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Can warning labels communicating the environmental impact of meat reduce meat consumption? Evidence from two multiple treatment reversal experiments in college dining halls

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ABSTRACT

Meat consumption has an adverse impact on both human and planetary health. To date, very few studies have examined the effectiveness of interventions tackling the overconsumption of meat in field settings. The present research addresses this gap by examining the impact of gain-framed labelling interventions communicating the adverse environmental consequences of meat consumption, using a multiple treatment reversal design across two university college dining halls over a period of five weeks. In College A the intervention weeks consisted of text-only or text-and-image labels communicating the adverse environmental consequences of meat consumption, and in College B patrons were exposed to either environmental or health labels (gain-framed; combining images and text). In total 13,869 (6,577 in College A and 7,292 in College B) meals (dishes) were analysed over the period of interest. Beta-binomial regressions found no statistically significant impact of the intervention periods compared to baseline on meat consumption in both College A and College B. The number of meal type options emerged as the only consistent predictor of meat consumption across models and across both colleges: meat consumption decreased with an increase in non-meat meal options. A post-study survey (College A: $n = 88$; College B: $n = 53$) revealed that patrons in both dining halls perceived environmental labels bearing both text and images as more informative and influential at changing behaviour compared to the other labelling interventions, although this did not translate into a change in behaviour. We discuss the implications of these findings for research, policy, and practice.

1. Introduction

Meat consumption has an adverse impact on both human and planetary health. Excessive meat consumption (particularly red and processed meat) is a concern both in terms of its high carbon footprint and role in climate change (Allen & Hof, 2019; Gomez-Zavaglia et al., 2020; Sabaté & Soret, 2014), and in terms of public health: excessive meat consumption is associated with increased risk of obesity, cardiovascular disease, infertility, diabetes, and cancer (Libera et al., 2021). Effective interventions are therefore urgently needed to shift consumer demand for meat to alternative products and plant-rich diets.

A recent systematic review of nudge (choice architecture) interventions on meat choice and consumption found a paucity of studies conducted in real-life settings (Bianchi et al., 2018). This is problematic because there is evidence to suggest that effect sizes obtained in real-world settings may often be smaller when compared to those obtained in laboratory settings (see Holden et al., 2016; Long et al., 2015). Thus, there is a need for research probing the effectiveness of interventions to reduce meat consumption in real-life settings.

Bianchi and colleagues' synthesis of 18 studies found evidence for the effectiveness of altering the size, availability of food options, and sensory properties of meat as interventions to modify the actual or intended consumption, purchase, or selection of meat in real- or virtual-environments. There have been recent notable efforts to extend these findings to real-life settings that have yielded promising results. In two sets of studies conducted in university cafeterias and dining halls interventions increasing the availability or proximity of vegetarian meal options were effective at reducing meat consumption (Garnett et al.,

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2019, 2020). Changing the salience of the vegetarian option within a university cafeteria menu and enhancing the visibility of the vegetarian dish increased vegetarian option sales, an effect that increased over time (Kurz, 2018). Another recent cafeteria study in Portugal found a multi-component intervention – including menu redevelopment and informational posters encouraging university cafeteria patrons to try the plant-based options – reduced meat consumption whilst maintaining patrons' satisfaction with the food offering (Guedes et al., 2023).

Some real-life settings however may not lend themselves to menu redevelopment, or availability and/or location interventions. For example, in Garnett and colleagues' (2020) studies increasing the proximity of vegetarian meal options only impacted behaviour when choices were spread apart over some distance (>1.5 m), but not when they were closer together. Eating habits are also deeply entrenched and likely necessitate a range of interventions to yield sustainable behaviour change (see Verplanken & Whitmarsh, 2021).

Labelling interventions have become popular for policymakers seeking to influence consumers of tobacco, alcohol, and more recently sugar-sweetened beverages (SSBs). Labelling interventions are relatively cheap and versatile; they can be implemented at the point of sale in many real-life settings, and in principle labelling can be combined with other interventions (such as availability or location interventions). In spite of the many benefits, evidence for the effectiveness of labelling interventions to influence meat consumption remains scant. The review by Bianchi and colleagues (2018) only identified labelling studies that involved simulated choice studies that did not measure actual consumption and used label descriptors such as 'pig/cow' (Kunst & Hohle, 2016) or 'Chef's Selection' (Bacon & Krpan, 2018), or that denoted the meat-free option with a green leaf symbol (Campbell-Arvai et al., 2014). Meat choice was not affected by any of these descriptive labels in these simulation studies.

Warning labels are a type of labelling intervention that has yielded particularly promising results in terms of affecting behaviour in real-life settings. Warning labels serve to highlight the detrimental consequences of consumers' behaviours. Warning labels on cigarette packages have been shown to increase intention to stop smoking and reduce intention to initiate smoking, as well as predict actual quit attempts and abstinence long-term (Francis et al., 2019; Hammond et al., 2003; Noar et al., 2016). In other domains, warning labels communicating the dangers of alcohol consumption have been found to reduce consumption speed (Stafford & Salmon, 2017), and population-level purchasing in the field (Zhao et al., 2020). Furthermore, health warning labels have been found effective at reducing parental selection and purchasing of SSBs (Hall et al., 2023; Mantzari et al., 2018), with a recent *meta*-analysis also showing promising results on actual consumption (Grummon & Hall, 2020). Thus, warning labels are a potentially powerful tool to reduce consumers' meat consumption in real-world settings. However, only two studies have been published to date examining the impact of warning labels on meat consumption using hypothetical online decision-making tasks. In one study of US meat eaters, Taillie and colleagues evaluated the impact of text-only warning labels on supermarket pre-packed meals denoting either: negative (i) health, (ii) environmental, or (iii) both health and environmental consequences of meat consumption (Taillie et al., 2021). The study found no statistically significant differences in the number of meat options chosen by participants randomised to see the health, environmental, or combined warning labels when compared to a no-label control group.

Another study examined the impact of pictorial warning labels on meat meal selection in a sample of UK meat eaters (Hughes, Weick, & Vasiljevic, 2023). Compared to text-only warning labels, pictorial warning labels can attract and hold people's attention better, garnering stronger cognitive and emotional appraisals, eliciting more negative attitudes towards smoking, and more effectively increasing behavioural intentions (see Noar et al., 2016, for a review). Hughes and colleagues found that pictorial warning labels focusing on either health, climate, or pandemic risks linked to consuming meat reduced the selection of meat meals when compared to a control group where no labels were shown.

