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Is purchasing of vegetable dishes affected by organic or local labels? Empirical evidence from a university canteen

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ABSTRACT

Previous studies have shown that the use of labels such as "organic" or "local" may improve the perceived healthiness, attractiveness and taste evaluation of healthy food products and increase their likelihood of being purchased. The aim of this work was to examine whether labeling vegetable items could promote consumption of at least one vegetable dish among students in a university canteen. We analyzed the purchasing of vegetable dishes among 458 students during an eight-week intervention in a university canteen, where vegetable items alternatively received neutral, organic and local labels. We implemented a multilevel Bayesian analysis to incorporate prior knowledge extracted from data preceding the experiment and to account for potential confounders related to the design of the experiment. Our results suggest that the labels "organic," "local" "organic & local" were not strongly associated with ordering at least one vegetable plate. Additional studies are warranted to further investigate the potential impact of vegetable plate labeling on customers' purchasing choices.

1. Introduction

Due to their nutrient density, high fiber content, and low energy contribution, vegetable-rich diets have been associated with better cardiovascular health (Aune et al., 2017; Bazzano et al., 2002), reduced cancer risk (Aune et al., 2017; Turati, Rossi, Pelucchi, Levi, & La Vecchia, 2015) and greater longevity (Bellavia, Larsson, Bottai, Wolk, & Orsini, 2013), as well as several positive psychological outcomes and better overall mental health (Conner, Brookie, Carr, Mainvil, & Vissers, 2017; Głąbska, Guzek, Groele, & Gutkowska, 2020). Moreover, according to several studies, diets that include more vegetables and less animal-based food products benefit the planet because of their lower environmental impact (Clark & Tilman, 2017; Tukker et al., 2011). Any type of plant-based food is, in fact, less detrimental to the environment than the most efficient production of animal-based food, regardless of how it is produced (Poore & Nemecek, 2018). Yet, despite the well-known benefits, vegetable consumption in most countries remains below World Health Organization recommendations (Kalmpourtzidou, Eilander, & Talsma, 2020), especially among young adults (Mello Rodrigues et al., 2019).

Several studies have advocated efforts in shifting human diets towards an increase of the vegetable component, especially in middle- and high-income countries (Ranganathan et al., 2016). Among the strategies that one can devise for this purpose, nudging interventions are approaches to promote healthy eating habits that consist of leveraging aspects of the architecture of a choice problem without prohibiting options and without altering the economic incentives of consumers (Thaler & Sunstein, 2008). Compared to more invasive approaches, the advantage of nudging interventions lies in that they generally involve easy-to-implement, inexpensive, and freedom-preserving modifications to the choice environment (Cadario & Chandon, 2018). In addition, while awareness-raising campaigns are often insufficient to trigger immediate individual behavioral change (Kelly & Barker, 2016; Marteau, 2017), researchers found nudges to be effective tools to guide food choices (Bauer & Reisch, 2019; Vandenbroele, Vermeir, Geuens, Slabbinck, & Van Kerckhove, 2020). In its broad sense, nudging people in a healthy direction may involve manipulating the visibility and accessibility of a product, as well as providing or disclosing relevant information (Sunstein, 2015; Wilson, Buckley, Buckley, & Bogomolova, 2016).

Advancements in decision neuroscience, consumer psychology, and food science have provided growing evidence that food choice and evaluation can be influenced by various factors other than the properties

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of the food itself, such as label, brand, price, social information, and packaging design (Motoki & Suzuki, 2020; Piqueras-Fiszman & Spence, 2015). In the context of influencing consumers' eating choices, a type of nudging involves the enhancement of the naming of healthier dishes to make them more appealing. Indeed, existing studies suggest that customers take into consideration the variety and accuracy of information presented on restaurant menus (Ozdemir & Caliskan, 2015). One change that seems especially worth examining, in light of its simplicity and potential effectiveness, is the emphasis of a plate name on the *organic* or *local* origin of its ingredients.

On the one hand, several studies reported that the *organic* label may increase the perceived healthiness, attractiveness, and taste of food products, possibly enhancing their likelihood of being purchased. *Organic* label was found to be especially effective for healthy but not for unhealthy food products (Nadricka, Millet, & Verlegh, 2020) and in particular among individuals who are interested in issues of sustainability (Laureati, Jabes, Russo, & Pagliarini, 2013). On the other hand, many studies also noticed strong positive attitudes of consumers towards food marketed as locally produced. Products named as *local* are often considered to be of better quality and taste, safer, and have better social and environmental outcomes (see Feldmann & Hamm, 2015 for a review).

The positive effects on purchase mediated by *local* and *organic* labels may be due to what is known as *halo effect* (Thorndike, 1920), a phenomenon that has been both theorized and empirically studied. Such effect is commonly defined as a cognitive bias in which a positive evaluation of a product in a particular dimension can influence product judgments on other specific, unrelated dimensions. In a consumer behavior context, an abundance of research has shown the halo effect exerted by labels on consumers' evaluations (Amos, Allred, & Zhang, 2017). For example, the health halo effect may extend the healthy perception of *organic* products to consumers' evaluations of other (positive) product dimensions, such as food safety, caloric content, and nutritional value (Ellison, Duff, Wang, & White, 2016; Lee, Shimizu, Kniffin, & Wansink, 2013; Schuldt & Schwarz, 2010). Similarly, some studies found that food labeled as *local* on a restaurant menu is perceived as healthier than food not carrying the *local* label (Bacig & Young, 2019; Gagić, Mikšić, & Petrović, 2015).

