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Eating to save the planet: Evidence from a randomized controlled trial using individual-level food purchase data

Andrew J. Jalil[a,*], Joshua Tasoff[b], Arturo Vargas Bustamante[c]

[a] Economics Department, Occidental College, 1600 Campus Road, Los Angeles, CA 90041, United States
[b] Economic Sciences, Claremont Graduate University, Harper E. 204, 160 E. Tenth Street, Claremont, CA 91711, United States
[c] Health Policy and Management, Fielding School of Public Health, University of California, Los Angeles, 650 Charles E. Young Drive South, Los Angeles, CA 90095, United States

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ABSTRACT

Meat consumption is a major driver of climate change. Interventions that reduce meat consumption may improve public health and promote environmental sustainability. We conducted a randomized controlled trial to examine the effects of an awareness-raising intervention on meat consumption. We randomized undergraduate classes into treatment and control groups. Treatment groups received a 50-minute lecture on how food choices affect climate change, along with information about the health benefits of reduced meat consumption. Control classrooms received a lecture on a placebo topic. We analyzed 49,301 students' meal purchases in the college dining halls before and after the intervention. We merged food purchase data with survey data to study heterogeneous treatment effects and disentangle mechanisms. Participants in the treatment group reduced their purchases of meat and increased their purchases of plant-based alternatives after the intervention. The probability of purchasing a meat-based meal fell by 4.6 percentage points ($p < 0.01$), whereas the probability of purchasing a plant-based meal increased by 4.2 percentage points ($p = 0.04$). While the effects were stronger during the semester of the intervention, dietary shifts persisted and remained statistically significant through the full academic year. Our study provides evidence that an intervention based on informing consumers and encouraging voluntary shifts can effectively reduce the demand for meat. Our findings help to inform the international food policy debate on how to counter rising global levels of meat consumption to achieve climate change goals. To our knowledge, our study is the first to assess the effectiveness of an educational intervention to reduce meat consumption using such high-quality data (i.e. individual-level food purchases) over a prolonged period.

1. Introduction

Meat consumption is a major cause of climate change, resulting in roughly 15% of all anthropogenic greenhouse gas (GHG) emissions (Bailey et al., 2014; Gerber et al. 2013; Godfray et al. 2018; Wellesley et al., 2015b). A host of international organizations have warned that the current scale of meat production is unsustainable and have advocated for shifts toward healthier, plant-based diets to achieve climate change goals (Intergovernmental Panel on Climate Change, 2020; Schiermeier, 2019; Springmann et al., 2016; Springmann et al., 2018; Tilman and Clark, 2014). Plants are vastly more efficient than meat, resulting in anywhere from 2 to 167 times less $C0_2$ equivalents per gram of protein produced (Poore and Nemecek, 2018). In addition, excessive levels of meat consumption, as seen in the developed world, are strongly linked to rising rates of non-communicable diseases (NCDs), such as obesity, heart disease, type-2 diabetes, and some cancers (Godfray et al., 2018; Wellesley et al., 2015b). A recent report from the EAT-Lancet commission, which establishes scientific targets for a global food system capable of supplying healthy and sustainable diets to 10 billion people by 2050, concludes that consumption of plants will need to increase by more than 100%, whereas consumption of meat, in particular red meat, will need to fall by more than 50%. The report also concludes that such a dietary shift would substantially reduce the incidence of chronic diseases and mortality, reflecting a win-win situation for both the environment and public health (Willett et al., 2019). However, projections based on current dietary trends indicate that global meat consumption is likely to double by midcentury, relative to 2005 levels, due to population growth and rising incomes in the developing world (Tilman et al., 2011).

The urgency of the climate crisis has prompted a call for increased

* Corresponding author.
E-mail addresses: jalil@oxy.edu (A.J. Jalil), Joshua.Tasoff@cgu.edu (J. Tasoff), avb@ucla.edu (A.V. Bustamante).

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research on interventions to reduce meat consumption and promote plant-based alternatives (Garnett, 2014; Hunter and Röös, 2016; Macdiarmid et al., 2016). A growing literature on 'green' nudges proposes ways of shifting consumers toward more sustainable lifestyles (Evans et al., 2017; Farrow et al., 2017; Schubert, 2017). However, little direct evidence exists on the effectiveness of interventions to decrease the demand for meat (Bianchi et al., 2018b,a). Some studies rely on non-randomized designs, limiting causal inferences. In addition, measuring behavioral change is difficult since acquiring high-quality outcome data, such as individual-level food purchases, is expensive and time consuming. Most existing research has relied on self-reported outcomes, gathered via surveys, food diaries, or selections in virtual settings to gauge the response of consumers—yet, such measures may provide inaccurate indicators of actual behavior due to recall bias and an inclination among study participants to offer socially desirable responses (Freedman et al., 2014; Hebert et al., 1995, 1997; Natarajan et al., 2010; Schoeller, 1995; Schoeller et al., 2013; Subar et al., 2015). A recent systematic review of the literature concludes that informational interventions (e.g. those providing information on health, environmental, or animal welfare considerations) are associated with reduced intentions to consume meat, but weak outcome measures (e.g. selections in virtual settings, self-reported data) preclude analyses on whether such intentions translate into actual behavioral change (Bianchi et al., 2018a).

In this study, we conduct a randomized controlled trial (RCT) to examine the effects of an awareness-raising intervention on meat consumption using individual-level food purchase data. We overcome data limitations of prior research by analyzing tens of thousands of food purchases made by study participants—undergraduate students at a U.S. residential college. Such individual-level data are rare. The setup at most colleges and universities preclude the collection of this type of data either because dining facilities are structured as a buffet, where it is not possible to track individual-level purchases, or because food services are outsourced to outside vendors. By contrast, the college where we have acquired data collects itemized purchases for all students with a meal plan, permitting us to identify study participants' individual food choices. Our dataset amounts to nearly 50,000 meal purchases over the course of a full academic year. To our knowledge, our study is the first to assess the effectiveness of an educational intervention to reduce meat consumption using individual-level food purchase data over a prolonged period.

Our study contributes to the international food policy debate on how to reduce meat consumption to achieve climate change goals. The EAT-Lancet Commission encourages policymakers to consider both soft and hard policy interventions to guide consumers toward more sustainable food choices (Willett et al., 2019). Soft interventions, such as education, advice, information, and labeling, do not restrict choice, whereas hard interventions, such as laws, fiscal measures, trade reconfigurations, or other structural changes, alter conditions in ways that are more intrusive. The Commission notes that policymakers may be inclined to start with soft interventions since such interventions may be less challenging to implement. Yet, little evidence is known on whether such interventions are effective, in the context of meat reduction. Because our study examines the effects of an educational intervention on actual food purchase behavior, our findings are arguably more reliable and relevant for policymakers than studies that assess dietary shifts based on self-reported outcomes since such measures may not correlate with actual behavioral changes due to social desirability or recall bias.

By conducting our awareness-raising intervention in a supportive college environment, we exploit a chief strength in the design of our intervention. A growing body of research in the literature, mostly focused on interventions to nudge consumers toward healthier diets, conjectures that success may depend critically on the choice architecture (Bailey and Harper, 2015). Many studies that find little-to-no dietary changes in response to education-based interventions hypothesize that an unsupportive environment—one that lacks convenient and affordable healthy food options—may present a barrier to eliciting behavioral change. By contrast, we are able to examine the effects of an education-based intervention on dietary change in a supportive environment because our study occurs in a setting with healthy and easily accessible alternatives. Our research design allows us to assess the effects of an informational intervention when the choice architecture is favorable, helping to inform the international food policy debate.