The present research sought to investigate the possible effects of warning labels on meat consumption in a real-life setting via two field experiments carried out across two college dining halls based in a British university. Extending previous studies that have used loss-framed warning labels highlighting the negative consequences of meat consumption (Hughes et al., 2023; Taillie et al., 2021), in the present research we focus on gain-framed warning messages highlighting the potential benefits of reducing meat consumption. Gain-framed messages are a common feature of alcohol warning labels, with one study finding them to be as prevalent in real-life as loss-framed messages (see Cho & Rim, 2013). Even though gain-framed messages are positively framed, they can still serve as a warning and signal consumption-related risks (see Bansal-Travers et al., 2011; Goodall & Appiah, 2008; Nan et al., 2015).

Previous work suggests that gain-framed messages can be more effective in promoting behaviour change, despite loss-framed messages being rated as more emotive, owing to the greater motivational value of gain-framed messages (see Rosenblatt et al., 2019). Consistent with this, Carfora, Pastore, and Catellani (2021) found that gain-framed messages induced moderate levels of fear and systematic processing, impacting attitudes and intentions to consume meat more consistently than loss-framed messages. Furthermore, a *meta*-analysis of past literature found that for prevention focused behaviours such as smoking cessation, sunscreen use and exercising gain-framed messages—messages that highlight potential gains of behaviour change—are more effective at changing behaviour than loss-framed messages (Gallagher & Updegraff, 2012). Since reducing meat consumption and switching from meat to a non-meat option (fish or vegetarian/vegan) is a preventative behaviour we reasoned that our labels should carry gain-framed messages.

Consistently across the two experiments reported below, we examine the efficacy of the same environmental warning labels but using different points of comparison. We focus on environmental warning labels because surveys consistently show high levels of climate concern amongst our target population of UK university students, trumping many other concerns (Chegg.org, 2021; Hickman et al., 2021). As noted above, past studies have shown that cigarette pack warnings combining both a text message and a graphic image are more effective than text-only warnings (Noar et al., 2016). Therefore, in College A we compared environmental warning labels with a text-only message versus environmental warning labels combining text-and-image, to test if the combined message is more effective at reducing selection of the meat option when compared to the text-only warning.

People may have different motivations when they choose to reduce meat consumption or shift towards plant-based diets. For example, Kalof and colleagues' (1999) interview data showed environmental concerns to be a strong predictor of vegetarianism. Other studies stress the importance of health and ethical motivations (Jabs et al., 1998; Ruby, 2012). Meanwhile, Tobler et al. (2011) found in a survey of over 6,000 people that health was a strong predictor of the willingness to reduce meat consumption. In terms of the relative importance of different motivations, Seffen and Dohle (2023) recently found that health concerns trumped environmental concerns in determining people's attitudes towards meat consumption in a representative sample of German consumers. In contrast, environmental concerns, not health concerns, predicted the number of meat meals selected in an online choice task carried out with UK meat eaters (Hughes et al., 2023). Clear experimental evidence on the effectiveness of each of the motivations in persuading people to reduce meat consumption is needed. Therefore, in College B we compared the impact of gain-framed environmental warning labels with the impact of gain-framed health warning labels on meat meal selection and consumption, in order to establish whether persuasive messages that highlight different benefits of reduction in meat consumption or that appeal to different concerns have differential effects on actual consumption behaviour.

We hypothesised that placing gain-framed warning labels/posters

pertaining to the effects of meat consumption will reduce the proportion/amount of meat dinners selected/consumed during the intervention periods when compared to the baseline (control) periods (in both College A and B). Based on prior research, we also hypothesised that labels and posters combining text-and-image will reduce the amount of meat dinners selected/consumed per day significantly more than labels and posters containing text-only messages (College A). We refrained from making a directional hypothesis regarding the impact of the environmental *vs.* health label, since prior studies have found mixed findings in this area.

2. Methods

2.1. Setting

The experiments were conducted in two dining halls (cafeterias) at two different residential colleges in a British University. The studies were conducted between 10th February and 15th March 2020. Meal choice/consumption was recorded for all resident students (each college has ca. 300 residents; approx. 50 % female) dining in the dining halls for each evening meal during the study period. Dining rights are accorded to all college residents who pre-pay for all their meals on a termly (semester) basis.

Our study was confined to dinnertimes, since this is the only mealtime in these university dining halls that all the student residents of the two colleges attend their respective dining hall. During breakfast and lunchtime only a buffet-style limited offering is served in all college dining halls. This is because during the day students attend lectures and extra-curricular activities spread-out throughout the whole campus of the university, rather than being confined to their college. At lunchtimes students can dine in other food establishments within the University. During dinner students dine in the college dining hall that they are resident of. Furthermore, only during dinner full cooked meals with four options (meat, fish, vegetarian, and vegan) are offered. We therefore deliberately targeted only dinnertime for the intervention – allowing us to ensure that only resident students of each college dine-in (thereby ensuring there is no cross-contamination of the intervention, by having students exposed to the warning labels only in their respective college). Furthermore, dinnertime was the only time which was appropriate for measuring the impact of the labelling intervention, due to the way meal offerings are presented as mentioned above.

The level of randomisation and analysis is at the dining hall level, not the individual patrons of the dining halls. The sample size per study thus corresponds to the number of days of the period of interest. The Monte Carlo sample size calculation, considering R = 10,000 samples, showed that the planned five-week ABACA design would allow us to detect an absolute decrease in meat meal selection of 14 % (a small-to-medium sized effect as estimated by Garnett et al. (2019) with a probability of more than 80 % at the 5 % level significance when considering two-sided Wald t-tests of Beta-binomial fits. Our estimations were based on the observational study by Garnett and colleagues (2019) who observed an absolute reduction in meat meal choices of 14 % in a college dining hall setting similar to our studies. More details on the estimation of the sample size can be found in Appendix 2 of the Online Supplementary Materials.

2.2. Design

A multiple treatment reversal design was employed in an ABACA format. Each period lasted one week. The study had repeated baseline phases (A: Baseline) interspersed with intervention phases.

In College A dining hall patrons were randomly assigned to see text-only environmental labels (B: Intervention 1) or text-and-image combined environmental labels (C: Intervention 2).

A: Baseline
B: Intervention 1: text-only environmental label
A: Baseline
C: Intervention 2: text-and-image environmental label
A: Baseline

In College B dining hall patrons were randomly assigned to see health labels (B: Intervention 1) or environmental labels (C: Intervention 2). Both the environmental and health labels in College B combined text and images.

