Department of **BIOLOGY**

A17753S1 PROJECT DISSERTATION

Candidate	Elizabeth Biggs
Supervisor	E.J. Milner Gulland, Elif Naz Çoker and Emma Garnett
Title	Meating environmental goals: trialing descriptive dynamic norms as a method to decrease meat consumption within a UK field setting.
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Abstract

To meet UK Net Zero Carbon Emission targets, meat consumption in the UK must decrease. In lieu of any UK government strategy to reduce meat consumption, behavioural interventions can be used. Behavioural interventions seek to affect actions individuals take, resulting in a desired behaviour change. Nudging is a type of intervention altering the physical, social and informational cues that influence human decision-making. One nudge yet to be tested in a UK field setting to reduce meat consumption is dynamic descriptive norm messaging. This field study tested the effect of two dynamic descriptive norms messaging interventions on meat consumption in a trial across eight canteens in Oxford, UK. These messages were workshopped in focus groups and evaluated by posttrial surveys. The messages differed by the referent social group to which the norm behaviour was assigned to, testing whether closeness of the referent group moderated the effect of the message on behaviour. The trial consisted of two eight-week periods: a baseline period with no intervention implemented, and an intervention period whereby messages were advertised. Generalised linear mixed effects models (GLMMs) suggest exposing diners to either message significantly lowered the odds of them choosing a vegetarian meal, in comparison to the control group. Whilst the GLMM produced significant interaction terms, we cannot confirm this was due to the actual effect of the interventions, or experimental design limitations. We found no evidence that messages increased vegetarian sales. Confirmatory research is essential to ascertain whether dynamic descriptive norms can reduce meat consumption.

Introduction

1. Humans respond to cues to inform their decision-making

Humans, like other animals, change their behaviour in response to a range of social and environmental cues. These cues, defined as passive stimuli that inherently provide the observer with information, can affect decision-making (Bradbury & Vehrencamp, 2001). Therefore, by manipulating cues, humans can be encouraged to make different choices. Within the field of social psychology, the alteration of cues to change human behaviours occurs through the implementation of behavioural interventions.

Behavioural interventions are modifications to a decision scenario that are designed to affect the actions that individuals take, resulting in a desired behaviour change (Cutler, 2004). Interventions have been used to encourage pro-health behaviours such as reduced consumption of sugar rich foods (Arno & Thomas, 2016), or pro-environmental behaviours such as anti-littering (Cialdini, et al., 1990). Interventions can include education, financial incentives and nudges.

Whilst education and monetary incentives target rational thinking, nudge techniques target intuitive thinking, whereby individuals use "mental shortcuts" that reduce processing power required to make decisions (Tversky & Kahneman, 1974). Nudges create small changes in the decision context ('choice architecture') of an individual, which can include alterations to the physical, social, and informational cues influencing decision-making (Thaler & Sunstein, 2008). Nudge interventions work by making the desired behaviour easier or more intuitive, and have been applied across governmental, health and environmental contexts (Montambault, et al., 2016; BIT, 2012; BIT, 2010; Dai, et al., 2021; Bianchi, et al., 2018).

2. Nudges can encourage pro-environmental behaviours

Behavioural interventions, such as nudges, can change behaviours to benefit both people and planet, such as the reduction of meat consumption. Recent analyses highlight that consumption of meat has a negative impact on the environment when considering a set of indicators including greenhouse gas emissions, eutrophication, land use and water use (Poore & Nemecek, 2018). When these indicators are considered together, the environmental impact of meat is markedly higher than the impact of consuming plant-based items such as pulses, peas, and nuts (Poore & Nemecek, 2018). In addition, high consumption of unprocessed red and processed meat causes human health issues, including increased risk of ischaemic heart disease, pneumonia, and diabetes (Papier, et al., 2021).

On average, the UK population consumes a high, but slowly decreasing amount of meat, which has decreased from 103.7 g per capita per day in 2008, to 86.3g in 2019 (Stewart, et al., 2021). This trend

does not meet targets set by the UK Climate Change Committee (UKCCC), which calls for further reduction of meat and dairy consumption by 35% from 2020 to 2050, as part of the 'Balanced Net Zero Pathway' to reduce overall GHG emissions by 100% by 2050 (UKCCC, 2020). The current absence of UK governmental strategies to reduce meat consumption means behavioural interventions could provide a cost-effective tool to encourage sustainable and healthy food purchasing and consumption (Reisch, 2021). However, before behavioural interventions can be enrolled, they must be tested within relevant decision-making contexts.

Food Canteens are one environment in which individuals make decisions about their food consumption. Food canteens have been used as a practical and translatable setting to test behavioural interventions to reduce meat consumption through financial incentives and nudging techniques. These interventions have been successful to differing extents (Table 1).

Table 1: Examples of previous behavioural interventions to reduce meat consumption in a canteen setting, and their effect on changing meat consumption. Grouped by the type of intervention.

Type of intervention	Intervention Example	Trial type and location	Effect of Intervention	Reference
Financial incentive	Introduction of small price differentials to vegetarian and meat meals.	Field Trial: Cambridge University College Canteens, UK	No overall significant effect on changing meat and non-meat item sales.	(Garnett, et al., 2021)
Nudge: physical environment	Changing the order of food presented in a canteen so that the vegetarian option is presented first, followed by the meat option (1.81m apart)	Field Trial: Cambridge University College Canteens, UK	Placing the vegetarian option first at 1.81m away from the meat option increased vegetarian sales by 4.5-6 percentage points. Order effects were inconsistent when the distant was shorter (<85cm).	(Garnett, 2020)
Nudge: information environment	Naming vegetarian items in an appealing way, highlighting taste and provenance	Field Trial: Cafés across the UK	When "Meat-Free Sausages and Mash" was re- advertised to highlight taste or provenance, sales increased.	(WRI, 2018)
Nudge: social environment	Increasing the salience (noticeability) of	Four Trials (all in the US): Café,	In trials 1-3, messages increased	(Sparkman, et al., 2020)

	norms through	Online and	vegetarian orders	
0/0/0/0/	dynamic descriptive	Restaurant	(1-2.5 percentage	
ЛПЛП	norms messaging	(x2)	points). In trial 4,	
	(e.g. "We've noticed		dynamic norms	
	customers are		significantly	
	starting to choose		reduced vegetarian	
	more meatless		orders.	
	dishes")			

Interventions that alter the social environment to achieve reduced meat consumption are less widely tested. One such intervention is increasing the salience (noticeability) of social norms, which have previously increased other desirable pro-environmental behaviours such as hotel towel re-use and energy conservation (Reno, et al., 1993; Goldstein, et al., 2008; Schultz, et al., 2007).

3. Using social norms to reduce meat consumption within canteens

Social norms are the "predominant behaviours, attitudes, beliefs, and codes of conduct of a group", and are differentiated into injunctive and descriptive norms (Cialdini & Jackobson, 2021). This study focusses on messages advertising descriptive norms, which state actual behaviours observed in relevant social groups (Cialdini, et al., 1990). Descriptive norms are proposed to influence behaviours by providing a decisional shortcut to identify useful behaviours, leading individuals to conform to the descriptive norm (Cialdini & Goldstein, 2004; (Melnyk, et al., 2011). Whereas injunctive norms are the expected, approved and desired behaviours of a given social group (Cialdini & Goldstein, 2004).

There is currently mixed evidence for the efficacy of descriptive norms messaging to decrease meat consumption. The success of norms messages to elicit desired behaviours could be due to whether the message describes a current (static norm) or changing behaviour (dynamic norm) (Sparkman & Walton, 2017). For example, static descriptive norm messaging trials in German university canteens did not change meat consumption patterns (Einhorn, 2020). The message trialled described that the majority of orders were vegetarian in the trial canteen (Einhorn, 2020). Contrastingly, dynamic descriptive norm messaging trials in US university canteens increased vegetarian sales between 1.4 - 1.7 percentage points (Sparkman, et al., 2020). This study trialled a messaging describing how vegetarian options are becoming increasingly popular amongst canteen attendees (Sparkman, et al., 2020).

Helpfully, dynamic descriptive norms can encourage behaviours that are currently performed by the minority, by stating that a behaviour is increasing in prevalence (Sparkman & Walton, 2017). This is relevant to current patterns of meat consumption with the UK, whereby low or no meat consumption is counter-normative and performed only by a slowly increasing minority of individuals (Stewart, et al., 2021). In online and field experiments in the US, dynamic descriptive norms have

been demonstrated to change attitudes and reduce meat consumption in a context where meat consumption was the prevailing norm (Sparkman & Walton, 2017; Sparkman, et al., 2020). In online trials of ten messages promoting plant-based food choices, the dynamic descriptive norm message (the only norm message tested) lead to the 2nd highest percentage of plant-based items selected (Blondin, et al., 2022). Overall, testing the effects of dynamic descriptive norms to change meat consumption shows promise to reduce meat consumption, but trials have been limited to US field settings or online study settings. Therefore, confirmatory research is required to clarify effects of dynamic descriptive norms messaging on meat consumption within different settings, such as UK canteens.