2. Methods

2.1. Control and treatment groups

We randomized ten undergraduate economics classes into treatment and control groups. The ten economics classes include core courses that must be taken sequentially (i.e. students cannot enroll in more than one of these classes in a semester), ensuring no overlap in student enrollment between treatment and control groups. Treatment classrooms received the intervention: a 50-minute lecture about how food choices affect climate change, along with information on the health benefits of reduced meat consumption. Control classrooms provide us with a comparison group not exposed to the intervention. Control classrooms received a lecture on a placebo topic (economic inequality), given the preference of the host college in keeping equal the number of days of course content between control and treatment classes. The same individual delivered the lectures for both the control and treatment groups. The lectures occurred in the middle of the fall semester, i.e. mid-October. We analyzed students' meal purchases in the college dining halls both before and after the lecture. The timeframe of the study spans twenty-six weeks (six weeks in the fall semester before the intervention, seven weeks in the fall after the intervention, and thirteen weeks in the spring semester).

2.2. Data

We track students' food purchases over the course of an eight-month academic year, amounting to nearly 50,000 meals. Food outcome data come from the cashier registers at the campus dining facilities. All students who live on campus (more than 80% of the student population) are required to have a meal plan, and most students who live off campus also possess a meal plan. Students purchase food at the dining facilities using their meal plan. At the point of purchase, cashiers swipe student ID cards and select one of four buttons that record the type of main entrée: beef, poultry, fish, and veg. Vegetarian and vegan meals, i.e. the "veg" option, are available, alongside meat-based meals, at every food station, providing students with a choice between a plant-based and a meat-based option. Meals are a la carte, as opposed to buffet, permitting us to identify participants' food choices. The prices of the meat and veg-based options at each food station are usually equal. At four of the five food stations, the prices are equal at $2.50 per meal on average; at the fifth station, the price of a meat-based meal is $4.00, compared to $2.50 for a plant-based meal. Prices were held constant pre versus post intervention. The dining facilities are the only locations where students may purchase meals on campus.

Survey data come from three surveys. Study participants in both the treatment and control group completed the first survey, which collects demographic characteristics and views about global warming, prior to the lectures. The second and third surveys, which ask study participants about their response to the intervention, were given only to those study participants who witnessed the intervention, i.e. those participants in the treatment group. The second survey, administered immediately after the intervention, asks whether participants perceived the information in the intervention as new, and the third survey, administered four weeks after the intervention, asks whether participants changed their diet, along with reasons.

Consent forms to students disclosed that participation involved three components: listening to a lecture, completing surveys, and authorizing the researchers to analyze data from student ID cards. Students were not made explicitly aware that we would be analyzing their food purchase data. Nearly all students present (more than 99%) consented to participate in the study. The Institutional Review Board of the host college approved the research design.

2.3. Intervention

We conducted a soft "awareness-raising" intervention rather than a hard intervention that involves more intrusive measures, in part, because soft interventions, particularly those that focus on education, are likely a necessary first step in the sphere of public policy. Governments and other organizations are unlikely to adopt hard interventions without broad public support, which in turn will likely require substantial public awareness about the climate and health consequences of meat overconsumption (Willett et al., 2019).

We designed the intervention based on the findings from two recent Chatham House reports (Bailey et al., 2014; Wellesley et al., 2015a). Chatham House conducted a study in a diverse set of countries (Brazil, China, France, Germany, India, Italy, Japan, Poland, Russia, South Africa, the UK, and the US) and concluded that (1) public awareness about the role of livestock in climate change is low, and (2) messages that emphasize co-benefits of reduced meat consumption (e.g. environmental and health) are more likely to elicit behavioral change than singular messages. Across countries, Chatham House observed that some participants considered meat to be an essential component of a healthy diet and alternative sources of protein to be inadequate—misconceptions that likely need to be addressed before initiating behavioral change. The EAT-Lancet Commission adopts a similar messaging strategy, emphasizing diets that are both healthy and environmentally sustainable.

For these reasons, our intervention centers on the dual climate-health benefits of reduced meat consumption, in favor of plant-based food options. We pretested and validated the intervention among a group of college students. The intervention, including time spent completing surveys, is roughly 55 min.

We focus the first 25 min of the intervention on the role of meat consumption as a driver of climate change. We note that more GHG emissions originate from livestock than from the global transportation sector. We stress three primary reasons: (1) ruminant animals produce methane as a byproduct of the digestive process; (2) the raising of livestock generates nitrous oxide via manure and nitrogen-based fertilizers used in the cultivation of animal feed; and (3) deforestation to clear land to graze livestock and grow feed releases carbon dioxide, both directly when forests are cut down and indirectly since leveled forests can no longer reabsorb emissions from the atmosphere. We emphasize that the production of meat requires far more resources (land and water) than plant-based alternatives, such as legumes (beans, lentils, peas), and that the GHGs associated with the production of meat from ruminants (cattle, lamb, goat, sheep) are substantially higher than those from non-ruminants (poultry, seafood) (Clune et al., 2017; Poore and Nemecek, 2018).

We then pivot to discuss the health benefits of reduced meat consumption for 20 min. This portion of the intervention conveys two main messages: (1) While meat contains valuable nutrients, it is not necessary to eat meat if consumers have access to a diversified portfolio of plant-based foods; and (2) the consumption of meat, in particular processed and red meat, is linked to rising rates of non-communicable diseases (Katz and Meller, 2014; Melina et al., 2016). We emphasize that in Western countries, dietary misconceptions surrounding meat consumption abound and that average levels of meat consumption far exceed healthy thresholds, e.g. in the case of the United States, by a factor of three (Wellesley et al., 2015a).

We conclude our intervention by (1) reiterating the main message, i.e. meat consumption is a major driver of climate change and contributes to rising rates of non-communicable diseases in Western countries, and (2) encouraging students to opt for plant-based options. Lastly, we provide students with a handout, containing resources, along with a list of plant-based food options at the dining facilities on campus. A more detailed description of the intervention, along with a figure that depicts the flow of the intervention, is in the appendix.

2.4. Measures

We report four food outcome variables: beef, poultry + fish, meat, and veg. Beef, poultry + fish, and veg denote meals whose main entree was recorded as beef, poultry or fish, and vegetarian or vegan, respectively. The "meat" variable is the sum of beef and poultry + fish, providing an estimate for overall meat consumption. At every food station, the vegetarian or vegan option usually has the same sides as the meat option; where they differ is the main entree, which is typically a legume (beans or lentils) or meat substitute (e.g. soy-based product or tofu) for the veg option and beef, poultry or seafood for the meat option. The intervention emphasizes the high GHGs associated with beef and the low GHGs associated with plant-based sources of protein, such as legumes. The intervention lumps poultry and fish, which have comparable contributions to GHG emissions per gram of protein, together under the category of "medium GHG emissions", apart from beef ("high GHG emissions") and plants ("low GHG emissions"). Since the educational intervention classifies beef, poultry + fish, and veg into these "high", "medium", and "low" categories, we carry over these categories to our statistical analysis. We measure the frequency of each of these variables.