Some of the existing research argues that the label *local* may be more powerful than the label *organic* in shifting consumers' demand (Bellows, Alcaraz, & Hallman, 2010; Stanton, Wiley, & Wirth, 2012). As reported by some authors, *local* has become the new *organic* (Jensen et al., 2019), and consumers are willing to pay more for locally produced food than for *organic* food (Adams & Salois, 2010). Indeed, many agree that the label "organic" has progressively lost part of its allure because the organic food sector has gradually been industrialized and globalized over the last years. Adams and Salois (2010) advocate that local food arose mainly in response to corporate co-optation of the organic food market and the arrival of "organic lite." What was once a certification in response to industrial agriculture, which indicated authenticity, small-scale production, community support, and animal welfare, has become a commercial label used by corporate businesses, which lost its initial social and ethical dimension. Conversely, the term local still keeps its familiar dimension, and thus the craftsmanship and care typical of this scale. However, it is still unclear whether these two food categories, *local* and *organic*, are two complementary or competitive trends in food consumption (Costanigro, Kroll, Thilmany, & Bunning, 2014; Ditlevsen, Denver, Christensen, & Lassen, 2020; Gracia, Barreiro-Hurlé, & Galán, 2014; Jensen et al., 2019; Naspetti & Bodini, 2008; Scalvedi & Saba, 2018). Whether one is more effective than the other in influencing consumer choice and food evaluation remains an open question.

In examining the determinants of vegetable consumption, existing research found both socio-demographic characteristics of the consumer and the availability and cost of products to be relevant aspects. In particular, females have traditionally been found to be more likely to adopt a vegetarian lifestyle than males (Janda & Trocchia, 2001; Kalof, Dietz, Stern, & Guagnano, 1999), and several studies, some of which focused on adolescents, found females to be more likely to choose vegetable-based dishes (Dos Santos et al., 2019; Hartwell et al., 2020) or to be nudged toward them (Zhou et al., 2019). In contrast, males were found to more likely view a meal as incomplete if it lacks meat (Kubberød, Ueland, Tronstad, & Risvik, 2002). Along with gender, also age, education, and socioeconomic status have been linked to vegetable consumption, with low consumption of vegetables being associated with lower education and socioeconomic status (Appleton et al., 2016), and younger age (Larson, Laska, Story, & Neumark-Sztainer, 2012). Conversely, high vegetable consumption has been related to someone's appreciation of health and healthy diet, as well as to a person's greater nutritional knowledge and culinary confidence (Appleton et al., 2016).

Socio-demographic factors have also been linked to a consumer's attitude towards *organic* or *local* food (Ditlevsen et al., 2020), with a number of studies observing a positive association between the perception of *organic* food and higher socioeconomic status (Aschemann-Witzel & Zielke, 2017; Curl et al., 2013) and a negative one with being men or older (Annunziata, Agovino, & Mariani, 2019). Women and consumers with higher knowledge of the environmental impact of food production practices are instead believed to be more likely to purchase *local* or environmentally friendly produced food (Feldmann & Hamm, 2015). Among young people, the probability of purchasing *organic* food (Dumortier, Evans, Grebitus, & Martin, 2017) has been found to be higher and generally motivated by environmental reasons (Tobler, Visschers, & Siegrist, 2011). Finally, older adults appear to be more likely to prefer buying *local* foods (Henseleit, Kubitzki, & Teuber, 2007). At the same time, a positive attitude toward them was also found among young individuals, who appeared more socially and politically aware of their food choices (Pugliese, Zanasi, Atallah, & Cosimo, 2013).

We also underline that awareness of environmental issues may especially be strong among younger generations (Cioffi, Levitsky, Pacanowski, & Bertz, 2015) and that consumers' environmental awareness (Bimbo, Russo, Di Fonzo, & Nardone, 2020; Bratanova et al., 2015; Vermeir & Verbeke, 2006) as well as education (Bellows et al., 2010; Tsakiridou, Boutsouki, Zotos, & Mattas, 2008) seem positively associated with their attitudes towards "natural" oriented food labels. With this in mind, it appears that young and educated subjects form a category of customers that could successfully be nudged to vegetable consumption through the *organic* and/or the *local* label of a plate.

Intending to identify new strategies to increase vegetable consumption among young people, the aim of this work was to test the effectiveness of *organic* and *local* labels - both individually and combined - in increasing the selection of the vegetarian dishes offered to students in a university canteen. In other words, we wanted to determine if labeling vegetable items as *organic*, *local*, or both (*organic & local*) tends to be associated with higher odds of purchasing at least one vegetable item for a lunch meal in a university canteen compared to standard labeling (that is, with no reference to the organic or local origin of the ingredients).

2. Methods

2.1. Study design

This study was designed as a *cluster crossover quasi-experiment* (Parienti & Kuss, 2007), and was carried out from October 14th, 2019 to December 6th, 2019 for a total duration of eight weeks. The experiment involved the naming of three vegetable plates served in a university canteen during lunch time on weekdays. Both before and during the study, these three vegetable plates - a green salad, a plate of cooked vegetables and a pulses salad - were the only vegetable dishes available a the canteen. These dishes were prepared every day with organic and local ingredients and with little-to-no-variation in the recipes across days. Moreover, their price (4€) and presentation (i.e., plating and ingredients) were kept constant before and during the study. All the vegetable dishes were available at the same pick-up point in the canteen and visible by the students only after the ordering. The intervention consisted in altering the naming of the vegetable plates by including key words that emphasized the organic and/or local origin of the ingredients. Specifically, during the eight weeks in which the experiment took place, the three vegetable plates alternatively received one of four labels: *unlabeled*, *organic*, *local* or *organic & local*. Only one of the labels was used for each day for all the vegetable plates. Although this choice makes this study a quasi-experiment and complicates the analysis of the data, offering the same dish of vegetables with multiple names on the same day would have made students immediately aware that the plates were, in fact, all identical (by comparison with other students). The keywords were added as part of the name of the dishes displayed by the booking systems (both pre-ordering and last-minute) and that customers have to select to order their meals; thus, it was not possible for students to overlook them. None of the keywords were previously used in vegetable labels or any other dish. The exact labelings corresponding to each intervention level are illustrated in Table 1.

To convey the local origin of the ingredients, the label "0 km" was used, which is commonly known to mean "locally grown." For the pulses used in the pulses salad we used instead the *Slow Food Presidia* denomination (Slow Food, n.d.), which can be obtained by products sourced from a local and small-scale production. This denomination is well-known to the students of the university where the experiment was implemented and was used in place of the label *local*.

