Final submitted version of paper subsequently published as: Major-Smith, K., Borne, G., Wallis, L., Smith, D. and Cotton, D. (2024) Impact of a default nudge intervention on plant-based milk consumption in a UK university café. *Global Environmental Psychology*

Impact of a default nudge intervention on plant-based milk consumption in a UK university café

Katie Major-Smith[1*] major.k@pgr.marjon.ac.uk (*corresponding author)
Gregory Borne[1] gborne@marjon.ac.uk
Laura Wallis[1] lwallis@marjon.ac.uk
Daniel Smith[2] dan.smith@bristol.ac.uk
Debby Cotton[1] dcotton@marjon.ac.uk

[1]Sustainability, Creativity and Innovation Research Group, Plymouth Marjon University, Plymouth, PL6 8BH, UK
[2]Population Health Sciences; Bristol Medical School, University of Bristol, Bristol, BS8 2BN, UK

ORCIDs
KM-S: 0000-0003-3700-9239
GB: N/A
LW: 0000-0001-7736-0731
DS: 0000-0001-6467-2023
DC: 0000-0001-7675-8211

Abstract

Encouraging plant-based food consumption among western consumers is vital for reducing the environmental impacts of animal agriculture. This study examined whether a default nudge intervention increased plant-based milk consumption in a UK university café using an ABAB experimental design. During the intervention phases, the default milk option was changed from dairy to oat milk. In the first intervention phase, customers were approximately three times more likely to consume plant-based milk when oat milk was the default option (from 16.6% to 51.9%). However, this effect was smaller in the second intervention phase compared to the first (from 51.9% to 46.0%), questioning the intervention's long-term impact. Comparable data in the university's second café (where no intervention occurred) found no differences in plant-based milk intake during the study period, suggesting that changes in plant-based milk consumption were due to the default nudge. Based on this intervention, the milk-based carbon footprint per drink reduced by an estimated 25-34%. These findings suggest that, in a UK university café context, default nudges can encourage plant-based milk consumption and reduce dairy intake. This provides implications for adopting sustainable default nudges in the university and wider food sector to help reduce the environmental impacts of animal agriculture.

Final submitted version of paper subsequently published as: Major-Smith, K., Borne, G., Wallis, L., Smith, D. and Cotton, D. (2024) Impact of a default nudge intervention on plant-based milk consumption in a UK university café. *Global Environmental Psychology*

Keywords: plant-based milk, sustainable diets, default nudge, university café, consumers, carbon footprint

1. Introduction

Food production is one of the largest drivers of environmental damage caused by human activity (WWF, 2020), with global climate targets in the Paris Agreement unable to be met if current trends within our food systems continue (Clark et al., 2020). While systemic change is needed to sustainably transform our food system, shifting western consumers' diets can significantly contribute to reducing the environmental impact of food production and help achieve climate commitments (BIT, 2021; Clark et al., 2020). Owing to the environmental damage caused by animal agriculture (Poore & Nemecek, 2018), and the overconsumption of animal products in the global north (Ritchie & Roser, 2023), consumers' diets need to become more plant-based (Scarborough et al., 2023).

To help promote plant-based diets, insights from behavioural sciences can be applied to understand what influences consumer behaviour. One framework is nudge theory (or 'nudging'), which aims to change people's behaviour by altering the environmental context in which individuals make decisions while maintaining freedom of choice (Thaler & Sunstein, 2008). The need for nudging is based on the recognition that when faced with decisions, individuals often use cognitive shortcuts instead of making well-reasoned choices (Kahneman, 2011). This can bias people's behaviour and result in them making less-optimal choices for them, society and the planet (Thaler & Sunstein, 2008). Having received much attention among policymakers during the past few decades, nudging has become widely embedded in western policy (Halpern, 2015).

Employing nudges has also become more common in the environmental sector. Termed 'green nudging', nudges are used to address environmental issues by promoting pro-environmental behaviours and can increase recycling rates (Akbulut-Yuksel & Boulatoff, 2021) and green energy use (Kaiser et al., 2020). There has been growing support to integrate green nudges into sustainability-related policy, including governmental and higher education policy (Carlsson et al., 2021; UNEP et al., 2020).

Although the effect of nudging on promoting sustainable behaviours seems promising, the impact of nudging on changing people's behaviour has been heavily debated, with concerns that their impact may be limited (Chater & Loewenstein, 2022; DellaVigna & Linos, 2022; Maier et al., 2022). Despite this, research suggests that the influence of nudges depends on the type of nudge and area of focus, with nudges being particularly effective at altering individuals' food choices (Mertens et al.,

2022). However, research in this area is still developing (Reisch & Sunstein, 2021), and the effectiveness of green nudges seems to vary between nudge types and context. For example, carbon labels to promote plant-based diets do not work effectively in real-world settings (Kaljonen et al., 2020), despite positive results in online experiments (Betz et al., 2022), and the impact of positive food descriptions (e.g., 'dish of the day') are mixed (Saulais et al., 2019; Zhou et al., 2019). Furthermore, nudges based on social norms can have unintended adverse effects by reducing or reversing the desired behaviour. For example, Griesoph et al. (2021) found that encouraging norms based on people's estimate of the number of vegetarian dishes sold in a German university canteen actually lowered the probability of individuals selecting vegetarian meals (see also Sparkman et al., 2020). This 'boomerang effect' (Osman et al., 2020) could be caused by psychological reactance (Brehm, 1966), where participants chose a meat meal because they felt that their meat-based choices were being restricted.

One nudge which seems particularly effective at increasing plant-based food consumption is the 'default' nudge, which makes sustainable food the default option (similar to using an 'opt-out' strategy; Meier et al., 2022). Although studies testing the influence of default nudges on real-world food choices are still emerging, they seem effective at reducing meat consumption and encouraging plant-based food intake. For example, Hansen et al. (2021) found that conference attendees whose catering choice defaulted to a vegetarian option ate significantly more vegetarian meals compared to attendees who received a meat option default (86-89% versus 2-12.5%), even though participants were able to select a meat choice instead. Similarly, Danish students ate approximately twice as many meat-free meals when allocated a default vegetarian meal choice with a meat option available upon request (Randers & Thøgersen, 2023), and providing students at an American university a default vegetarian menu while placing a meat menu nearby increased the likelihood of a vegetarian meal being selected (from 40.0% to 89.7% when the vegetarian meal was framed as 'appealing'; from 7.5% to 73.2% when framed as 'unappealing') (Campbell-Arvai et al., 2014). Furthermore, restaurant customers in the Netherlands consumed more meatless meals when this was the menu default, despite a meat alternative being available upon request (from 8.6% to 80.0% for bean wrap, and 16.1% to 58.3% for seaweed wrap) (Taufik et al., 2022). Although only a handful of studies have explored default nudges and sustainable food consumption, their positive impact on decreasing meat intake has encouraged public support for policy to incorporate default nudges to increase sustainable diets (Reisch & Sunstein, 2021).

These default nudges may be particularly effective because of various cognitive biases which drive inertia, including: i) status quo bias, where people have a tendency to continue with the current situation instead of changing (Samuelson & Zeckhauser, 1988), a bias which is even stronger for

individuals paying less attention (Thaler & Sunstein, 2008); ii) loss aversion, where people's perception of the negative impact of losing something (i.e., the default) is greater than the potential benefit of gaining it (Kahneman, 2011); and iii) perceptions of endorsement, where people believe that the default has been selected to benefit them and is the socially acceptable action to take (Meier et al., 2022). Although people's predisposition to take no action makes default nudges effective, the extent of their impact depends on how the nudge is implemented (Sunstein, 2017). Based on a systematic review of studies applying default interventions to decrease meat reduction, Meier et al. (2022) identified four factors which increased effectiveness of this nudge. These were: 1) the alternative requiring more effort; 2) awareness of the alternative being low, 3) the appearance of the default being more attractive than the alternative; and 4) people paying low attention. These factors emphasise the myriad of influences that affect the success of default nudges and highlight the complexities of delivering such nudges in real-world settings.