We restrict our data analysis to meals where we are able to distinguish between the meat and veg-based option: lunch on weekdays and dinner on Mondays-Thursdays. Meals over the weekend and dinner on Friday are buffet, rather than a la carte. Cashiers do not distinguish between meat and non-meat options at breakfast. In addition, we only include food purchases that represent main courses and omit other purchases, such as snacks. Because the cashiers' registers contain four buttons—beef, poultry, fish, and veg—the cashiers record lamb and pork entrees as beef. While we are unable to identify which food transactions were beef, as opposed to lamb or pork, the vast majority are beef. The campus dining facilities offer beef entrees daily, with lamb and pork available on an irregular basis.

We include gender and minority status for analysis of heterogeneous effects. Survey research on meat consumption indicates that consumption varies by gender and race (Gossard and York, 2003). Other research indicates gender-related barriers, i.e. associations between meat and masculinity, that make men less willing to reduce their meat consumption (Ruby and Heine, 2011). But so far, we lack clear evidence on whether such a gender difference exists in response to policy interventions. We look at minority status to address population heterogeneity (socioeconomic and demographic) between white and non-white students, and other unobserved differences (e.g. cultural factors that influence food choices, community norms and peer effects).

We construct a variable "Climate Care" from four survey questions that measure participants' views on climate change before the guest talks: 1) In your view, how important is it that the government takes actions to address global warming?; 2) In your view, how important is it that people take individual actions to reduce their personal contribution to global warming?; 3) How willing are you to make lifestyle changes to reduce your contribution to global warming?; and 4) Do you believe you have a clear understanding of the specific actions you can take to reduce your contribution to global warming? Responses to each question are recorded on a 5-point Likert scale. We conduct factor analysis to reduce the dimensionality of the survey questions. We define the variable "Climate Care" as the principal factor.

We construct four additional variables from surveys provided to the treatment group: "New Info", "Taught", "Persuaded," and "Motivated". These variables ask participants how they responded to the intervention. The variable “New Info” measures the degree to which study participants perceived the information as new, in a survey immediately after the intervention. We construct this variable as the average of a standardized 5-point Likert response to two survey questions: 1) How much of the material from the presentation on climate change did you already know?; 2) How much of the material from the presentation on health did you already know? The other three variables come from a survey one month after the intervention, which asked participants to circle all reasons that apply (if any): I tried to reduce my consumption of animal products because the presentation (a) *taught* me about the link between animal products and climate change/health, (b) *persuaded* me that it is important to reduce consumption of animal products, or (c) increased my *motivation* to make a change. The three variables—“Taught”, “Persuaded”, and “Motivated”—are indicator variables that equal 1 for study participants who selected (a), (b), and (c), respectively.

2.5. Analyses

We first describe the sample characteristics. A comparison of means examines the balance between the treatment and control groups. To estimate the average treatment effects of the intervention, we use a difference-in-difference framework. Specifically, we estimate the following logit regression:

$$F_{m,i,d,h} = \alpha + \beta_0 T_m + \beta_1 A_m + \beta_2 T_m A_m + \rho_i + \gamma_d + \delta_h + \varepsilon_{m,i,d,h}$$

where F is one of four food indicator variables that equals one if the meal purchase, *m*, belongs to that category (beef, poultry + fish, meat, or veg) for individual *i,* on day *d*, at hour *h.* T_m is an indicator variable for meals purchased by an individual in the treatment group, and A_m is an indicator variable for meals purchased after the intervention. The key variable of interest is the interaction term, T_m*A_m, which measures the effect on the food outcome variable of being in the treatment group, relative to the control group, after the intervention. The interaction term provides an estimate of the effectiveness of the intervention in shifting participants' food choices. We control for individual (ρ_i), date (γ_d), and hour (δ_h) fixed effects.

In our sensitivity analysis, we examine the persistence of dietary changes by disaggregating the results into the fall and spring semesters. We construct cumulative probability distribution functions of individual-level dietary changes and measure heterogenous treatment effects by gender and minority status. We provide evidence on mechanisms driving changes in food choices by merging survey data with our regression analysis.

3. Results

3.1. Sample characteristics

Table 1 shows demographic characteristics for the five classes randomized to the control and the five to the treatment group. The sample size is 215 students (113 in the control and 102 in the treatment). The notes to Table 1 describe how we classify individuals. The gender, racial, and age composition of the treatment and control groups is similar.

Table 2 displays summary statistics for food purchase behavior before the intervention. The control and treatment groups are similar prior to the intervention, with meat consumption being slightly lower and veg consumption slightly higher in the treatment group at the outset. In both groups, the consumption of meat-based meals is roughly three times as large as the consumption of veg-based meals. The number of meals in the pre-intervention period is 12,557. The sum of the beef, poultry + fish, and veg variables in Table 2 is less than one since we omit a category: “salad bar”. We do not explicitly analyze salad bar purchases since meat options are available at the salad bar, and the cashiers do not distinguish between salads with and without meat.

Table 1
Treatment and Control Characteristics.

	Means		
Variable	Control	Treatment	p-value
Female	0.354	0.431	0.319
	(0.480)	(0.498)	
Nonwhite	0.425	0.373	0.493
	(0.497)	(0.486)	
Age	19.1	19.1	0.859
	(1.55)	(1.25)	
# students	113	102	

Notes: The table reports the share of students who are female and nonwhite and the average age of participants. Nonwhite includes students who self-identified as American Indian or Alaska Native, Asian, Black or African American, Native Hawaiian or Other Pacific Islander, or as of Hispanic or Latino origin. Standard deviations are in parentheses. The last column displays the p-value for a test of equality of means between the control and treatment groups.

Table 2
Summary Statistics: Frequency of a Given Meal Type Before Intervention.

	Means		
Variable	Pre-Intervention Control	Pre-Intervention Treatment	p-value
Beef	0.190	0.166	0.095
	(0.392)	(0.372)	
Poultry + Fish	0.464	0.422	0.128
	(0.499)	(0.494)	
Meat	0.653	0.588	0.096
	(0.476)	(0.492)	
Veg	0.187	0.211	0.506
	(0.390)	(0.408)	
# meals	6,559	5,998	

Notes: The table reports the frequency, by food category, before the intervention. The “meat” variable aggregates beef, poultry, and fish, providing an estimate for overall meat consumption. Standard deviations are in parentheses. The last column displays the p-value for a test of equality of means between the control and treatment groups.

3.2. RCT results

Fig. 1 summarizes the main findings. Panels A and B show the frequency that an entrée is meat or veg for the control and treatment groups. The dots denote averages within time bins. The intervention occurs in mid-October denoted by the vertical dashed lines. We include trend lines before and after the intervention.

In Panel A, the frequency of a meat-based meal is lower in the treatment group initially. After the intervention, the frequency of meat consumption in the treatment group experiences a large and immediate decline. In contrast, the frequency of meat consumption in the control group experiences no immediate change. For the control group, the frequency of meat consumption persists at roughly the same level for the remainder of the year, with a small upward trend. For the treatment group, the decline in meat consumption remains through the end of the fall semester (i.e. mid-December). After the winter break (i.e. mid-January), the frequency of meat entrees increases slightly, although it remains lower, on average, compared to the pre-intervention period.

In Panel B, the frequency of a veg purchase is slightly higher in the treatment group, initially. After the intervention, the frequency of veg experiences a discontinuous increase for the treatment group, with no corresponding change for the control group. The increase in veg for the treatment group persists through the academic year, with no apparent reversal over time. Together, the results from Panels A and B show that after the intervention, study participants in the treatment group replaced meat-based meals with veg-based meals, with no commensurate dietary shifts in the control group.