A: Baseline
B: Intervention 1: text-and-image health label
A: Baseline
C: Intervention 2: text-and-image environmental label
A: Baseline

The order of allocation of the two different interventions to one of the two intervention periods in each college was defined by the order of randomly generated uniform variates (with random seed set to the first author phone extension). The experimental design and analysis plan were prospectively registered with the Open Science Framework (https://doi.org/10.17605/OSF.IO/EWSAZ). In the original protocol we planned an extra intervention week in College B only with labels combining the health and environmental text-and-image messages (this was randomised to happen w/c 16th March 2020). Due to COVID-19, all participant testing was stopped on the 15th March in the University where these colleges are based, which meant that we had to stop the trial at College B without the final intervention week. The analyses presented here are based on five weeks of available data.

In our pre-registration we also noted that, if feasible, we would repeat the testing phase during the following academic term where we will measure the effects of the interventions over an additional five-week period (in order to replicate our findings from the initial five weeks of testing). Again, due to COVID-19 and ensuing lockdown restrictions across the UK, catering provision was halted at both college dining halls, and we were unable to repeat the experimental phase.

Perceptions and acceptability of the interventions were gauged via online post-study surveys conducted on the online survey platform Qualtrics (https://www.qualtrics.com). Surveys probing for patrons' perceptions of the tested intervention are commonplace in online hypothetical experimental studies (see Hughes et al., 2023; Taillie et al., 2021), but are also becoming more popular following field experiments of intervention effectiveness (see Guedes et al., 2023). All students with dining rights for the two college dining halls were invited to take part in the post-study surveys in exchange for being entered into a prize draw for the chance of winning a £50 shopping voucher. Eighty-eight and 53 residents completed the survey in College A and B, respectively.

2.3. Intervention

In the intervention periods every dinner time, labels and posters communicating the adverse effects of meat consumption on the environment (or health in College B) were displayed across the dining halls. The messages were gain-framed and emphasised the positive effects of reducing meat consumption. In College A these labels comprised either: (a) a text-only message *"To save the planet try switching from meat today"*, or (b) a combined text-and-image message containing the same text combined with an image of a polar bear standing on a melting iceberg. For the text-only label we positioned a simple black arrow towards the text in order to keep the potential engagement with the message constant across the text-only and text-and-image labels. In College B both intervention labels combined text and image. Depending on the intervention week, either the environmental or the health messages were displayed, with the environmental label being the same as in College A, and the health message displaying the message *"To boost your health try switching from meat today"* (displayed together with an image of a person enjoying a healthy plant-based meal). Below the label messages the

source of the message was presented in brackets and in a smaller font size (for the environmental labels: Intergovernmental Panel on Climate Change, 2019; for the health label: Academy of Nutrition and Dietetics, 2016; see Melina et al., 2016). It is well-established that credible sources increase the efficacy of persuasive messages (Fragale & Heath, 2004; Hovland & Weiss, 1951). Thus, we reasoned that including an expert source for the message would increase credibility and in turn increase patrons' willingness to shift away from meat.

The various message and image options were vetted amongst a group of Behavioural Science experts ($n = 10$; Female = 5, Male = 5) based at the university where the two experiments were conducted. The group included international experts in behaviour change, risk perception, intervention evaluation, experimental design, and stimuli/intervention generation. When asked to review and advise on the development of our intervention material, we asked the Behavioural Science experts to recommend features that would make the warning labels most persuasive and easiest to understand. We already knew we wanted to focus on text-only *vs*. text-and-image messages in one college, and text-and-image labels of health and environmental consequences of meat consumption in the other college. So, the experts were asked to advise us on the design features that would make our labels most persuasive and understandable. Some of the experts' recommendations included: making the textual message shorter and snappier; consider using expert references for the textual information provided; and providing an arrow in place of the image in the text-only label condition [to make the labels with images and without images more comparable, and make sure that the labels with images are not simply more attention-grabbing due to the image presented].

Furthermore, we also asked a group of MSc students ($n = 20$; Female = 14, Male = 6; Age Range = 21–30) in Behavioural Science to rate and comment on the initial labels which were vetted by the Behavioural Science experts. In an iterative fashion we then asked the Behavioural Science experts again for their opinion after we obtained the ratings of the MSc students. See Fig. 1 for the three intervention labels used in Colleges A and B.

2.4. Procedure

The study was approved by Durham University Psychology Research Ethics Committee [PSYCH-2019–11-20T07_43_43-dfmq76], approval date 22nd January 2020. In keeping with research governance for interventions that target environments and not individuals directly, consent was obtained from gatekeepers with authority over these environments (in this instance the catering manager of the college dining halls as well as the Principals/Presidents of the two colleges participating in the studies; see Garnett et al., 2019). Signed consent forms, approved by the Research Ethics Committee, were obtained from each of these gatekeepers before study commencement.

Data collection took place every dinnertime from 5 pm to 7 pm (including weekends) during the five-week study period 10th February – 15th March 2020. Research assistants were stationed in the two college dining halls at the end of the serving counters where they unobtrusively recorded each patron's daily dinner meal choice. Dining hall patrons were not made aware that a study was being conducted in the dining hall, though we reasoned that they may become aware that a study is taking place simply by the presence of additional posters and labels during the intervention periods of the study. Research assistants had a cover story purporting that they are conducting a review of the dining hall service provision in case any patrons asked about their presence. Due to the nature of the intervention the research assistants themselves were not blind to intervention randomisation.

The dining halls have a three weekly rotating menu, and during dinnertime the menu offers four different main meal types: meat, fish, vegetarian, and vegan. The order of presentation of the options on the serving counter follows the convention where the meat option is presented first, with the fish next to it, and then the vegetarian and vegan options. Although four main meal options are the default, unexpectedly during some of the study days at both colleges only three or two options were offered (most often with the fish option missing). The number of daily meal options was therefore recorded in our dataset, and we used this as a covariate in our analyses.

In the intervention periods, labels and posters communicating the adverse effects of meat consumption to the planet (and human health in College B), were put up all over the dining hall (particularly on or around the meals, the menus, and on or around the already existing tablets in the dining hall where students normally scan their campus card before collecting their food; see Appendix 1 in Online Supplementary Materials for photographs of the dining halls during intervention weeks).

