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Changing the default meal option at university events to reduce harmful environmental impacts: Six randomized controlled trials

Angela W. Zhang [a], Christopher Wharton [b], Sara Cloonan [c], Renate Boronowsky [d], Varun Magesh [e], Ilana Braverman [f], Alejandra Marquez [g], Heather Leidy [h], May C. Wang [d], David A. Cleveland [e], Jennifer Jay [d], Chad Stecher [b,*]

[a] University of Southern California, United States
[b] Arizona State University, United States
[c] University of Georgia, United States
[d] University of California, Los Angeles, United States
[e] University of California, Santa Barbara, United States
[f] Greener by Default, United States
[g] Tufts University, United States
[h] University of Texas at Austin, United States

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ABSTRACT

Animal agriculture is a leading contributor to greenhouse gas emissions and other harmful environmental impacts, which underscores the need to shift away from the consumption of animal-based products. One promising nudge intervention is making plant-based meals the default option, so we tested this approach at six different university events across four academic institutions for effecting sustainable dietary change. Event attendees preselected their meal on one of two randomly assigned RSVP forms: one with a plant-based default and one with a meal with meat default. The results from our randomized controlled trial showed that participants had a 43-percentage point greater probability of selecting the plant-based meal when it was indicated as the default option. This effect was similar across events and academic institutions, which indicates that this default intervention is generalizable and can be successfully implemented at university events. The combined effect of using plant-based defaults at these six events was an estimated reduction of 104,387 kg of CO2 emissions, 299.9 m^2 of land use, 959.0 g of nitrogen use, and 259.5 g of phosphorus use, which represent roughly 45–46.2% reductions in harmful environmental impacts relative to the meals chosen when using a meat default. Given the significance and magnitude of these environmental benefits, our results support the widespread implementation of plant-based defaults for helping universities improve their sustainability.

1. Introduction

Animal agriculture is a leading contributor to greenhouse gas (GHG) emissions (Allen & Hof, 2019; Shafiullah et al., 2021). The food system accounts for 34% of all anthropogenic GHG emissions annually (Crippa et al., 2021), with 57% of all these emissions from animal-based foods compared with just 29% from plant-based foods (Xu et al., 2021). Animal agriculture also uses roughly 80% of the world's agricultural land (Alexander et al., 2017; Godfray et al., 2018) and requires substantially more nitrogen and phosphorus-based inputs than plant-based foods (Cordell et al., 2009; Scherer & Pfister, 2015). As such, reducing animal-source food consumption has been cited as a key strategy for reaching the climate targets outlined in the Paris Agreement (Bassi et al., 2022; Clark et al., 2020) and is the recommendation of the EAT-Lancet Commission's Global Planetary Health Diet (Willett et al., 2019). Limiting animal-based food consumption has significant public health implications as well, including reduced risk of cardiovascular disease, some types of cancer, and type 2 diabetes (Boutron-Ruault et al., 2017). Despite declines in animal-based food consumption in recent decades (Bassi et al., 2022), there is still a critical need to hasten the shift away

* Corresponding author. 500 N 3rd Street Phoenix, AZ, 85006, United States.
E-mail addresses: Christopher.Wharton@asu.edu (C. Wharton), renate.ware@gmail.com (R. Boronowsky), ilana@greenerbydefault.org (I. Braverman), Heather.Leidy@austin.utexas.edu (H. Leidy), cleveland@ucsb.edu (D.A. Cleveland), Chad.Stecher@asu.edu (C. Stecher).

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from excessive consumption of animal-based products in order to improve the sustainability of the global food system.

Behavioral economics provides several relatively low-cost and scalable strategies that can been used to reduce the consumption of animal-based products. One such strategy is the use of choice architecture tools, often called "nudges," to change the way an individual choice is presented while still preserving freedom of choice (Thaler & Sunstein, 2009). Default nudges (e.g., providing a preselected option on a survey or form) are a commonly used choice architecture tool that leverage Type 1 processing, or fast, automatic, heuristic-based cognitive processes, to facilitate decision making (Hansen & Jespersen, 2013; Van Gestel et al., 2021). Changing the default option has proven to be a particularly effective behavior change technique because it often requires some degree of physical or cognitive effort to opt out of the preselected option, and previous research on status quo bias suggests that most people are not motivated enough to override the status quo (i.e. the preselected option) (Fiske & Taylor, 2017; Haggag & Paci, 2014; Jachimowicz et al., 2019). Defaults also imply that the preselected option is the recommended or normative one, which further motivates the decision-maker to stick with that option (McKenzie et al., 2006). Finally, some have suggested that people may interpret opting out of the default as losing something already endowed (Dinner et al., 2011; Kahneman et al., 1991; Marzilli Ericson & Fuster, 2014). Importantly, defaults have been used to promote environmentally friendly behavior, such as increasing green energy consumption (Ebeling & Lotz, 2015; Kaiser et al., 2020; Liebe et al., 2021) and reducing paper consumption (Egebark & Ekström, 2016).