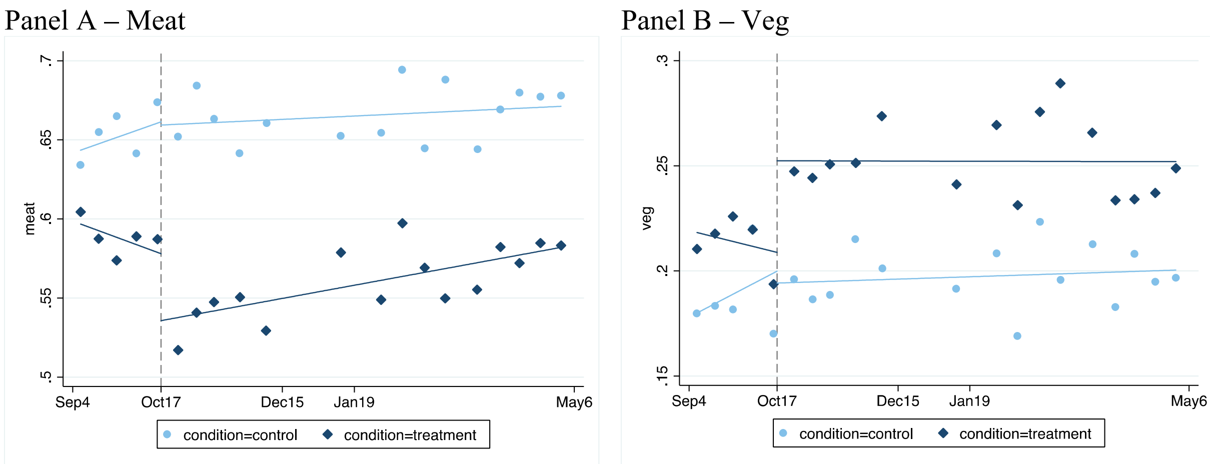

Fig. 1. Frequency of Meat and Veg Consumption. Notes: The figure shows the frequency that an entrée is meat or veg. The dots denote averages within time bins. The intervention occurs in mid-October, denoted by the vertical dashed lines. The figures include trend lines before and after the intervention.

3.3. *Average treatment effects*

Table 3 shows the average treatment effects. Columns 1–3 show that after the intervention, the frequency of beef, poultry + fish, and meat fell in the treatment group, relative to the control group, by 2.3, 2.5, and 4.6 percentage points, respectively. By contrast, the frequency of veg increased by 4.2 percentage points. All changes are statistically significant.

Table 4 disaggregates the results into the fall (Sep-Dec) and spring (Jan-May) semesters to investigate the persistence of the effects. While the pre-intervention period is the same, the regressions for the fall and spring semesters restrict the post-intervention period to the fall and spring semesters, respectively. In the fall semester, the frequency of beef, poultry + fish, and meat fell by 3.3, 3.2, and 6.1 percentage points respectively, whereas veg increased by 3.7 percentage points after the intervention. In the spring semester, the frequency of beef, poultry + fish, and meat fell by 1.1, 2.6, and 3.5 percentage points respectively, whereas veg increased by 4.5 percentage points. The signs of all coefficients are the same in the spring semester as those in the fall, and three of the four coefficients—those for poultry + fish, meat, and veg—remain statistically significant, suggesting that effects persisted through the spring semester, months after the intervention.

The baseline logit results cluster standard errors at the class level, the unit of randomization. As a robustness check, we employ four alternative approaches for clustering standard errors, recommended for regressions with fewer than 40 clusters (Conley and Taber, 2011; MacKinnon and Webb, 2017, 2018). We use the boottest package in

Table 3
Logit Average Marginal Treatment Effects: Both Semesters.

	Both Semesters			
	(1) Beef	(2) Poultry + Fish	(3) Meat	(4) Veg
Treated	−0.023*	−0.025**	−0.046***	0.042**
	(0.013)	(0.010)	(0.016)	(0.020)
Mean DV	0.165	0.450	0.615	0.219
Pseudo R2	0.111	0.100	0.149	0.145
# meals	49,293	49,293	49,289	49,221

Notes: The coefficients measure the average marginal treatment effects. The "meat" variable aggregates beef, poultry, and fish, providing an estimate for overall meat consumption. Standard errors are clustered at the unit of randomization, the class level. Mean DV: mean of the dependent variable. All columns control for individual, date, and hour fixed effects. *p < 0.1; **p < 0.05; ***p < 0.01

Table 4
Logit Average Marginal Treatment Effects: By Semester.

	(1) Beef	(2) Poultry + Fish	(3) Meat	(4) Veg
Fall				
Treated	−0.033***	−0.032***	−0.061***	0.037*
	(0.012)	(0.011)	(0.017)	(0.021)
Mean DV	0.168	0.442	0.610	0.213
Pseudo R2	0.118	0.095	0.143	0.142
# meals	25,328	25,505	25,499	25,442
Spring				
Treated	−0.011	−0.026**	−0.035**	0.045**
	(0.014)	(0.012)	(0.017)	(0.022)
Mean DV	0.167	0.454	0.621	0.216
Pseudo R2	0.109	0.103	0.152	0.152
# meals	36,035	36,344	36,344	36,295

Notes: The coefficients measure the average marginal treatment effects. Standard errors are clustered at the unit of randomization, the class level. Mean DV: mean of the dependent variable. All columns control for individual, date, and hour fixed effects. *p < 0.1; **p < 0.05; ***p < 0.01

Stata to estimate p-values from linear probability models using wild-bootstrapped clusters by class and again by class-individual (Roodman et al., 2019). We also estimate models allowing for heterogenous treatment effects by class using both logit and linear probability models, clustering standard errors at the class level. None of the results substantively change (see Table A.1 in the appendix). For example, for the treatment effect on meat consumption over both semesters (Table 3, Col 3), the p-values are 0.027, 0.028, < 0.001, and 0.002 using these alternative approaches.

3.4. *Treatment effects distribution*

To investigate whether some individuals responded more than others, Fig. 2 shows the cumulative distribution functions for individual-level changes in meat (Panel A) and veg (Panel B) frequency. In Panel A, the distribution for the treatment group is consistently to the left of the distribution for the control group, revealing reductions in meat consumption in the treatment group, relative to the control group, at virtually all points in the distribution. In Panel B, the distributions are flipped, with the treatment group consistently to the right of the control group. The figures show that roughly 75% of participants in the treatment group reduced their consumption of meat and increased their consumption of veg, relative to the control group, after the intervention. The gaps between the two distributions increase moving toward the tails, revealing small changes for some, moderate changes for