2.1.1. Treatment assignment

On each weekday that was part of the study all three vegetable items were assigned to one of the labelings illustrated in Table 1. Vegetables items on Monday and Friday were *unlabeled*, while the experimental labels *organic*, *local* and *organic & local* were alternated between Tuesday, Wednesday and Thursday in a fashion defined prior to the study to ensure variation across weeks. The choice of using standard labels only on Monday and Friday was motivated by the intent to induce balance between the number of visits on days with *unlabeled* vegetables and those on days with experimental labels within each week. Due to students' schedule at the time of the experiment, it was expected that the number of visits on Monday and Friday combined would be comparable to the number of visits on some of the other days, namely Tuesday and Thursday, when attendance was expected to be high. The main aspects of this study design are: (i) we observed the same labeling on multiple days; (ii) on a given day, all customers experienced the same label (as a result, customers who visited the canteen multiple days could be exposed to multiple labels); (iii) we did not observe all combinations of days of the week and labels. Therefore, we included in our statistical model an adjustment to account for potential systematic differences in customers' propensity of ordering a vegetable plate on different weekdays (see Section 2.4).

2.2. Setting

The research was conducted at the canteen of the University of Gastronomic Sciences of Pollenzo (UNISG), a private institution located in northern Italy and attended by Italian and international students. The canteen was open on weekdays during lunch time (from 12 p.m. to 2 p.m.).

Table 1
Labelings of the three vegetable plates corresponding to the four intervention levels.

Unlabeled	Organic
Green salad	Organic green salad
Cooked vegetables	Cooked organic vegetables
Pulses salad	Organic pulses
Local	**Organic & Local**
Green salad (0 km)	Organic green salad (0 km)
Cooked vegetables (0 km)	Cooked organic vegetables (0 km)
Slow food presidia pulses	Organic & Slow food presidia pulses

2.2.1. Subjects

This study focuses on the items purchased for lunch by the students of UNISG (undergraduate and graduate students of all age). All students signed an informed consent at the time of enrollment in which they allowed the University for the *statistical data processing of aggregate and individual anonymous data*. Student purchases are identified only by a number, which differs from their student ID number and therefore anonymous. Subjects were kept unaware of the ongoing experiment, as providing them with any information would have led them to identify the nature of the investigation. More information on these subjects can be found in Section 3.1.

2.2.2. Lunch menu

The three vegetable plates whose labels were affected by the experiment were part of a list of nine items available at lunch in the canteen. The nine items were: (1) an entree (e.g., a soup); (2) a first course (e.g., pasta); (3) a second course (e.g. animal or vegetable proteins); (4) a green salad; (5) cooked vegetables; (6) a pulses salad; (7) a dessert; (8) fruit; (9) a yogurt. On most days, only one recipe was available for each of the nine item types. Item categories (4–6) are the vegetable plates that were involved in the intervention. Vegetable plates, yogurt and fruit (items 4–6, 8 and 9) were prepared almost identically every day, while the recipe offered for the other items (items 1–3 and 7) varied substantially from day to day. For their orders, customers selected single dishes to compose their own menu (e.g., an entree and a main course), as there were no pre-defined menu deals. The conventional price for an entry was €5, €6 for a first course, €7 for a second course and €4 for a dessert. Vegetable plates, yogurt and fresh fruit were priced respectively €4, €2 and €1. The only beverage available during lunch was free tap water.

2.2.3. Booking methods

Each item in the menu could be purchased using either of these methods:

1. *Pre-ordering*: online on the pre-ordering website, where every Friday the menu of the following week was uploaded by the canteen staff. Pre-orders were to be placed at least 24 h in advance and required the use of pre-purchased credits to submit the order.
2. *Last-minute*: in-person on site, where touch-screen devices installed at the entrance of the canteen allowed patrons to print the receipts of their pre-orders (to be shown at the pick-up point) as well as to buy food for same-day consumption.

In both cases, orders were placed before students could see the dishes, so elements such as food plating and disposition could not influence customers' choices. This set-up reduce possible confoundings and is an advantage of the experimental design.

With respect to the goal of determining whether the labeling of vegetable plates is associated with higher consumption of vegetables, there is an important distinction to make between pre-orders and last-minute orders. When students pre-ordered, all nine items featured on the menu for that day were available for selection. Instead, when ordering on site, limited-quantity items (entree, first course, second course and dessert) might be sold out and a customer could only make their selection among the items that were still available. At the extreme, if all of the limited-quantity items were sold out, the student might only be able to order the vegetable items, the yogurt and the fruit, which were always available. Because there might be fewer choices when ordering last-minute, we included an adjustment for the booking method as a relevant precision variable in our statistical models (see Section 2.4.1).

2.3. Data

The data analyzed was obtained by merging data from the canteen management software (Europos by X. ELA SAS) with subjects' demographic information recorded by UNISG. Demographic information were collected by UNISG at the time of students' enrollment by means of an online registration form requesting personal data as reported on ID, such as age, sex and nationality. The resulting data included all orders made at the canteen during the duration of the experiment, and for each order it specified the unique ID corresponding to the customer who placed the order, the customer-specific characteristics (sex, attended university program and age), the day on which the order was made, the day on which the order was consumed (henceforth *menu date*), the types of item ordered (among the nine available types illustrated in Section 2.2.2), the items' names. There were a total of 4133 orders and 458 subjects in the dataset. An extended version of this data was previously analyzed in Migliavada, Ricci, and Torri (2021).

2.3.1. Historical data

Available data included two fall periods prior to the main study (2017 and 2018), for a total of 7452 orders and 643 subjects. This historical data could provide valuable information on the factors associated with ordering a vegetable plate prior to the experiment.

2.3.2. Data pre-processing

The canteen wherein the experiment took place occasionally hosted guest chefs (e.g., Michelin star chefs) on dates that were selected independently of the schedule of the experiment and were unknown at the time that the rotation of labels was decided. There happened to be seven occasions during the duration of the experiment (Nov. 11, 12, 21, 27 and 28, Dec. 3 and 4) in which the canteen featured guest chefs. Those dates were excluded from the data that were analyzed because students were known to display different booking behaviors when ordering menu items prepared by guest chefs.

On two dates (Oct. 17 and 31), due to an error in the booking system the labels assigned to vegetable plates on the pre-ordering website and on the last-minute ordering devices were misaligned. In particular, the vegetable labels assigned on the pre-ordering platform (respectively, *organic & local* and *organic*) were compliant to the labels assigned by the experimental design, while those visible on the last-minute ordering system (respectively, *local* and *unlabeled*) were not. This issue concerned 54 vegetable items ordered last minute on 2019-10-17 and 33 vegetable items ordered last minute on 2019-10-31. The mislabeling that occurred on those two dates was due to technical issues unrelated with the other characteristics of the experiment. All orders were analyzed considering the *actual* label that they had when the customer made the order.