Default nudges have successfully been used to influence food choices and facilitate healthier dietary behaviors (Bergeron et al., 2019; Loeb et al., 2017; van Kleef et al., 2018). Additionally, recent findings suggest that default nudges can be used to promote more sustainable food choices (Banerjee et al., 2023; Boronowsky et al., 2022; Erhard et al., 2023; Hansen et al., 2021; Hielkema et al., 2022; J. Meier et al., 2022; Morren et al., 2021; Vandenbroele et al., 2020). For example, Taufik et al. (2022) used online and field experiments to show that changing the default options on restaurant menus increased orders for plant-based meals relative to a meat dish, suggesting that default nudges are an effective tool for promoting out-of-home adoption of plant-based meal alternatives (Taufik et al., 2022). Additionally, Hielkema et al. (2022) showed that a vegetarian default significantly increased vegetarian food choice among those who were not trying to reduce meat intake. Interestingly, the vegetarian default did not have a significant effect on vegetarian food choice among those who were trying to reduce their meat intake (Hielkema et al., 2022).

Several studies have estimated the important environmental benefits from inducing more sustainable food choices through default interventions (Banerjee et al., 2023; Boronowsky et al., 2022; Kurz, 2018; Morren et al., 2021). In terms of GHG emissions, sustainability-based default interventions have been shown to reduce emissions by as little as 5% (Kurz, 2018) to as much as 53% (Banerjee et al., 2023). The environmental benefits from reductions to animal-based food consumption have also been estimated in terms of land, nitrogen, and phosphorus use (Boronowsky et al., 2022; Morren et al., 2021). For example, Boronowsky et al. (2022) estimated a reduction of up to 41.8% in land use, 38.9% in nitrogen use, and 42.7% in phosphorous use (Boronowsky et al., 2022) from a plant-based default intervention. Critically, these estimates were informed by lifecycle assessment values and were compared against per capita per meal planetary boundary thresholds specified by the EAT-Lancet Commission's Global Planetary Health Diet (Hansen et al., 2021; Willett et al., 2019). These studies suggest that default interventions are an effective strategy for reducing the planetary impact of animal-based food consumption, and the next step in this research is to test the generalizability of this approach across institutional settings.

The current paper estimates the effect of a plant-based default intervention on meal choices among academic event attendees at six different events across four higher education institutions to assess the generalizability of this approach across institutions. Existing research has demonstrated the success of default interventions for promoting sustainable food choices at academic events at a single higher education institution (Boronowsky et al., 2022; Hansen et al., 2021). The current study will expand on these findings by testing the same default intervention across four institutions. If successful, this research will help to identify a generalizable intervention that can help higher education institutions make meaningful reductions to their climate impact (Cleveland & Jay, 2021; Hoolohan et al., 2021; Sen et al., 2022).

In this study, participants at six different academic events were randomly assigned to one of two conditions: (1) a default meat group, where the default choice was a meal with meat and participants had the option of opting out and choosing a plant-based meal; and (2) a default veg group, where the default choice was a plant-based meal with the option of opting out and choosing a meal with meat. For these events, participants were asked to pre-select their meal choice, which means they were not exposed to visual or odor cues. Additionally, since participants were making decisions about the future, they were also less likely to be exposed to states such as hunger or thirst (Miller et al., 2016). As a result, our findings capture the combined effect of a plant-based default and preselection on meal choices. Based on the success of prior studies that implemented plant-based defaults through preselection, we hypothesized that more participants would choose the plant-based meal when that option was set as the default, and we hypothesized that the default intervention would be equally effective across academic institutions. We also collected demographic data to conduct exploratory analysis on the effectiveness of the intervention for different groups such as age, race, and gender. Using the same calculation methods as Boronowsky et al. (2022) combined with nutrition information from Chipotle and online recipes for meals similar to those served at the academic events in this study, we then estimated the environmental impact of the plant-based default interventions.

2. Materials and methods

2.1. Experimental design

This study tested a default intervention using a parallel, randomized controlled trial design with an equal allocation ratio between the study group that received a plant-based meal as the default option or the study group that received a meal with meat as the default option. The default interventions were implemented through a standardized questionnaire delivered as part of an RSVP form at one of six independent events held on four different higher education institutions: Arizona State University (ASU), the University of California at Los Angeles (UCLA), the University of California at Santa Barbara (UCSB), and the University of Texas at Austin (UT-Austin). Each intervention was approved by the corresponding institutional review board, and de-identified study data for all events were made publicly available. At each event, event coordinators decided how the RSVP form would be distributed to all invited attendees and which catering options would be offered. All event attendees were eligible for the study regardless of gender, age, occupational status, or any other characteristic. Importantly, the events would have been planned and held regardless of this study, but the meal options were restricted to either a plant-based option or one or two meat-based options that were only revealed after participants made their choice between the plant-based or meat-based meals. These events ranged from an annual all-faculty and staff meeting to an undergraduate sorority house event, which allowed us to examine potential heterogenous effects of default meal options across settings and demographic groups. See Supplemental Materials 1 for detailed descriptions of each academic event, the meal options provided on the RSVP forms, and the meal options provided at the actual events. The study design and analytical plan was retrospectively registered at ClinicalTrials.gov (NCT STUDY00016889), and the study protocol and de-identified study data and can be accessed at the ASU Research Data Repository.