Further research is needed to determine the impact of default nudges on encouraging sustainable food choices beyond meat reduction and whether these replicate in real-world settings. Existing research has focused on reducing meat consumption, but no studies have tested whether default nudges (or any type of nudge) can reduce dairy milk intake and increase plant-based milk consumption (Reisch et al., 2021), even though plant-based milk has a substantially lower environmental impact than dairy (Ritchie, 2022). The environmental damage caused by dairy production (Poore & Nemecek, 2018) adds urgency to research examining the role of default nudges in shifting consumers' diets away from this food group (Grundy et al., 2022). Even more important is the need for research which tests the effectiveness of default nudges in real-world settings since this is currently very limited (Meier et al., 2022), highlighting the need for research to continue contributing to this knowledge-base. While default nudges are known to be effective (Meier et al., 2022), conceptual replications of default nudges in different contexts will help determine the robustness of this intervention in enhancing sustainable food consumption, as well as the potential effect sizes of such interventions. For instance, although default nudges encouraging meat-free meal choice have shown to be effective in restaurant settings (Campbell-Arvai et al., 2014; Hansen et al., 2021; Randers & Thøgersen, 2023; Taufik et al., 2022), it is not clear the extent to which these results generalise to drink choices in café settings; it is perhaps plausible that factors influencing drink purchasing and the context in which this behaviour occurs differ. For example, café customers may have stronger location-bound preferences than restaurant customers, meaning they may be less influenced by default nudges. That is, café customers may have stronger preferences for the drink they purchase because they are likely to buy the same drink from the same location repeatedly (known as having a strong location-bound preference; Venema & Jensen, 2023). Restaurant

customers, however, may be more susceptible to nudges because they less frequently go to restaurants, so have weaker location-bound preferences, emphasising the importance of replicating this nudge in different contexts.

The present study aims to contribute to the growing literature on the effectiveness of nudge interventions on sustainable food consumption by testing the effect that a default nudge has on currently unexplored sustainable drink behaviour (plant-based milk consumption). Specifically, this study aims to answer the research question: Does changing menu defaults increase plant-based milk consumption in a UK university café? To do this, we test the hypothesis that making plant-based milk the default option in drinks will increase plant-based milk consumption by conducting an experimental study which changes the default milk option in one university café but not in a second café at the same university.

2. Materials and methods

2.1 Intervention

An intervention where plant-based milk is the default milk option for drinks sold at a university café was tested during the study (for the theoretical framework behind this intervention, see supplementary section S1). Specifically, customers purchasing drinks from XX University's main café (known as Barjon Café) were automatically given oat milk in their drink unless they requested otherwise. Oat milk was chosen because it is the most requested plant-based milk among the café's customers and has low environmental impact; compared to dairy milk, producing oat milk uses significantly less land and water, and emits fewer greenhouse gas emissions (Ritchie, 2022). While delivering the intervention, three signs were displayed informing customers that oat milk would be automatically applied to drinks for environmental reasons and that alternative milks were available upon request (see supplementary section S2). Two signs were located on the café's counter, one of which was next to the till where customers ordered and paid for their drinks, increasing the likelihood of customers reading it. A third sign was displayed on the wall next to the café's entrance so that customers could read the sign before entering the café. The other milk options available upon request were almond, coconut, dairy and soy; the baristas asked all customers if they had any allergies before serving them. The study received ethical approval from XX University's Research Ethics Panel.

2.2 Setting

The experiment took place at XX University's Barjon Café. Managed by an external catering company, this café is located on the main campus and is predominantly used by staff and students. The café is much busier during weekdays than weekends. A second café, the Grandstand Café, was used as a comparison site during which data on drink sales was collected but no intervention applied. Managed by the same catering team as Barjon Café, the Grandstand Café is situated in the university's sports centre, located just off the main campus. During weekdays, this café is used by staff, students and members of the public visiting the sports centre, while during weekends it is mainly used by the public.

2.3. Study Design

To test the intervention, an ABAB experimental design was implemented (also known as a type of single-case design) from 30th January-31st March 2023. As Barjon Café's drink sales are highest during term time, the study was implemented during a semester. An ABAB design contains four phases: A1 (baseline), B1 (first intervention), A2 (second baseline) and B2 (second intervention). This design was selected because it effectively tests the impact of an intervention by using baseline data to describe any changes to behaviour prompted by the intervention (by comparing B1 to A1), predicts behaviour if the intervention was not implemented (A1), tests if the intervention replicates (by comparing B2 to A2), and indicates potential carryover effects (by comparing A2 to A1; Kazdin, 2019; Nock et al., 2007). Furthermore, given the restrictions of conducting research in a real-world setting, applying this type of experimental design is more feasible than other research designs (e.g., conducting a randomised-controlled trial was not possible because of the challenges of randomly allocating customers to conditions). The Grandstand Café was used as a control comparison where no intervention was conducted to provide stronger support that any observed changes in plant-based milk consumption at Barjon Café could be attributed to the intervention (Rare & BIT, 2019).

To determine the sample size of drink sales needed for each condition given various effect sizes, and thus the length of each study phase, a power analysis was conducted. This was based on the mean number of hot and cold beverages (which contain milk) sold in Barjon Café during a semester weekday in 2022, and the number which contained plant-based milk. Barjon Café sold a mean of 256 drinks daily, with 21 (8.2%) containing plant-based milk. Power analyses explored the sample size needed within each study phase to detect a 2.5, 5, 10 and 20%-point difference in plant-based milk consumption between conditions. For a proportion test with an alpha level of 0.05 and a power of 0.8, this showed that to detect a small effect of a 2.5%-point increase in plant-based milk consumption the sample size for each study phase would need to be 2148 drink sales (approximately eight days). Taking this into consideration, as well as the 2022/23 academic timetable, it was decided

that two weeks for each study phase would be sufficient to detect even a small change in plant-based milk consumption of 2.5%-points. While this study may have been overpowered, especially considering the larger effect sizes from previous default nudges on meat reduction, this also allowed us to examine the longer-term effect of the default nudge intervention.

During the first phase (A1) baseline data were collected on customers' drink purchasing and milk preferences in Barjon Café. During this time, drinks continued to be served and sold in the same way that they normally were (i.e., default of dairy milk) and data were collected for three weeks from 30th January-19th February. This phase incorporated a half term week from 13th-19th February and even though data were collected during this week, these data were removed during the analysis because a higher proportion of the public visited the Grandstand Café, and fewer students visited Barjon Café, which could bias results (for more information on this, and robustness checks which show that the inclusion of this week does not alter the conclusions of the results reported below, see supplementary section S3). The first intervention phase (B1) was then implemented, which ran for two weeks from 20th February–5th March. This was followed by the second baseline phase (A2) during which the intervention ceased and dairy milk was again the default. This A2 phase ran for two weeks from 6th–19th March. The final phase (B2) repeated the intervention and ran for two weeks from 20th–31st March. During all phases, the baristas collected data on the number of drinks sold daily (from 7.30am to 5pm) and which milk was consumed, with data hand-recorded on paper-based recording sheets. The same information was collected from the Grandstand Café, except for 17th March when no data were collected because of staff changes. The two Barjon Café baristas received training (from XXX) prior to the study starting, and both baristas were present for the duration of the study except for a few hours on 20th and 21st March when two different baristas managed the café, both of whom received brief training. Due to differences in customers of both cafés during weekends (e.g., a greater proportion of the public visiting the Grandstand Café and substantially less customers visiting Barjon Café) and the challenges of training the weekend baristas because of frequent staff changes, weekend data were not collected.

2.4 Pre-registered Analysis Plan

This study was pre-registered on the Open Science Framework (https://osf.io/3pg59) on 27th January 2023. The primary analyses using aggregate-level data were conducted as described in the pre-registration document, but with the addition of non-preregistered equivalence tests for the Grandstand Café (see below). However, we were unable to conduct mixed-effects models using individual-level data (for more information, see supplementary section S4).