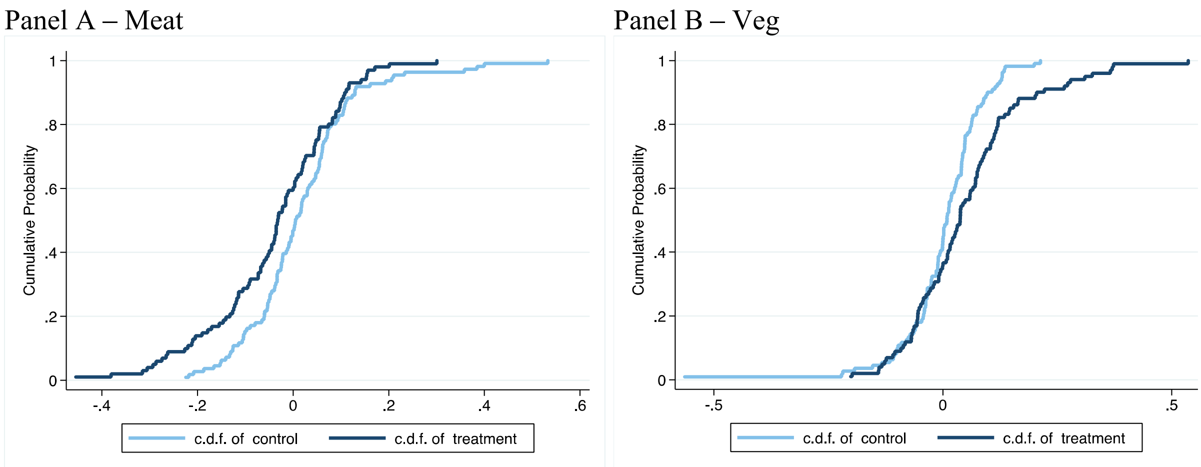

Fig. 2. Change in Average Consumption by Individual. Notes: The figure shows the cumulative distribution function (c.d.f) of individual-level changes in the average daily frequency of meat- and veg-based meals after the intervention.

others, and large changes in meat and veg frequency for those at the tails of the distributions.

3.5. Heterogeneous treatment effects

The previous analysis suggests that the treatment effects differ across individuals. We can assess whether the treatment effect varies as a function of observable characteristics, such as gender and minority status, by interacting indicator variables for these observables in our logit model. Table 5 displays the main results.

The top panel shows the average marginal treatment effects by gender. The decline in meat consumption and increase in veg consumption is larger and more significant for women than men. Meat frequency declined by 6.3 and 3.4 percentage points, while veg frequency increased by 4.8 and 3.4 percentage points for women and men, respectively. Interestingly, women and men responded differently in terms of the type of meat that they chose to reduce. Women reduced their consumption of poultry + fish (7.1 percentage points), whereas men reduced their consumption of beef (3.4 percentage points).

The bottom panel shows the average marginal treatment effects for white and nonwhite participants. The decline in meat consumption and increase in veg consumption is large and strongly significant for white participants: Beef, poultry + fish, and meat fell by 3.1, 4.4, and 6.7 percentage points, while veg increased by 4.8 percentage points. By contrast, the coefficients for nonwhite participants are statistically insignificant.

3.6. Mechanisms

We now use survey data to provide evidence on the mechanisms of the treatment effect. Participants completed surveys, which collected views about global warming and reasons to change. Table 6 displays the average marginal effects for the treatment group after the intervention with interaction terms for views about global warming ("Climate Care"), new information ("New Info"), and reasons for dietary change ("Taught," "Persuaded," and "Motivated"). These variables capture (i) the extent to which participants reported caring about climate change before the intervention, (ii) the degree to which participants perceived the information in the intervention as new, and (iii) self-reported reasons for dietary changes (i.e. whether study participants reported

Table 5
Heterogeneous Treatment Effects by Gender and Minority Status.

	(1) Beef	(2) Poultry + Fish	(3) Meat	(4) Veg
Gender				
Male	−0.034***	0.004	−0.034*	0.034
	(0.011)	(0.010)	(0.017)	(0.021)
Female	0.002	−0.071***	−0.063***	0.048*
	(0.028)	(0.020)	(0.024)	(0.025)
Male = Female p-value	0.138	0.002	0.260	0.531
Pseudo R2	0.111	0.100	0.149	0.145
# meals	49,293	49,293	49,289	49,221
Minority Status				
White	−0.031**	−0.044*	−0.067***	0.048***
	(0.013)	(0.023)	(0.025)	(0.019)
Nonwhite	−0.013	0.006	−0.015	0.029
	(0.019)	(0.012)	(0.018)	(0.023)
White = Nonwhite p-value	0.325	0.137	0.088	0.324
Pseudo R2	0.111	0.100	0.149	0.146
# meals	49,293	49,293	49,289	49,221

Notes: The coefficients measure the logit average marginal treatment effects. Nonwhite includes participants who self-identify as American Indian or Alaska Native, Asian, Black or African American, Native Hawaiian or Other Pacific Islander, or as of Hispanic or Latino origin. Standard errors are clustered at the unit of randomization, the class level. Mean DV: mean of the dependent variable. All columns control for individual, date, and hour fixed effects. The estimation period includes both semesters. *p < 0.1; **p < 0.05; ***p < 0.01

Table 6
Mechanisms.

	(1)	(2)	(3)
Treated	−0.046***	−0.042***	−0.041
	(0.016)	(0.015)	(0.037)
Treated × Climate Care		−0.034*	−0.024*
		(0.019)	(0.015)
Treated × New Info			0.003
			(0.016)
Treated × Taught			0.100***
			(0.019)
Treated × Persuaded			−0.106*
			(0.055)
Treated × Motivated			−0.054***
			(0.014)
Pseudo R2	0.149	0.149	0.150
# meals	49,289	49,289	23,701

Notes: The outcome variable is meat frequency. The coefficients measure the logit average marginal treatment effects. Climate Care, New Info, Taught, Persuaded, and Motivated are variables constructed from surveys. Standard errors are clustered at the unit of randomization, the class level. All columns control for individual, date, and hour fixed effects. Column 3 drops the control group since the variables New Info, Taught, Persuaded, and Motivated come from surveys given to the treatment group after the intervention. The estimation period includes both semesters. *$p < 0.1$; **$p < 0.05$; ***$p < 0.01$

reducing their meat consumption because the intervention taught, persuaded, or motivated them). For simplicity, the table reports the results for only one food outcome variable, meat frequency. Column 1, which serves as a baseline for comparison, reports the same coefficient as the one in Table 3, Column 3.

Column 2 interacts the treatment group with the variable "Climate Care". The interaction term measures the extent to which those individuals in the treatment group who reported caring more about climate change reduced their meat consumption, relative to other individuals in the treatment group. While the effect of being in the treatment group is largely unchanged—at −4.2 percentage points—the interaction term with the new "Climate Care" variable is negative and marginally significant: A one-standard deviation increase in the "Climate Care" variable is associated with an additional 3.4 percentage point decline in meat frequency.

Column 3 incorporates four additional variables from surveys provided only to the treatment group: "New Info", "Taught", "Persuaded," and "Motivated." Because these four variables are only available for those participants who watched the intervention, we restrict the regression in column (3) to the treatment group. The coefficient on the "New Info" interaction is roughly zero and statistically insignificant, suggesting that those participants who reported learning more from the intervention were not more likely to reduce their meat consumption. The coefficients on the last three interaction terms are, however, highly significant. The coefficient on the "Taught" interaction is positive, whereas the coefficients on the "Persuaded" and "Motivated" interactions are negative, revealing that those participants who reduced their meat consumption were the ones who reported being persuaded and motivated, rather than the ones who reported being taught. In addition, the "Climate Care" interaction is still negative and marginally significant.