Another factor which may affect the behavioural responses to norms is the remoteness of the referent group used (Liu, et al., 2019). Remoteness describes how closely an individual identifies with the social referent group stated within the norms message. When an actor closely identifies with the referent group, this can increase the uptake of a social norms message (Burchell, et al., 2012). To my knowledge, there are no field studies that have specifically trialled the use of different referent groups for dynamic descriptive norms to promote the reduction of meat consumption (Sparkman, et al., 2020). Thus, the present study aimed to test two different messages with contrasting referent groups to assess whether referent groups change behavioural responses to a dynamic descriptive norms message.

Aims and objectives

The primary aim of this study was to test two different dynamic descriptive norm messages' effect on meat purchasing at lunchtime within a UK university canteen setting. The study included a trial with three treatment groups: one control group and two message intervention groups that were assigned different dynamic descriptive social norms messages. These messages differed by referent group ('close' vs 'remote').

Participating canteens were allocated to each treatment non-randomly considering the decision context of each canteen. The two different decision contexts were 'online', whereby individuals selected lunch in advance to receiving it on an online booking system, and 'in-person' whereby individuals selected - and immediately received - their lunch at the canteen. It was important to equally allocate canteens with different contexts to each treatment group to minimise potentially confounding effects of varied decision contexts, which prevented randomisation.

The following hypotheses were tested:

- H1: Canteens that are assigned **any** dynamic descriptive norms treatment will have a significantly larger increase in the percentage of vegetarian meals sold per day between the baseline and intervention period in comparison to control canteens.
- H2: Canteens that are assigned the 'close' dynamic descriptive norms treatment will have a larger increase than those assigned the 'remote' norm in the percentage of vegetarian meals sold per day between the baseline and intervention period in comparison to control canteens.

The secondary aim was to provide practical recommendations for the implementation of salient and audience-appropriate dynamic descriptive norms messaging in this particular context. This included identifying referent groups that canteen customers would strongly associate with. This was addressed through pre-intervention focus group discussions to design messages to implement within the subsequent trial, and a post-trial survey.

Methods and Materials

Overview

This study tested for an effect of two different dynamic descriptive social norms messaging interventions on vegetarian lunch sales across canteens in University of Oxford Colleges, UK. The messages' content and design were informed by focus group discussions (FGDs), before implementation in a 16-week trial. The trial consisted of a baseline and intervention period. Lunchtime sales data were collected throughout, and statistical models were constructed to test hypotheses. To evaluate the salience and individual responses to interventions, post-trial surveys were completed.

This research was approved by the University of Oxford Central University Research Ethics Committee (Approval Reference: R78478/RE002). As the messaging intervention in the trial altered the decision-making environment, rather than targeting individuals, canteen customers were not informed of the trial, as in Garnett et al. (2021). I obtained written consent from FGD participants and catering managers representing each canteen.

Focus Group Discussions

Study Setting

I held three, one hour long, FGDs in the Autumn Term 2021. All participants were student members of Wadham College which was not participating in the trial, and participants had previously purchased lunches within the College canteen. Based on Newing (2011), each focus group had 4-8 participants, who were recruited through poster advertising.

Study Design

To curate audience-appropriate messaging interventions, FGDs explored the following three topics:

- i. **Social Group Influence**: participants discussed which social groups influence their current meal choices.
- ii. **Message wording**: participants wrote down their initial responses to posters (Figure 1), which were then discussed.
- iii. Poster design: participants offered opinions on the design and salience of posters (Figure 2).

These topics were explored using post-it note exercises, mind mapping and interaction with posters (Figures 1 and 2).



Figure 1: Message 1: 'Remote' static descriptive norm message (static = a behaviour occurring currently, remote group = University of Oxford students), Message 2: 'Close' static descriptive norm message (static = a behaviour occurring currently, close group = Wadham Students) and Message 3: 'Close' dynamic descriptive norm message (dynamic = how a behaviour is changing, close group = Wadham Students).



Figure 2: Message 1 with the Radcliffe Camera Library in the background and Message 3 with an image of Wadham College in the background. Posters were presented to participants to investigate whether students identified more closely with an image and message about their own College or with an image and message representing the university as a whole.

Data Collection, Analysis and Use

I audio recorded and transcribed discussion using the software NVivo. Transcripts and participant post-it notes were inductively coded for common themes, whereby the coding structure was refined throughout analysis (Newing, 2011) (Appendix 1).

Results from FGDs informed wording and design of posters used in the trial. Discussion of social group influence over food choice confirmed the choice of social groups that constituted 'close' and 'remote' referents. This confirmation of referent groups followed theory that social groups influence behaviour through a desire to conform to social norms (Cislaghi & Heise, 2018), and the degree to which these norms are conformed to is influenced by how strongly one identifies with the referent group (Stok, et al., 2016).

Trialling Messages

Study Setting

I conducted the trial during the Autumn (11/10/21 - 03/12/21) and Winter (17/01/22-11/03/22) terms at eight University of Oxford Colleges (Table 2). Colleges expressing interest were included if they collected detailed lunchtime sales data, sold >30 meals a day on average, and did not introduce novel behavioural interventions during the trial. Originally there were ten Colleges recruited to the trial, but two had to be excluded mid-trial following introduction of novel interventions.

Each College canteen can be accessed by College members, which include students, their guests and staff. All canteens serve hot lunchtime meals Monday – Friday. Lunchtime sales were chosen to study as they are the most consistently-served meal across Colleges. College canteens also varied by the context in which a customer decides on their lunch meal, with some Colleges requiring pre-booking on an online system, while others did not. These two contexts change the immediacy of consequences of the food choice decision. Therefore, I blocked Colleges into two groups according to lunch choice method (online booking or in-person) and allocated them equally as possible to each treatment. Lunchtime services varied by College in a range of other dimensions, including average number of lunches sold per day, number and price of different hot lunch option served, and the proportion of vegetarian meals served (Table 2).

Table 2: Table showing the student demographics and canteen characteristics of each College involved in the trial.

	College	e Student Demog	raphics	Colle	ge Canteen Cha	racteristics
College	Total Number of Students	Postgraduate students (research and taught) (%)	Female Students (%)	Decision Context	Mean total sales per lunchtime [SD] Baseline period	Mean total sales per lunchtime [SD] Intervention period
А	717	40.7	57	In Canteen	115 [16]	105 [14]
В	631	100.0	46	In Canteen	202 [25]	190 [19]
С	1137	100.0	39	In Canteen	96 [21]	81 [17]
D	618	37.5	48	48 In Canteen		228 [35]
E	612	28.4	48	Online	50 [10]	52 [11]
F	672	35.0	53	Online	46 [16]	46 [19]
G	753	50.1	44	In Canteen	126 [17]	123 [17]
н	681 36.9		49	In Canteen	133 [57]	187 [40]

Study Design and Data Collection

Alongside information from FGDs, I finalised the content and design of the messages using the following criteria:

- **Truthful**. Untruthful messages would dishonestly mislead individuals, and could lead them to doubt their credibility (Richter, et al., 2018).
- Using neutral terminology. Studies suggest that the terms 'Vegetarian' or 'Vegan' might have negative connotations (Cole & Morgan, 2011; Holzer, 2017). Therefore, 'Veggie' was used as an alternative term.
- Avoiding "loss" phrasing. Instead of using 'Meat-free' to describe dishes, 'Veggie' was used to shift focus away from what an individual loses (meat) to what they gain (WRI, 2019).
- Avoiding harmful phrasing. Messages in this study were discussed with an Eating Disorder counselling professional from the University of Oxford.
- **Distinct Referent Groups**. Two distinct referent groups were required to test hypothesis 2. 'People in the UK' was chosen as a large referent group that directly contrasts 'Students of

the College', which has a smaller number of members, and was perceived by FGD

participants as a key social group influencing personal food choice.

I assigned each participating College to a treatment, accounting for decision context (Table 3).

Table 3 : Table describing the allocation and justification of different treatments implemented with	thin
the trial.	

Treatment	Colleges Allocated to Treatment	Message Displayed	Evidence for truthfulness of Message
'Close' Message	A, B, F and G	We've noticed that more and more College[X] students are choosing veggie lunches.	After allocation of the 'close' message, College caterers were consulted about their perceived trends in meat consumption over time in their Colleges, and asked whether they perceived this statement to be true or false. All caterers confirmed this trend was true.
'Remote' Message	C, D and E	Did you know? More and more people in the UK are choosing veggie options* *According to Stewart et al, 2021.	Trend taken from analysis of the UK National Diet and Nutrition Survey programme, whereby from 2008-2019, average meat consumption decreased from 103.7g to 86.3g per capita per day (p _{trend} <0.0001) (Stewart, et al., 2021).
Control	Н	No message displayed.	No intervention required in the control group.

