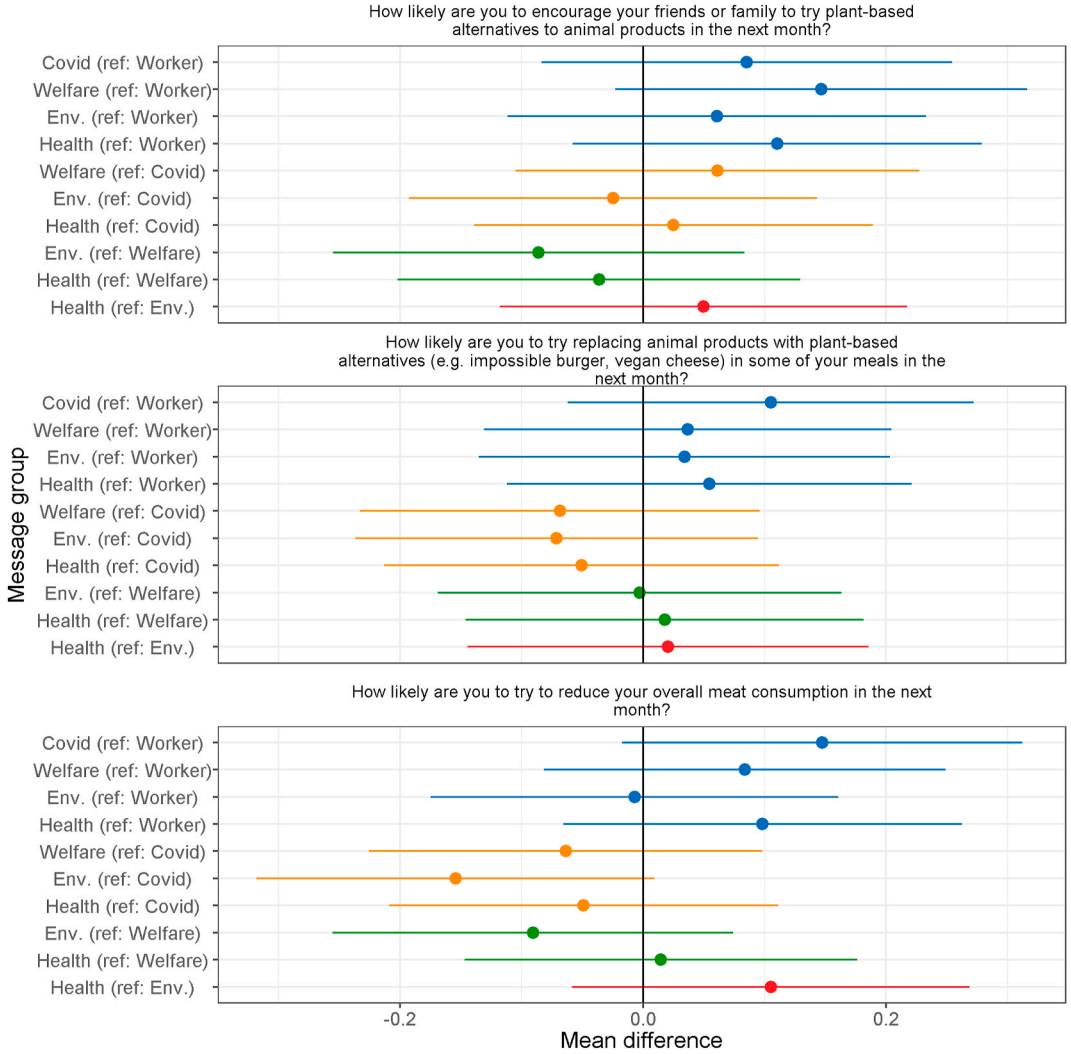


**Fig. 1.** Mean difference (with 95% confidence intervals, adjusted for covariates) in the likelihood (on a 5 point scale) of replacing animal products with plant based alternatives, reducing overall meat consumption, and encouraging friends and family to try plant-based alternatives in the next month between different message conditions ("ref:" refers to the reference level that the message is being compared to).

these variables were significantly and moderately to highly correlated with our primary outcomes (Tables S–2). In adjusted regression analyses, gender (female), education, age, and more urban areas of residence were also significant predictors of primary outcomes (Tables S–2). Ordinal logistic regressions, conducted as a sensitivity analysis, led to similar results.

### 4.3. Secondary exploratory outcomes and moderation analyses

Overall, the personal health message led to the highest trust in the messenger (Fig. 2). Trust in the messenger was higher for the personal health message compared to the animal welfare message (adjusted analysis estimate = 0.203, p-value = .010), the environment message (adjusted analysis estimate = 0.217, p-value = .007) and the worker safety message (adjusted analysis estimate = 0.174, p-value = .030) and was marginally significantly higher than the COVID/pandemic message (adjusted analysis estimate = 0.153, p-value = .051).