2.5 Data Analysis

2.5.1 Aggregate Data

To test whether the intervention significantly impacted plant-based milk consumption, a Poisson regression model was conducted to estimate the risk ratio effect of each phase (i.e., B1, A2 and B2) relative to the A1 baseline phase. This analysis: 1) examined whether the B1 intervention phase affected plant-based milk consumption (comparing B1 to A1); 2) examined differences between the two baseline phases, indicating potential carryover effects from the first intervention phase (comparing A2 to A1); and 3) examined the effect that the B2 intervention phase had on plant-based milk consumption compared to the first baseline phase (comparing B2 to A1). To estimate unbiased standard errors when using Poisson regression with a binary outcome, we applied robust standard errors (Zou, 2004). For this analysis, the data were disaggregated into one row per drinks purchase, with the outcome a binary variable of whether the drink contained dairy milk or plant-based milk.

As the third component uses the first baseline phase (A1) as a comparison for the effect of the second intervention phase (B2), this may not accurately reflect the true effect of the second intervention phase if differences occurred between the two baseline phases. For example, if plant-based milk consumption was higher during the second baseline phase (A2) than the first (A1), then the intervention's effect would be different when comparing it to the first baseline phase instead of the second. Therefore, to more accurately assess whether the intervention replicated, using the Poisson model above a post-estimation linear hypothesis test was conducted to compare whether the effect size of the B1 intervention phase differed from the B2 intervention phase, adjusting for any potential A2 differences from the A1 baseline. If a difference was found, then a further Poisson model comparing B2 to the baseline A2 phase was conducted to estimate this risk ratio.

To examine whether there was a causal effect between the intervention and plant-based milk consumption, the analyses above were replicated in the comparison Grandstand Café site, in addition to non-preregistered equivalence tests to formally test for the absence of an effect (Lakens et al., 2018). For all analyses, data on consumption of the default plant-based milk (oat milk) were collated with consumption data of other plant-based milks (e.g., if customers requested a different plant-based milk instead of the default oat milk). This is because separate analysis of plant-based milk consumption was not necessary for answering the research question. Analyses were conducted in R 4.2.3 using the packages ggplot2 (Wickham, 2016), marginaleffects (Arel-Bundock, 2023), readxl (Wickham & Bryan, 2023), sandwich (Zeileis et al., 2020) and Tidyverse (Wickham et al., 2019).

We also conducted a carbon footprint analysis to calculate any changes in greenhouse gas emissions due to the intervention. The carbon footprint of each drink and milk option was

quantified, after which the mean carbon footprint of milk per drink consumed in each condition was calculated (to account for different sample sizes between the phases), which combined the carbon footprints of dairy milk, oat milk and other plant-based milk options; for more details, see supplementary section S5.

2. Results

3.1 Barjon Café

The mean number of drinks sold daily in Barjon Café during the study period was 206 (standard deviation=54, range=103 to 404). The percentage of plant-based milk consumed during the A1 baseline phase was 16.6%, which increased to 51.9% during the B1 intervention phase. This decreased to 23.0% during the A2 baseline phase and then increased again to 46.0% during the B2 intervention phase. The amount of plant-based milk consumed was 5.9%-points lower in the B2 intervention phase compared to the B1 intervention phase, showing that rates of plant-based milk consumption reduced as the default nudge progressed (Table 1 and Figure 1; rates of plant-based milk consumption also appeared to decrease over time within the B1 and B2 intervention phases). Plant-based milk consumption increased by 6.4%-points during the A2 baseline phase compared to the A1 baseline phase.

Table 1. Mean percentage of plant-based milk consumed, and total number of drinks sold, in Barjon Café and Grandstand Café during the A1 baseline phase, B1 intervention phase, A2 baseline phase and B2 intervention phase. Binomial confidence intervals for each percentage are shown in brackets.

	A1	B1	A2	B2
Barjon Café	16.6% (15.1, 18.2)	51.9% (49.7, 54.0)	23.0% (21.2, 24.9)	46.0% (43.7, 48.4)
Total drinks sold	*2315*	*2076*	*2021*	*1829*
Grandstand Café	15.0% (12.7, 17.4)	12.1% (9.78, 14.6)	12.2% (10.1, 14.6)	14.4% (11.9, 17.1)
Total drinks sold	*909*	*730*	*868*	*730*

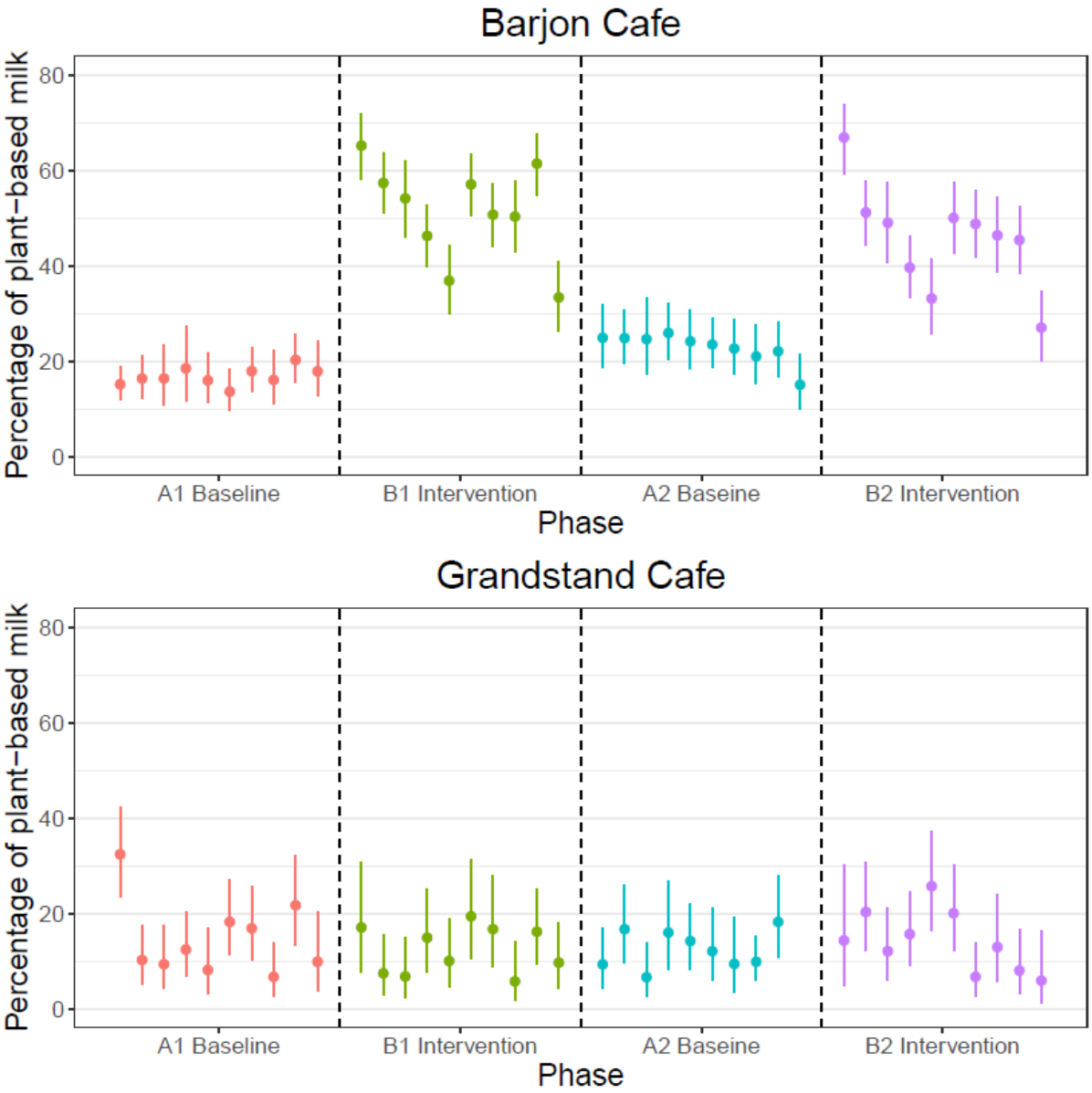

Figure 1. Percentage of plant-based milk consumed during weekdays in Barjon Café and Grandstand Café during the A1 baseline phase, B1 intervention phase, A2 baseline phase and B2 intervention phase. Each point represents a weekday and error bars for each percentage represent binomial confidence intervals. Grandstand Café data for the 17th March 2023 during the A2 phase is missing as data were not recorded due to staff changes.