Possible event attendees on the pre-specified guest lists were evenly randomized into either a Default Meat or a Default Veg group using a random number generator in Excel or Stata. Randomization was performed by the research team at each intervention site, and participants were blinded to their study group assignment. Both study groups received an RSVP form that included a standardized demographics questionnaire assessing age, gender, race/ethnicity, dietary preferences (e.g. vegan), and occupational status (i.e., undergraduate, graduate student, faculty, or staff) (see Supplementary Materials 2 for the full RSVP form). To prevent individual ingredient preferences from influencing meal choices, the meal choice question employed purposefully vague language such as “a plant-based meal” and “a meal containing meat.” The meal choice question on the Default Meat group’s RSVP form stated that the default meal contained meat, and the question’s response was pre-filled selecting the meat meal. Participants were told they could opt out of the meat meal by selecting a plant-based meal if they desired. Specifically, the meal choice question said: “We will be serving meals that contain meat for this event. Indicate below if you would instead like to switch to a plant-based meal (no animal products).” If more than one meat option was provided at the event, participants who selected the meat option were then shown the two meat options and prompted to select one. This design ensured that the specific type of meat meals provided did not influence participants’ selection of plant-based meals or meals containing meat. The Default Veg group’s meal choice question stated the opposite, that the plant-based meal option was the default, and the question’s response was pre-filled selecting the plant-based meal. Participants in the Default Veg group could opt out if they wanted a meal containing meat. If the meal with meat option(s) was either the accepted default, or chosen in the Default Veg group, then for events with multiple meat options a second question was asked to select between the two meat options (typically a choice between meals containing beef or chicken). Besides the meal choice question, the RSVP forms were identical for each study group, except that the UCSB forms did not include the gender or race/ethnicity questions and the UCLA forms did not include gender.

Table 1
Sample demographics.

Variable	Observations	Count	Percent
ASU	360	136	37.8
UCLA	360	78	21.7
UCSB	360	128	35.6
UT-Austin	360	18	5.0
Vegetarian or Vegan Diet	328	37	11.3
Black	176	9	5.1
White	176	117	66.5
Asian	176	39	22.2
Other Race	176	11	6.3
Hispanic	198	53	26.8
Female	180	167	92.8
Age 18-24	323	148	45.8
Age 25-34	323	100	31.0
Age 35-44	323	30	9.3
Age 45-54	323	29	9.0
Age >54	323	16	5.0
Faculty	315	28	8.9
Graduate Student	315	101	32.1
Undergraduate	315	114	36.2
Staff	315	72	22.9

Note: ASU: Arizona State University; UCLA: University of California at Los Angeles; UCSB: University of California at Santa Barbara; UT-Austin: University of Texas at Austin.

2.2. Data

Data on meal selection (plant-based or meat-based) and demographics from participants of the six independent events were collected from March 2022 to August 2022. Data were collected via a Google Form (UCLA) or Qualtrics survey (ASU, UT-Austin, UCSB), and de-identified data were combined for analysis. Although two different survey platforms were used to collect data, all the surveys used the same layout and provided the same instructions. There were two large sources of item non-response on the demographics questionnaire: some RSVP forms did not ask about race/ethnicity and/or gender, and additional item non-response occurred since participants were told that the demographics questions were optional. The full dataset includes 180 participants in the experimental group and 180 participants in the control group.

2.3. Empirical strategy

The primary outcome for this study was the choice of either the plant-based meal or the meal with meat. We used regression analysis to compare the meal choices between participants in the Default Veg and Default Meat groups, which allowed us to control for all of the observable demographics of participants presented in Table 1. First, ordinary least squares (OLS) regression models were used to predict a binary outcome (1 = if the plant-based meal was chosen; 0 = if a meal with meat was chosen). OLS was used instead of non-linear models because the mean of our binary outcome was near 0.5, so we were not concerned with model predictions less than zero or greater than one, and because OLS, often called a linear probability model, is easy to interpret. Our main independent variable of interest was an indicator variable (1 = Default Veg group; 0 = Default Meat group) where the coefficient estimated for this indicator variable reflects the treatment effect of the Default Veg question relative to the Default Meat question. To estimate heterogenous treatment effects, we estimated models that also included an interaction term between the study group indicator variable and one of the binary demographic variables, e.g. an interaction with gender (1 = females; 0 = males). To test the robustness of these estimated effects, logistic regression models were also used to predict the binary outcome measure of meal choice (see Supplementary Materials 3). All models were estimated using heteroskedasticity-robust standard errors, and all statistical analyses were performed using Stata/MP v16.1.

To estimate the reduction in negative environmental impacts from these default interventions, we used modeled meals and lifecycle assessment data in a similar method to (Boronowsky et al., 2022). First, we constructed recipes based on actual meals served at events using online recipes and Chipotle nutrition facts. Then, using these recipes, we constructed environmental impact estimates for all the meals served at events (See Supplemental Material 4 for detailed recipes). Within the same event, these meals did not differ by more than 150 calories. We used published environmental footprint values for individual ingredients (see Supplementary Materials 4) to create per-meal estimates for GHG emissions and land, nitrogen, and phosphorus use (Clune et al., 2017; Heller & Keoleian, 2015; Leach et al., 2016; T. Meier & Christen, 2013; Nijdam et al., 2012; Waite et al., 2019; Whitener et al., 2021). When environmental impact estimates for an ingredient in the recipe were not available, we made a plausible substitution using an ingredient with similar caloric value. For each event, we calculated environmental impact estimates based on the meals that were actually served at that event. Since we only had information on the number of plant-based or meat meals selected, if more than one type of meat (e.g. beef or chicken) or plant-based meal was served at an event, we estimated the environmental impact of each type of meal (meat and plant-based) by taking the average of the two options. Finally, we extrapolated these estimates to our intervention results by calculating the environmental footprint of each event according to the distribution of plant-based or meat meals chosen, and calculated the overall reduction in negative environmental impacts between the meal choices in the Default Veg versus Default Meat study groups. To illustrate the difference in environmental impact calculations by meat type, we also estimated the environmental benefits if these events were to only serve a red meat option or a poultry option.