Individuals who received the COVID/pandemic message were more likely to agree afterwards with the statement that "there is a direct connection between raising animals for food and the novel coronavirus"

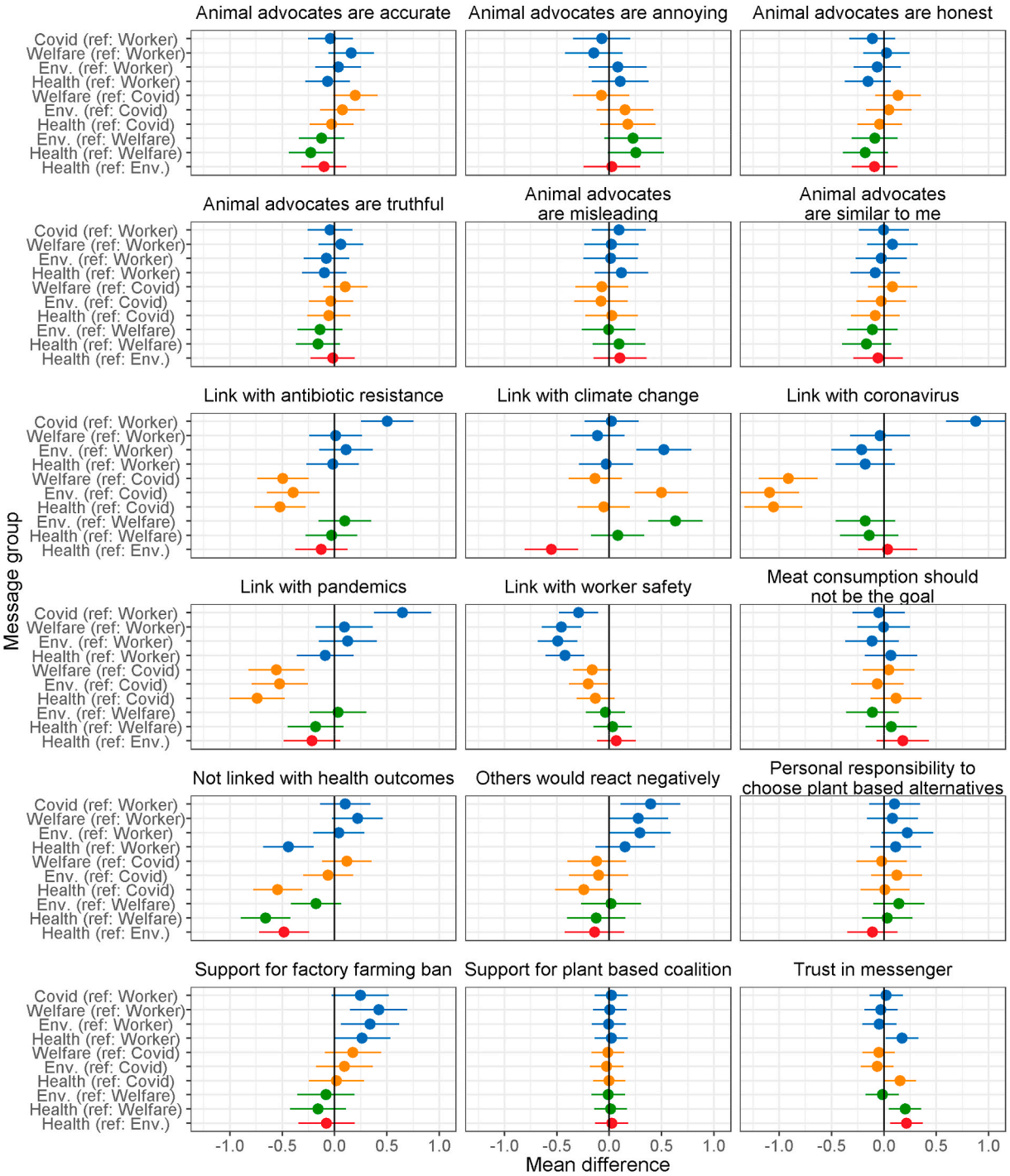


**Fig. 2.** Mean difference (with 95% confidence intervals; adjusted for covariates) in secondary outcomes (e.g., trust in messenger, beliefs about outcomes of meat consumption, support for factory farm ban and coalition working to promote plant based alternatives; measured on 5–7 point scales), between message conditions ("ref:" refers to the reference level that the message is being compared to).