4. Discussion

Our study builds on prior research that examines the willingness of consumers to reduce their meat consumption in response to awareness-raising messaging (Hunter and Röös, 2016; Macdiarmid et al., 2016). Our findings indicate that dietary change occurred as a result of a 50-minute intervention. Study participants in the treatment group shifted from meat toward plant-based alternatives. By contrast, there were no commensurate dietary shifts (and hence, no evidence of spillover effects) in the control group. Dividing the estimated marginal effects by the average level in the pre-intervention period suggests that beef, poultry + fish, and meat fell by 14.1%, 5.9%, and 7.8%, respectively, and veg increased by 19.7% through the end of the academic year. Interestingly, while some effects subsided between the fall and spring semester, others persisted. In the fall semester, beef, poultry + fish, and meat fell by 19.7%, 7.7%, and 10.4%, respectively, whereas veg increased by 17.6%. In the spring semester, beef, poultry + fish, and meat fell by 6.9%, 6.1%, and 6.0%, respectively, whereas veg increased by 21.3%. Our distribution analysis suggests that while most people displayed some dietary changes, a small number of individuals dramatically reduced their meat consumption in favor of plant alternatives. Surveys corroborate these empirical findings. In surveys given to the treatment group after the intervention, in response to the question, "did you try to reduce your meat consumption, and if so, why?", a large majority (82%) circled yes, with study participants uniformly citing health reasons and/or climate change.

According to our analysis by gender, men chose to focus their reduction efforts on beef. Prior to the intervention, 20.0% of the meals that men purchased had beef as the main entrée, compared to 11.9% of the meals that women purchased. The intervention stressed that the GHGs of beef are substantially higher than those of poultry and fish. In reducing their consumption of beef, men chose to switch toward veg meals, rather than to poultry + fish. For men, the coefficient on poultry + fish is roughly zero, whereas the coefficient on veg is positive, and nearly identical in magnitude to the coefficient for the decline in beef. Men shifted not to the animal products with a lower carbon footprint, but rather to the plant-based options. By contrast, women, who were eating less beef at the outset of the study, chose to focus their reduction efforts on poultry and fish. The intervention stressed that the GHGs of poultry and fish usually exceed those of plant-based protein sources, such as legumes. Prior to the intervention, 38.5% of the meals that women purchased had poultry or fish as the main entree, suggesting much greater room to reduce. These differences in starting levels may account for the differential response of men and women to the intervention.

Our findings suggest that the shift away from meat and toward veg occurred primarily among white participants. The reasons for these differential effects by minority status are unclear. Minority status may serve as a proxy for socioeconomic characteristics and/or parental education in our sample. In the study setting, nonwhite students are more likely to come from lower-income households and to be first-generation college students. Less familiarity with plant-based alternatives, peer effects, cultural factors that influence food selection, or differences in the perception of climate change as a priority may drive this result. These findings suggest that interventions may need to be tailored to the cultural context of the targeted population.

Our study assesses the effectiveness of an intervention to reduce the demand for meat, i.e. to address a problem associated with overconsumption. By contrast, throughout history, underconsumption due to food scarcity and insecurity was the major nutritional problem (Mozaffarian et al., 2018). A vast literature exists on the effectiveness of interventions to address malnutrition from underconsumption (Ainsworth and Ambel, 2010; Gelli et al., 2019; Science, 2014). Yet, a new nutritional problem has been emerging in recent decades: the rise of obesity and other chronic diseases due to overconsumption (Swinburn et al., 2019). This new threat poses a different set of challenges for governments and policymakers, seeking to stem the public health and environmental problems associated with overconsumption of unhealthy and unsustainable foods.

In contrast to other dietary interventions that focus primarily on improving one's own health, our intervention contains a prosocial message that emphasizes altruistic motivations: saving the planet. According to our analysis of the mechanisms behind switches in food choices, study participants who reported caring more about climate change responded more strongly to the intervention. Our findings suggest that the treatment largely worked by persuading and motivating people who already cared about global warming to change their behavior. Those who self-reported to care less or stated they were less knowledgeable exhibited weaker treatment effects.

These results indicate that those individuals who already had a nascent interest were more likely to initiate behavioral change. The broader implications of these findings are that individuals with little prior knowledge or interest in the issue may be less likely to respond immediately to awareness-raising interventions. However, such interventions may help to push those individuals toward future behavioral change through repeated exposure. For instance, the literature on campaigns to promote smoking cessation suggests that behavioral change is more likely to occur as a result of an accumulation of messaging that raises overall societal awareness and gradually moves consumers toward action (Cummings and Proctor, 2014).

In spite of the unique nature of our data and the strength of our findings, we acknowledge study limitations. First, our sample consists of college students who may not be representative of the average population. Second, the same individual delivered all guest lectures and the study occurred in a supportive setting. Whether the results would carry over to other situations would likely depend on the design and implementation of the intervention and the availability and price of plant-based options.

5. Policy implications

Our results hold valuable policy implications. Because we track actual behavior, our findings are more reliable and relevant for policymakers than studies that rely on self-reported outcomes, which may be prone to social desirability and recall bias. Our results suggest that the underinvestment of resources in policies to counter rising levels of meat consumption may be a product of the paucity of research on this topic, rather than a lack of efficacy. A recent report by Chatham House concludes that governments and other organizations are reluctant to implement policies to reduce meat consumption out of a perception that dietary change is too complicated or impractical (Bailey et al., 2014). By contrast, our results show that a 50-minute educational intervention caused a long-term substantial reduction in meat consumption. Our intervention, which operates via education to encourage voluntary behavioral shifts, is one of the least intrusive measures policymakers and program administrators could adopt to counter rising global levels of meat consumption.

Our intervention focuses on a combined climate change-health message due to its prominence in the international food policy debate. Scientific committees and other organizations are adopting this messaging strategy. The EAT-Lancet Commission emphasizes "win-win diets (i.e. healthy and environmentally sustainable)" (Willett et al., 2019). Chatham House also argues that policymakers should adopt a combined environmental-health message. Because dietary misconceptions are widespread, messages that focus only on the environment run the risk of not resonating with individuals who want to take actions (i.e. reducing meat) to combat climate change, but mistakenly fear that doing so will harm their health. Our findings corroborate the recommendations of these scientific committees and organizations (Bailey et al., 2014; Wellesley et al., 2015a). Our study shows, using high-quality individual-level food purchase data, that a combined climate change-health messaging strategy can, in fact, motivate people to reduce their meat consumption.

Although our study occurred in a particular environment (U.S. university campus), our findings have external validity in settings with similar features. Two key features facilitated the dietary changes we observe in our setting: 1) a receptive audience, i.e. an audience that views climate change as a policy priority; and 2) a supportive environment, i.e. an environment with affordable and readily available plant-based options. Our findings are likely to be externally valid in locations that share these same characteristics. For example, corporations, businesses, government organizations, and colleges and universities are likely to both have receptive community members and dining facilities that could offer plant-based options. While interventions may need to be tailored to the particular cultural context of each setting, the results of our study should be a catalyst for researchers, policymakers, and program administrators to implement and validate similar interventions in these types of locations.