3. Results

3.1. Sample characteristics

Descriptive statistics for the entire sample are shown in Table 1. Nearly three-quarters of the final sample were from ASU (n = 136/360; 37.8%) or UCSB (n = 128/360; 35.6%), where two different events were included at each institution. Approximately 1 in 10 participants were vegetarian or vegan (n = 37/328; 11.3%). The two largest racial/ethnic groups among the participants were White (n = 117/176; 66.5%) and Asian (n = 39/176; 22.2%). Nearly 50% were aged 18–24 years (n = 148/323; 45.8) and 31% were aged 25 to 34 (n = 100/323). More than one-third had undergraduate student status (n = 114/315; 36.2%) and 32% had graduate student status (n = 101/315). All participants were retained in the study and analyzed according to their originally assigned study group.

A comparison of the sample demographics between the two study groups is displayed in Table 2. There were few differences in socio-demographic characteristics between the two study groups. A higher percent of participants in the Default Veg group identified as White (74.4% vs. 58.9%, p = .03), while a higher percent of participants in the Default Meat group identified as "Other Race" (11.1% vs. 1.2%; p = .01) and were aged 18–24 (51.3% vs. 40.6%, p = .06).

For the meal choice question, participants selected between a "meal with meat" or a "plant-based meal," where the plant-based meal was never specified. If the "meal with meat" was selected, then in most events the next question provided participants with more information about the two meals with meat to inform event planning. At one event at ASU, the meat options offered were "Tuscan Grilled Chicken Sandwich" and a "Cobb Salad Bowl" that contained turkey. At the second ASU event, the meat options were a "Buffalo Chicken Wrap" and a "Chef's Salad" that contained turkey. For the event at UCLA, the meat options were burrito bowls with either chicken or steak. More information about the language presented in each RSVP form is presented in Supplemental Materials 1.

3.2. Bivariate analysis

Fig. 1 compares the proportion of plant-based versus meat-based

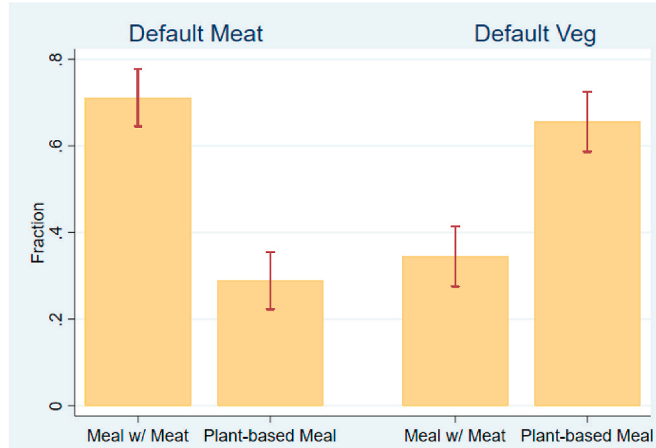

Fig. 1. Meal Choice of Participants by Study Group
Note: Default Meat is the study group where the meals with meat were set as the default option, and Default Veg is the study group where the plant-based meal was set as the default option. Histogram includes 95% confidence intervals.

meals selected by participants of the six independent events by study group. In the Default Meat group, participants were more likely to select one of the meat-based meals than the plant-based meal. Alternatively, in the Default Veg group, participants were more likely to select the plant-based meal than either of the meat-based meals, suggesting that the default nudge was successful at increasing participants' choice of the plant-based meal.

Table 2
Comparison of sample demographics by study group.

Variable	Default Veg (Percent)	Default Meat (Percent)	Two-sided T-test P value
ASU	35.56	40.00	0.386
UCL	25.00	18.33	0.125
UCSB	35.00	36.11	0.826
UT-Austin	4.44	5.56	0.630
Vegetarian or Vegan Diet	14.29	8.13	0.078
Black	5.81	4.44	0.682
White	74.42	58.89	0.029
Asian	18.60	25.56	0.270
Other Race	1.16	11.11	0.006
Hispanic	26.47	27.08	0.923
Female	92.13	93.41	0.743
Age 18-24	40.61	51.27	0.055
Age 25-34	35.15	26.58	0.096
Age 35-44	9.70	8.86	0.797
Age 45-54	10.30	7.59	0.396
Age >54	4.24	5.70	0.549
Faculty	11.11	6.54	0.155
Graduate Student	30.86	33.33	0.640
Undergraduate	34.57	37.91	0.539
Staff	23.46	22.22	0.795
Total	360		

Note: ASU: Arizona State University; UCLA: University of California at Los Angeles; UCSB: University of California at Santa Barbara; UT-Austin: University of Texas at Austin.

3.3. Multivariate analysis

Finding #1: Plant-based default increased likelihood of choosing plant-based meal option.