The Poisson regression model showed that, compared to the A1 baseline phase, customers were three times more likely to consume plant-based milk during the B1 intervention phase (RR=3.13, 95% confidence interval [CI] [2.83; 3.46], p<0.001) and just under three times more likely in the B2 intervention phase (RR=2.78, 95% CI [2.50; 3.08], p<0.001). Customers were also 40% more likely to consume plant-based milk during the A2 baseline phase compared to the A1 baseline phase

(RR=1.39, 95% CI [1.23; 1.57], p<0.001), suggesting that carryover effects occurred from the B1 intervention phase to the A2 baseline phase.

Next, a post-estimation hypothesis test was conducted to assess whether effect size of the B1 intervention differed from the B2 intervention while adjusting for any differences between the A1 and A2 baseline phases. This test showed that the size of the B2 intervention was approximately one-third smaller than the B1 intervention (RR=0.64, 95% CI [0.56; 0.73], p<0.001). Finally, a comparison of the A2 baseline phase and B2 intervention phase showed that customers were twice as likely to consume plant-based milk in the B2 intervention phase compared to the A2 baseline phase (RR=2.00, 95% CI [1.82; 2.20], p<0.001), confirming that the B2 intervention phase had a weaker effect than the B1 intervention phase.

3.2 Grandstand Café

The mean number of daily drinks sold in the Grandstand Café was 83 (standard deviation=22, range=35 to 173). The percentage of plant-based milk consumed was approximately equal through all study phases (A1 baseline=15.0%, B1 intervention=12.1%, A2 baseline=12.2%, B2 intervention=14.4%; see Table 1 and Figure 1).

A Poisson regression model confirmed this interpretation, finding little difference in plant-based milk consumption between the four phases. Plant-based milk consumption did decrease slightly during the B1 intervention phase (RR=0.81, 95% CI [0.63; 1.03], p=0.114) and A2 baseline phase (RR=0.82, 95% CI [0.64; 1.03], p=0.117), compared to the A1 baseline phase, although no difference was found for the B2 intervention phase (RR=0.96, 95% CI [0.76; 1.22], p=0.762). Equivalence tests suggested that these Grandstand Café results were consistent with effect sizes +/- 2.5%-points or smaller, but likely inconsistent with effect sizes larger than +/- 5%-points (see supplementary section S6 for full details).

3.3 Carbon Footprint

The mean carbon footprint of milk per drink was lower in the B1 and B2 intervention phases when oat milk was the default milk compared to the A1 and A2 baseline phases (Table 2). While estimated carbon footprints vary between Poore and Nemecek (2018) and Singh-Povel et al. (2022), differences found between each phase for both sources are similar. Compared to the A1 baseline phase, there was a 30-34% decrease in milk-related greenhouse gas emissions during the B1 intervention phase, and a 25-28% reduction in the B2 intervention phase. When comparing the B2 intervention phase against the A2 baseline phase, carbon footprint reduction is slightly lower at 21-22%.

Table 2. Mean carbon footprint of milk per drink consumed in Barjon Café during the A1 baseline phase, B1 intervention phase, A2 baseline phase and B2 intervention phase. This incorporates all milk types consumed during each study phase (i.e. oat milk, dairy milk and other types of plant-based milk). 95% confidence intervals for these mean values are displayed in brackets.

	Mean carbon footprint of milk per drink ($kgCO_2eq$)	
Phase	Using Poore & Nemecek (2018) data	Using Singh-Povel et al. (2022) data
A1	0.79 (0.77 to 0.81)	0.39 (0.38 to 0.40)
B1	0.56 (0.54 to 0.58)	0.26 (0.25 to 0.27)
A2	0.75 (0.73 to 0.76)	0.36 (0.35 to 0.37)
B2	0.59 (0.5 to 0.61)	0.28 (0.27 to 0.29)

3. Discussion

These results demonstrate that changing a menu's milk option default from dairy to oat milk can increase customers' plant-based milk consumption in a UK university café. Customers were approximately three times more likely to consume plant-based milk when oat milk was the default option instead of dairy milk, with the mean milk-based carbon footprint per drink reducing by 25-34%. Comparable data in a second café at the university found no changes in plant-based milk consumption during the study period, suggesting that the observed differences in intake were due to the intervention. These findings suggest that default nudges can significantly enhance sustainable food consumption beyond meat reduction and help shift consumers' diets, providing implications for the wider adoption of default nudges in the food sector. To our knowledge, this is the first study examining the impact of default nudges on dairy reduction and plant-based milk consumption (Grundy et al., 2022; Reisch et al., 2021), and it is intended that these findings will contribute to the growing literature on, and support for, the usefulness of default nudges in encouraging sustainable food consumption.

Supporting previous research examining meat consumption (Campbell-Arvai et al., 2014; Hansen et al., 2021; Randers & Thøgersen, 2023; Taufik et al., 2022), this study shows the positive impact that default nudges have on reducing consumption of environmentally harmful foods in real-world food settings. The large environmental impact of animal agriculture (Poore & Nemecek, 2018), linked with overconsumption of animal products in the global north (Ritchie & Roser, 2023), means that western consumers' diets need to become more plant-based. Changing consumers' diets is difficult, yet applying default nudges in food environments, such as cafés, restaurants and fast-food outlets, could

support consumers making pro-environmental food choices (Reisch & Sunstein, 2021). Strengthened by the inertia people experience because of status quo bias (Samuelson & Zeckhauser, 1988), loss aversion (Kahneman, 2011) and perceptions of endorsement (Meier et al., 2022), default nudges could help facilitate large-scale societal changes in consumers' eating behaviour.

Utilising default nudges to reduce dairy milk intake among consumers is also likely to benefit organisations. Food businesses commonly employ sustainability strategies to reduce their environmental impact, with targets linked to reducing companies' carbon footprints and rate of unsustainable procurement (Scott, 2018). Utilising default nudges to increase plant-based milk intake would help companies achieve such targets (Ritchie, 2022). The university sector, in which this study took place, is committed to reducing their emissions and mitigating climate change impacts. Globally, over 1100 educational institutions have committed to becoming net zero by 2050 (UNFCCC, n.d.), while in the UK the development of the Climate Commission for Further and Higher Education (Climate Commission for UK Further and Higher Education, 2021a) and the Department for Education's newly published sustainability strategy (Department for Education, 2022), aim to help educational institutions achieve this. The current study has high ecological validity because it tested the intervention in a university café, thus increasing the generalisability of findings to other university contexts (Schmuckler, 2001). The use of default nudges encouraging plant-based milk consumption at universities, in combination with other efforts, could help the sector achieve net zero.

Furthermore, integrating default nudges into real-world food environments is relatively straightforward to employ and seems to have low impact on customer satisfaction. While the prospects of increasing consumer loyalty and attracting new customers are important drivers for businesses implementing sustainable standards (Sharma, 2019), companies are reluctant to take actions which could negatively impact customer satisfaction (Chkanikova & Mont, 2015). Encouragingly, the present study received little negative customer feedback; only one formal complaint was made and four drinks (out of 3905; 0.1%) were returned by customers who disliked the taste of oat milk. Although formal customer feedback was not obtained during the study, anecdotal evidence from customers and baristas suggest that customers were receptive to the change. Importantly, no negative feedback was received by the baristas (who are first point of call for informal customer feedback), suggesting that applying default nudges to promote plant-based milk intake does not diminish customer satisfaction. However, this finding may be context-dependent. Attending university offers students an opportunity to break previously practiced behaviours and acquire new habits (Verplanken et al., 2008), with attendance found to evoke new behavioural patterns (Wood et al., 2005) and increase environmental action among students, including

sustainable transport use (Haggar et al., 2019). Delivering interventions during this life stage could be more effective than at other times. Furthermore, research indicates that environmental concern is stronger among younger individuals and those more highly educated (Li et al., 2019; Panzone et al., 2016), suggesting that university students and staff may be more receptive of changes made for environmental purposes. Additionally, climate change has become a prominent theme among university students, with UK students demanding stronger sustainable action from universities (Climate Commission for UK Further and Higher Education, 2021b). Thus, customers in non-university settings may react differently to milk default changes, meaning that generalisability of the study findings may be limited beyond the university sector. Research exploring customer perceptions of plant-based milk default nudges is needed across multiple settings.