2.5. Measures

2.5.1. Intervention impact

Primary outcome. The proportion of meat dinner dishes selected and consumed daily in each intervention period compared to baseline, defined as the number of meat dinner dishes divided by the total number of dishes served on a given day.

Secondary outcomes. The daily compositional proportions of i)

Fig. 1. Intervention labels similar to those used in the study: (a) text-only environmental label, (b) text-and-image environmental label, (c) text-and-image health label. (Image credits: environmental label: Linking Tourism & Conservation on Flickr.com [Polar bear on sea ice North of Svalbard – modified]; health label: Gustavo Fring on Pexels.com [Woman Holding a Bowl with Salad while Sitting Behind a Table Full of Vegetables]). For the actual images used in the study please contact the corresponding author.

meat, ii) fish, iii) vegetarian and vegan dinner dishes selected and consumed in each intervention period compared to baseline.

Covariates. The following variables were recorded as potential covariates in the modelling of the primary outcome: day of the week to control for possible fluctuations in meal-choices associated with certain menus (*e.g.,* "Special Dinner Fridays" or "Sunday Roast"), rotating weekly menu, number of meal type options (meat, fish, vegetarian, and vegan), and maximum daily temperature, rainfall and sunshine on each given day in the British town where the university is based at (since temperature may affect meal choices).

2.5.2. Perceptions and acceptability survey

Demographic information. The post-study survey measured participants' demographic information (age, gender, ethnicity, incl. household-level income, SES occupation and education of the highest earner in the household since participants were all university students; see Oguz et al., 2013).

Perceptions and acceptability of the labels. Respondents were provided with the two intervention labels administered in their respective college and were asked to rate which of the two labels they found more: *noticeable, informative, attention grabbing, thought provoking, effortful to read/process, truthful, credible, uncomfortable, guilt inducing, worry inducing,* and *which one they would prefer to become governmental policy*. A third response option of *Did not Notice/Don't Know* was also allowed for all the above questions.

Participants were also asked to rate on 7-point Likert scales their agreement with *whether they learnt something new from the labels*, their *level of support for the different types of labels* and *support for using labelling interventions in their college dining halls*, *their perception of whether the labelling interventions changed their attitudes towards meat consumption* and *whether their buying habits will in future change due to the labelling interventions*. Participants also rated the *importance of health* and *environmental concerns for themselves in general*.

2.6. Analysis

The daily number of meat dinner dishes selected and consumed over the total number of dishes served during the period of interest were modelled by means of beta-binomial regression analyses (see Rigby et al., 2019) with intervention type as a 3-level categorical predictor with 'baseline' as a reference group. The beta-binomial model was preferred to the binomial regression, regularly used in this context, as the assumption of fixed probability of selecting a meat dish given the predictors was not satisfied. The main analyses controlled for the day of the week (7 level factor) and for the daily number of available meal type options (ranging from 2 to 4, where 4 corresponds to meat, fish, vegetarian and vegan options). A standard p-level of 0.05 for statistical inference was used, and 95 % Confidence Intervals (CIs) as well as effect sizes were computed. Analyses were conducted in R-4.0.2.

Sensitivity analyses considered alternative statistical modelling (beta regression for the daily proportions of meat dinner dishes) and further predictors, like the rotating weekly menu, the daily temperature, rainfall, and sunshine levels in the University town the study was based at.

Days during which data were not available due to formal functions held in the two college dining halls (four and two days in Colleges A and B respectively over the study period) were not considered in our analyses.

For the online post-study survey, we analysed three-level categorical outcomes assessed by displaying the proportion of each level for each question by means of ternary plots, as well as by defining 95 % CIs corresponding to tests of equality of proportions of all pairwise comparisons (*i.e.,* binomial exact tests). Ternary plots or triangular diagrams consist of an equilateral triangle in which a given plotted point represents the relative proportions of three components (in our case a = *Label Type 1*, b = *Label Type 2*, and a third option c = *Didn't Notice/Don't Know*), generally expressed as percentages and constrained by a + b + c = 100 % (see Howarth, 1996). For survey outcomes measured on seven-level Likert scales, non-parametric bootstraps were used to define 95 % CIs for the mean.

3. Results

3.1. Descriptive analyses

In total 13,869 (6,577 in College A and 7,292 in College B) meals (dishes) were analysed over the period of interest. Online Supplementary Materials Appendix 6 (Table S5) shows the breakdown per intervention period and college. Fig. 2 displays the number of meals as a function of time per meal type (coloured lines in electronic materials) for Colleges A (left) and B (right). Weeks are colour coded by condition and a bar on the x-axis indicates the number of options per day (in levels of greys). Meat appears to be the most popular meal choice across both colleges, and the selection of meat notably peaks on days when there were fewer meal type options. The proportion of meals chosen per meal type can be seen in Appendix 3 (Fig. S5) in Online Supplementary Materials.

Fig. 3 displays the daily proportions of meat, fish and vegetarian/vegan meals by means of ternary plots for College A (left) and B (right). Symbols are colour-coded by intervention type. Different symbols are used depending on the number of meal options available per day. We can note that the overall pattern is similar in both colleges. Unexpectedly and deviating from the set rotational weekly menus fish was not available every day (there were 8 days without fish at both College A and B), while vegetarian/vegan and meat options were always available. The probability of selecting the meat option appears to decrease with the number of alternative meal (non-meat) options. Regarding the effect of the intervention, we can visually note that in College A days during the two intervention weeks seemingly show an increased probability of selecting the vegetarian/vegan options over the fish (when available) and meat options. The information presented in this ternary plot can be found in tabular form in Appendix 3: Tables S1 and S2 in Online Supplementary Materials.

3.2. Intervention impact

Primary outcome. Beta-binomial regressions demonstrated that the interventions did not have a statistically significant effect on meat consumption across both dining halls (College A: t = -1.800, p = 0.086 text-only; t = -0.16, p = 0.870 text-and-image combined; College B: t = -0.819, p = 0.421 health, t = 0.117, p = 0.908 environmental). When controlling for the number of meal type options and day of the week, we found that number of meal type options consistently across both dining halls had a statistically significant effect on meat consumption (College A: t = -5.600, $p < 0.0001$; College B: t = -4.456, p = 0.0002). When there were more meal options then meat was less likely to be selected and consumed. Day of the week effects had a statistically significant influence only in College B where on Tuesdays and Thursdays there was a decrease in meat selection and consumption. See Tables 1 and 2 for the primary models for each college respectively.