than individuals who received any other message (Fig. 2; COVID/pandemic vs environment message adjusted analysis estimate = 1.091, p-value = .000; COVID/pandemic vs personal health message adjusted analysis estimate = 1.055, p-value = .000; COVID/pandemic vs animal welfare message adjusted analysis estimate = 0.914, p = .000; COVID/pandemic vs worker safety message adjusted analysis estimate = 0.878, p = .000). Individuals who received the COVID/pandemic message were also more likely to agree afterwards with the statement that "there is a link between raising animals for food and the risk of global pandemics" than individuals who received any other message (Fig. 2; COVID/pandemic vs environment message adjusted analysis estimate = 0.524, p-value = .000; COVID/pandemic vs personal health message adjusted analysis estimate = 0.739, p-value = .000; COVID/pandemic vs animal welfare message adjusted analysis estimate = 0.558, p = .000; COVID/pandemic vs worker safety message adjusted analysis estimate = 0.650, p = .000). Additionally, individuals who received the COVID/pandemic message were more likely agree afterwards with the statement that "there is a link between raising animals for food and antibiotic resistance" than individuals who received any other message (Fig. 2; COVID/pandemic vs environment message adjusted analysis estimate = 0.395, p-value = .002; COVID/pandemic vs personal health message adjusted analysis estimate = 0.522, p-value = .000; COVID/pandemic vs animal welfare message adjusted analysis estimate = 0.493, p-value = .000; COVID/pandemic vs worker message adjusted analysis estimate = 0.504, p-value = .000).

Individuals who received the environment message were more likely to agree afterwards with the statement "there is a link between raising animals for food and climate change" than individuals who received any other message (Fig. 2; environment vs COVID/pandemic message adjusted analysis estimate = 0.499, p-value = .000; environment vs animal welfare message adjusted analysis estimate = 0.633, p-value = .000; environment vs worker safety message adjusted analysis estimate = 0.522, p-value = .000; environment vs personal health message adjusted analysis estimate = 0.552, p-value = .000). Additionally, individuals who received the personal health message were more likely to disagree afterwards with the statement "plant-based diets are NOT associated with better health outcomes" than individuals who received any other message (Fig. 2; personal health vs worker health message adjusted analysis estimate = 0.440, p-value = .000; personal health vs COVID/pandemic message adjusted analysis estimate = 0.543, p-value = .000; personal health vs animal welfare message adjusted analysis estimate = 0.660, p = .000; personal health vs environment message adjusted analysis estimate = 0.482, p-value = .000). Individuals who received the worker health message were more likely to agree afterwards with the statement "conditions in factory farms and slaughterhouses can threaten worker safety and health" than individuals who received any other message (Fig. 2; worker safety vs covid/pandemic message adjusted analysis estimate = 0.293, p-value = .002; worker safety vs animal welfare message adjusted analysis estimate = 0.456, p-value = .000; worker safety vs environment message adjusted analysis estimate = 0.492, p-value = .000; worker health vs personal health adjusted analysis estimate = 0.423, p-value = .000).

There was some evidence that those who received the worker safety condition were less likely to agree afterwards with the statement that "we should ban factory farming" (Fig. 2; worker safety vs COVID/pandemic message adjusted analysis estimate = −0.246, p-value = .077; worker safety vs animal welfare message adjusted analysis estimate = −0.422, p-value = .002; worker safety vs environment message adjusted analysis estimate = −0.339, p = .017; worker safety vs personal health adjusted analysis estimate = -0.264, p = .058). There was also some evidence that those who received the worker safety condition were less likely to agree afterwards with the statement that "people I know would react negatively if I were to choose plant-based alternatives to meat more often" than those who received the COVID/pandemic, animal welfare, or environment message (Fig. 2; worker safety vs COVID/pandemic message adjusted analysis estimate = −0.395, p-value = .007; worker safety vs animal welfare message adjusted analysis estimate = −0.277, p-value = .059; worker safety vs environment message adjusted analysis estimate = −0.294, p = .048).

Message condition did not influence people's perceived responsibility to choose plant-based alternatives, their support of a global coalition working to develop a food system more focused on plant-based choices, or their evaluations of activists against factory farming (as honest, annoying, truthful, misleading, accurate, or similar in values to themselves). There were also no significant interaction effects between prior beliefs about COVID-19 and prior attitudes towards plant-based alternatives and the effect of message condition, suggesting that messages did not differently impact these sub-groups.