While the present findings provide promising implications for the employment of default nudges in aiding plant-based milk consumption, the study raises an important consideration on their long-term effectiveness. Research examining default nudges (and nudges more generally) has tended to focus on their short-term impact (Hansen et al., 2021; Randers & Thøgersen, 2023; Taufik et al., 2022). While the present study took the same short-term perspective, the decrease in plant-based milk consumption during the second intervention phase compared to the first as well as over time in both intervention phases illustrates the potential for the effectiveness of default nudges to diminish over time. A possible explanation for this reduction in plant-based milk consumption could be related to the ease customers experienced requesting dairy milk (Meier et al., 2022), with the baristas initially directing customers to read the information sign outlining the change in milk default and option to request an alternative milk, despite being asked not to during their training. Although this action only occurred for a few days, it may have increased customers' awareness of alternative milks being available and reduced efforts of requesting it. It should also be noted that customers' engagement with the information signs was not measured, so the number of customers aware of the plant-based milk default or the impact that the signs had on the type of milk customers consumed is not known. Further research examining the impact of information signs on the effectiveness of default nudges is needed to determine if increased sign reading among customers influence their drink purchasing choice. These issues highlight the challenges of conducting experiments in real-world settings and mirror the unexpected problems reported in previous nudge-based research on sustainable food consumption (Kaljonen et al., 2020; Sparkman et al., 2020). Further research exploring the long-term impacts of default nudges and the role that accompanying information signage has on the intervention's effectiveness, both on plant-based milk intake and sustainable food consumption more generally, is needed.

An additional limitation of the study findings is not being able to examine individual-level data and assess repeat purchases among customers, which meant that each drink purchase was treated as an independent datapoint in analyses. While this is unlikely to have impacted the study's overall conclusion given the large effect size, using repeated individual-level data may have provided a more detailed assessment of the association between the intervention and purchasing behaviour, highlighting, for example, if the intervention effect differed between repeat customers and one-time customers. This is important because previous research suggests that nudges may not work as effectively for individuals who have developed location-bound preferences through repeated interaction with the choice architecture in which the nudge was implemented. For example, in a hospital canteen setting, a nudge influenced new customers/visitors more than repeat customers/hospital staff (Venema & Jensen, 2023). While the effect sizes of the default nudge found in the present study are large (i.e., ~35%-point increase in plant-based milk consumption), they are slightly lower than the effect sizes of default nudges on meat reduction in restaurants (e.g., ~40%-point to ~80%-point increase; Campbell-Arvai et al., 2014; Hansen et al., 2021; Randers & Thøgersen, 2023; Taufik et al., 2022). While requiring replication, this suggests that location-bound preferences may have impacted the effectiveness of the default nudge. Individual-level data would have allowed us to investigate this further by examining the milk consumed by repeat versus new customers. Furthermore, differences may have occurred in the present study because customers who repeatedly purchased drinks could have learnt to state their milk preference when ordering drinks while one-time customers may not have. Alternatively, repeat customers may have been more inclined to follow the default nudge because they perceived consuming oat milk as being socially acceptable. Therefore, the intervention may have been either more or less impactful on repeat purchasers compared to those who purchased a drink once. If true, treating each drink purchase as independent datapoints may have caused an underestimation or overestimation of the true effect size. Furthermore, individual-level data would have allowed the exploration of carryover effects (Sparkman et al., 2020).

Despite these considerations, this study shows the positive impact of default nudges on encouraging sustainable food consumption and the value that integrating the implementation of them into policy would have on increasing plant-based diets (Reisch & Sunstein, 2021). To further maximise the effect of default nudges, consideration needs to be made on how to support the continuation of sustainable food consumption after exposure to the default nudge has ended, since their promotion of long-term behaviour change can be restricted (Sunstein, 2017). Discussions on the continuing impact of nudges are occurring in the context of behavioural public policy (Sanders et al., 2018) but further research is needed to establish best methods of ensuring they support

repeated performance of sustainable behaviour in the future. By taking this long-term perspective, the utility of implementing default nudges widely throughout the food sector will increase, helping encourage the long-term adoption of sustainable diets in western society.

5. Conclusion

This study examined the impact of a default nudge intervention on sustainable plant-based milk consumption in a UK university café. We found that customers were approximately three times more likely to consume plant-based milk when oat milk was the default milk option instead of dairy milk and that the mean milk-based carbon footprint per drink reduced by 25-34%. These findings suggest that default nudges can help encourage plant-based diets among consumers by reducing dairy consumption and enhancing sustainable plant-based milk consumption. However, the effect of this intervention decreased slightly as the study progressed, emphasising the need for future research to examine the long-term impact of default nudges on sustainable food consumption. These findings highlight the potential impact of default nudges on reducing the environmental impact of animal agriculture by encouraging plant-based diets among consumers, and provide implications for the adoption of plant-based milk default nudges in university cafés and more widely across the food sector.

Data statement

Data and analysis code are available on the OSF: https://osf.io/nauzp/

References

Akbulut-Yuksel, M., & Boulatoff, C. (2021). The effects of a green nudge on municipal solid waste: Evidence from a clear bag policy. *Journal of Environmental Economics and Management*, *106*, 102404. https://doi.org/10.1016/j.jeem.2020.102404

Arel-Bundock, V. (2023). *Marginaleffects: Predictions, comparisons, slopes, marginal, means, and hypothesis tests*. https://cran.r-project.org/package=marginaleffects

Betz, A. K., Seger, B. T., & Nieding, G. (2022). How can carbon labels and climate-friendly default options on restaurant menus contribute to the reduction of greenhouse gas emissions associated with dining?. *PLOS Climate*, *1*(5), e0000028. https://doi.org/10.1371/journal.pclm.0000028

BIT. (2021). *Net Zero: principles for successful behaviour change initiatives*. https://drive.google.com/file/d/1-NhoheMrPtvm6Cf42LKPNZvCaeJFphrh/view

Brehm, J. W. (1966). *A theory of psychological reactance.* Academic Press.

Campbell-Arvai, V., Arvai, J., & Kalof, L. (2014). Motivating sustainable food choices: The role of nudges, value orientation, and information provision. *Environment and Behavior*, *46*(4), 453–475. https://doi.org/10.1177/0013916512469099

Carlsson, F., Gravert, C., Johansson-Stenman, O., & Kurz, V. (2021). The use of green nudges as an environmental policy instrument. *Review of Environmental Economics and Policy*, *15*(2), 216–237. https://doi.org/10.1086/715524

Chater, N., & Loewenstein, G. (2022). The i-frame and the s-frame: How focusing on individual-level solutions has led behavioral public policy astray. *Behavioral and Brain Sciences*, 1–60. https://doi.org/10.1017/S0140525X22002023

Chkanikova, O., & Mont, O. (2015). Corporate supply chain responsibility: Drivers and barriers for sustainable food retailing. *Corporate Social Responsibility and Environmental Management*, *22*(2), 65–82. https://doi.org/10.1002/csr.1316

Clark, M., Domingo, N. G. G., Colgan, K., Thakrar, S. K., Tilman, D., Lynch, J., Azevedo, I. L., & Hill, J. D. (2020). Global food system emissions could preclude achieving the 1.5° and 2°C climate change targets. *Science*, *370*(6517), 705–708. https://doi.org/10.1126/science.aba7357

Climate Commission for UK Further and Higher Education. (2021a). *Climate action toolkit for the higher education sector*. https://www.eauc.org.uk/climate_action_toolkit

Climate Commission for UK Further and Higher Education. (2021b). *COY16 student statement*. https://www.eauc.org.uk/student_climate_commissioners_publish_coy16_stu

DellaVigna, S., & Linos, E. (2022). RCTs to scale: Comprehensive evidence from two nudge units. *Econometrica*, *90*(1), 81–116. https://doi.org/10.3982/ECTA18709