The trial had a simple A/B design, with an eight-week baseline period followed by an eight week intervention period. The length of each period was chosen to maximise the number of lunchtime observations within time constraints. This temporal design has been used in similar experiments trialling behaviour change interventions within canteen settings (Garnett, et al., 2021; Bacon, et al., 2018). During the intervention period at 'in-person' Colleges, I placed messages by menus or on lunch servery counters (Figures 3a-b). Messages were placed at the point of decision-making in a highly visible location, to ensure message salience, following recommendations from similar trials (Sparkman, et al., 2020). In contrast, I placed messages for the 'online' Colleges as text above the online booking menu (Figures 3c-d). All messages remained implemented throughout the Winter Term.

I collected lunchtime hot meals sales data and menus from each College at the end of the baseline and intervention periods. As catering managers reported that students make up the majority of consumers within canteens, they were the target audience for messaging interventions. Thus, as far as possible, only student sales data were collected. It was not possible to exclude staff sales from Colleges B, C and E. Menus for each lunchtime were also collected to calculate 'Vegetarian Availability' – the proportion of hot lunchtime options that are vegetarian served each day.



= College name removed for anonymisation

Day Selected - Wednesday 02 Feb 2022

<		Febru	ary 2	022		>	Sittings available on Wednesday 02 Feb 2022 BreakFast - 8.00am Breakfast in Hall	We have noticed that more and more	students are choosing veggie options lain Course 1
Mon	Tue	Wed	Thu	Fri	Sat	Sun	Lunch - 12.30pm Lunch Dine in Hall/Takeaway Dinner - 6.00pm Takeaway Dinner Service	Wild mushroor N Potato, spinach & cl	m and spinach risotto (GF) fain Course 2 hickpea Indian style patties (GF,
31	1	2	3	4	5	6	Lunch is available from 12.30pm to 1.30pm Booking closes on Wednesday 02 Feb 2022 @ 10:00 You have no meals booked	N Tomato and chil	VEGAN) fain Course 3 li seafood spaghetti (DF.SF)
7	8	9	10	11	12	13	242 spaces available, 4 Max guests per member		Side Dishee
14	15	16	17	18	19	20	Book	G Mange	Sarlic ciabatta tout (VEGAN, GF)
21	22	23	24	25	26	27		Sediterranear	oup of the day n vegetable (VEGAN, GF)
28	1	2	3	4	5	6		Sel	ection of Salads

Meat Chicken avocado salad (GF)

Vegetarian/Pescatarian Sea food salad (GF)

Vegan Moroccan pomegranate and root vegetable salad (VEGAN)

> Dessert Vanilla cheesecake Fruit pots (VEGAN, GF)

c)

7 8 9 10 11 12 13

BUTTERY WEEK1		6-1-1-1	-					Milk			Tree	Prove da	Sesame	Eau	Sulphur
Nameordish	rice	Celery	Giuten	Crusteen	CEES .	rish	Lupin	Dairy	Mollusca	Mushard	Nuts*	reanuts	Seeds	Soya	Dioxide
LUNCH	1	-	12	5	20	1	行送	17	196	1	1.1	1-	100	100	
Crème Dubarry	_	*						*							
Chicken and Black Bean			1											1	~
Hot Dog, Onions, Roll and Relish			~												1
v Deep Fried Tofu with Stir Fried Vegetables, Plum and Ginger			~											~	*
Lattice Potatoes			1								-				
Rice	1			î			1						-		
Peas	1		-			_							-		
Treacle Tart and Custard			*		•			*			м	м	м		
We endeavor to produce the menu as adv products due to the Covid-19 pandemic.	vertise We ca	d but ao	tvise dis for spec "En	hes may b ofic food a ter your sp	e subje llergies ecial r	equirer	hange a advance ments h	at short notice'	notice as a When	result of you book	supply on line,	or deliver please e	y issues o nter deta	of som	e he box
N.B. Menu may be subject to change	Add	🖌 its	ite allerg	en is presen	t in the	ingredi	ents or	M	suppler sa	ys it may co	ontain a	ind 💉	free from	listed a	llergens
 Almond, Brazil nut, cashew, headhut, macada Whiist great care is tailen i Tr 	in our fo	Ouccrision od prepar nce of alle	d nut, per ation and orgens can	can, pistachio, service, we re mot be exclud	walnut siy on su ed and i	oplier in tence w	Cereals o formation s are deci	to list the aring the l	gluten (inclu e allergers pr information t	ding wheat, i esent in the othe best of	ye, barkey ingredient four know	and cats) 5 used to p ledge.	roduce our	recipes.	

Figure 3: Location of messages. 3a and b) 'Close' messages in two different College canteens, 3c) 'Close' message on the menu grid of a College online meal booking system and 3d) 'Remote' message on the online meal booking system of a College. College names are blocked out by a black box in 3a-c).

d)

Data Preparation

For statistical analysis, I aggregated Vegan and Vegetarian sales into 'Veg' category, and Meat and Fish sales into the 'Meat' category. This simplified statistical analyses whilst maintaining meaning within categories.

Analytical Approach

I carried out descriptive and inferential analysis using packages Ime4 and sjPlot in the software R (version 3.6.1) (Bates, et al., 2015; Lüdecke, 2021; R Core Team, 2022). I constructed, diagnosed and interpreted statistical models for hypothesis testing.

Model Construction

To test for effects of treatments on vegetarian sales, I constructed a generalised linear mixed effect model (GLMM) with a binomial distribution (link function = logit). This model was calculated through maximum likelihood methods and was chosen through forward selection (Appendix 3).

The model tested for change in the response variable 'Vegetarian sales (%)' between baseline and intervention periods, in response to treatments: 'close' message, 'remote' message or control. Vegetarian sales (%) is the percentage of hot lunchtime meals sold on a given day and canteen that were classed 'Veg'. 'Vegetarian sales (%)' was entered into GLMMs as a single term which combined the count of 'Veg' and 'Meat' meals sold on given day in a canteen.

To construct the model, I sequentially entered 'core', and then 'additional' fixed effects to create a series of GLMMs (Appendix 3). 'Core' fixed effects included 'Time Period' and 'Treatment', which were necessary for construction of interaction coefficients to test hypotheses 1 and 2. These interaction terms are sometimes called difference-in-difference estimators (UCLA, 2021). 'Additional' fixed effects were meaningful covariates, including 'Week', 'Veg Availability' and 'Mean Temperature', incorporated to explain variation in vegetarian sales (%) over time. To account for intercollege variation, I entered Colleges as a 'random effect' into GLMMs.

Aikake's Information Criteria values (an estimator of model prediction error) and observation numbers were used to select a GLMM for hypothesis testing. Visual inspection of quantile-quantile and residual vs predicted plots showed assumptions were not violated, tested by the DHARMa package in R (Appendix 6) (Hartig, 2022). Further information regarding construction and selection of GLMMs, model diagnostics and estimation of random effect sizes can be found in Appendices 2-6.

Post-Trial Survey

Study Setting

Students from intervention group colleges were recruited by email adverts to participate in an online survey. In some colleges, the email was sent out before the end of the trial, in which case subsequent days were not entered into the final trial lunchtime sales data for analysis (n=5). A total of 234 participants completed the survey across 7 colleges.

Study Design

The online survey consisted of five questions asking whether participants noticed the messaging intervention, their emotional response to it, and whether they perceived it changing their lunchtime selections (Appendices 8-9). All participants could enter a book token prize draw upon survey completion.

Data Collection, Preparation and Analysis

Once prize winners were randomly selected, personal information was deleted. I uploaded survey responses to NVivo for thematic analysis, following protocols from Newing (2011).

Results

Design of Messages for the Trial

FGDs informed trial messages by determining the referent group and design of the 'in-person' messages.

The question '*What social groups influence your current food choices?*' identified relevant referent groups for messages. FGDs did not directly determine how closely individuals identified with each social group, therefore the 'closeness' and 'remoteness' of each referent group is inferred from the level of influence each group has over food choice. 'College' was allocated as the 'close' referent as it was most frequently mentioned as a social group that influenced current food choices (Figure 4). By contrast, 'People in the UK' was chosen as the 'remote' referent group as it was not mentioned, suggesting that it was not an influential social group regarding food choice. Moreover, 'People in the UK' is a broad but relevant referent group to diners as they are 'a person in the UK'.