### 4.4. *Qualitative analysis of message responses and barriers and motivations affecting post-message behavioral intentions*

Qualitative analysis of respondents' reactions to the message revealed that a majority of participants in each message condition described being receptive to (i.e. believing in and being surprised, interested, or concerned by) at least one component of the message they received (60–71%, Tables S–3). In each messaging condition, a quarter to a third of the study participants reported either reacting against the message or being unsurprised by it. Reactance against the message encompassed believing the message information was false or incomplete, disbelief that the behavior change conclusion followed logically from the information provided, or belief that the message was intended to manipulate viewers. Reactance was most common in the COVID/pandemic message (16% of recipients, Tables S–3) and least common in the animal welfare message (6% of recipients, Tables S–3). Lack of surprise at any of the message contents (i.e. the recipient believed they already knew the facts that had been shared in the message they received) was most common in the personal health message and least common in the worker safety condition (18% and 8% respectively, Tables S–3).

Fifty-six barriers and motivations to future behavior were identified in respondents' answers to open-ended post-message questions about their own intended dietary choices and encouragement of others. Of these, 32 were mentioned by 10 or more respondents as factors in their decision to try plant-based meat alternatives in the next month, and 26 were mentioned by 10 or more respondents as factors in their decision to encourage others to try plant-based meat alternatives (Figs. 3 and 4, S-2, S-3).

The most common reasons respondents did not intend to try plant-based foods themselves were perceptions that plant-based alternatives taste bad (n = 266), are expensive (n = 201), and are unhealthy (n = 168; Figs. 3, S-2). Taste concerns were often driven by negative past experiences, while health concerns encompassed a wide range of issues including lack of proteins, allergens, and too much of undesirable ingredients like salt and carbohydrates (Tables S–1). Additionally, many respondents reported that they did not think they needed to change their diet (n = 92), that they enjoyed eating meat (n = 78), and that they needed the nutrients and protein of meat (n = 76), while some also suggested they would rather eat whole plant foods (n = 64) instead of highly processed alternatives (n = 62) that are 'fake' (n = 36).

The most common reasons respondents intended to try plant-based foods themselves in the future were that they believed plant-based foods are healthy (n = 225) and they already were in the habit of eating these foods (n = 126). Many respondents also believed these products taste good (n = 112) or were curious about their taste (n = 68) and believed these products help the environment (n = 94) and animal welfare (n = 77). Thirty-seven percent of respondents provided two or more reasons for their dietary behavioral intentions, as this response captures: "I would want to try the alternatives because first of all they might taste better. Second of all, there's a chance they could be better for me while also helping the environment. The only reason I wouldn't is because pricing may be higher in certain instances or harder to find."