Sensitivity analyses. We carried out a series of sensitivity analyses to determine the robustness of our primary models. All these models were in line with the primary model (see Appendix 4: Figs. S6 and S7 in Online Supplementary Materials). We also present the indices for the best fit models in both dining halls defined by means of a generalised AIC based stepwise forward and backward model selection assuming the beta-binomial as conditional distribution with the logit link function (Rigby et al., 2019), which again highlight that number of meal options is a statistically significant predictor of meat selection and consumption (see Appendix 5 in Online Supplementary Materials).

Secondary outcome. We explored the possibility of using compositional regression models to model the impact of the interventions on the secondary outcomes as per protocol. However, due to the unexpected

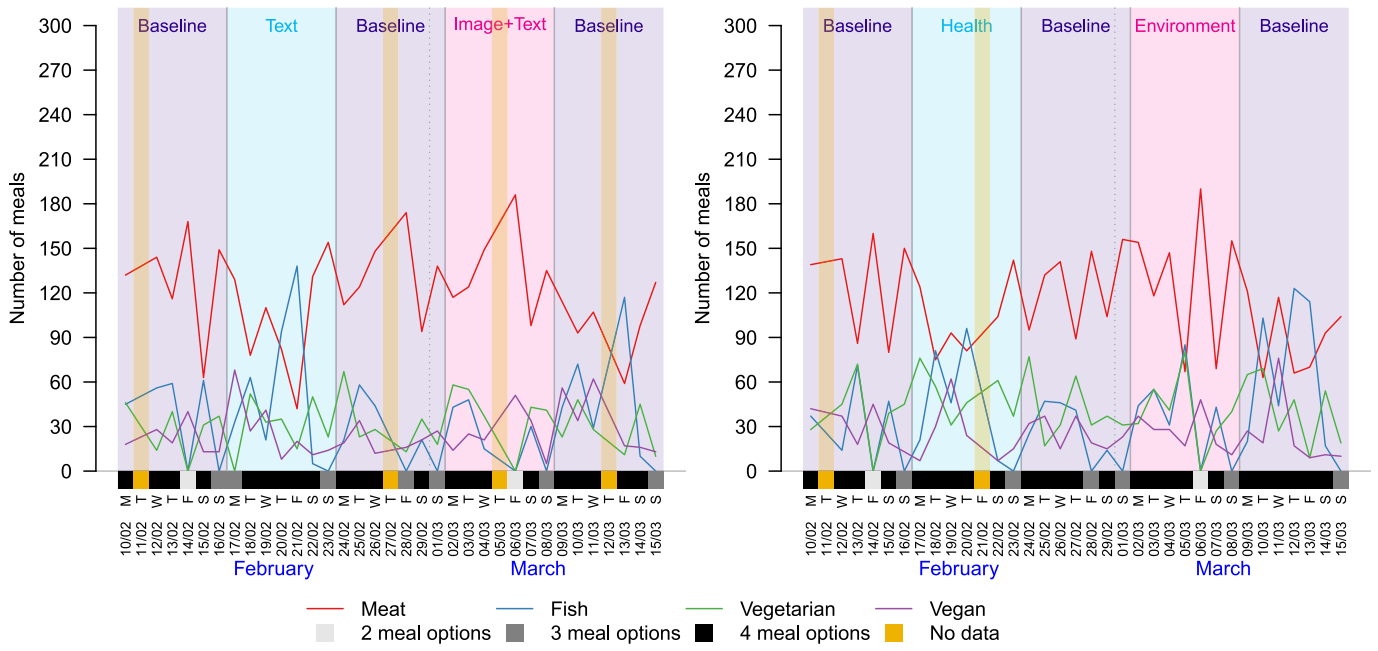

Fig. 2. Number of meals (y-axis) in College A (left) and College B (right) as a function of time (x-axis) per meal option (colour-coded solid lines). Weeks are colour coded by conditions. A bar on the x-axis indicates the number of options per day in levels of greys. Days without data appear in yellow. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

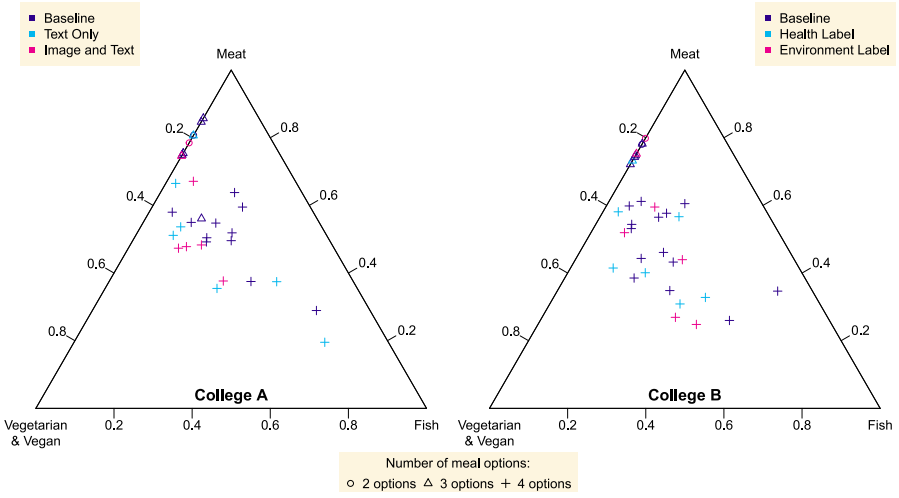

Fig. 3. Ternary plots graphically displaying meal selections in percent in College A (left) and College B (right). Each symbol corresponds to a day, colour-coded by intervention type, and shaped according to the number of meal options per day.

Table 1
Beta-binomial regression modelling the impact of the two interventions in College A controlling for number of meal options and day of the week.

	Estimate	Std. Error	low 95 %CI	high 95 %CI	Effect Size	t-value	p-value	Sig
(Intercept)	4.219	0.756	2.642	5.796		5.580	<0.0001	***
Condition "Text Only"	−0.295	0.164	−0.637	0.047	0.744	−1.801	0.0869	
Condition "Image & Text"	−0.029	0.180	−0.405	0.346	0.971	−0.163	0.8720	
Number of meal type options	−1.068	0.191	−1.466	−0.670	0.344	−5.600	<0.0001	***
Tuesday	−0.121	0.239	−0.619	0.378	0.886	−0.505	0.6194	
Wednesday	0.451	0.227	−0.022	0.923	1.569	1.988	0.0607	
Thursday	−0.054	0.301	−0.682	0.574	0.947	−0.179	0.8597	
Friday	−0.489	0.263	−1.037	0.060	0.613	−1.859	0.0778	
Saturday	0.240	0.228	−0.237	0.717	1.271	1.051	0.3060	
Sunday	0.296	0.295	−0.320	0.912	1.345	1.003	0.3277	

Note. Significance is denoted as *** < 0.001; ** < 0.01, * < 0.05.