Table 3 presents the estimated effects of the plant-based default on the choice of plant-based meals across the six events. Column (1) shows the results of the first OLS regression model, where the binary outcome indicating the choice of the plant-based meal was regressed on an indicator for receiving the plant-based default (i.e., being in Default Veg study group). Column (2) shows the same model with the addition of all observed demographics: age, gender, race/ethnicity, dietary preferences (e.g. vegan), occupation, and study site. As seen in Column (1), the plant-based default resulted in a 36.7 percentage point (p.p.) (95% CI: 27.0, 46.3; $p < .001$) higher likelihood of choosing the plant-based meal option on average across the six events. The estimates in Column (2) show that, after controlling for the minor demographic differences between study groups, the plant-based default resulted in a 43.0 p.p. (95% CI: 28.1, 57.8; $p < .001$) higher likelihood of choosing the plant-based meal. Additionally, participants who reported following a vegetarian or vegan diet were 55.9 p.p. (95% CI: 40.3, 71.5; $p < .001$) more likely to choose the plant-based meal if they were in either study group.

Finding #2: Descriptive statistics for impact of plant-based default across academic institutions.

Table 4 shows the OLS estimates for the heterogenous treatment effect from the plant-based default nudge at each of the four academic institutions. Each column in Table 4 reports a separate regression where the treatment effect of the plant-based default is estimated for one of the four institutions relative to the others. For example, column (1) indicates that the plant-based default increased the likelihood of choosing the plant-based meal by 43.4 p.p. on all campuses except for ASU. For the ASU events, the plant-based defaults only increased the likelihood of choosing the plant-based meal by 27.3 p.p., which is 16.1 p.p. (95% CI:

Table 3
Impact of plant-based default on choice of plant-based meal.

Independent Variable	(1)	(2)
Default Veg	0.367[a] [0.270, 0.463]	0.430[a] [0.281,0.578]
Vegetarian or Vegan		0.559[a] [0.403,0.715]
Non-Vegetarian or Vegan		*Ref.*
Black		−0.310 [-0.860,0.240]
White		−0.0767 [-0.472,0.318]
Asian		0.0373 [-0.375,0.450]
Other race(s)		*Ref.*
Hispanic		−0.138 [-0.319,0.042]
Non-Hispanic		*Ref.*
Female		0.0913 [-0.165,0.347]
Male		*Ref.*
<45 y/o		0.121 [-0.089,0.331]
45+ y/o		*Ref.*
Faculty		0.174 [-0.049,0.397]
Graduate student		0.0942 [-0.165,0.353]
Undergraduate		−0.246 [-0.521,0.029]
Staff		*Ref.*
ASU event		−0.0852 [-0.275,0.105]
Non-ASU event		*Ref.*
Intercept		0.195 [-0.272,0.661]
Observations	**360**	**151**

Note: This table presents OLS estimates for a model of the binary outcome indicating the choice of the plant-based meal (95% confidence intervals are listed in brackets).
$^{*}p < .05$; $^{**}p < .01$.
[a] $p < .001$.

4.0, 36.2; $p = .116$) less of an increase than experienced on the other three campuses. However, this difference between ASU and the other campuses was not statistically significant. Columns (2)–(4) similarly show that the impact of the plant-based default was not statistically different at any of the other three academic institutions.

Finding #3: Descriptive statistics for the heterogenous impact of the plant-based default across demographic groups.

Table 5 shows the preliminary OLS estimates for the heterogenous treatment effect from the plant-based default according to the observed demographics of participants. As in Table 4, each column in Table 5 reports a separate regression where the treatment effect of the plant-based default is estimated for one subgroup relative to the other subgroups in the same demographic dimension. For example, column (1) indicates that the plant-based default increased the likelihood of choosing the plant-based meal by 47.7 p.p. for all participants less than 45 years old, and that for participants ≥45 years old, the plant-based defaults only increased the likelihood of choosing the plant-based meal by 30.8 p.p., or 16.9 p.p. (95% CI: -17.5, 51.2; $p = .334$) less of an increase than experienced among the younger participants, but this difference was not statistically significant. Columns (2)–(4) similarly show that the impact of the plant-based default was not statistically different by gender, Hispanic ethnicity, or race. Column (5) indicates that graduate students experienced a 34.6 p.p. (95% CI: 3.3, 66.0; $p = .031$) greater increase in the likelihood of choosing the plant-based meal from receiving the plant-based default relative to undergraduates, staff, or faculty. Supplementary Materials Table S4 and Table S5 show that the plant-based default did not have a significantly different effect between participants who did and did not follow a vegetarian or vegan diet.

3.4. Environmental impact of the plant-based default intervention

Finding #4: Increased plant-based meal consumption reduced negative environmental impacts.

Table 6 shows the difference in GHG emissions and land, nitrogen, and phosphorus use associated with the meal choices of participants in the Default Meat versus Default Veg groups estimated separately for the events held at each of the four academic institutions. Importantly, the actual meals served were used to estimate environmental impacts for all four events, and events that had a red meat meal had the greatest potential for negative environmental impacts. For example, UCSB and UCLA both served a red meat and poultry option while ASU and UT Austin only served poultry option(s) as their meal with meat. At UCLA and UCSB, GHG emissions reductions from the default interventions were 35.0% and 11.6% percentage points greater, respectively when using red-meat as the only meat option compared to using poultry as the only meat option (Table 7). Additionally, while the percentage point change in participants choosing the plant-based option was similar across institutions (see Table 4), the baseline percent of participants choosing a meal with meat versus the plant-based option was different and contributed to large differences in the overall environmental impact of meal choices at each institution. For example, the increase in GHG emissions between participants in the Default Meat compared to the Default Veg group ranged from 40,791 kg of CO2 at the UCSB events to 1,723 at the small UT-Austin event. Additionally, differences in the size of the events and type of meat included in the meals with meat options contributed to the large differences in the environmental impact of default interventions, particularly for events that include a beef meal option which had the largest negative environmental impacts. Overall, in terms of GHG emissions, the default interventions lowered GHG emissions by 104,387 kg of CO2 (a 40.1% difference between the Default Meat and Default Veg groups). These plant-based default interventions also lowered land use by 299.9 m^2 (a 46.2% difference between the Default Meat and Default Veg groups) and lowered phosphorus use by 259.5 *g* (a 35.9% difference between the Default Meat and Default Veg groups).