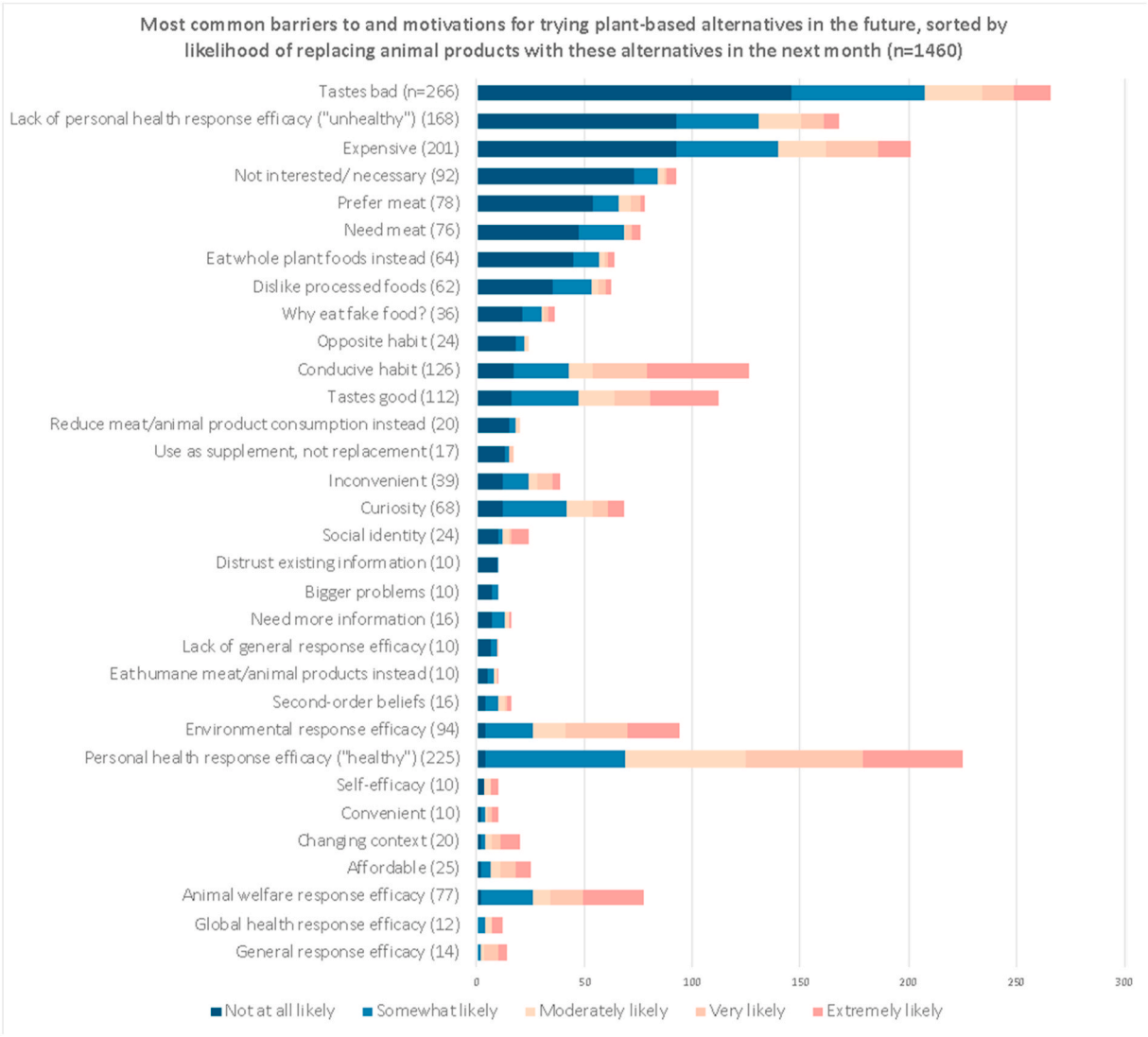


**Fig. 3.** Most common barriers to and motivations for trying plant-based foods, sorted by self-reported likelihood of doing so in the next month, derived from qualitative analysis of open-ended questions.

When it came to their decision to encourage others to try plant-based foods, the vast majority of respondents who did not intend to do this reported being affected by a personal norm against telling others what to do (n = 249) and a concomitant respect for others' personal autonomy and right to make their own choices (n = 207; Figs. 4 and S-3 and Tables S–1). An additional common barrier was second-order beliefs related to meat consumption (n = 109), i.e. perceptions that others like and eat meat. Relatedly, respondents were concerned that others would judge them or react negatively if the respondent sought to persuade them to change (n = 103). They also reported concerns that their encouragement wouldn't work (i.e. lack of social response efficacy; n = 84) and that it would be hypocritical to encourage others to try plant-based alternatives when they themselves don't eat these foods (i.e. moral consistency; n = 76). Respondents who reported that they were at least somewhat likely to encourage others were most commonly motivated by a desire to help others improve their health by eating plant-based foods (n = 201). Less common but still important motivations to reaching out to others were beliefs that it would help the environment (n = 100) or improve animal welfare (n = 54). Twenty-seven percent of respondents provided two or more reasons for their intentions to encourage others. One respondent captured the tension many in this subsection reported between these different motivations and barriers:

"Millions of animals are literally being abuse[d] and tortured everyday. There is no reason why I would not want to encourage everyone to stop eating animal products. Sometimes, it's hard to do it without alienating people, so you just have to hint and praise them for the good stuff they're doing, like switching to oatmilk [sic] and slowly telling them why it's good to keep going."

The qualitative data also provided further evidence for the trend identified in quantitative data that different messaging treatments changed beliefs specific to the messaging condition in question. For all messaging conditions, respondents were most likely to mention response efficacy related to a specific outcome (i.e. animal welfare, personal health, pandemic/public health, worker safety, environment) if they were in the group that received messaging about that outcome (Tables S–4). For instance, people in the personal health messaging condition were the most likely to mention personal health response efficacy as a motivation for future action. This held true for both personal dietary intentions and intentions about encouraging others. Some respondents explicitly reflected on the message's influence on them, as in this response: "I would like to try plant-based alternatives mainly to avoid hurting animals but still enjoying foods that have a similar taste to meat. And after reading that passage on climate change, switching to plants would also make me feel like I'm contributing something in the