Participant-identified social groups that currently influence personal food choice

Figure 4: Map illustrating the embedded and discrete social groups (circles) that influence current personal food choice of participants. Subset circles within larger circles indicate social groups that were mentioned to be embedded within broader social groups. The relative width of the circle indicates the number of references to that social group across all focus groups, which is inclusive of references to any of the subset social groups (see key). References are an independent mention of a theme (i.e. social group) within the focus group discussion transcript. Lines between circles indicate explicit links that participants made between the social groups.

Participants also highlighted that when descriptive norms messages were supported by statistics, they perceived that this increased their likelihood of following the stated norm. However, due to lack of data, statistics about changing vegetarian sales over time could not be calculated for each college. Therefore, it was decided that no statistic was used in either message for consistency.

Finally, participants mentioned that images of Wadham College in the background of messages containing Wadham College as the referent group, made the message more relevant and reliable. Therefore, images of the referenced college in the 'close' messages were used in the trial to reinforce the referent group, for messages displayed in the 'in-person' context. No image was placed in the background of the 'remote' messages, or for messages displayed on online systems due to technical constraints.

Do different dynamic descriptive norms messages affect vegetarian sales at lunchtime within a UK canteen setting?

Summary of all sales

Across eight college canteens, a total of 38,216 hot lunchtime meals were sold in the baseline period, and 38,127 meals were sold in the intervention period. Sales data from 45 of 640 lunchtimes across the trial were omitted as they included incomplete data, or were 'meat-free days' whereby no choice was afforded between meat or non-meat options. Total sales and mean percentage of daily vegetarian sales varied between each college (Table 4). Per college, total meals sold ranged from 1,841 – 9,757 (mean = 4,777; sd = 2,700) in the baseline period, and 1,844 – 8,884 (mean = 7,766; sd = 2,602) in the intervention period. Mean daily vegetarian sales percentages per college were 30% -46% in the baseline period, and 28% - 43% in the intervention period.

Overall effect of treatments on Vegetarian Sales

The GLMM suggested that exposing diners to either 'close' or 'remote' message significantly lowered the odds of diners choosing a vegetarian meal, in comparison to the odds of diners choosing a vegetarian meal in a control college (Interaction term Coefficients (β) in GLMM: 'Close' Message*Intervention Period: (β = 0.68, CI = 0.63-0.74, p<0.001; Table 5); 'Remote' Message*Intervention Period: (β = 0.72, CI = 0.66-0.79, p<0.001; Table 5). This result remained significant even when Veg Availability and Mean Temperature were added to the model (Appendix 4). **Table 4**: Descriptive summary of lunch servings, total sales and daily vegetarian sales (%) per college. Totals for lunch serving and meals sold are provided for each treatment group ('close' message, 'remote' message and control) and all colleges. To calculate mean daily vegetarian sales (%) for each college and period, the daily vegetarian sales (%) for that college and time period was summed and then divided by the number of lunch servings for that college and time period.

		1	Baseline Per 1/10/2021 - 03	iod /12/21		Intervention P 17/01/22-11/0	eriod)3/22	Difference			
College Code	Treatment Group	Lunch Servings	Total meals sold	Mean of daily Vegetarian sales (%) [SD]	Lunch Servings	Total meals sold	Mean daily Vegetarian sales (%) [SD]	between mean daily vegetarian sales of Baseline and Intervention periods (% change)	Change in total meals sold between the baseline and intervention period (% change)		
А	'Close' Message	31	3,572	40 [15]	32	3,361	39 [13]	-3	-6		
В	'Close' Message	40	8,073	38 [6]	40	7,603	38 [6]	-1	-6		
F	'Close' Message	40	1,843	46 [9]	40	1,844	39 [11]	-15	0		
G	'Close' Message	39	4,928	30 [12]	37	4,536	28 [11]	-8	-8		
'Close' Message Totals		150	18,416		149	17,344					

'Remote' Message Totals		107	14,468		39	13,498			
E	'Remote' Message	37	1,841	31 [14]	39	2,023	34 [15]	8	10
D	'Remote' Message	40	9,757	43 [6]	39	8,884	43 [7]	0	-9
С	'Remote' Message	30	2,870	35 [13]	32	2,591	33 [12]	-4	-10

Н	Control	40	5,332	33 [8]	39	7,285	41 [5]	23	37
Control Totals		40	5,332		39	7,285			
				1	-		1		
All College Totals		297	38,216		298	38,127			

Table 5: Table of coefficients produced by GLMM outputs. P values <0.05 are highlighted by bold text. Coefficients are accompanied by full explanations to aid the reader.

Predictor	Type of coefficient	Explanation and Interpretation of estimate	Coefficient	Confidence Interval	P Value
Intercept (Week 1, Baseline Period, Control Treatment)	Odds	Odds of choosing veg week 1, control group, baseline period. Odds are calculated by dividing the probability of choosing vegetarian by the probability of not choosing vegetarian under the given conditions. There is a significantly lower probability of choosing vegetarian, than not choosing vegetarian under the intercept conditions.	0.53	0.35-0.79	0.002
Time period (intervention)	Odds ratio	Odds ratio of choosing veg: odds (intervention) / odds (baseline), holding all other fixed effects constant. The odds of choosing a vegetarian option in the control college is significantly 1.35 higher during the intervention period than in the baseline period.	1.35	1.25-1.45	<0.001
Week of term (2) (3) (4) (5) (6) (7) (8)	Odds ratio	Odds ratio of choosing veg: odds (week X) / odds (week 1), holding all other fixed effects constant. The odds of choosing a vegetarian option in weeks 2, 3, 7 and 8 are significantly lower than week 1. There are no significant differences in odds between weeks 4, 5, 6 and week 1.	0.90 0.91 1.00 1.06 0.99 0.88 0.93	0.85-0.95 0.86-0.97 0.95-1.07 1.00-1.12 0.93-1.05 0.83-0.93 0.63-0.74	<0.001 0.002 0.870 0.063 0.683 <0.001 0.027
'Close' Message	Odds ratio	Odds ratio of choosing veg: odds ('close' message) / odds (control), holding all other fixed effects constant. The odds of choosing a vegetarian option in colleges assigned 'Close' Message is non-significantly different from the odds in the control college.	1.21	0.77-1.90	0.399

		odds ('remote' message) / odds (control), holding all other fixed effects constant. The odds of choosing a vegetarian option in colleges assigned 'remote'			
		message is non significantly different than the odds in the control college.			
		Ratio 1: Ratio 2			
Time period (Intervention) * Treatment ('Close' Message)	Ratio of odds ratios	Ratio 1 Odds ('close' message) intervention / odds ('close' message) baseline Ratio 2 Odds (control) intervention /odds (control) baseline Ratio 1 is 0.68 times significantly smaller than ratio 2.	0.68	0.63-0.74	<0.001
Time period (Intervention) * Treatment ('Remote' Message)	Ratio of odds ratios	Ratio 1: Ratio 2 Ratio 1 Odds ('remote' message) intervention / odds ('remote' message) baseline Ratio 2 Odds (control) intervention / odds (control) baseline Ratio 1 is 0.72 times significantly smaller than ratio 2.	0.72	0.66-0.79	<0.001

Table 6: Actual values for mean vegetarian sales (%) in the baseline and intervention period, with individual lunchtime servings from each college canteen aggregated by treatment ('close' message, 'remote' message or control group). Mean Vegetarian sales (%) are calculated by averaging the mean vegetarian sales (%) per day per college in each of the treatment groups, grouped by period. Percentage changes are calculated from unrounded raw mean vegetarian sales (%). Predicted values for these conditions from the GLMM can be found in Appendix 7.

Raw values	Baselin	e Period	Intervention Period		Difference between
Treatment	Mean	Standard	Raw	Standard	Intervention and
	Vegetarian	Deviation	Vegetarian	Deviation	Baseline periods
	Sales (%)		Sales (%)		(percentage change (%))
'Close'					
Message	39	12	36	12	-7
'Remote'					
Message	37	12	37	13	+1
Control	33	8	4	5	+23

Testing Hypotheses

Testing H1: Canteens that are assigned **any** dynamic descriptive norms treatment will have a significantly larger increase in the percentage of vegetarian meals sold per day between the baseline and intervention period in comparison to control canteens.

Firstly, across the four college canteens assigned the 'close' message, a decrease in raw vegetarian sales of 7.2% was observed between the baseline and intervention period (Table 6). This decrease in vegetarian sales (%) was significantly different to the trend in the control college (Coefficient (β) = 0.68, CI= 0.63-0.74, p< 0.001; Table 5). The GLMM reported that the odds of choosing a vegetarian option in the intervention period vs the baseline period, when exposed to the 'close' message, was 0.68 of that in the control college.

Secondly, across the three college canteens assigned the 'remote' message, the raw mean daily vegetarian sales (%) increased by 0.6%, from 36.6% (sd = 12.4) to 36.8% (sd = 12.5) between the baseline and intervention periods. However, the odds of choosing a vegetarian option in the intervention period vs the baseline period, when exposed to the 'remote' message, was 0.72 of that in the control college (CI = 0.66-0.79, p< 0.001; Table 5).