Department for Education. (2022). *Sustainability and climate change: A strategy for the education and children's services systems*. https://www.gov.uk/government/publications/sustainability-and-climate-change-strategy/sustainability-and-climate-change-a-strategy-for-the-education-and-childrens-services-systems

Griesoph, A., Hoffmann, S., Merk, C., Rehdanz, K., & Schmidt, U. (2021). Guess what …?—How guessed norms nudge climate-friendly food choices in real-life settings. *Sustainability*, *13*(15), 1–18. https://doi.org/10.3390/su13158669

Grundy, E. A., Slattery, P., Saeri, A. K., Watkins, K., Houlden, T., Farr, N., Askin, H., Lee, J., Mintoft-Jones, A., Cyna, S., Dziegielewski, A., Gelber, R., Rowe, A., Mathur, M. B., Timmons, S., Zhao, K., Wilks, M., Peacock, J. R., Harris, J., … Zorker, M. (2022). Interventions that influence animal-product consumption: A meta-review. *Future Foods*, *5*, 100111. https://doi.org/10.1016/j.fufo.2021.100111

Haggar, P., Whitmarsh, L., & Skippon, S. M. (2019). Habit discontinuity and student travel mode choice. *Transportation Research Part F: Traffic Psychology and Behaviour*, *64*, 1–13. https://doi.org/10.1016/j.trf.2019.04.022

Halpern, D. (2015). *Inside the nudge unit: How small changes can make a big difference.* Random House.

Hansen, P. G., Schilling, M., & Malthesen, M. S. (2021). Nudging healthy and sustainable food choices: Three randomized controlled field experiments using a vegetarian lunch-default as a

normative signal. *Journal of Public Health*, *43*(2), 392–397. https://doi.org/10.1093/pubmed/fdz154

Kahneman, D. (2011). *Thinking fast and slow.* Penguin Books.

Kaiser, M., Bernauer, M., Sunstein, C. R., & Reisch, L. A. (2020). The power of green defaults: The impact of regional variation of opt-out tariffs on green energy demand in Germany. *Ecological Economics*, *174*, 106685. https://doi.org/10.1016/j.ecolecon.2020.106685

Kaljonen, M., Salo, M., Lyytimäki, J., & Furman, E. (2020). From isolated labels and nudges to sustained tinkering: Assessing long-term changes in sustainable eating at a lunch restaurant. *British Food Journal*, *122*(11), 3313–3329. https://doi.org/10.1108/BFJ-10-2019-0816

Kazdin, A. E. (2019). Single-case experimental designs. Evaluating interventions in research and clinical practice. *Behaviour Research and Therapy*, *117*, 3–17. https://doi.org/10.1016/j.brat.2018.11.015

Lakens, D., Scheel, A. M., & Isager, P. M. (2018). Equivalence testing for psychological research: A tutorial. *Advances in Methods and Practices in Psychological Science*, *1*(2), 259–269. https://doi.org/10.1177/2515245918770963

Li, D., Zhao, L., Ma, S., Shao, S., & Zhang, L. (2019). What influences an individual's pro-environmental behavior? A literature review. *Resources, Conservation and Recycling*, *146*, 28–34. https://doi.org/10.1016/j.resconrec.2019.03.024

Maier, M., Bartoš, F., Stanley, T. D., & Wagenmakers, E.-J. (2022). No evidence for nudging after accounting for publication bias. *PNAS*, *119*(31), e2200300119. https://doi.org/10.1073/pnas.2200300119

Meier, J., Andor, M. A., Doebbe, F. C., Haddaway, N. R., & Reisch, L. A. (2022). Review: Do green defaults reduce meat consumption? *Food Policy*, *110*, 102298. https://doi.org/10.1016/j.foodpol.2022.102298

Mertens, S., Herberz, M., Hahnel, U. J. J., & Brosch, T. (2022). The effectiveness of nudging: A meta-analysis of choice architecture interventions across behavioral domains. *Proceedings of the National Academy of Sciences of the United States of America*, *119*(1), 1–10. https://doi.org/10.1073/pnas.2107346118

Nock, M. K., Michel, B. D., & Photos, V. I. (2007). Single-case research designs. In D. McKay (Ed.), *Handbook of research methods in abnormal and clinical psychology* (pp. 337–350). Sage Publications.

Osman, M., McLachlan, S., Fenton, N., Neil, M., Löfstedt, R., & Meder, B. (2020). Learning from behavioural changes that fail. *Trends in Cognitive Sciences*, *24*(12), 969–980. https://doi.org/10.1016/j.tics.2020.09.009

Panzone, L., Hilton, D., Sale, L., & Cohen, D. (2016). Socio-demographics, implicit attitudes, explicit attitudes, and sustainable consumption in supermarket shopping. *Journal of Economic Psychology*, *55*, 77–95. https://doi.org/10.1016/j.joep.2016.02.004

Poore, J., & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. *Science*, *360*(6392), 987–992. https://doi.org/10.1126/science.aaq0216

Randers, L., & Thøgersen, J. (2023). From attitude to identity? A field experiment on attitude activation, identity formation, and meat reduction. *Journal of Environmental Psychology*, *87*, 101996. https://doi.org/10.1016/j.jenvp.2023.101996

Rare, & BIT. (2019). *Behaviour change for nature: A behavioural science toolkit for practioners*. www.bi.team

Reisch, L. A., & Sunstein, C. R. (2021). Plant-based By default. *One Earth*, *4*(9), 1205–1208. https://doi.org/10.1016/j.oneear.2021.08.007

Reisch, L. A., Sunstein, C. R., Andor, M. A., Doebbe, F. C., Meier, J., & Haddaway, N. R. (2021). Mitigating climate change via food consumption and food waste: A systematic map of behavioral interventions. *Journal of Cleaner Production*, *279*, 123717. https://doi.org/10.1016/j.jclepro.2020.123717

Ritchie, H. (2022). *Dairy vs. plant-based milk: What are the environmental impacts?* Our World in Data. https://ourworldindata.org/environmental-impact-milks

Ritchie, H., & Roser, M. (2023). *Meat and Dairy Production*. Our World in Data. https://ourworldindata.org/meat-production

Samuelson, W., & Zeckhauser, R. (1988). Status quo bias in decision making. *Journal of Risk and Uncertainty*, *1*, 7–59. https://doi.org/10.1007/BF00055564

Sanders, M., Snijders, V., & Hallsworth, M. (2018). Behavioural science and policy: Where are we now and where are we going?. *Behavioural Public Policy*, *2*(2), 144–167. https://doi.org/10.1017/bpp.2018.17

Saulais, L., Massey, C., Perez-Cueto, F. J., Appleton, K. M., Dinnella, C., Monteleone, E., Depezay, L., Hartwell, H., & Giboreau, A. (2019). When are "Dish of the Day" nudges most effective to increase vegetable selection?. *Food Policy*, *85*, 15–27. https://doi.org/10.1016/j.foodpol.2019.04.003

Scarborough, P., Clark, M., Cobiac, L., Papier, K., Knuppel, A., Lynch, J., Harrington, R., Key, T., & Springmann, M. (2023). Vegans, vegetarians, fish-eaters and meat-eaters in the UK show discrepant environmental impacts. *Nature Food*, *4*, 565–57. https://doi.org/10.1038/s43016-023-00795-w

Schmuckler, M. A. (2001). What is ecological validity? A dimensional analysis. *Infancy*, *2*(4), 419–436. https://doi.org/10.1207/S15327078IN0204_02

Scott, C. (2018). Sustainably sourced junk food? Big food and the challenge of sustainable diets. *Global Environmental Politics*, *18*(2), 93–113. https://doi.org/10.1162/glep_a_00458

Sharma, E. (2019). A review of corporate social responsibility in developed and developing nations. *Corporate Social Responsibility and Environmental Management*, *26*(4), 712–720. https://doi.org/10.1002/csr.1739

Singh-Povel, C. M., Van Gool, M. P., Gual Rojas, A. P., Bragt, M. C. E., Kleinnijenhuis, A. J., & Hettinga, K. A. (2022). Nutritional content, protein quantity, protein quality and carbon footprint of plant-based drinks and semi-skimmed milk in the Netherlands and Europe. *Public Health Nutrition*, *25*(5), 1416–1426. https://doi.org/10.1017/S1368980022000453

Sparkman, G., Weitz, E., Robinson, T. N., Malhotra, N., & Walton, G. M. (2020). Developing a scalable dynamic norm menu-based intervention to reduce meat consumption. *Sustainability*, *12*(6), 1–38. https://doi.org/10.3390/su12062453

Sunstein, C. R. (2017). Nudges that fail. *Behavioural Public Policy*, *1*(1), 4–25. https://doi.org/10.1017/bpp.2016.3

Taufik, D., Bouwman, E. P., Reinders, M. J., & Dagevos, H. (2022). A reversal of defaults:

Implementing a menu-based default nudge to promote out-of-home consumer adoption of plant-based meat alternatives. *Appetite*, *175*, 106049. https://doi.org/10.1016/j.appet.2022.106049

Thaler, R. H., & Sunstein, C. R. (2008). *Nudge: Improving decisions about health, wealth, and happiness*. Penguin Group.