Table 2
Beta-binomial regression modelling the impact of the two interventions in College B controlling for number of meal options and day of the week.

	Estimate	Std. Error	low 95 %CI	high 95 %CI	Effect Size	t-value	p-value	Sig
(Intercept)	3.809	0.847	2.053	5.565		4.499	0.0002	***
Condition "Health Label"	−0.119	0.146	−0.421	0.183	0.888	−0.819	0.4215	
Condition "Environmental"	0.016	0.140	−0.273	0.306	1.017	0.117	0.9077	
Number of meal type options	−0.923	0.207	−1.353	−0.494	0.397	−4.456	0.0002	***
Tuesday	−0.529	0.200	−0.943	−0.115	0.589	−2.649	0.0147	*
Wednesday	0.017	0.185	−0.368	0.401	1.017	0.090	0.9288	
Thursday	−0.853	0.192	−1.252	−0.455	0.426	−4.445	0.0002	***
Friday	−0.494	0.307	−1.130	0.141	0.610	−1.613	0.1210	
Saturday	−0.018	0.189	−0.411	0.374	0.982	−0.096	0.9241	
Sunday	0.035	0.289	−0.564	0.634	1.035	0.120	0.9053	

Note. Significance is denoted as *** < 0.001; ** < 0.01, * < 0.05.

absence of fish options on several days during the study period, the compositional regression models could not be fitted.

3.3. Perceptions and acceptability post-study survey

In College A $n = 88$, and in College B $n = 53$ patrons took part in the post-study survey. The demographic characteristics of the patrons who completed the post-study survey for both colleges are presented in Appendix 7 (Table S6) in the Online Supplementary Materials.

Ternary plots presented in Fig. 4 show the distribution of three-level categorical outcomes (see also Appendix 7: Table S7 in Online Supplementary Materials). Binomial exact test 95 % CIs for the proportion of a given response option (*e.g.,* 'Text-and-Image') when only considering one other response option (*e.g.,* 'Text') are shown in Fig. 5. The results revealed that in College A the patrons who completed the survey found the combined text-and-image environmental label to be *more noticeable, informative, attention grabbing, thought provoking, uncomfortable, effortful to process, and guilt and worry inducing* when compared to both the text-only label and those who answered *Did not Notice/Don't Know*. The ratings of *label truthfulness, credibility* and *policy preference* did not differ between the three answer options. In College B a similar pattern of results was obtained whereby respondents favoured the environmental (text-and-image) label which was identical to the one used in College A, when compared to the health label [with the exception that the health label was rated as more noticeable and equally attention grabbing as the environmental label only in College B].

For outcomes measured on seven-level Likert scales, non-parametric bootstraps showed that patrons in both College A and B were overall supportive of the different labelling interventions in the college dining halls and rated both health and the environment as important concerns for them (with health concerns trumping environmental concerns in both colleges). However, responders across both colleges were also significantly more likely to say that they did not learn anything new with the labels, and they did not think the labels changed their attitudes and future shopping habits. In College A, they were also significantly more supportive of the text-only than the text-and-image combined label (which is in line with prior research, see Noar et al., 2016). In College B, respondents were overall more supportive of the environmental than the health label. For a breakdown of these analyses see Fig. 6 below (and Appendix 7: Table S8 in Online Supplements).

4. Discussion

This paper examined the efficacy of gain-framed warning labels that appeal to environmental (or health) benefits of reducing meat consumption in college dining halls. Across two experiments we found no statistically significant effects of environmental or health warning labels on reducing meat consumption. The number of meal type options was a consistent predictor of reduced meat consumption in both colleges, whereby meat consumption decreased with the increase in (non-meat) meal options. This finding dovetails previous studies and highlights the importance of the availability of alternative (non-meat) meal options (Bianchi et al., 2018; Garnett et al., 2019, 2020).

Our findings extend previous research regarding the impact of text-only (Taillie et al., 2021) and text-and-image (Hughes et al., 2023) warning labels on meat selection in online choice tasks. Unlike previous studies, we examined meat consumption across a five-week period in a real-world setting within two university dining halls. However, we

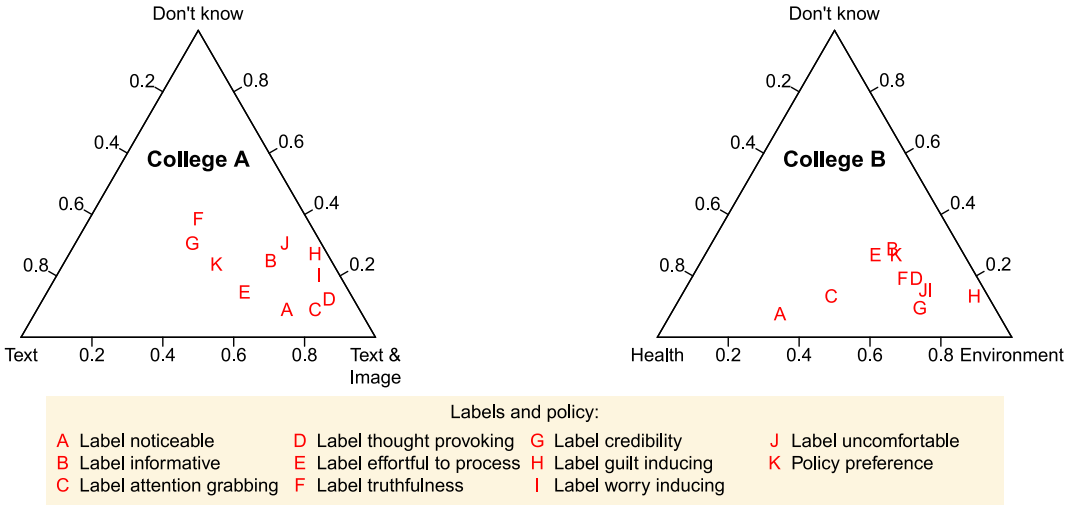

Fig. 4. Ternary plots graphically displaying the percentage of answer for each level of each three-level categorical questions in College A (left) and College B (right). Each letter corresponds to a question item.