2.4. Statistical methodology

Given the characteristics of the study design and considering that prior information was available through the historical data, we chose to address the primary goal of the study using a hierarchical Bayesian model. The hierarchical aspect of the model concerned a multilevel analysis to account for the correlation between repeated observations on the same subject and between observations on the same menu date. In addition, the Bayesian approach allowed us to extract relevant prior information by using the historical data to inform the choice of prior distributions for the model parameters of the analysis of the experimental data.

2.4.1. Analysis of experimental data

Recall that the primary goal of the study was to assess the association between the purchase of vegetables and the labeling of the vegetables. The analysis of the experimental data was performed using a hierarchical Bayesian longitudinal logistic regression model that adjusted for the observed covariates. This model accounted for two sources of correlation: (i) between orders placed by the same subject and (ii) between orders placed for the same menu date. Let $p_{it} \in \{0, 1\}$ be the probability that subject i purchased at least one vegetable plate for menu date t. In the chosen logistic model, the log-odds were modeled as:

$$\log\left(\frac{p_{it}}{1-p_{it}}\right) = \beta_0 + \underbrace{\mathbf{x}_i^T\boldsymbol{\beta}_x + \beta_{0,i}}_{\text{subject-specific}} + \underbrace{\mathbf{d}_t\boldsymbol{\beta}_d + \tau_t}_{\text{day-specific}} + \underbrace{m_{i,t}\beta_m}_{\substack{\text{day and subject}\\ \text{specific}}} + \underbrace{\boldsymbol{\ell}_t\boldsymbol{\beta}_\ell^*}_{\substack{\text{label}\\ \text{effect}}}.$$

Here, β_0 is the intercept of the model; $\mathbf{x}_i$ is a vector with subject i's sex (as on their ID; 1 if equal to female and 0 otherwise), program (1 if graduate and 0 if undergraduate), and standardized age. Also, $\beta_{0,i}$ is subject's i's random intercept that captures their specific propensity to include a vegetable plate to their order. Moreover, $\mathbf{d}_t$ is the collection of indicator functions for the day of the week corresponding to menu day t (Tuesday, Wednesday, Thursday or Friday, leaving Monday as the reference day); τ_t is day t's random intercept that captures variations in the propensity of purchasing at least one vegetable plate common to all subjects visiting the canteen on day t (e.g. due to the other items offered in the menu on that day); $m_{i,t}$ is equal to 1 if subject i ordered last minute on day t and to 0 if they pre-ordered; ℓ_t is the label of vegetable plates on day t (*organic*, *local* or *organic & local*, leaving *unlabeled* as reference). In the above model, β_{0i}, τ_t and β_d account for, respectively, aspects (i), (ii) and (iii) of the study design as outlined in Section 2.1.1. The coefficients of interest are $\boldsymbol{\beta}_\ell^*$, which capture the association between the labels and the log-odds of purchasing at least one vegetable plate. In this model, the intercept can be interpreted as the log-odds of the probability of purchasing at least one *unlabeled* vegetable plate for a subject who is male, undergraduate, with age equal to the average age of students attending the canteen and typical (that is, a subject j with $\beta_{0j} = 0$) on a typical Monday (that is, a day k coinciding with a Monday and with $\tau_k = 0$).

The specified model was first fit on the historical data to learn about the distribution of the parameters β_0, $\boldsymbol{\beta}_x = (\beta_{female}, \beta_{graduate}, \beta_{age})$, β_m, and $\boldsymbol{\beta}_d = (\beta_{Tue}, \beta_{Wed}, \beta_{Thu}, \beta_{Fri})$. At this stage, these parameters were assigned an (improper) flat prior distribution, while multivariate Normal distributions centered at zero and with variances Σ_N and Σ_T were assigned to, respectively, the parameters $\{\beta_{i0}\}_{i=1}^N$ and $\{\tau_t\}_{i=1}^T$ (with N and T be, respectively, the number of subjects and the number of dates in the historical data). Σ_N and Σ_T were themselves regarded as parameters and assigned prior distributions (for technical details, see `brms` (Bürkner, 2017)).

The posterior distributions estimated through this first step were used to set the parameters of the prior distributions for the analysis of the experimental data. Specifically, for the analysis of the experimental data, the parameters β_0, $\boldsymbol{\beta}_x$, $\boldsymbol{\beta}_d$, and β_m were all assigned Normal prior distributions with mean and standard deviations equal to the mean and standard deviation of the respective posterior distributions estimated on the historical data. This two-step procedure allowed to make use of the historical data and was especially important to include in the model systematic effects of weekdays on the propensity to order a vegetable plate, which would have been difficult to estimate from the experimental data alone given the relation between weekdays and labeling imposed by the study design and the presence of random intercepts for each date.

2.4.2. Sensitivity analyses

We performed four sensitivity analyses. First, while the correlation between the orders placed by the same subjects constituted an evident factor to be accounted for (as different individuals can reasonably be expected to exhibit different attitudes towards ordering a vegetable plate), the potential correlation between orders placed for the same menu dates by different subjects could be less evident. In our results, we included point estimates and 95% credible interval for the standard deviation of the menu-date random effect (τ_t in the model equation), which is an indicator of the presence of within menu-date correlation.