4. Discussion

The results of the present study show that changing defaults is a low-effort, high-impact, and generalizable strategy for nudging individuals towards more sustainable food choices, which was successful at reducing the GHG emissions and land, nitrogen, and phosphorus use associated with food consumption at six independent events across four different higher education institutions. On average, making the plant-based meal the default choice on the event RSVP forms increased the likelihood of choosing a plant-based meal by 43.7 percentage points. Importantly, our exploratory analyses show that the effect of the plant-based default was equally experienced across institutions, and preliminary findings suggest that the effect of defaults was also similar across demographic groups. Additionally, increased plant-based meal consumption at these events prevented an estimated 104,387 kg of CO2

Table 4
Descriptive Statistics for impact of Plant-Based Default on Choice of Plant-Based Meal by Study Site.

Independent Variable	(1)	(2)	(3)	(4)
Default Veg	0.434[b] [0.315,0.553]	0.330[b] [0.219,0.441]	0.375[b] [0.276,0.474]	0.362[b] [0.241,0.482]
Default Veg [a] ASU	−0.161 [-0.362,0.040]			
Default Veg [a] UCLA		0.199 [-0.020,0.418]		
Default Veg [a] UT-Austin			−0.0500 [-0.506,0.406]	
Default Veg [a] UCSB				0.0299 [-0.171,0.231]
ASU	0.0483 [-0.102,0.198]	−0.0347 [-0.149,0.080]	−0.0357 [-0.150,0.079]	−0.0202 [-0.170,0.129]
UCLA	0.0808 [-0.044,0.206]	−0.0122 [-0.177,0.153]	0.0758 [-0.050,0.202]	0.0899 [-0.069,0.248]
UT-Austin	0.0661 [-0.169,0.302]	0.0710 [-0.163,0.305]	0.0967 [-0.255,0.449]	0.0847 [-0.171,0.341]
Intercept	0.249 [0.150,0.347]	0.301 [0.204,0.397]	0.278 [0.185,0.371]	0.270 [0.159,0.381]
Demographics Included	Yes	Yes	Yes	Yes
Observations	**360**	**360**	**360**	**360**

Note: This table presents OLS estimates for a model of the binary outcome indicating the choice of the plant-based meal (95% confidence intervals are listed in brackets).
**$p < .01$.
[a] $p < .05$.
[b] $p < .001$.

(a 40.1% reduction), and reduced land use by 299.9 m^2 (a 46.2% reduction), nitrogen use by 959.0 *g* (a 34.9% reduction), and phosphorus use by 259.5 *g* (a 35.9% reduction). These estimates indicate a larger environmental benefit than previous reported in literature, e.g., defaults in Kurz (2018) were estimated to reduce CO2 emissions by only 5%. Additionally, all of these environmental impacts represent important steps towards reaching the dietary goals outlined by EAT-Lancet Commission's Global Planetary Health Diet (Willett et al., 2019), and demonstrate the significant role of dietary change for improving the sustainability of higher education institutions.

We observed significant and large effect sizes from our plant-based defaults across all sites, which is in line with the results from several recent studies that have similarly used defaults to promote more sustainable dietary behaviors and reduce meat consumption (Boronowsky et al., 2022; Hansen et al., 2021; Kurz, 2018; Taufik et al., 2022). For example, Taufik et al. (2022) re-designed a restaurant menu to frame the plant-based meal as the default option, which increased consumer selection of plant-based meals in an online experiment and a field experiment in a Dutch restaurant by 71.4 percentage points and 42.2 percentage points, respectively. With respect to academic settings, Hansen et al. (2021) reported large increases (2.75 times; 95% CI: [1.59, 4.79]) in vegetarian meal choice after implementing a vegetarian default at three academic conferences. Similarly, Boronowsky et al. (2022) showed that plant-based default nudges were effective at increasing plant-based meal consumption by 4.04 times (95% CI: {2.04, 7.99]) at three large events in the U.S. Our findings corroborate and expand on this existing evidence by demonstrating that defaults can be used to significantly increase the choice of plant-based meals across a range of institutional settings.

We also found preliminary evidence that the effects of the default interventions did not differ by the demographic characteristics or dietary preference of participants, which was an unexplored facet of the default interventions in prior studies (Boronowsky et al., 2022; Hansen et al., 2021; Kurz, 2018; Taufik et al., 2022). Specifically, the plant-based default had similar effects on meal choice across age, gender, race/ethnicity, occupation, and dietary preference (see Table 5, Table S4 and Table S5). However, further research is needed to demonstrate that the default intervention is effective across individual characteristics for promoting more sustainable meal choices at academic events. Importantly, our study was underpowered for estimating heterogeneous treatment effects (see Table 5, Table S4 and Table S5), so these results should be interpreted with caution. Future dissemination and implementation science research should investigate the potential barriers to the widespread use of plant-based defaults across higher education institutions in the U.S. Research is also needed to examine the effect of repeatedly experiencing a plant-based default, which is a potential limitation to the long-term effectiveness of this approach that has been raised in the literature (Kurz, 2018).