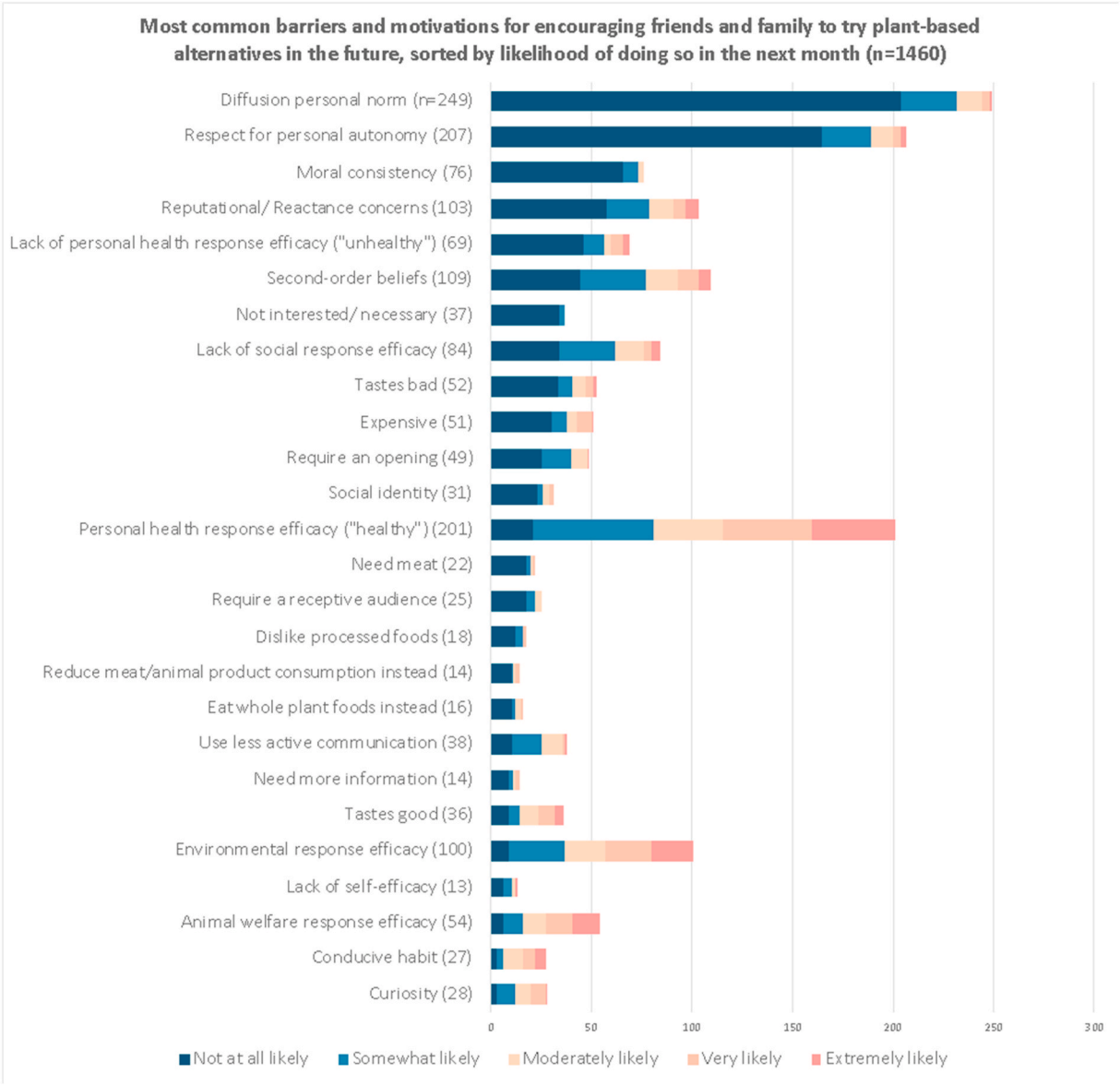


**Fig. 4.** Most common barriers to and motivations for encouraging others to try plant-based foods, sorted by self-reported likelihood of doing so in the next month, derived from qualitative analysis of open-ended questions.

fight against climate change."

## 5. Discussion

We tested the relative impact of five messages on public beliefs and behavioral intentions related to consumption of animal products and plant-based alternatives: environmental, personal health, animal welfare, and messages using the saliency of the COVID-19 pandemic to highlight the link between animal agriculture and pandemic risk and worker safety. We also examined public reactions to messages and additional barriers and motivations to behavior change through qualitative analysis of open-ended survey questions. We found that after adjusting for covariates, such as baseline behavioral intentions related to meat consumption, message framing did not significantly affect participants' intentions to try plant-based alternatives, reduce their meat consumption, or encourage others to try plant-based alternatives compared to other more standard messages. While we did find qualitative evidence for slightly greater reactance in the COVID-19 pandemic message, this did not appear to lead to significant changes in behavioral intentions compared to the other messages. Rather, we found that behavioral intentions were more affected by participants' prior attitudes towards plant-based alternatives, prior intentions to reduce meat consumption, as well as demographics, such as gender, age, and education. We also found no evidence that messages were more or less effective at influencing particular subsections of the target audience with specific prior attitudes towards meat consumption and COVID-19, as has been suggested by the elaboration likelihood model of persuasion and other studies (Niemiec, Sekar, et al., 2020; Petty & Cacioppo, 1986, pp. 1–24).