We also presented and discussed the results of our analysis without including τ_t, to assess whether it was a critical element of the adopted model. Second, the primary analysis was repeated using a frequentist Generalized Linear Mixed Effects (GLME) logistic regression model including two random intercepts, one for subjects and one for menu dates. A comparison of the results of the GLME with those obtained with the adopted Bayesian model appeared useful to motivate the choice of the latter over the former approach. Third, a valid concern with the chosen methodology might be that, if the labels impacted the purchasing of the three vegetable plates differently, unwanted noise might arise from pooling together the three plates in a single response variable indicating whether *any* of them were purchased. Therefore, we implemented the analysis detailed in Section 2.4.1 alternatively setting p_{it} as the probability that subject *i* purchased at least (i) a green salad, (ii) a plate of cooked vegetables, and (iii) a pulses salad. Fourth, a different concern with the chosen study design may be that labeled treatments could have been seen as overlapping by some or all customers. For example, a possible source of confusion may be that the keyword *Slow Food* used to indicate the *local* origin of the pulses salad (see Table 1) also warranties the environmental sustainability of the products receiving such denomination. This asymmetry may create confusion with the *organic* classification, which is granted upon a separate application to products satisfying legal requirements, some of which overlap with those adopted by Slow Food. To address this concern, we repeated the analysis detailed in Section 2.4.1 by aggregating all label treatments into a single *non-standard* label and comparing this to the unlabeled (standard) case.

2.4.3. Statistical software and implementation details

The statistical software used for all analyses was R (version 4.0.3). The Bayesian models were estimated using the `brms` (Bürkner, 2017) R package (version 2.12.6). The `brms` package calls Stan (Team & others, 2020). Stan is a probabilistic programming language that implements Hamiltonian Monte Carlo (HMC) samplers, which is an efficient Markov Chain Monte Carlo (MCMC) method (Neal & others, 2011). The specific variant of HMC used is known as No U-Turn Sampler (Hoffman & Gelman, 2014). The Bayesian models for the primary as well as for the sensitivity analysis were fitted using four independent chains of length 5000 iterations, with a warm-up period of another 5000 iterations each. The acceptance probability and the tree depth were set as the default. The GLME models were implemented using the R package lme4 (Bates et al., 2012) (lme4 1.1–23).

3. Results

3.1. Students' characteristics and vegetable plates choice

During the duration of the experiment, a total of 458 students consumed at least one meal at the canteen. Table 2 displays the baseline characteristics of these individuals. The mean age of students was 24.4 years. The median age was 22.9 years, and the observed minimum and maximum were 18.3 and 64.4 years, respectively, indicating the distribution of ages in the sample were right-skewed. The majority of students were female (55.0%), had Italian nationality (60.7%), and were undergraduates (65.9%).

Table 2
Descriptive statistics of baseline student-level characteristics.

Baseline Student-level[a] Characteristic	Total (N = 458)
Age, years, mean ± SD [min, max]	24.4 ± 5.7 [18.3, 64.4]
Female Sex, n (%)	252 (55.0)
Nationality	
Italian, n (%)	278 (60.7)
Foreigner, n (%)	180 (39.3)
Education Level	
Graduate, n (%)	156 (34.1)

There were no missing values for each of the reported characteristics.
[a] Baseline is defined as time at first order date in study. Note: Column percentage uses Total N as denominator.

Fig. 1 is a histogram of the number of days during the main study that a student attended the canteen for a lunch meal. The majority of students (79.0%) attended the canteen for a lunch meal at most 13 times out of 31 possible days to attend during the main study. The mode was 9 days. Two students ate at the canteen on 25 days (80.6% of 31 possible days), which was the maximum number of canteen visits during the main study.

Table 3 summarizes the crude proportions of ordering at least one vegetable item per menu day by vegetable label type, across all menu days of the study. During the study, 35.8% of the 1302 orders placed at the canteen during a standard label menu day included at least one vegetable item. Similarly, 33.2% included at least one vegetable item during *organic* label days, 41.0% during *local* label days, and 35.3% during *organic&local* (termed 'both') label days.

3.2. Choice of vegetable items before the intervention

The results presented in the current and subsequent subsection reflect the two stages of the statistical approach detailed in Section 2.4. Recall that the first step of our analysis consisted in extracting information from the data collected before the experiment by fitting a hierarchical Bayesian longitudinal logistic regression model to quantify the associations between the available covariates and the purchase of vegetables in a given meal. The MCMC chains passed all common convergence diagnostics. The estimates recovered from this analysis are reported in Table 4 in terms of log-odds and shown in Fig. 2 in terms of odds (yellow).

Based on the historical data, we estimated the odds of a female student ordering at least one vegetable item to be 59% higher (OR: 1.59; 95% credible interval: 1.22, 2.10) when compared to a male student. Similarly, for a meal that was ordered last-minute, the odds of including at least one vegetable item were estimated to be 53% higher (OR: 1.53; 95% credible interval: 1.33, 1.77). Moreover, graduate students were estimated to be 36% (OR: 0.64; 95% credible interval: 0.47, 0.87) less likely to purchase at least one vegetable plate compared to undergraduate students. Also, while none of the estimated coefficients for the day of the week was strictly speaking significant at the 95% level, the 95% credible interval for the odds ratios of ordering at least one vegetable item on Tuesday vs. Monday and Wednesday vs. Monday were, respectively, (0.66, 1.08) and (0.59, 1.00), suggesting that, everything else equal, the odds of purchasing of a vegetable plate would likely be lower on one of those weekdays compared to Monday. Lastly, regarding the random effects, the estimates for the variabilities (standard deviations) of the students' intercepts were 1.40 (95% credible interval: 1.27, 1.53) and those of the menu dates were 0.22 (95% credible interval: 0.12, 0.32).

3.3. Effect of experimental labels on the choice of vegetable plates

The second step consisted in fitting the hierarchical Bayesian longitudinal logistic regression model to the experimental data, using the means and standard errors estimated from the historical data to elicit informative prior distributions. For example, we set the prior distribution on the coefficient β_{age} to be a Normal distribution with mean 0.229 and standard deviation 0.078. We added to the model three indicator variables corresponding to the different experimental labels: *organic*, *local*, and *organic & local* (also denoted as *both*). Again, the MCMC chains passed all common convergence diagnostics.