When considering policy recommendations, we must acknowledge limitations to the external validity and scalability of these results. In the current study, default interventions were implemented at catered events attended by university students and employees, which are not representative of the general population. While our sample was representative in terms of age groups and gender, the same cannot be said about the racial and ethnic background of the sample. For example, previous research has shown that willingness to reduce meat consumption is influenced by cultural beliefs related to meat consumption (Ellithorpe et al., 2022), which can vary by racial and ethnic group. Since only events that would have occurred regardless of our study were used, recruitment of events was opportunistic. Additionally, due to the nature of some events, the number of participants for some events turned out to be unpredictable which led to a smaller sample size than desired at UT Austin. Additionally, data collection took place at four universities in the southwestern United States, three of which are located in large metropolitan areas. Both education level and living in the Western U.S. have been associated with an increased likelihood of being vegetarian or vegan (Cramer et al., 2017). Further, a paper by Hielkema and Lund (2021) found that consumers living in more rural areas (e.g., countryside, small city) were less likely to reduce meat intake than those living in larger cities. Thus, more research is needed to test the impact of default interventions across a more diverse set of academic institutions before we can recommend scaling this approach to all academic settings

Table 5
Descriptive statistics for the heterogenous impact of Defaults on Choice of Plant-Based Meal by Demographics.

Independent Variable	(1)	(2)	(3)	(4)	(5)
Default Veg	0.477[c] [0.314,0.640]	0.495[c] [0.344,0.647]	0.404[c] [0.244,0.564]	0.515[b] [0.188,0.843]	0.248[a] [0.008,0.489]
Default Veg [a] ≥45 y.o.	−0.169 [-0.512,0.175]				
≥45 years old	0.0606 [-0.187,0.308]				
Default Veg [a] Female		−0.341 [-0.766,0.084]			
Female		0.268 [-0.067,0.603]			
Default Veg [a] Hispanic			0.163 [-0.192,0.519]		
Hispanic			−0.230 [-0.474,0.013]		
Default Veg [a] Black				−0.412 [-1.131,0.306]	
Default Veg [a] White				−0.0837 [-0.462,0.294]	
Default Veg [a] Asian				0.142 [-0.221,0.512]	
Black				−0.195 [-0.737,0.347]	
White				−0.0632 [-0.532,0.405]	
Asian				−0.0184 [-0.355,0.318]	
Default Veg [a] Undergraduate Student					−0.0506 [-0.552,0.451]
Default Veg [a] Graduate Student				0.323	[-0.001,0.653]
Default Veg [a] Faculty					0.298 [-0.127,0.723]
Undergraduate					−0.119 [-0.352,0.114]
Graduate					−0.109 [-0.389,0.155]
Faculty					0.064 [-0.121,0.318]
Intercept	−0.032 [-0.549,0.485]	−0.013 [-0.524,0.499]	−0.369 [-0.832,0.094]	−0.171 [-0.804,0.462]	0.022 [-0.424.0.467]
Demographics Included	Yes	Yes	Yes	Yes	Yes
Observations	**151**	**151**	**151**	**151**	**151**

Note: This table presents OLS estimates for a model of the binary outcome indicating the choice of the plant-based meal (95% confidence intervals are listed in brackets).
[a] $p < .05$.
[b] $p < .01$.
[c] $p < .001$.

in the U.S. Additionally, future research should investigate the impact of default interventions within day-to-day food services contexts, as opposed to individual events, to identify other opportunities for improving the sustainability of academic institutions.

Another important limitation of the present study is the statistical power of some of our analyses. Based on the average proportion of participants choosing the plant-based meal among the Default Meat groups (28.9%), our full sample (n = 360) was powered to detect effect sizes from the plant-based default of 14.1 percentage points or more with 80% power at a 5% significance level. After removing incomplete observations, our sample size of 151 participants with complete demographic data was powered to detect effect sizes of at least 22.2 percentage points, which is more than sufficient given our observed effect size of 43.7 percentage points. However, we did not conduct power analysis to determine adequate sample sizes for each demographic group. Furthermore, due to event operators' reservations about collecting demographic data on campus events, we only had a total of 151 responses out of 360 observations with complete demographic data. As a result, some of the heterogenous treatment effect analyses were underpowered given the small size of some demographic groups (e.g. only 18 non-Female participants) and events (e.g. one event had only 18 participants). For comparisons to a subgroup of only 18 participants, we were powered to detect effect sizes of at least 33.3 percentage points. The estimated difference in the effect of plant-based defaults between females and males in this study was 34.1 percentage points so we had enough power to determine statistical significance, but these results should still be interpreted with caution, and crucially, these heterogenous effects should be investigated in future research that includes more participants of diverse backgrounds.

Another limitation was our use of model meals for estimating the environmental benefits from the plant-based default interventions. Additionally, we did not record participants' choice between the red meat and poultry options after they selected the meal with meat option. A more accurate estimation of the environmental impacts from these interventions would require obtaining the individual recipes used to prepare each meal option and using actual values for the number of each

Table 6
Reduction in environmental impacts associated with each academic institution.