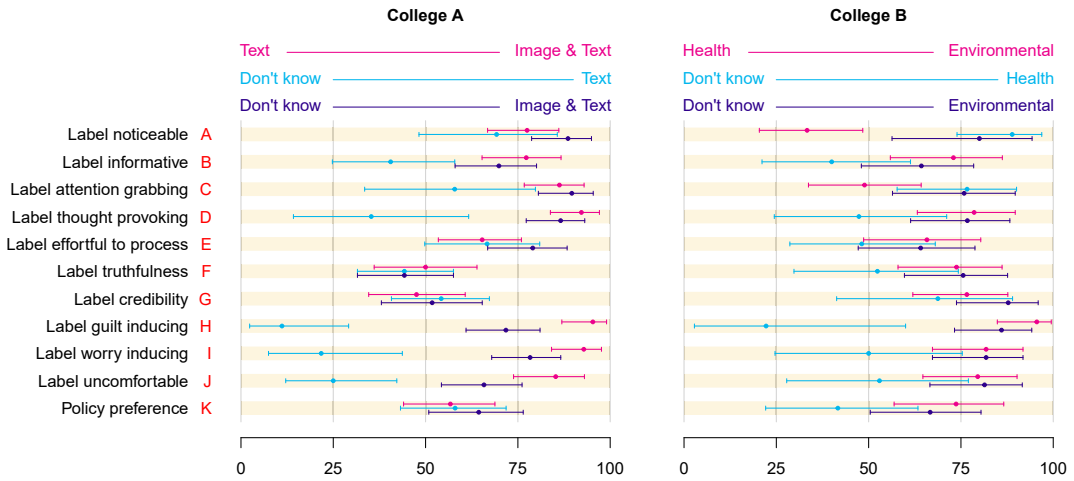

Fig. 5. 95% Confidence Intervals (CIs) corresponding to the tests of equality of proportions for all pairwise comparisons of three-level categorical outcomes in College A (left) and College B (right). The x-axis displays central tendencies and 95% CIs for the proportion of a given response option (*e.g.*, 'Text-and-Image') when compared to one other response option (*e.g.*, 'Text'). CIs that do not cross the midpoint (50) indicate a preference towards one of two pairwise response options.

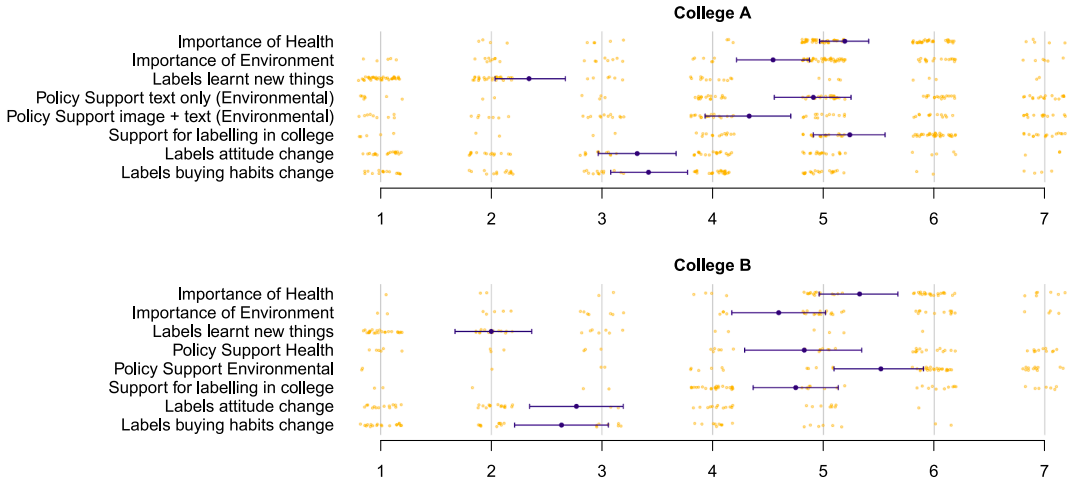

Fig. 6. 95% percentile bootstrap Confidence Intervals (CIs) for the mean of survey respondents' ratings on each Likert-type question rated on a 1–7 scale.

found no evidence that adding an image to the text warnings communicating the environmental or health consequences of meat consumption improves the impact of the warning labels on meat consumption. Thus, differences in the use of images may not suffice to explain the divergent results obtained in previous online choice tasks. Furthermore, prior work tentatively suggests that gain-framed (*vs.* loss-framed) warning messages may be more effective at changing meat consumption. Thus, in the present research we employed gain-framed warning messages. However, this yielded similar results as the loss-framed warning messages employed by Taillie and colleagues (2021).

A post-study survey revealed that dining hall patrons perceived the text-and-image environmental labels (in both College A and B) as more informative and guilt/worry inducing (when compared to text-only environmental labels and the health [text-and-image] labels, as well as compared to those who did not notice the labels or did not have an opinion). In other words, even though respondents found the labels combining text-and-image *relatively* more emotive and informative, this was not sufficient to change patrons' behaviour during dinnertime. This is in line with a recent *meta*-analysis showing that pictorial warnings on tobacco packs increase affective and some cognitive risk appraisals, but do not increase beliefs about disease risk and harm, thus potentially limiting their behavioural impact (Noar et al., 2020).

Furthermore, though overall supportive of the labelling interventions presented in both colleges and purporting a high level of concern for the environment (and health), patrons also self-reported that they did not learn new information from the labels and indicated that their attitudes and future shopping habits will not change as a result of the labels. Furthermore, even though adding images to the environmental label increased the perceived informativeness, respondents did not feel the information conveyed was new. The participants across the two dining halls were university students, who are a highly educated subsection of the population. This may partially explain their self-reporting in the post-study survey that they did not learn new information from the warning labels used in the present research. In addition, the sample composition may also explain the divergence in findings between the present experiments and the one reported by Hughes et al. (2023) who sampled a nationally representative sample of UK meat eaters.

Another interpretation of this overall pattern of results is that, while aware of the environmental impact of consuming meat, patrons are nevertheless reluctant and to some extent disinclined to change their eating habits (Tobler et al., 2011). This is in line with recent findings showing that daily habits such as meat consumption can be difficult to modify (see Verplanken & Whitmarsh, 2021). A reluctance to change eating habits may also explain why respondents were more supportive of environmental (*vs.* health) warning labels whilst reporting stronger

health (*vs.* environmental) concerns.