In addition, several pieces of evidence from research in the field suggest that the dietary shifts we observe in our study may hold in other contexts. First, based on extensive interviews with study participants in a diverse set of countries, Chatham House documents a willingness to reduce meat consumption in response to information about climate change and health, with participants in lower-income countries (e.g. Brazil, China, India) expressing greater willingness than those in higher-income countries (e.g. U.S.) (Bailey et al., 2014). These promising findings suggest that our empirical results from a U.S. context may translate across countries. Second, a recent study that analyzed 240,000 recipes from a popular German website documents a growing trend toward plant-based recipes (Asano and Biermann, 2019). Interviews with participants on this platform suggest that increased awareness about climate change is one factor driving this trend—a finding that corroborates the experimental evidence of our study. Third, another recent study finds that sales of meat-based meals fell at a college campus in the U.K. in response to a simple change to the choice architecture (i.e. an increase in the number of plant-based options) (Garnett et al., 2019). The reduction in meat consumption at college dining facilities in different countries (the U.K. in the choice architecture study and the U.S. in our study) provides strong evidence that interventions have the potential to reduce meat consumption in an international context. This growing body of work suggests that researchers, policymakers, and program administrators should be developing and validating interventions across many different settings, regions, and countries. These interventions could consider both an educational component and modifications to the choice architecture, such as increased availability of affordable plant-based options.

Historically, successful awareness-raising campaigns to change behavior have used education about the consequences of an action to encourage behavioral change. Our intervention follows a similar approach. For example, in the context of cigarette smoking, campaigns have educated the public about the health consequences of smoking to encourage people to reduce or stop their cigarette usage (i.e. "don't smoke"). Likewise, in the context of our study, our intervention provides education on the climate change-health consequences of meat consumption to encourage more sustainable food choices (i.e. "choose more plants and less meat"). Organizations across countries and national governments could embark on public awareness-raising campaigns to shift the demand for meat, similar to 20th century campaigns to reduce tobacco use. Additionally, because behavioral shifts may be more likely in settings with readily available alternatives, improvements to the choice architecture in private and public canteens, as many organizations have recently undertaken, may be needed, in conjunction with education-based campaigns (Cardoso et al., 2018).

Our intervention fits into a class of policies that influence decisions without restricting choice (Thaler and Sunstein, 2003). In contrast to nudges that change the choice architecture to steer decision making, our intervention is a "boost"—a policy designed to foster people's competencies to make better choices (Hertwig and Grüne-Yanoff, 2017). While boosts may require more investment than nudges (e.g. education to select better choices versus repositioning of better options in more accessible locations), boosts may have broader effects by changing behavior across multiple settings.

Our study adds to the growing literature in behavioral economics, using randomized controlled trials and other experimental evidence, on the role of information in behavioral change. For example, in recent years, researchers have shown that information (i) on the returns to education reduces high school dropout rates, (ii) on the college application process increases applications and admittances for low-income high school students, (iii) on the risks of HIV infection reduces teen pregnancy rates, (iv) on the design of retirement plans boosts savings, and (v) on the benefits of insurance coverage reduces the number of people choosing to incur a tax penalty to forego health insurance (Bettinger et al., 2009; Dupas, 2011; Duflo and Saez, 2003; Goldin et al., 2019; Hoxby and Turner, 2013; Jensen, 2010;). In each case, information led to better outcomes. The design of public policies increasingly reflects insights from the field of behavioral economics (Madrian, 2014). Our study, by showing that information can lead to more sustainable food choices, contributes to the rapidly growing literature in behavioral economics, and brings insights from behavioral economics into the interdisciplinary policy debate on sustainable food systems.

Scientific committees and other organizations advocate educational campaigns, not only to induce behavioral change, but also to increase societal support for other policy changes. The EAT-Lancet Commission encourages educational campaigns that raise societal awareness because such campaigns will likely be necessary to build public and political support for other policy changes (Willett et al., 2019). After the intervention, most study participants recognized the importance of reducing meat consumption. In response to the question, “Do you think that reducing consumption of animal products is important?”, the average response of participants after the intervention was 4.5 on a 5-point scale (1 = not at all, 5 = very much). However, this poses a follow-up question: While the movements observed in this study—an 8% decline in meat and 20% increase in veg consumption—are substantial, persistent and strongly significant, why were the effects not larger, given that most participants recognized the problem after the guest talk? Much larger movements away from meat and toward plants are necessary in high-income countries, such as the United States, to meet sustainability targets (Willett et al., 2019). In surveys, participants provided three common reasons for not reducing their meat consumption further.

The first two reasons relate to the choice architecture. First, many participants reported issues with satiety after eating the plant-based option at the dining facilities. The portion sizes and prices of the plant- and meat-based meals are usually equal at each food station, even though plants tend to have fewer calories per volume than meat. Increasing the size of the plant-based meal or ensuring that each plant-based meal has foods that are more satiable, such as legumes or whole grains, could remedy the situation. Alternatively, lower prices for plant-based meals could allow people to purchase more to reach satiety. Pricing that accounts for the negative externalities of meat consumption would raise the price of meat substantially above plant-based alternatives. Second, many participants noted that they would reduce their meat consumption if a wider and tastier range of plant-based options were available, suggesting an interest in reducing their meat consumption with an expanded set of choices.

The third reason relates to peer and social factors. Many participants reported feeling uncomfortable – socially isolated – as the only individual not eating meat amongst their friends and family. The partial reversal of the decline in meat frequency between the fall and spring semester recess (see Fig. 1) may reflect family influences as study participants returned home for the winter break and regressed to old habits. By contrast, many participants who reported successful reductions in meat consumption cited a close friend or family member who made similar shifts as a motivating influence. The survey responses suggest not only that social and peer effects matter enormously, but also that interventions that induce even a small percentage of people to reduce their meat consumption could have spillover effects that accumulate over time. As more people reduce their meat consumption, others may eventually follow suit.

6. Conclusion

Conventional wisdom holds that dietary change away from animal-sourced and toward plant-based foods is too difficult to tackle – that public resistance would be too fierce. But this view is largely untested. Norms can change, as evidenced by the drastic reductions in cigarette use during the second half of the twentieth century due to policy interventions. Using individual-level food purchase data, our study provides direct evidence that an informational intervention that emphasizes health and climate change benefits, in a supportive setting, can reduce the demand for meat. The reluctance of governments and other organizations to implement policies to reduce meat consumption out of the accepted wisdom that dietary change is too challenging may be misplaced. The underinvestment of resources in policies to counter rising levels of meat consumption may be a product of the paucity of research on this topic, rather than a lack of efficacy. Other interventions—animal welfare or social justice messages, reminders, labeling, repositioning, changing default options, meat taxes, subsidies for plant-based foods—could also be effective, but the evidence base is currently lacking. In light of the growing environmental consequences of meat consumption, more research is sorely needed to inform the international food policy debate. Such interventions have the potential to improve public health and promote environmental sustainability.

7. Data Statement

Individual participant data that underlie the results reported in this article, after de-identification, will be made available to researchers who provide a methodologically sound proposal. Proposals should be directed to corresponding author at jalil@oxy.edu. To gain access, data requestors will need to sign a data access agreement. Additional materials, i.e. STATA code to replicate statistical analysis, informed consent form, intervention materials (handouts, surveys, slides), will also be made available.

CRediT authorship contribution statement

Andrew J. Jalil: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Writing - original draft, Visualization, Funding acquisition. **Joshua Tasoff:** Conceptualization, Software, Formal analysis, Investigation, Writing - review & editing, Visualization. **Arturo Vargas Bustamante:** Conceptualization, Investigation, Writing - review & editing, Visualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A

A.1. Detailed description of the intervention

This section of the appendix provides a more detailed description of the intervention. Fig. A.1 depicts the flow of the intervention.