Therefore, as both interaction terms were significantly lower than one, **H1 can be rejected.** This is because both 'close' and 'remote' messages lowered the odds of choosing a vegetarian meal, when comparing the change in vegetarian sales (%) between the baseline and intervention terms in the message groups, compared to the control groups.

Testing H2: Canteens that are assigned the 'close' dynamic descriptive norm treatment will have a larger increase than those assigned the 'remote' norm in the percentage of vegetarian meals sold per day between the baseline and intervention period in comparison to control canteens.

Both interaction terms in the GLMM for 'close' and 'remote' messages are significantly smaller than one ('Close' message: β = 0.68, CI= 0.63-0.74, p< 0.001; 'Remote' message: β = 0.72, CI = 0.66-0.79, p< 0.001; Table 5). The confidence intervals of the 'close' message coefficient overlap with the central estimate of the 'remote' message, suggesting that the interaction terms are not significantly different to each other.

Thus, **H2 can be rejected**, as interaction terms suggest that both messages decrease the odds of individuals choosing vegetarian options to similar extents, when comparing changes in sales across the baseline and intervention period, between the message and control groups.

Vegetarian Sales in the Control College

Due to catering changes in colleges, out of the three colleges assigned to the control group, two were omitted and only one college remained. The control college had a large increase in vegetarian sales (%) between the baseline and intervention period, from 33.3% (sd = 7.6) to 40.9% (sd = 5.1). No interaction term between the control group and intervention period is reported in the GLMM, but the odds for choosing a vegetarian item in the intervention period were 1.35 times greater than odds in the baseline period in the control college (CI = 1.25-1.45, p < 0.001; Table 5).

Other fixed effects

Diners had significantly lower odds of choosing a vegetarian option within weeks 2, 3, 7 and 8 in comparison to Week 1 (Table 5). The fixed effects of Veg Availability and Mean Temperature were not included in the final GLMM due to lack of data across all Colleges and time confounding influence, respectively (Appendix 3). However, Veg Availability did have a significant odds ratio coefficient of 11.8 (CI = 9.61 - 14.48, p<0.001; Appendix 4). This suggests that for every 10 percentage point increase in the availability of vegetarian options (e.g. from 50% to 60% of servings), the odds of choosing vegetarian was 1.8 times greater. Mean Temperature had a smaller coefficient of 1.01, indicating that warmer temperatures slightly increase the odds of choosing vegetarian options ($\beta = 1.01$, CI = 1.00 - 1.01, p<0.001; Appendix 4).

Evaluating the salience of, and responses to, Messages

To explore the salience of, and reactions to, trial messages, a post-trial survey was circulated to student members of trial Colleges. 231 respondents completed the survey, with an average of 33 respondents per College.

Salience of the Messages

The trial message was most salient in College F, where 86% of survey participants noticed the message on the online booking system (Table 7). In contrast, only 29% of survey participants noticed the message on the online system of College E where the message was placed above the Menu Allergen Grid.

Table 7: Summary of the number and proportion of respondents that noticed and correctly identified the							
message in each college.							
College and number	Percentage of						

College and number of participants noticing the message	Location of Message	Treatment	Percentage of participants that noticed the message (%)
F (n = 42)	Online Meal	Online Meal Booking System (Close' Message	
A (n = 28)	In Canteen	'Close' Message	67
B (n = 10)	In Canteen	'Close' Message	50
C (n = 6)	In Canteen	'Remote' Message	43
E (n = 7)	Online Meal Booking System	'Remote' Message	29
D (n = 6)	In Canteen	'Remote' Message	25
G (n = 11) In Canteen 'Close' Message		19	

Responses to the messages

Perceived Behavioural change

Only 8% of participants exposed to the 'close' message, and 21% of participants exposed to the 'remote' message, reported the message changed their lunchtime meal choice (Figure 5). 56% of participants that said the message did not change their meal selections mentioned that this was because they already followed vegan/veggie/pescatarian diets, suggesting that they already performed the normative behaviour stated by the message. Participants who said that the message did change their lunchtime meals choices, noted that the message helped them 'choose more varied meal options' and encouraged them to 'join the trend'. No participant mentioned that the message/poster would encourage them to increase meat consumption.



Figure 5: Pie charts of responses to question four from participants exposed to the (5a) 'close' message and (5b) 'remote' message. Questions four stated: 'If you did notice this poster/message, did the poster/message change your lunchtime meal choice?'.

How messages made participants feel

To evaluate the audience-appropriateness of messages, participants were asked how the messages made them feel. Responses were categorised into 'Positive' and 'Negative' statements, grouped by the trial messages participants had been exposed to (Table 8). There were ~four times more positive than negative responses to the "close" message, and five times more in response to the 'remote' message.

Interestingly, the college with the highest number (and proportion) of survey participants noticing the message, had the largest raw decrease in mean vegetarian sales between the baseline and intervention period. However, when asked how the message made them feel, 23 respondents from this college noted positive emotional responses and only 3 noted negative responses.

Table 8: Frequency word clouds of emotions referenced by respondents to Question 3, grouped by emotion and treatment group. The larger the word, the more frequently the word was mentioned. In addition, words coloured orange were most frequently mentioned relative to the other words in the cloud, followed by words in black, and then grey. 'N =' denotes the number of individual responses attributed to each emotion category (positive or negative), sorted by treatment group. Responses classed as 'neutral' or 'off topic' have not been included.

	Emotion Category	
Message	Positive	Negative
'Close'	sustainable optimistic veggies impressed belonging intrigued effort environmentally friendly veggie appreciate glad acknowledged options nice positive like love pleasantly pleased happy interested see surprised good great appreciative direction nudging encouraged excited choosing hopeful others pleases	unhappy funny concerned confused frustrated pitiful irritated unnecessary
	n = 50	n = 12
'Remote'	glad amused gratified <mark>happy</mark> positive encouraging validated	irritated forced
	n = 10	n = 2

Discussion

Overall, I found no evidence that either message increased vegetarian sales (Table 5-6). Modelling sales data suggested that exposing individuals to either message lowered the odds of individuals choosing a vegetarian option compared to unexposed individuals. Therefore, hypothesis 1 is rejected as the effect of either message was in the opposite direction than hypothesised. Interestingly, both the 'close' and 'remote' message produced similar interaction term estimates, therefore hypothesis 2 is also rejected. Whilst I cannot conclusively explain the effects of the messages, I present two potential mechanisms:

1. 'Close' and 'Remote' messages increase meat consumption in Oxford College Canteens.

Being exposed to either 'close' or 'remote' norm message could have created a "Boomerang effect". This effect occurs when norm messages increase an undesired behaviour by inducing "psychological reactance", whereby individuals feel their freedom of choice is threatened (Brehm & Brehm, 1981). Boomerang effects have been reported in other descriptive norm interventions to encourage proenvironmental behaviours (Schultz, et al., 2007; Richter, et al., 2018). Evidence has shown that these effects are strongest in high economic status groups where individuals prioritise: (a) making selfdetermined choices that do not appear to conform to others and (b) maintaining autonomy (Eom, et al., 2018; Na, et al., 2016; Stephens, et al., 2007). Therefore, trialling a norm messaging intervention in a University where the majority of enrolled students come from households that have an income above national average, suggests that boomerang effects could be expected (University of Oxford, 2021; ONS, 2021). However, no individuals stated in the post-trial survey that exposure to norm messages increased their meat consumption, which suggests that a boomerang effect might not explain findings.

2. The control group was not representative of normal consumption behaviours over the trial period.

The aim of including a control group in the study design was to represent how meal selections would change between the baseline and intervention period in the absence of an intervention. However, if changes in the control group between these periods are not representative of what underlying meal selection would have been in the treatment colleges in the absence of the intervention, then the control group becomes an inappropriate comparison group. Unfortunately, two colleges assigned to the control group were omitted from the study, leaving a single control college. In this control college, mean vegetarian sales increased by 23% between the baseline and intervention period. This is a remarkably large shift, suggesting the control college is likely to have been unrepresentative of underlying trends.

Upon further investigation, I found at the start of the intervention period the control college switched the order of their menu, in addition to the order of food served within the canteen, so that in both cases the vegetarian or vegan option was mentioned/served first. Previous studies suggest physically placing a non-meat option before a meat option within a canteen increases non-meat sales when the distance between the two options is large (i.e. 1.8m), but impacts on sales are inconsistent when it is small (<85cm) (Garnett, 2020). In the control college, as the physical distance between the non-meat and meat options was 0m, I cannot conclude that this physical repositioning caused the large uplift in the control college's vegetarian sales. However, a field study has demonstrated switching the position of a vegetarian option so that it is placed at the top of the menu, decreases the share of meat dishes sold by 11% (Andersson & Nelander, 2021). Therefore, menu switching could have accounted for the control College's increases in vegetarian sales.