UNEP, GRID-Arendal, & BIT. (2020). *The little book of green nudges: 40 nudges to spark sustainable behaviour on campus*. https://www.unep.org/resources/publication/little-book-green-nudges

UNFCCC. (n.d.). *Race to zero*. UNFCCC. Retrieved May 9, 2023, from https://unfccc.int/climate-action/race-to-zero-campaign#Minimum-criteria-required-for-participation-in-the-Race-to-Zero-campaign

Venema, T. A. G., & Jensen, N. H. (2023). We meat again: A field study on the moderating role of location-specific consumer preferences in nudging vegetarian options. *Psychology and Health*, *0*(0), 1–15. https://doi.org/10.1080/08870446.2023.2182896

Verplanken, B., Walker, I., Davis, A., & Jurasek, M. (2008). Context change and travel mode choice: Combining the habit discontinuity and self-activation hypotheses. *Journal of Environmental Psychology*, *28*(2), 121–127. https://doi.org/10.1016/j.jenvp.2007.10.005

Wickham, H. (2016). *ggplot2: Elegant graphics for data analysis*. Springer-Verlag.

Wickham, H., Averick, M., Bryan, J., Chang, W., McGowan, L. ., François, R., Grolemund, G., Hayes, A., Henry, L., Hester, J., Kuhn, M., Pedersenm, T. L., Miller, E., Bache, S. M., Müller, K., J., O., Robinson, D., Seidel, D. P., Spinu, V., … Yutani, H. (2019). Welcome to the tidyverse. *Journal of Open Source Software*, *4*(43), 1686. https://doi.org/10.21105/joss.01686

Wickham, H., & Bryan, J. . (2023). *readxl: Read excel files*. https://cran.r-project.org/package=readxl

Wood, W., Tam, L., & Witt, M. G. (2005). Changing circumstances, disrupting habits. *Journal of Personality and Social Psychology*, *88*(6), 918–933. https://doi.org/10.1037/0022-3514.88.6.918

WWF. (2020). *Living planet report 2020 - Bending the curve of biodiversity loss*. https://livingplanet.panda.org/en-gb/

Zeileis, A., Köll, S., & Graham, N. (2020). Various versatile variances: An object-oriented implementation of clustered covariances in R. *Journal of Statistical Software*, *95*(1), 1–36. https://doi.org/10.18637/jss.v095.i01

Zhou, X., Perez-Cueto, F. J., Dos Santos, Q., Bredie, W. L., Molla-Bauza, M. B., Rodrigues, V. M., Buch-Andersen, T., Appleton, K. M., Hemingway, A., Giboreau, A., Saulais, L., Monteleone, E., Dinnella, C., & Hartwell, H. (2019). Promotion of novel plant-based dishes among older consumers using the 'dish of the day' as a nudging strategy in 4 EU countries. *Food Quality and Preference*, *75*, 260–272. https://doi.org/10.1016/j.foodqual.2018.12.003

Zou, G. (2004). A modified poisson regression approach to prospective studies with binary data. *American Journal of Epidemiology*, *159*(7), 702–706. https://doi.org/10.1093/aje/kwh090

Final submitted version of paper subsequently published as: Major-Smith, K., Borne, G., Wallis, L., Smith, D. and Cotton, D. (2024) Impact of a default nudge intervention on plant-based milk consumption in a UK university café. *Global Environmental Psychology*

Supplementary Information for 'Impact of a default nudge intervention on plant-based milk consumption in a UK university café'

S1. Theoretical Framework

The default nudge intervention was developed using the Behaviour Change Wheel as a framework (Michie et al., 2011). The Behaviour Change Wheel, which outlines eight steps to developing and measuring an intervention, utilises the Capability, Opportunity, Motivation and Behaviour (COM-B) model of behaviour change, which helps identify the influences that capability, opportunity and motivation have on behaviour (Michie et al., 2014). The broad aim of the present study was to increase sustainable food consumption among staff and students at Plymouth Marjon University, aligning with the university's net zero sustainability strategy (step 1: define the problem in behavioural terms). Early on during the intervention development, a series of behaviours were listed which could help achieve this goal. Such behaviours included staff and students consuming plant-based lunches in the cafeteria, chefs learning how to prepare more plant-based meal options, and the university's food outlets offering a wider selection of plant-based options. By utilising findings from relevant literature and feedback from the university's catering manager, behaviours were assessed on the impact that the behaviour would have on increasing sustainable food consumption at the university, the feasibility of implementing the behaviour and the likelihood of effectively measuring the behaviour (which are among the recommended assessment criteria in the Behaviour Change Wheel Guide; Michie et al., 2014). This process resulted in the identification of the target behaviour to be increasing plant-based milk consumption in purchased drinks (step 2: select target behaviour) and the behaviour was specified in greater detail, particularly with regards to who would be performing the behaviour and when and where the behaviour would be carried out (step 3: specify the target behaviour). It was decided that customers of the university's main café, which consisted predominantly of staff and students, would be encouraged to consume plant-based milk in their drinks.

To determine the influential factors of choosing and consuming plant-based milk in drinks, a COM-B diagnosis was conducted (step 4: identify what needs to change). This process involved mapping relevant information on the COM-B model, resulting in the physical and psychological capabilities, social and environmental opportunities, and reflective and automatic motivation consumers experience when consuming plant-based milk. The barriers to and drivers of performing this behaviour were obtained through the results of two studies previously conducted by the researchers on this topic, the first of which obtained quantitative data through an online survey focusing

specifically on UK consumers' plant-based milk consumption behaviour, while the second gained qualitative insights through interviews on the same topic with consumers, retailers and manufacturers involved in the plant-based dairy industry. As multiple influences were listed under all six COM-B domains, only the barriers and drivers which were relevant to a university café and for which it was feasible to develop an intervention for were explored in depth. Next, the intervention functions linked to the relevant COM-B domain were identified (step 5: identify intervention functions). Developed from 19 behaviour change frameworks, the Behaviour Change Wheel created nine function types to help identify the potential areas that an intervention could target (such as education, persuasion or training). As the relevant COM-B domains mapped to all intervention functions, meaning that all areas could potentially be relevant, each intervention function was assessed based on their feasibility and appropriateness. This left seven intervention functions.

To start shaping the intervention design, the Behaviour Change Technique Taxonomy app was used to link the intervention functions to the Behaviour Change Technique Taxonomy v1 (Step 7: identify behaviour change techniques; note that step 6 (identify policy categories) was not undertaken as it was not relevant to this study). The Behaviour Change Technique Taxonomy v1 outlines 93 techniques used in behaviour change research and strengthens the accuracy of sharing intervention procedures and replication by providing a detailed definition of each (Michie et al., 2013). By examining the most applied behaviour change techniques on the app and reviewing the effectiveness of published plant-based food consumption interventions, a series of potential interventions were developed. Each were evaluated using the acceptability, practicability, effectiveness, affordability, side effects and equity (APEASE) criteria as a framework (Michie et al., 2014) by using findings from published studies and feedback from the university's catering manager and director of finance. Finally, consideration was given to the mode of delivering the intervention, particularly on how the intervention would be delivered, who would receive the intervention and potential obstacles that might occur (step 8: identify mode of delivery). This resulted in the default nudge being selected because of the ease of implementation and effectiveness of this nudge type (Meier et al., 2022).