The discrepancy between self-reported high levels of concern for the environment and health outcomes and the lack of behavioural impact arising from the warning labels used in this study may also arise from perceived taste differences between meat and non-meat meal options. Prior research suggests that across a varied range of participants non-meat options are often rated as less tasty, which may impact their uptake (see Röös et al., 2022; Weinrich, 2018).

4.1. Strengths and limitations

The two studies presented in this report are to our knowledge the first two field experiments testing the impact of different warning labels on meat consumption in college dining hall settings. The use of a randomised experimental design with repeated baseline measures across a period of five weeks and employing behavioural measures of meal choice and consumption further strengthen the conclusions of these studies. One of the biggest confounds in studies of this type is the price of the different meal options (see Leach et al., 2016). However, as our experiments were performed in college dining halls where the food had all been prepaid for in the termly catered accommodation fees, price was not a factor that could influence meal choices.

Our studies are limited in several respects. Our studies focused on two common motivations to reduce meat consumption: concerns about the environment and health. However, other motivations have been reported in the literature that we did not explore in the present research and that could have a different influence on meat consumption. Particularly, ethical concerns about animal treatment and cruelty (Rozin, 2004) and animal rights (Regan, 1984) are amongst those motivations that may lead people to opt for plant-based diets (see also Jabs et al., 1998; Ruby, 2012). Future research should examine the impact of such motivations on modifying meat consumption.

Individual-level data was not available from the dining halls, hence we could not model patrons' individual choices over time. Individual-level data could improve our estimate of the effect size of the impact of labelling, and future studies should where possible aim to collect such data. Choosing a meal in a college dining hall is not made in isolation, therefore the meal choices of patrons coming earlier in the queue may have exerted a social facilitation effect upon subsequent patrons' choices (Clendenen et al., 1994). Disentangling potential social facilitation effects was beyond the aims of the present research, however future studies may wish to model the potential effects of social facilitation on meal selection within dining halls. Our post-study survey attracted a limited number of patrons, therefore some of the conclusions arising from the survey may not be reflective of all the residents of College A and B who dined in the dining halls over the five-week study period. Due to time-constraints the post-study survey did not explicitly ask survey participants whether they had noticed the warning labels in their respective dining halls during the intervention weeks. This was indirectly assessed when asking patrons' their perceptions of the different labels where we gave them the option to choose one of the two intervention labels used in their respective college dining hall with a third option of *'Didn't Notice/Don't Know'*. The frequencies of how many people chose the *'Didn't Notice/Don't Know'* option across questions differed and ranged from 7.7 % to 38.6 %, showing that only a minority of participants who took part in the post-study surveys self-reported they didn't notice the labels. However, future studies may wish to supplement these findings, by including an explicit question as to whether participants noticed the labels in the dining halls during the intervention weeks.

As noted above, due to COVID-19 we could not examine the combined impact of environmental and health labels since this intervention was planned for the sixth week of testing in College B when COVID-19 related restrictions were put in place. Future research should examine the joint impact of different label combinations; some of which may be more effective than individual labels themselves. Whether the effects obtained in our studies replicate across other contexts (*e.g.,* restaurants) and amongst different clientele (*e.g.,* older patrons) would also be a fruitful avenue for future research.

4.2. Implications and conclusion

Increasingly, scholars highlight the crucial role that universities and other organisations may play in promoting sustainability and protecting the environment (Garnett & Balmford, 2022). College and university dining halls (cafeterias) offer unique settings for trialling out new interventions aimed at promoting sustainable and healthy behaviours given the large number of students who get their meals daily (and in the case of the colleges sampled in this research, students get their meals predominantly from these dining halls). In the UK, there have been relevant moves across different universities to encourage reduction of meat consumption. For example, Goldsmiths (a London based university) recently banned beef from university cafés to tackle climate change (Walker, 2019). Similarly, the University of Cambridge also replaced beef and lamb dishes with plant-based meals in its menus ("University of Cambridge: Removing meat 'cut carbon emissions'", 2019), with a further commitment by the University of Cambridge Student Union to migrate to 100 % vegan offering by 2028 (Shah, 2023). However, despite claims that the moves to ban or remove meat from dining-establishment menus would be effective, experimental evidence in this area is scarce. Importantly, it is unknown whether banning meat may backlash (*e.g.,* lead to increase in meat consumption in other contexts). Thus, it is important to test the impact of interventions empirically. The present paper further attests to the value of using college and university dining halls to test the effectiveness of interventions to change food consumption. Our studies suggest that gain-framed warning labels communicating the environmental or health impact of meat consumption may have a limited effect on meat choice and consumption amongst student patrons in a university dining hall setting. Furthermore, our studies replicate other findings in this area by showing that the number of food meal options affects meat choice and consumption. Based on current evidence policies which change the default number of meal (non-meat) options may therefore lead to more impactful and sustained reductions in meat consumption than either loss- or gain-framed warning labels.

Ethical statement

The study was approved by Durham University Psychology Research Ethics Committee [PSYCH-2019-11-20T07_43_43-dfmq76], approval date 22nd January 2020. In keeping with research governance for interventions that target environments and not individuals directly, consent was obtained from gatekeepers with authority over these environments (in this instance the catering manager of the college dining halls as well as the Principals/Presidents of the two colleges participating in the studies; see Garnett et al., 2019). Signed consent forms, approved by the Research Ethics Committee, were obtained from each of these gatekeepers before study commencement.

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CRediT authorship contribution statement

Milica Vasiljevic: Conceptualization, Methodology, Resources, Supervision, Data curation, Project administration, Writing – original draft. **Jack P. Hughes:** Writing – review & editing, Resources, Methodology, Investigation, Data curation, Conceptualization. **Christina D. Andersen:** Writing – review & editing, Resources, Methodology, Investigation, Data curation, Conceptualization. **Georgia Pennington:** Writing – review & editing, Resources, Methodology, Investigation, Data

curation, Conceptualization. **Ana C. Leite:** Writing – review & editing, Resources, Methodology, Investigation, Data curation, Conceptualization. **Mario Weick:** Writing – review & editing, Resources, Methodology, Conceptualization. **Dominique-Laurent Couturier:** Writing – review & editing, Visualization, Methodology, Formal analysis, Conceptualization.

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.

Data availability

Data from the two colleges are not available for sharing due to commercial sensitivities.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.foodqual.2023.105084.

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