Our results are contrary to some previous studies that have found that message framing may differentially impact public behaviors and intentions with regard to meat consumption (Cordst et al., 2014; Palomo-Velez et al., 2018). For example, Cordst et al. (2014) found that animal welfare and personal health framing were more effective at reducing meat consumption than climate change or personal image messages. However, other studies suggest that different message framing may have similar effects on dietary choices (Carfora et al., 2019; Wolstenholme et al., 2020) or that one-off messages may have no effects at all (Campbell-Arvai et al., 2014).

While we did not find that message framing differentially influenced behavioral intentions, we did find that each message influenced

different beliefs related to the negative outcomes of meat consumption. For example, the message using the saliency of the COVID-19 crisis to highlight the link between animal agriculture and public health risks was effective at increasing beliefs that raising animals for food is linked with the risk of global pandemics and antibiotic resistance. The environment message increased beliefs that there is a link between raising animals for food and climate change, while the personal health message enhanced the belief that there is a link between personal health and meat consumption. These quantitative trends were confirmed by our qualitative analysis. These results indicate that indeed, participants were updating their beliefs based on the messages, at least temporarily. However, these updated beliefs did not lead to differential changes in behavioral intentions.

A limitation of our experiment was that we did not include a true control (i.e. no message) condition; thus, it is possible that the altered beliefs were equally effective across messaging conditions at increasing behavioral intentions. However, given past research suggesting that people typically find some arguments more persuasive than others (Myers et al., 2012; van der Linden et al., 2015), we believe it is more likely that the updated beliefs were insufficient for achieving changes in behavioral intentions across messaging conditions. This would support previous studies suggesting that there are often many other salient attitudes, beliefs, and social, economic, and structural barriers influencing behavior, which can create an "attitude-action gap" (Kollmuss & Agyeman, 2002; Nilsson et al., 2020): in this study alone, our qualitative analysis found as many as 56 barriers and motivations in respondents' short answers, including taste, cost, social factors, and habits. Achieving behavior change will thus likely require developing multi-pronged interventions that simultaneously address these interconnected barriers and build on diverse motivations. Indeed, recent studies suggest that to address these complexities, informational messages may have to be combined with more intensive interventions such as defaults, daily text reminders, goal setting, and self-monitoring to effectively reduce meat consumption (Amiot et al., 2018; Campbell-Arvai et al., 2014; Carfora et al., 2017).

We found in qualitative survey responses that the most commonly reported barriers to encouraging others to eat plant-based foods were social perceptions, which were among the most infrequently mentioned barriers to personal dietary change. These included the beliefs that reaching out to others threatens others' autonomy, that most others have positive attitudes towards meat and negative attitudes towards vegans or vegetarians, and that others would react negatively to encouragement to try plant-based alternatives. These results suggest that different outreach interventions may be required for motivating persuasive, outward-facing action compared to personal, private action (Jones & Niemiec, 2020). Indeed, recent studies suggest that interventions designed to change social perceptions may be critical for motivating people to reach out to others about environmental issues such as climate change (Geiger & Swim, 2016).

We did find evidence to suggest that participants were more likely to trust the messenger when they were delivered a message that highlighted the personal health benefits of reducing meat consumption. Trust refers to one's intention to accept vulnerability based upon positive expectations of the intentions or behaviors of another (p. 395; Rousseau et al., 1998). Public trust in an organization is often influenced by perceptions of whether that organization shares similar values with the public (Vaske et al., 2007) and has been found to influence public behavior and levels of support for a variety of public policies (Smith & Mayer, 2018; Vaske et al., 2007). Our findings suggest that the personal health framing may be a way for groups advocating for reductions in consumption of animal products to build public trust, perhaps because personal health is a shared value the majority of people have. The different message conditions did not seem to affect participants' beliefs about activists against factory farming more generally, however. This may be because the messages were framed as being "crafted from recent news articles and scientific papers." Participants may therefore not have linked the message they received with messages currently being crafted by activists against factory farming.

Our findings regarding the importance of the personal health message was further confirmed by the high salience of personal health concerns in respondents' open-ended answers. Specifically, participants discussed how personal health concerns guided both their own dietary behavioral intentions and their intentions to encourage others to increase plant-based food consumption. These findings also support prior studies, which have found that public health frames may be particularly effective at motivating support for climate change action (Myers et al., 2012) and reducing meat consumption (Fehrenback 2015; Cordts et al., 2014).