Figs. 2 and 3 provide a visual summary of the posterior distributions for the odds ratios of the regression coefficients of the fixed effects of the model (thus excluding the controls for each student and menu date). Fig. 2 compares the posteriors of control variables estimated after the

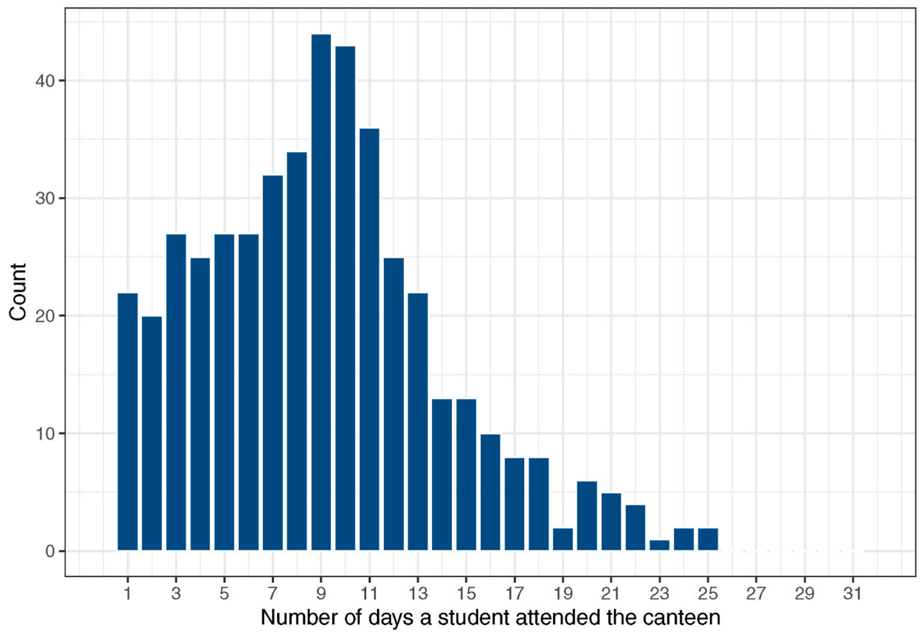

Fig. 1. Histogram of the number of days a student attended the canteen for a lunch meal.

Table 3
Percentage of orders including at least one vegetable plate by plate labels.

Label	N	(%)
Standard	1302	35.8
Organic	906	33.2
Local	793	41.0
Organic & Local (Both)	1132	35.3

Table 4
Posterior mean, standard error and 95% credible intervals for the log-odds ratios estimated on the historical dataset. The coefficients are part of a Bayesian hierarchical logistic model where the variable of interest is the purchasing of at least one vegetable plate by a student for a given menu date.

	Estimate	Std. Error	Lower Bound	Upper Bound
Intercept	−1.199	0.153	−1.500	−0.901
Sex: female	0.470	0.138	0.201	0.744
Education: graduate	−0.450	0.159	−0.759	−0.140
Tuesday	−0.168	0.128	−0.420	0.081
Wednesday	−0.260	0.134	−0.525	0.001
Thursday	0.043	0.126	−0.206	0.291
Friday	−0.011	0.128	−0.263	0.244
Age	0.229	0.078	0.076	0.380
Last minute	0.428	0.072	0.286	0.569

first step of fitting the model to the historical data (yellow densities) and those estimated after the second step of fitting the model to the experimental data (red densities). The associations between the available covariates and the purchasing of a vegetable plate estimated on the historical data were largely confirmed on the experimental data. Slight changes involved the estimated associations of education (OR: 0.63 vs. 0.69) and age (OR: 1.25 vs. 1.22) with the purchasing of a vegetable plate, while the estimated association of sex with the outcome of interest was stronger (OR: 1.59 vs. 1.75). The numerical estimates for the log-odds ratio are also reported in Table 5 (a).

As shown in Fig. 3, we did not observe a noticeable association between the labels *local* or *organic & local* and the log-odds of purchasing at least one vegetable plate. The point estimate for the association between the *local* label and the purchasing of a vegetable plate was small and positive and the 95% credible interval included both values above and below one (OR: 1.14; 95% credible interval: 0.71, 1.74). The odds ratio of the probability of including a vegetable plate labeled *organic & local* versus an *unlabeled* vegetable plate was estimated to be very small and with uncertain direction (OR: 1.05; 95% credible interval: 0.70, 1.60). Moreover, according to our model the probability of a negative association between the purchase of at least one vegetable and the label *organic* was 79% (OR: 0.83; 95% credible interval: 0.53, 1.26). Finally, the estimates for the variabilities (standard deviations) of the students' intercepts were 1.54 (95% credible interval: 1.37, 1.71) and those of the menu dates were 0.32 (95% credible interval: 0.18, 0.50).

3.4. Sensitivity analyses

To evaluate the impact of allowing for day-to-day variations in the log-odds that a subject purchases a vegetable plate *other than* those predicted by the other variables included in our model (observed subject characteristics, weekday that the menu day falls in, whether a subject ordered last-minute and the label of vegetable plates for that menu day), we repeated the analysis removing the random effect τ_t's from the model.

First, we notice that the resulting posterior distributions for the control variables were very similar (they are not shown here but can be found in Fig. 5 in Appendix). Instead, the posterior distribution of the coefficients of the experimental labels were quite different for the model without τ_t and are displayed in Fig. 4. We notice that failing to allow for the presence of day-to-day variation unexplained by the observed variables would result in concluding that the experimental label *local* was positively associated with the purchasing of a vegetable plate. Instead, accounting for the existence of such additional variation (which can be motivated, for example, by the fact that a substantial part of the menu changed between any two different menu dates), led us to conclude that the available evidence does not in fact allow us to exclude that any estimated effect of the labels might just be due to chance.Second, we compared our two-step Bayesian mixed effects model with an equivalent frequentist model (GLME) of only the experimental data. The estimated coefficients and their corresponding confidence intervals on the odds ratio scale are shown in Table 5. The benefit of the two-step Bayesian approach is evident. Without the additional information extracted from the historical data, the frequentist model estimated significant and negative effects for all of the experimental labels compared to the