S2. Sign Displayed During Intervention Implementation


BETWEEN 20TH FEBRUARY AND 3RD MARCH FROM 7.30AM–5PM ON WEEKDAYS OAT MILK WILL BECOME OUR DEFAULT OPTION IN DRINKS
Almond, coconut, dairy and soy milk are still available – please just ask.
This is because studies have shown that compared to dairy, oat milk emits a third of the greenhouse gases, needs less than 10% of the land and requires a fraction of the water. And it tastes just as good!

S3. Inclusion of Week Three (Half-Term Week) in A1 Phase

As noted in our original analysis plan, prior to data collection we were unclear whether to remove data from the third week of the experiment (from 13th-19th February) as this was a half-term week at the University. As such, both the number of customers at the university's two cafés, and potentially the type of visitors, may differ from other weeks, potentially biasing results. For instance, during the half-term week fewer students, and proportionally more non-students, would use the cafe; if baseline plant-based milk preferences differ between these groups – say, non-students being less likely to order plant-based milk – this could bias comparisons between the later phases of the experiment.

In the first two weeks of the A1 baseline phase in the Barjon Café, 16.6% of drinks contained plant-based milk; this dropped to 12.7% during week three (similar, albeit slightly smaller, changes were also observed in the Grandstand Café, from 15.0% to 11.7%). The number of drinks sold also dropped considerably in week three at the Barjon Café, from 1,172 in week 2, to 308 in week three, and back to 1,023 in week four (as the Grandstand Café is more open to members of the public, the decrease in the number of drink sold per week was smaller, from 434 in week 2, to 326 in week three, and 356 in week four). Given these differences, to remove this potential risk of bias we decided to remove the week three data from our main analyses. Note that in our analysis plan we stated that "although data for reading week [half term] from the 13th -19th February may be removed if found to bias the baseline dataset", we acknowledge that this rationale was rather vague and lacked a clear quantifiable criterion of what would be classified as "bias".

However, even if we include week three in our analyses as a robustness check, we still observe a similar pattern of results to those reported in the main text. If we include week three in the A1 baseline phase, the proportion of plant-based milk drinks sold in Barjon Café was 16.1% (compared to 16.6% without week three) and 14.1% in Grandstand Café (compared to 15.0% without week three). The Poisson regression results were also practically identical. At Barjon Café, customers in the B1 intervention phase were over 3 times more likely to have plant-based milk compared to the A1 baseline phase (RR = 3.22, 95% CI [2.92; 3.54], $p<0.001$; compared to excluding week three; RR = 3.13, 95% CI [2.83; 3.46], $p<0.001$), 40% more likely in the A2 phase (RR = 1.43, 95% CI [1.27; 1.61], $p<0.001$; compared to excluding week three; RR = 1.39, 95% CI [1.23; 1.57], $p<0.001$), and just under three times more likely in the B2 intervention phase (RR = 2.85, 95% CI [2.58; 3.16], $p<0.001$; compared to excluding week three; RR = 2.78, 95% CI [2.50; 3.08], $p<0.001$). Similarly, at the Grandstand Café there was little difference in results including vs excluding the week three data (B1 RR = 0.86, 95% CI [0.67; 1.09], $p=0.233$; compared to excluding week 3; RR=0.81, 95% CI [0.63; 1.03],

p=0.114: A2 RR = 0.87, 95% CI [0.69; 1.09], *p*=0.246; compared to excluding week three; RR=0.82, 95% CI [0.64; 1.03], *p*=0.117: B2 RR = 1.02, 95% CI [0.82; 1.28], *p*=0.867; compared to excluding week three; RR=0.96, 95% CI [0.76; 1.22], *p*=0.762).

S4. Pre-registered Analysis Plan Changes

We were not able to conduct mixed-effects models using individual-level data. Instead, our analyses here focus on the aggregate-level data because it was not possible to obtain individual-level data from the catering company's 'dining-in scheme' app. This was because the default nudge was not implemented on the app, meaning that customers using the app to order drinks did not experience oat milk being the default milk option. In practice, no customers used the app to order drinks during the study period, meaning that individual-level data was not available. Furthermore, for customers simply using the app to pay for drinks in Barjon Café, the type of milk consumed was not recorded on the app (but was recorded by the baristas). This means that 1) it was not possible to assess whether repeat drink purchases happened from the same individuals, and 2) individual-level carryover effects could not be measured, so the extent that the individual-effects of the plant-based milk default 'spilled' over into subsequent conditions could not be assessed with certainty.

S5. Carbon Footprint

To test for any changes in the carbon footprint of milk consumption in Barjon Café, two sources were utilised to calculate a milk-based carbon footprint. These were Poore and Nemecek (2018; although exact numbers were taken from Ritchie (2022) for ease) and Singh-Povel et al. (2022). Two sources were used because their calculated carbon footprints of different milk types vary greatly, with the calculations of Poore and Nemecek (2018) being much higher than those of Singh-Povel et al. (2022). For example, Poore and Nemecek's (2018) carbon footprint calculation of one litre of dairy milk is approximately double that of Singh-Povel et al. (2022) (3.15 vs 1.5kgCO_2eq), triple for oat milk (0.9 vs 0.3kgCO_2eq), quadruple for soy milk (0.98 vs 0.264kgCO_2eq) and 50% higher for almond milk (0.7 vs 0.465kgCO_2eq). These differences may be due to variations in the lifecycle analyses performed or to the geographic focus, with Poore and Nemecek (2018) examining global milk production and Singh-Povel et al (2022) examining European production. Although the precise carbon footprints from Poore and Nemecek (2018) and Singh-Povel et al. (2022) differ, the carbon footprint of dairy milk is still substantially higher in both, and using both sources allows a comprehensive understanding of the intervention's potential impact on Barjon Café's milk carbon footprint.

To calculate any differences in carbon footprint when oat milk was the default milk compared to dairy milk, the carbon footprint of all milk options in each drink type sold in Barjon Café was calculated. This incorporated the amount and type of milk used. Since Poore and Nemecek (2018) did not have data on the carbon footprint of coconut milk, the carbon footprint for almond milk was applied. This is because the carbon footprint calculations by Singh-Povel et al. (2022) showed that the differences between coconut and almond milk are negligible. The total carbon footprint of milk consumed during each study phase was then calculated, giving a total footprint for plant-based milk (by combining the carbon footprints of all plant-based milk options) and dairy milk. Finally, the average carbon footprint per drink for each phase was calculated to allow a comparison of milk carbon footprints between phases.

S6. Grandstand Café Equivalence Tests

Although the Poisson regression results suggest the absence of a difference between the intervention phases in the Grandstand Café, they are not evidence for a *lack of effect* (that is, they do not test whether the Grandstand Café data are consistent with negligible effect sizes). To formally test this, we conducted additional equivalence tests which were not preregistered in our initial preregistration. Using the contrasts (i.e., the predicted percentage difference in plant-based milk consumption between conditions) from the Poisson model, equivalence tests suggested that these results were strongly consistent with a lack of meaningful effects within the range +/- 10%-points (B1 vs A1; $p<0.001$: A2 vs A1; $p<0.001$: B2 vs A1; $p<0.001$), somewhat consistent with a lack of meaningful effects within the range +/- 5%-points (B1 vs A1; $p=0.108$: A2 vs A1; $p=0.083$: B2 vs A1; $p=0.006$), but were not consistent with the absence of smaller minimum effect sizes of +/- 2.5%-points (B1 vs A1; $p=0.595$: A2 vs A1; $p=0.561$: B2 vs A1; $p=0.137$). In other words, our Grandstand Café results were consistent with effect sizes +/- 2.5%-points or smaller, but likely inconsistent with effect sizes larger than +/- 5%-points.