We focus the first 25 min of the intervention on the role of meat consumption as a driver of climate change. We note that more GHG emissions originate from livestock than from the global transportation sector. We stress three primary reasons: (1) ruminant animals produce methane as a byproduct of the digestive process; (2) the raising of livestock generates nitrous oxide via manure and nitrogen-based fertilizers used in the cultivation of animal feed; and (3) deforestation to clear land to graze livestock and grow feed releases carbon dioxide, both directly when forests are cut down and indirectly since leveled forests can no longer reabsorb emissions from the atmosphere. We emphasize that the production of meat requires far more resources (land and water) than plant-based alternatives, such as legumes (beans, lentils, peas), and that the GHGs associated with the production of meat from ruminants (cattle, lamb, goat, sheep) are substantially higher than those from non-ruminants (poultry, seafood) (Clune et al., 2017; Poore and Nemecek, 2018).

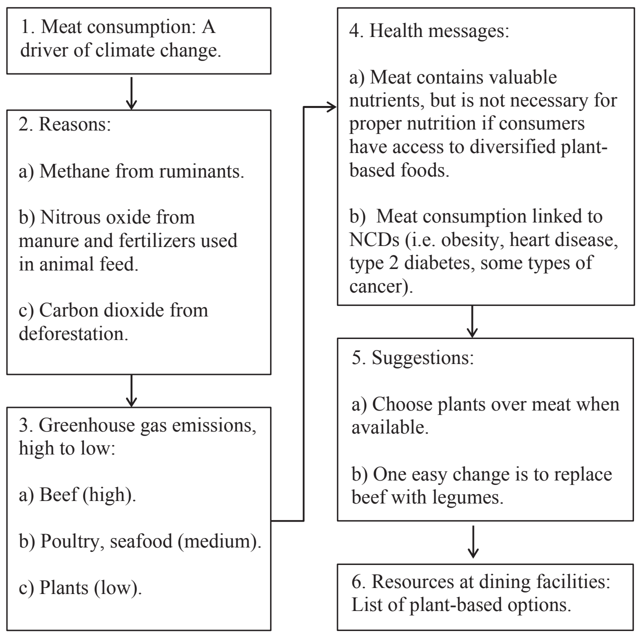

Fig. A1. Flow of Intervention.

We incorporate a variety of approaches to communicate this information. We show videos of (1) a team of researchers collecting methane, via an inflatable bag, from a feeding cow, (2) manure cesspools from a large hog farm, and (3) the cutting down of forests in Brazil to clear land to graze cattle. We play a four minute expert podcast interview on the link between meat overconsumption and climate change (BBC World Service, 2017). As an interactive exercise, we present a series of slides in which we ask students to select the meal option, between two choices, that has the lower carbon footprint.

We then pivot to discuss the health benefits of reduced meat consumption for 20 min. This portion of the intervention conveys two main messages: (1) While meat contains valuable nutrients, it is not necessary to eat meat if consumers have access to a diversified portfolio of plant-based foods; and (2) the consumption of meat, in particular processed and red meat, is linked in the scientific literature to rising rates of non-communicable diseases (Katz and Meller, 2014; Melina et al., 2016). We emphasize that in Western countries, dietary misconceptions surrounding meat consumption abound and that average levels of meat consumption far exceed healthy thresholds, e.g. in the case of the United States, by a factor of three (Wellesley et al., 2015a). We include quotes, citations, and infographics from reputable organizations and experts, such as the World Health Organization, Yale University's School of Public Health, the American Institute for Cancer Research, and the U.S. Federal Dietary Guidelines. We also provide students with a sense of the evidence underpinning public health recommendations for reduced meat consumption. We describe how (1) prospective epidemiological cohort studies find associations in Western countries between high levels of meat consumption, particularly processed meat, and obesity, type-2 diabetes, heart disease and some types of cancer; and (2) small-scale randomized controlled trials demonstrate an amelioration in heart disease, obesity, and type-2 diabetes when switching from standard Western meat-centric diets toward plant-based diets (Barnard et al., 2006; Ornish et al., 1990; Song et al., 2016). Students spend five minutes reading highlighted excerpts of an article from Kaiser Permanente, the largest managed care organization in the U.S., that describes the health benefits of plant-based diets and offers dietary recommendations on how to follow such a diet healthfully, i.e. suggested daily servings of vegetables, fruits, whole grains, legumes, leafy green vegetables, nuts, and seeds. We emphasize to students that meat consumption is not necessary for optimal athletic performance by projecting images of accomplished athletes who follow either an exclusively or predominantly plant-based diet. As an example of how to move toward a plant-based diet, we suggest swapping beef with legumes—a simple dietary change that if widely enacted, would dramatically reduce agricultural GHG emissions.

We conclude our intervention by (1) reiterating the main message, i.e. the overconsumption of meat is a major driver of climate change and contributes to rising rates of non-communicable diseases in Western countries, and (2) encouraging students to opt for plant-based options. We showcase to students a rich cultural variety by projecting images of plant-based meals from diverse heritages (African, American South, Chinese, Indian, Japanese, Jewish, Korean, Latin American). Lastly, we provide students with a handout, containing resources, along with a list of plant-based food options at the dining facilities on campus.

The intervention was restricted to the environmental and health consequences of meat consumption—not other factors. The intervention did not discuss animal welfare or social justice issues (i.e. the plight of indigenous communities due to deforestation, conditions for factory farm workers), though future interventions could examine the responsiveness of people to these issues. In addition, the intervention presented environmental issues through the lens of climate change (i.e. methane from ruminants, nitrous oxide from manure and fertilizers in the cultivation of feed for livestock, carbon dioxide from deforestation). The intervention did not focus on other environmental consequences of meat consumption (i.e. species extinction, air pollution, ocean dead zones), though future interventions could certainly incorporate these additional topics.

The treatment group received a follow-up survey one month after the intervention. The survey asked whether participants changed their diet, along with reasons. This survey may have also served as a reminder to study participants about the intervention. We are able to investigate, however, whether this reminder influenced food purchase behavior. Fig. 1 shows a sudden shift in food purchase behavior in the treatment group immediately after the intervention. However, one month later, i.e. when the follow-up survey was administered, there is no noticeable movement in food purchase behavior. To verify, we ran a regression to tease out whether food purchase behavior shifted after the date of the follow-up survey, apart from any shifts already observed after the intervention. There are no statistically significant movements in food purchase behavior after the survey, apart from those that already occurred after the intervention. These findings suggest that the survey did not affect food purchase behavior.

A.2. Robustness Checks

The baseline logit results cluster standard errors at the class level, the unit of randomization. As a robustness check, we employ four alternative approaches for clustering standard errors, recommended for regressions with fewer than 40 clusters (Conley and Taber, 2011; MacKinnon and Webb, 2017, 2018). We use the boottest package in Stata to estimate p-values from linear probability models using wild-bootstrapped clusters by class and again by class-individual (Roodman et al., 2019). We also estimate models allowing for heterogenous treatment effects by class using both logit and linear probability models, clustering standard errors at the class level. None of the results substantively change. Table A.1 reports p-values for the treatment effect on each of the outcome variables, over both semesters, using these alternative methods for clustering standard errors.

Table A1
Robustness Checks.

Test	Beef	Poultry +Fish	Veg	Meat
Baseline	0.077	0.014	0.042	0.004
Wild Bootstrap by Class	0.174	0.002	0.09	0.027
Wild Bootstrap by Class-Individual	0.196	0.027	0.065	0.028
Heterogenous Treatment Effects by Class - Logit	0.003	0.000	0.000	0.000
Heterogenous Treatment Effects by Class - Linear Probability	0.056	0.000	0.001	0.002

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