We found some preliminary evidence to suggest that the message highlighting the threats to slaughterhouse worker health led to less support of a factory farm ban, but greater perceptions of supportive social norms around reducing meat consumption. These results, however, should only be interpreted as preliminary evidence, as many of the effect sizes were only marginally significant. It is possible that individuals who read the worker health message believed that others would support them reducing their meat consumption due to concerns about worker health. This may be because boycotting certain products due to worker conditions is becoming an increasingly normative practice (Paek & Nelson, 2009). However, these same individuals may not have believed banning the entire industry of factory farming was the correct way to address exploitative worker conditions. Rather, participants may have thought more regulations ensuring worker safety would be a more appropriate response. For instance, several respondents expressed concern in their qualitative answers about the lost jobs and livelihoods that might come from banning meat. Overall, our results highlight the need for future studies examining the link between messages about worker exploitation and behavioral intentions.

There are several additional limitations to our study that should be considered in the interpretation of our results. First, we only measured behavioral intentions, rather than actual behavior. While intentions are strongly correlated with behavior, there are often additional barriers preventing behavior change even among those with strong intentions (Grimmer et al., 2017). Second, each of our messages included multiple arguments, citations, and statistics; it is unclear which aspects of the messages may have been more or less motivating to respondents. Additionally, we did not control for gain or loss frames in our messages; some messages, such as the COVID and worker health framing, discussed reducing meat consumption to prevent potential societal losses, while other messages, such as the personal health framing, discussed gains from reduced meat consumption. Prior studies suggest that framing issues in terms of certain gains may be more effective at increasing public support for climate change action (Spence & Pidgeon, 2010; van der Linden et al., 2015) and motivating certain public health behaviors (O'Keefe and Jensen 2007) compared to focusing on potentially uncertain losses. Future studies are needed on the impact of gain versus loss framing on meat consumption.

Furthermore, in our experiment, we did not specify a messenger, and instead said that the message was crafted based on recent news articles and scientific papers. While this allowed us to examine the impact of the message regardless of the messenger, in reality, the message may be interpreted differently if delivered by NGOs, advocacy groups, scientists, or other opinion leaders (Nisbet & Kotcher, 2009). Future studies could follow up on ours by examining whether the choice of messenger interacts with the message framing in influencing public opinion and behavior. It is possible that reactance may be higher if the message is delivered by advocacy groups that are seen as extreme by the general public. Future studies could also examine how the call to action at the end of messages impacts behaviors. In the present study, we included a statement in all messages that emphasized respondents' ascription of responsibility in order to leverage personal (i.e. moral) norms (Carfora et al., 2020; Niemiec, Champine, et al., 2020); however, it is possible that such a strong statement advocating for action may have contributed

to reactance among participants (Reynolds-Tylus, 2019) or may not have been effective for individuals with little intrinsic motivation to reduce consumption of animal products. Future research is needed on the effectiveness of personal norms messaging on public attitudes and behaviors related to meat consumption.

Overall, our study provides evidence that different message framing, including messages that harness the saliency of the COVID-19 crisis, can alter beliefs about the negative consequences of meat consumption. However, these altered beliefs did not lead to different intentions to reduce meat consumption across message conditions, possibly due to the variety of other barriers identified in qualitative responses, such as cost, taste, and social factors. We did find evidence that messages that highlight the personal health benefits of reduced meat consumption may be more effective at increasing public trust in the organizations or individuals delivering these messages. Personal health concerns were often brought up in qualitative responses as both barriers and motivations to behavior change. Our results therefore suggest that organizations seeking to reduce meat consumption may potentially be most effective by highlighting personal public health benefits in messaging and implementing more intensive behavior change programs that address additional barriers and motivations to reducing meat consumption (e.g., see Harguess et al., 2020 for examples). Overall, our work demonstrates the importance of continued research to better understand how societies can move towards more sustainable food systems in the face of urgent and intertwined global crises.

## Author contribution

RMN and CD developed the idea for the study and experimental protocol and RMN collected data and led the writing of the paper. MSJ conducted qualitative analysis and ANM conducted quantitative analysis. CD and MSJ contributed to writing the first draft of the paper and all authors reviewed the paper and edited it for clarity.

## Declaration of competing interest

None.

## Acknowledgements

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. Declarations of interest: none. RMN has full access to the data reported in the manuscript; data and code available upon request.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.appet.2021.105293.

## Ethics statement

This study obtained ethics approval from Colorado State University's institutional review board (Protocol #20–10317H). All participants gave informed consent before taking part in this study.

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