Regardless of explanation, I found no evidence that a dynamic norm messaging intervention increased vegetarian sales in a College canteen setting. This result is similar to recent findings from an online UK study that suggest dynamic norms did not change the interest, attitudes, expectations and intentions to change meat consumption (Aldoh, et al., 2021). Aldoh et al (2021) suggest that among the UK population, consumers are already aware that meat consumption is decreasing. Therefore, delivering dynamic normative information may have had little influence on meat consumption behaviours in the trial, as it may have already influenced consumer behaviours. In addition, I found no evidence for a distinction between the effects of 'close' or 'remote' messages on vegetarian meal selection. This contrasts well-reported findings that social norms are more influential when the referent group is socially 'close' to the observer, rather than 'remote' (Goldstein, et al., 2008; Rimal, 2008).

Limitations and Future Directions

Carrying out this study within an Oxford College system presented unique challenges (Table 9).

Table 9: A selection of experimental issues faced in this study, how they were resolved and how could they best
be accounted for in future studies (future solutions).

Challenge	How challenge was addressed	Future Solutions
Colleges beginning nudge interventions mid-trial.	Colleges were asked in advance to avoid running interventions during the trial. Two Colleges introduced vegetarian as a default option and increased vegetarian availability in the intervention term. Both interventions were previously evidenced to increase vegetarian sales (Garnett, et al., 2019; Hansen, et al., 2019). Therefore, these Colleges were dropped from the trial.	Confirm with catering managers that they are aware of what an intervention is, and when they cannot run one.
Canteens only operate for 8-10 weeks each term.	The trial was run over the maximum period within study time constraints.	Departmental University canteens that are open all year round could be used as an alternative study site.
Canteens had termly and weekly changes in menus to reflect seasonal food availability. Some Canteens had occasional themed weeks.	The fixed effect 'Week' of term was entered into GLMMs, accounting for weekly rotations and themed weeks. Between-term changes in menus could not be accounted for.	Interventions could be randomly assigned to days rather than terms, as in (Garnett, et al., 2021; Bacon, et al., 2018). However, this could be logistically impractical, and interventions could have effects that spill into non-intervention days. Therefore, interventions could be run over multiple terms and compared to historic sales data to test intervention effects.
Occasional Events in Canteens.	Some catering managers stated that lower lunchtime sales in 8 th week of the baseline term was due to Christmas events. This issue was not addressed in this study as events were not interfered with.	Future trials could run over longer periods, allowing for the removal of days that are associated with large College events.
Canteens had different decision contexts (i.e. online booking or in-person).	Each message treatment group was assigned one College	As far as possible, all study sites should have the same decision context.

canteen with an online meal	
booking system.	

Beyond addressing study-site specific limitations, further changes to methods could explore in which decision contexts, and amongst whom, dynamic descriptive norms meaningfully change meat consumption, if at all.

Firstly, to identify which groups of people respond to positively norm interventions, individual-level sales data could be collected. This could test whether prior levels of meat consumption or demographic groupings are correlated with an individual's behaviour response to a norm intervention to reduce meat consumption, as in Garnett et al (2021). If certain groups of individuals are found to specifically reduce or increase their meat consumption in response to norm messaging, then interventions can be appropriately targeted towards subgroups that positively respond to them.

Secondly, understanding whether dynamic descriptive norms have varying effect sizes across different decision contexts would also help the targeting of norm interventions. Currently, how, and in which decisions contexts, dynamic descriptive norms mediate behaviour change is poorly understood (Sparkman & Walton, 2017; Loschelder, et al., 2019). Proposed mediators include individuals wanting to pre-conform to future trends, and convert communicator effects, whereby people who have recently changed their behaviours are especially persuasive advocates (Sparkman & Walton, 2017; Levine & Valle, 1975). If the importance of these mediators vary in different decision contexts (e.g. online versus in-person meal decision contexts), then dynamic norms might not produce the predicted and desired behaviour changes. For example, in an 'in-person' field study in the US, Sparkman et al (2020) found that dynamic messages changed individuals' perceptions of future meat consumption norms, whilst a replicate online study in the UK showed that dynamic messages did not change these perceptions (Aldoh, et al., 2021). Why these differences occurred is yet to be investigated. Therefore, testing how the proposed mechanisms of effects of dynamic norms change across different decision contexts presents an important direction for future research (Sparkman & Walton, 2017).

Conclusion

This study is the first attempt to test descriptive dynamic norm message interventions with different referent groups in a UK canteen setting. Although results are inconclusive, this study presents no evidence that dynamic descriptive norm interventions reduced meat consumption in the studied context. Recommendations for future testing of this intervention include - but are not limited to - testing norms messages across a diversity of decision contexts and collection of individual sales data. These additional tests would build evidence for the 'certainty of effectiveness' and other criteria that assesses the potential success of behavioural interventions (Sparkman, et al., 2020).

Overall, understanding which behavioural interventions effectively reduce meat consumption in the UK is essential if the UK government is to rely on consumer behaviour change to reach its UKCCC targets, in the absence of any regulatory policies to reduce meat consumption (UKCCC, 2020). This study highlights that dynamic descriptive norm interventions will require further testing to ensure their effectiveness.

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Management Report

Gaant Chart of Progress

		Month									
	Task	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
	Recruitment of Colleges to Main Trial										
Planning	CUREC Submission										
	Finalise trial design										
	Plan Questions and catering										
Focus Group Discussions	Run focus groups										
Focus Group Discussions	Thematic Analysis of Results										
	Intervention Refinement										
	Baseline Period										
	Set up Intervention										
Main Trial	Intervention period										
	Data Collection										
	Statistical Analysis										
	CUREC Amendment										
Post-trial Surveys	Recruit Participants										
	Close surveys and analyse results										
	Plan and Write Dissertation										
Synthesis	Viva										
	Public engagament events										

In late September, I reached out to over 30 University of Oxford College Domestic Bursars to introduce the Main Trial and register interest of participation. By the end of October, I had held meetings with staff at 15 different colleges, which lead to 13 colleges agreeing to take part in this project through written consent. I had also submitted my CUREC forms which were subsequently accepted after a round of editing. I ensured that all 13 colleges were aware of what was required of them to take part (i.e. not running any interventions during the trial period), and key dates for data collection.

In October and November I planned Focus Groups, which included the initial designing of posters and familiarising myself with the analytical software NVivo. After Recruiting enough participants for each focus group in late November, I facilitated three focus groups in December. I transcribed the audio recordings and then thematically analysed transcripts in NVivo. I then refined the intervention messages wording and design on the basis of transcript analysis. In late December, I collected baseline period data. At this point, three colleges had to be omitted from the trial due to low sales at lunchtime (<30) or incorrect data collection. Of the remaining 10 colleges, each were assigned a treatment group for the Main Trial:

- 'close' message, n = 4.
- 'remote' message, n = 3
- control group, n =3

In January, I printed off posters, and set up the interventions in the respective colleges. During late January, I was informed that two of the control colleges had introduced interventions to reduce

meat consumption, so I had to remove them from the trial. This unfortunately reduced the control group to one college. To ensure that the messages remained in place throughout the trial in treatment colleges, I visited each of the canteens assigned a message once a week throughout the intervention period. Where messages were placed online, I recruited a student to check whether the message remained on the online booking platform once a week. Throughout January – March I consulted ICCS lab group members to construct a statistical analysis plan for my data. I constructed GLMMs with dummy data to practice following the statistical analysis plan.

At the beginning of March, it was suggested that I circulated post-trial surveys to evaluate the salience and acceptability of the intervention, according to those that had been exposed to it. Therefore, I designed these surveys, amended and submitted my CUREC form, and circulated the forms to catering managers and operational college staff on the week commencing 7th March. At the same time, I collected sales data from the intervention period from each college and began statistical analysis. I asked that staff circulate the online survey to all students from the week commencing 14th March, however some circulated the survey before this before the trial had ended. At those colleges, I had to omit the sales data from the days after the survey was circulated. A week after staff sent a reminder email to fill out the form, I closed the surveys and analysed results in early April. I also contracted COVID-19 during April, reducing my working capacity for two weeks.

I began writing my dissertation in November 2021, where I outlined and continually refined the methodology. After statistical analysis of the main trial was completed, I began writing the full dissertation.

During this project, I have been keen to extend the impact of my research beyond the testing of an intervention. I have built relationships with caterers and key decision makers within the operations of Oxford Colleges, having informal meetings with them to discuss reducing the biodiversity impact of their operations beyond this project. I have enjoyed giving the following outreach talks:

- 26th April 2022: Somerville Sustainability Mixer Event: *'Can behavioural interventions increase sustainable food consumption within college canteens?'*
- 12th May 2022: Kellogg Sustainability Week: 'Small Changes, Big Impact? How can we change our, and others', food consumption patterns to become more environmentally friendly?'