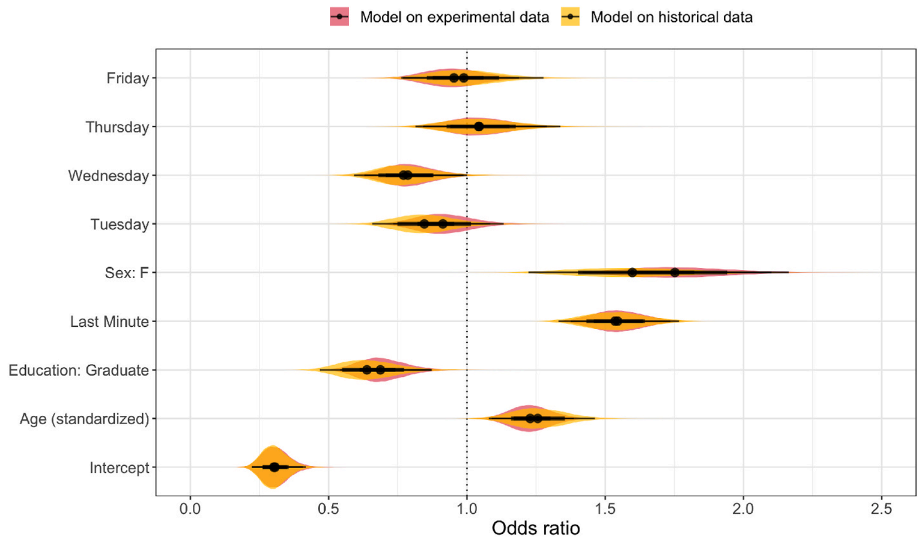

Fig. 2. Violin plots and credible intervals (thin line: 95% CI, thick line: 50% CI) summarizing the posterior distributions of the odds ratios for the coefficients of interest that are shared between the historical data (yellow densities) and the experimental data (red densities).

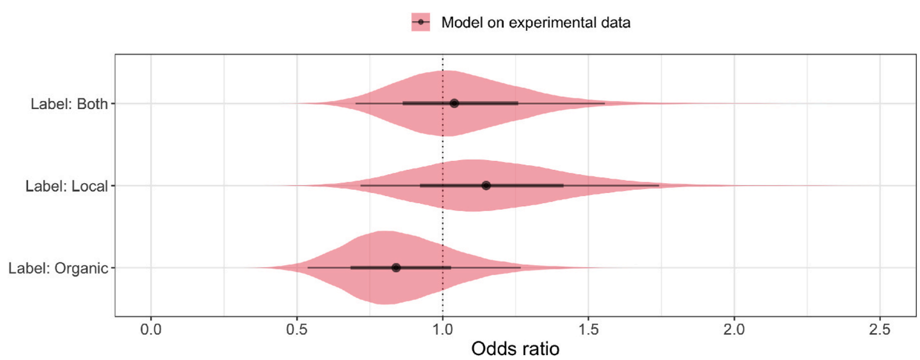

Fig. 3. Violin plots and credible intervals (thin line: 95% CI, thick line: 50% CI) summarizing the posterior distributions of the odds ratios for the coefficients related to the label indicator variables.

Table 5
Comparison of the point estimates and corresponding errors under the (a) Bayesian and (b) Frequentist model.

	(a) Bayesian GLME			(b) Frequentist GLME		
	Estimate	Lower Bound	Upper Bound	Estimate	Lower Bound	Upper Bound
Intercept	−1.185	−1.498	−0.874	−1.273	−1.647	−0.900
Label: Organic	−0.178	−0.622	0.237	−1.480	−2.456	−0.505
Label: Local	0.133	−0.331	0.555	−1.169	−2.167	−0.170
Label: Both	0.041	−0.356	0.443	−1.358	−2.350	−0.367
Sex: F	0.560	0.350	0.773	0.679	0.349	1.009
Education: Graduate	−0.374	−0.614	−0.136	−0.230	−0.601	0.141
Tuesday	−0.091	−0.309	0.125	1.463	0.446	2.480
Wednesday	−0.239	−0.464	−0.012	1.228	0.189	2.266
Thursday	0.041	−0.172	0.254	1.443	0.443	2.443
Friday	−0.049	−0.271	0.172	−0.027	−0.412	0.357
Age (standardized)	0.206	0.086	0.327	0.142	−0.052	0.337
Last Minute	0.435	0.318	0.551	0.405	0.199	0.612

unlabeled case, as well as significant and positive effects for all weekdays with experimental labels, compared to Monday. However, the correlation matrix of the fixed effects indicated an extremely high correlation (above 90%) between the fixed effects of all weekdays with experimental labels and the fixed effects of the labels themselves. Such a high correlation, which is to be expected given the design of the experiment, indicates that the estimated model is highly unstable and that the available data does not feature enough variation of experimental labels across weekdays to allow separating the effect of weekdays from that of the labels. The two-step Bayesian approach therefore allowed to fully account for the experimental design, by estimating the effect of weekdays using both historical and experimental data.

Lastly, we considered two different model specifications. We fitted the model separately for green salads, cooked vegetables, and pulses salad in the first one. In the second one, we aggregated all experimental labels in a single *non-standard* label. The two models yielded very similar results to those obtained with the standing model approach (see Figs. 6 and 7 in Appendix).

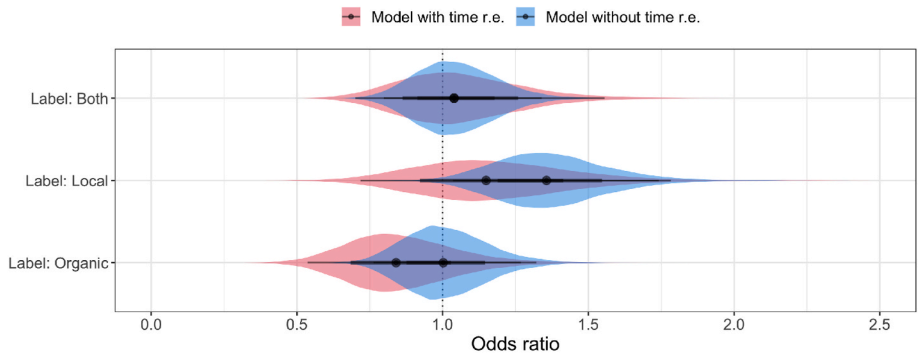

Fig. 4. Violin plots and credible intervals (thin line: 95% CI, thick line: 50% CI) summarizing the posterior distributions of the odds ratios for the coefficients of the experimental labels. The two colors represent two different models, with and without the random effect (r.e.) for accounting for time.