Institution		GHGEs	Land Use	Nitrogen Use	Phosphorus Use
		kg CO2 – eq	*m^2*	*g*	*g*
ASU (n = 136)	Default Meat group	59,229	71.6	787.7	158.2
	Diff. to Default Veg	12,001	9.4	164.9	16.7
	(Percent diff.)	(20.3%)	(13.1%)	(20.9%)	(10.5%)
UCLA (n = 78)	Default Meat group	84,095	272	737.6	245.4
	Diff. to Default Veg	49,871	170.3	371.5	135.3
	(Percent diff.)	(59.3%)	(62.8%) \	(50.4%)	(55.1%)
UCSB (n = 128)	Default Meat group	109,001	276.2	1,092.5	270.7
	Diff. to Default Veg	40,791	116.6	397.0	99.9
	(Percent diff.)	(37.4%)	(42.2%)	(36.3%)	(36.9%)
UT-Austin (n = 18)	Default Meat group	8,075	29.4	134.0	49.4
	Diff. to Default Veg	1,723	3.1	25.7	7.6
	(Percent diff.)	(21.3%)	(10.4%)	(19.1%)	(15.4%)
Total (n = 363)	Default Meat group	260,399	649.4	2751.8	723.7
	Diff. to Default Veg	104,387	299.9	959.0	259.5
	(Percent diff.)	(40.1%)	(46.2%)	(34.9%)	(35.9%)

Note: This table shows the difference in each of the environmental factors listed in the column headers associated with the actual meals served at each event in the Default Meat versus Default Veg groups (the percent difference between the Default Meat and Default Veg groups is shown in parentheses). GHGEs: greenhouse gas emissions.

Table 7
Differences in Environmental Impact Reduction with Red meat vs. Poultry Meals.

Institution		GHGEs	Land Use	Nitrogen Use	Phosphorus Use
		kg CO2 – eq	*m^2*	*g*	*g*
UCLA (n = 78)	Reductions w/ red meat	91,011	315.3	540.3	231.1
	Reductions w/ poultry	8,731	26.2	202.7	39.4
	(Percentage point diff. in reductions)	(35.0%)	(34.0%)	(16.3%)	(28.0%)
UCSB (n = 128)	Reductions w/ red meat	61,837	190.9	463.5	138.0
	Reductions w/ poultry	19,745	42.4	330.5	61.8
	(Percentage point diff. in reductions)	(11.6%)	(12.2%)	(61.8%)	(7.5%)
Total (n = 206)	Reductions w/ red meat	152,848	506.2	1003.8	369.1
	Reductions w/ poultry	28,477	68.6	533.2	101.3
	(Percentage point diff. in reductions)	(23.0%)	(23.7%)	(9.4%)	(18.3%)

type of meat meal selected, which were not collected for several events. In general, the environmental impacts will heavily depend on the composition of the plant-based meals and meals containing meat. Extensive research has established the negative environmental impacts of beef over most types of animal-source foods including dairy products, chicken, and pork (Cederberg et al., 2011; Clune et al., 2017). Additionally, not all plant-based foods have the same environmental impact with the production of crops like rice resulting in a relatively high amount of GHG emissions compared to other plant-based foods (Vetter et al., 2017). As a result, the largest reductions in GHG emissions require selecting lower environmental impact plant-based and animal-source foods, with the most dramatic reductions achievable by a switch from beef to plant-based protein.

5. Conclusion

This study found substantial environmental benefits from implementing plant-based default interventions at academic events across four higher education institutions. Through this nudge intervention approach, we observed significant reductions in GHG emissions and resource utilization from increased plant-based meal choices. Importantly, our findings underscore the generalizability of this plant-based default intervention across academic institutions. Future research among larger and more diverse samples is needed to more rigorously examine how this default intervention is experienced across demographic groups. Future research should also identify and address potential barriers to widespread implementation while also assessing the long-term sustainability of default interventions, thereby contributing to broader initiatives aimed at achieving global dietary sustainability goals.

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Ethical statement

The default interventions were implemented through a standardized questionnaire delivered as part of an RSVP form at one of six independent events held on four different higher education institutions: Arizona State University (ASU), the University of California at Los Angeles (UCLA), the University of California at Santa Barbara (UCSB), and the University of Texas at Austin (UT-Austin). Each intervention was approved by the corresponding institutional review board, which also approved the combination of de-identified study data across all events.

CRediT authorship contribution statement

Angela W. Zhang: Writing – review & editing, Writing – original draft, Project administration. **Christopher Wharton:** Writing – review & editing, Project administration, Methodology, Funding acquisition, Conceptualization. **Sara Cloonan:** Writing – review & editing, Writing – original draft, Project administration, Formal analysis, Data curation. **Renate Boronowsky:** Writing – review & editing, Project administration. **Varun Magesh:** Writing – review & editing, Project administration. **Ilana Braverman:** Writing – review & editing, Validation, Supervision, Resources, Project administration, Methodology, Funding acquisition, Conceptualization. **Alejandra Marquez:** Writing – review & editing, Project administration. **Heather Leidy:** Writing – review & editing. **May C. Wang:** Writing – review & editing, Supervision, Resources, Project administration, Methodology, Investigation, Conceptualization. **David A. Cleveland:** Writing – review & editing, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization. **Jennifer Jay:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. **Chad Stecher:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

No conflict of interest.

Data availability

We are preparing a publicly available data set and analytical code

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.appet.2024.107572.

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