Additionally, I have been balancing my Master's Project with co-authoring two publications. Whilst I completed my participation in these two studies before my Master's project, the editing and reviewing of manuscripts overlapped with my Master's project until March. One paper is currently in review at Nature Food, and the other was published in April in Nature.

Appendices

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Appendix 1. Codebook for Focus Group Transcript Analysis

References fell under top level parent codes, which comprised of multiple child codes which aggregated references that relate to common themes. This allows for categorical analysis of participant responses.

Name	Files	References
1. Food choice influencers	0	0
Mechanisms of social influence	3	17
Reasons	2	7
Social media	2	7
Social pressure	1	3
Other influence	1	1
Price	1	1
Types of social groups	3	85
Colleagues	1	4
Culture	3	15
Eating companions	2	4
Family	3	12
Friends	3	16
School	2	3
Sports teams	3	5
University	3	14
University of Oxford College	2	12
2 Message 1 SDNR	4	60
60%	4	22
Change in eating babits	1	22
Negative reaction	1	2
No chango in opting habits		0
Other reactions	1	4
	2	
Question	<u> </u>	
Question Deference group	2	0
Kererence group	2	4
Wording	3	6
3. Message 2 SDNC	4	50
	3	15
Belonging to college	2	2
Comparison to "Close" Message	1	3
Emotional response	2	4
Persuasion	2	/
Question	1	2
Referent group	4	16
Trust	0	0
Wording	1	1
4. Message 3 DDNC	4	48
Change in eating habits	3	10
Negative reaction	3	12
No stat	1	12
Positive reaction	1	1
Question	1	2
Suggestions	3	3
Trust	1	1
Veggie identity	1	1
Wadham identity	3	6
5. Design of Poster	4	76
Design negative	3	11
Design positive	2	8
Design suggestions	3	32
Poster position	1	3
Poster taglines	4	22
Did you know? tagline	4	11
Variety tagline	3	11

Table 1: Codebook with parent (numbered) codes and their nested child codes.

Appendix 2. GLMM Variables

Table 2: A list of all response variables and fixed effects entered in the construction process of GLMMs (Simmons, et al., 2011).

Variable	Description and Explanation	Variable type
Meat Count	Count of Meat meals sold on a given day and canteen.	Response Variable
Veg Count	Count of Vegetarian meals sold on a given day and canteen.	Response Variable
Time Period	Factor with two levels: baseline and intervention.	Core fixed effect
Treatment	Factor with 3 levels: 'close' message, 'remote' message and control.	Core fixed effect
Treatment * Time Period	Produces two Interaction terms between each treatment group level and the intervention period. This is the differences-in-differences estimator to detect change between the baseline and intervention period in treatment colleges, in comparison to the control college.	Core fixed effect
Week	Factor with 8 levels: each week of term. Explanation: this fixed effects accounts for variation produced by weekly menu rotations and themed weeks.	Additional fixed effect
Veg Availability	Proportion of hot lunchtime options that are vegetarian served each day.	Additional fixed effect
Mean Temperature	The Mean Temperature from the Radcliffe Meteorological Station, Oxford (SoGE, 2022). Explanation: temperature has been observed to correlate with food and drink selections (Garnett, et al., 2019) (Pechey, et al., 2016)	Additional fixed effect
College	Explanation: Entered to account for intercollege demographic and operational variation.	Random Effect

Appendix 3. GLMM Construction and Selection

GLMMs were constructed through forwards selection, whereby fixed effects were gradually incorporated into a GLMM (table X). GLMM F was selected for interpretation, as it had the lowest AIC value without removing observations, and without incorporating the time confounding variable of Mean Temperature. The Akaike information criterion (AIC) value is an estimator of prediction error, with smaller values indicating a better fit of the data to the model.

Whilst including fixed effect 'Vegetarian Availability' decreased the AIC value, it also removed 47 observations, with 45 of those from a single college assigned the 'Close' Message treatment. Moreover, the fixed effect 'Mean temperature' had a small negative, but significant correlation with the time variable 'Day of Trial' (-0.402, p<0.001). Therefore, the model without these two effects (GLMM F) was used to report results in the study.

GLMM	Fixed effects included	Observations	AIC Value
А	Time Period + Treatment	595	5897.282
В	Time Period + Treatment + Time Period*Treatment	595	5824.661
С	Time Period + Treatment + Week	595	5847.530
D	Time Period + Treatment + Vegetarian Availability	548	4961.864
E	Time Period + Treatment + Mean Temperature	595	5888.143
F	Time Period + Treatment + Week + Time	595	5772.262
	Period*Treatment.		
G	Time Period + Treatment + Week + Time	595	5763.774
	Period*Treatment + Mean Temperature.		
Н	Time Period + Treatment + Week + Time	548	4844.682
	Period*Treatment + Vegetarian Availability		
1	Time Period + Treatment + Week + Time	548	4830.55
	Period*Treatment + Vegetarian Availability + Mean		
	Temperature.		

Table 3: An exhaustive list of	f all GLMMs constructed in the	forwards selection process.

Appendix 4. Model Outputs from GLMMG-I

Predictors	Odds Ratios	CI	р
(Intercept)	0.5	0.33 – 0.75	0.001
Time Period	1.38	1.28 - 1.48	<0.001
[Intervention]			
Treatment ['Close'			
Message]			
Treatment ['Remote'	1.21	0.77 – 1.90	0.407
Message]			
Week [2]	1.14	0.71 – 1.81	0.592
Week [3]	0.88	0.83 – 0.94	<0.001
Week [4]	0.89	0.83 – 0.94	<0.001
Week [5]	1.01	0.95 – 1.07	0.831
Week [6]	1.03	0.97 – 1.09	0.338
Week [7]	0.97	0.92 - 1.03	0.379
Week [8]	0.88	0.83 - 0.93	<0.001
Mean Temperature	0.93	0.88 – 0.99	0.025
Time Period	0.68	0.63 – 0.74	<0.001
[Intervention] *			
Treatment ['Close'			
Message]			
Time Period	0.72	0.66 – 0.79	<0.001
[Intervention] *			
Treatment ['Remote'			
Message]			

 Table 4: GLMMG Model output. Intraclass correlation = 0.01

 Table 5: GLMMH Model output. Intraclass correlation = 0

Predictors	Odds Ratios	CI	р
(Intercept)	0.15	0.11 - 0.19	<0.001
Time Period	1.33	1.23 – 1.43	<0.001
[Intervention]			
Treatment ['Close'	1.19	0.89 – 1.58	0.241
Message]			
Treatment ['Remote'	1.15	0.86 - 1.54	0.351
Message]			
Week [2]	0.89	0.83 – 0.95	<0.001
Week [3]	0.92	0.86 - 0.98	0.012
Week [4]	1	0.94 - 1.07	0.897
Week [5]	1.05	0.98 – 1.12	0.136
Week [6]	0.99	0.93 – 1.06	0.789
Week [7]	0.88	0.83 – 0.94	<0.001
Week [8]	0.92	0.86 – 0.98	0.009
Veg Availability	11.61	9.46 - 14.24	<0.001
Time Period	0.65	0.59 – 0.72	<0.001
[Intervention] *			
Treatment ['Close'			
Message]			

Time Period	0.73	0.66 - 0.79	<0.001
[Intervention] *			
Treatment ['Remote'			
Message]			

 Table 6: GLMMI Model output. Intraclass correlation = 0.02

Predictors	Odds Ratios	CI	р
(Intercept)	0.14	0.10-0.18	<0.001
Time Period	1.36	1.26 - 1.47	<0.001
[Intervention]			
Treatment ['Close'	1.18	0.89 – 1.57	0.254
Message]			
Treatment ['Remote'	1.14	0.85 – 1.53	0.366
Message]			
Week [2]	0.87	0.81 – 0.93	<0.001
Week [3]	0.88	0.83 – 0.95	<0.001
Week [4]	1	0.94 - 1.06	0.964
Week [5]	1.01	0.94 - 1.08	0.817
Week [6]	0.97	0.91 - 1.03	0.296
Week [7]	0.88	0.82 – 0.93	<0.001
Week [8]	0.91	0.85 – 0.97	0.004
Mean Temperature	1.01	1.00 - 1.01	<0.001
Veg Availability	11.8	9.61 - 14.48	<0.001
Time Period	0.65	0.59 – 0.72	<0.001
[Intervention] *			
Treatment ['Close'			
Message]			
Time Period	0.73	0.67 – 0.80	<0.001
[Intervention] *			
Treatment ['Remote'			
Message]			

Appendix 5. Random Effects



The BLUPs plot indicates the conditional modes and variance of predicted responses from each college, holding a set of fixed effect values constant. Conditional modes are the difference between the population level average predicted response (Vegetarian Percentage) and the response predicted for a particular college. Conditional modes are computed from the second order derivates of the conditional distribution of the random effects, holding a set of fixed effects constant. Fixed effects are held at Week = 1 and Time Period = Baseline.



Figure 2: LHS – QQ plot of DHARMa residuals. RHS – DHARMa Residuals vs Predicted

DHARMa is a package that simulates residuals, which are standardised values between 0 and 1. DHARMa plots of simulated residuals can be visually inspected to detect deviations from the expected distribution (qqplot) and to test for simulated outliers. Visual inspection of the QQ plot residuals tell us that random effects have a gaussian distribution, and visual inspection of the residuals vs predicted plot tells us that there is linearity of residuals against the predictors on the scale of the link function.

Appendix 7. Predicted Values From GLMMF

Predicted probabilities of choosing a vegetarian option under each time period, week or treatment condition can be calculated using the function plot_model(plot type = "int", pred.type = "re") which calls ggpredict() in the package "SJplot". This function holds all other covariates at their typical value (ie. numeric to their mean, factors to their reference level and character vectors to their mode).Predicted values are still on the population level, but random effect variance is considered, meaning that the intervals are prediction intervals and larger than confidence intervals. More technically speaking, type = "random" accounts for the uncertainty of the fixed effects conditional *on the estimates of the random-effect variances and conditional modes (BLUPs).*



Predicted Probabilities of Vegetarian Meal Selection

Figure 3: Predicted probability of choosing a vegetarian item in the Baseline and Intervention periods, grouped by treatment (GLMM F). Bars depict prediction intervals, which consider the uncertainty in the fixed effects and the mean random effect variance (Johnson, 2014). Message 1 = 'Close' Message and Message 2 = 'Remote' Message.

Table 7: Predicted values for the probabilities of choosing a vegetarian item in the baseline and intervention period, grouped by treatment, based upon GLMM1. Model is adjusted for Week = 1 and the population mean of colleges.

Model GLMM	Baseline Period		Intervention Period		Difference	
Treatment	Predicted value	Prediction Interval	Predicted Value	Prediction Interval	between Intervention and Baseline periods (percentage points)	
'Close' Message	0.39	[0.08,0.82]	0.37	[0.08,0.81]	-5.1282	
'Remote' Message	0.38	[0.08,0.81]	0.37	[0.08, 0.81]	-2.263157	
Control	0.35	[0.07, 0.80]	0.42	[0.09,0.84]	20	



Predicted Probability of Vegetarian Meal Selection

Figure 4: Predicted probability of choosing a vegetarian item based on Time period, Week and Treatment group (GLMM1). Model is adjusted for Week = 1 and College = 0 (Population Level). Bars depict prediction intervals, which consider the uncertainty in the fixed effects and the mean random effect variance (Johnson, 2014). Message 1 = 'Close' Message and Message 2 = 'Remote' Message.

Table 8: Predicted values for the probabilities of choosing a vegetarian item grouped by Time Period, Week andTreatment (GLMMF). Model is adjusted for Week = 1 and the population mean of colleges.

Model GLMMF		Baseline Period		Intervention Period		Raw	Difference
Treatment	Week	Predicted	Prediction	Predicted	Prediction	difference	between
		value	Interval	Value	Interval	between	Intervention
						Intervention	and Baseline
						and Baseline	periods
						periods	(percentage
							points)
'Close'	1	0.39	[0.08, 0.82]	0.37	[0.08, 0.81]	-0.02	-5.128205128
Message	2	0.37	[0.07, 0.81]	0.35	[0.07, 0.79]	-0.02	-5.405405405
	3	0.37	[0.08, 0.81]	0.35	[0.07, 0.79]	-0.02	-5.405405405
	4	0.39	[0.08, 0.82]	0.37	[0.08, 0.81]	-0.02	-5.128205128
	5	0.4	[0.09, 0.83]	0.38	[0.08, 0.82]	-0.02	-5
	6	0.39	[0.08, 0.82]	0.37	[0.08, 0.81]	-0.02	-5.128205128
	7	0.36	[0.07, 0.80]	0.34	[0.07, 0.79]	-0.02	-5.55555556
	8	0.37	[0.08, 0.81]	0.36	[0.07, 0.80]	-0.01	-2.702702703
'Remote'	1	0.38	[0.08, 0.81]	0.37	[0.08, 0.81]	-0.01	-2.631578947
Message	2	0.35	[0.07, 0.80]	0.35	[0.07, 0.79]	0	0
	3	0.35	[0.07, 0.80]	0.35	[0.07, 0.79]	0	0
	4	0.38	[0.08, 0.81]	0.37	[0.08, 0.81]	-0.01	-2.631578947
	5	0.39	[0.08, 0.82]	0.38	[0.08, 0.82]	-0.01	-2.564102564
	6	0.37	[0.08, 0.81]	0.37	[0.07, 0.81]	0	0
	7	0.35	[0.07, 0.79]	0.34	[0.07, 0.79]	-0.01	-2.857142857
	8	0.36	[0.07, 0.80]	0.35	[0.07, 0.80]	-0.01	-2.77777778
Control	1	0.35	[0.07, 0.80]	0.42	[0.09, 0.84]	0.07	20
	2	0.32	[0.06, 0.78]	0.39	[0.08, 0.83]	0.07	21.875
	3	0.32	[0.06, 0.78]	0.39	[0.08, 0.83]	0.07	21.875
	4	0.35	[0.07, 0.80]	0.42	[0.09, 0.84]	0.07	20
	5	0.36	[0.07, 0.81]	0.43	[0.09, 0.85]	0.07	19.4444444
	6	0.34	[0.07, 0.79]	0.41	[0.09, 0.84]	0.07	20.58823529
	7	0.32	[0.06, 0.77]	0.38	[0.08, 0.82]	0.06	18.75
	8	0.33	[0.06, 0.78]	0.4	[0.08, 0.83]	0.07	21.21212121

Appendix 8. Post-trial Survey Questions for Colleges with online meal booking systems

1. Please note that you may only participate in this survey if you are 18 years of age or over.

- I certify that I am 18 years of age or over

2. Do I have to take part?

You do not have to take part. You can withdraw before completion of the survey by closing the browser tab of this survey. However, you may not withdraw your answers after submitting your answers. All questions are optional. If you have read the information above and agree to participate with the understanding that the data (including any personal data) you submit will be processed accordingly, please tick the box below to start.

- Yes I agree to take part in this survey
- No, I do not agree to take part in this survey
- 3. Did you notice a message on your meal booking system, as indicated on the image?
 - Yes
 - No

4. If yes, what did the message say?

- Please clear your plate away when you have finished, thank you!
- Oxford City Council are improving their recycling services
- We have notices that more and more [X College] students are choosing veggie options

5. If you did notice this message, how did it make you feel?

[Open text box]

6. If you did notice this message, did it change your lunchtime meal choice?

- Yes
- No
- I don't know

7. If you did notice this message, please explain why this poster might have, or might have not, changed your meal choice.

[Open text box]

8. Thank you for taking part in this survey, your response is highly valued.

If you would like to be entered for your college prize draw to win a £25 Blackwell's Bookshop voucher, please enter your email address here. The winner from your college will be contacted with further details by the end of March 2022.

Appendix 9. Post-trial Survey Questions for Colleges with in-person canteen decisions

1. Please note that you may only participate in this survey if you are 18 years of age or over.

- I certify that I am 18 years of age or over

2. Do I have to take part?

You do not have to take part. You can withdraw before completion of the survey by closing the browser tab of this survey. However, you may not withdraw your answers after submitting your answers. All questions are optional. If you have read the information above and agree to participate with the understanding that the data (including any personal data) you submit will be processed accordingly, please tick the box below to start.

- Yes I agree to take part in this survey
- No, I do not agree to take part in this survey

3. Did you notice a poster in your college canteen that had this image in the background?

- Yes
- No

4. If yes, what did the message on the poster say?

- Please clear your plate away when you have finished, thank you!
- Oxford City Council are improving their recycling services
- We have notices that more and more [X College] students are choosing veggie options

5. If you did notice this poster, how did it make you feel?

[Open text box]

6. If you did notice this poster, did this poster change your lunchtime meal choice?

- Yes
- No
- I don't know

7. If you did notice this poster, please explain why this poster might have, or might have not, changed your meal choice.

[Open text box]

8. Thank you for taking part in this survey, your response is highly valued.

If you would like to be entered for your college prize draw to win a £25 Blackwell's Bookshop voucher, please enter your email address here. The winner from your college will be contacted with further details by the end of March 2022.