4. Discussion

An increase in vegetable consumption is desirable for both human and planetary health. Among the strategies implemented to achieve this goal, behavioral interventions such as the adoption of nudging techniques have attracted great attention during the last decade. In particular, the use of labeling to promote vegetable consumption has been found to be an inexpensive and easy method to implement, although mixed results have been reported in terms of its effectiveness (Laiou et al., 2021). Therefore, the purpose of this study was to evaluate the efficacy of *organic* and *local* labels in increasing the selection of vegetarian dishes in a university canteen.

Overall, we did not find a significant contribution of the labels *organic*, *local*, and *organic & local* in nudging the consumption of vegetable dishes. More specifically, the point estimate for the association between the *local* label and the purchasing of a vegetable plate was small and positive (OR: 1.143), but a non-negligible part of the 95% credible interval corresponded to a negative association (95% CI for the OR: 0.71, 1.74). Additionally, we estimated the effect of the *organic* label to possibly be (mildly) detrimental to the purchase of vegetables: the odds of purchasing at least one vegetable plate were estimated to be 17% lower (OR: 0.83) when the vegetable plates were labeled as *organic* than for the *unlabeled* case. Still, the 95% credible interval for the odds ratio (0.53, 1.26) also included values above one. Finally, the association between the label *organic & local* and the purchasing of a vegetable plate was estimated to be even milder and of more uncertain direction than for the *organic* and *local* labels alone (OR: 1.05; 95% credible interval: 0.70, 1.60).

Prior studies focused on the effect of *organic* and *local* food labels, specifically on: customers' preferences (Stanton et al., 2012); willingness to pay (Costanigro et al., 2014; Costanigro, McFadden, Kroll, & Nurse, 2011; Gracia et al., 2014); and rating of taste (Bernard & Liu, 2017). Similarly to those studies, we estimated the effect of the *local* label to be positive and larger in magnitude compared to the *organic* label. Somewhat differently from what Gracia et al. (2014) reported on customers' willingness to pay for *organic*, *local* and *organic & local* eggs, we did not find in our context (i.e., for vegetable items) that the *organic & local* label had a stronger estimated effect than the *local* label alone. We would like to emphasize two main aspects concerning our results to ease the comparison with existing and future research. First, the relatively high uncertainty regarding the sign of the estimated labels' effects can partly be attributed to the design of the specific experiment that our study analyzed. Indeed, the fact that the main courses varied considerably across days and that all customers were exposed to the same label on a given day implied that no actual comparison group existed at any point in time. To account for this, our model included a day-specific parameter to capture the potential correlation in the probability that subjects would order a vegetable plate on a given menu day. Moreover, the fact that *unlabeled* items were offered on fixed weekdays (Monday and Friday) throughout the experiment called for the need to include controls for weekday effects on customers' propensity to purchase a vegetable plate with their lunch order. Thanks to the analysis of historical data, we were able to include both day-specific and weekday controls in our model despite the high correlation between them and the labels' effects. However, because we only observed the same labels up to five (for *local*) and six (for *organic* and for *organic & local*) days, the available data did not allow us to estimate the parameters of interest with higher precision when including all necessary controls. The posterior distributions of the standard deviations of subject and time-specific random effects corroborated the existence of both between-subject and between-day variations in the historical and experimental data. Second, it is worth noting that, even if labels' effects could have been estimated with more precision, most of their posterior distributions concentrated around values that were relatively small in magnitude. To better contextualize the magnitude of estimated effects, we considered a wide range of values for the probability of ordering an unlabeled vegetable plate, (from 10% to 90%). We calculated that an odds ratio of 1.25 would correspond to an increment of 3–5 percentage points in the probability of ordering at least one vegetable item when given an experimental label. From Fig. 3 we observe that the posterior distribution of the label *organic* almost exclusively concentrates around values lower than 1.25, and also those of the labels *organic & local* and *local* assign most probability to values lower than 1.25 (respectively, 70.51% and 79.65%).

In accordance with the literature (Mello Rodrigues et al., 2019; Ramsay, Rudley, Tonnemaker, & Price, 2017), the analysis of both historical and experimental data pointed to a greater tendency for females to consume vegetables than for males (considering sex as reported on IDs). Among students and controlling for age, we observed that undergraduates were significantly more likely to order at least one vegetable plate than graduates, contrary to what was recently reported by Wilson, Matthews, Duffey, Papalia, and Bopp (2020) and McLean--Meyinsse (2021), who found the consumption of vegetables to be independent of academic class. However, we believe this discrepancy should not be stressed, as it may largely depend on the specific university analyzed where all undergraduate students are exposed to nutrition-related subjects. Finally, we estimated from historical data that students were more likely to include a vegetable plate in their lunch on Monday than on Tuesday or Wednesday. We speculate that this result may depend on students' desire to compensate for a possible lower consumption of vegetables over the weekend, as hypothesized in previous studies (An, 2016; Yang, Black, Barr, & Vatanparast, 2014).

To the best of our knowledge, our study was the first to assess the influence of *organic* and *local* labels in an experiment conducted in a real-life setting such as a university canteen. Also, differently from other published work on the effects of *organic* and *local* labels, our study analyzed an intervention carried out over a longer period of time and examined actual purchasing rather than intended consumption choices.

Moreover, the availability of historical data and the employment of a Bayesian approach allowed us to control for heterogeneous vegetable consumption patterns (e.g., subject and time-specific). In particular, we demonstrated in Section 3.4 that failing to include all necessary controls in our model would potentially have led to erroneous conclusions. In this sense, our analysis highlights the importance of striving to account for all potential sources of confounding that can arise in experimental research.

The present study also had several limitations that we would like to emphasize. First, as noted previously, not having a comparison group on a given menu day limited the possibility to assess the potential (causal) association between vegetable plate labels and the purchase of vegetable items. Accounting for the menu date as a random effect was one way to allow for day-specific variability; conversely, not including a day-effect would have seemed problematic given the lack of a comparison group on a given day. Second, as shown in Fig. 1, the majority of students attended the canteen less than half of the days when the experiment was carried out. By including random intercepts for each subject, our analysis models the effect of an individual as noise and separates it from the effect of the labels on the response. However, individuals' "noises" are estimated with a varying amount of data for each subject, and in this sense our data suffers from unbalancedness. Unfortunately, this is a problem that affects many real-setting studies, and the available data did not include factors that may help characterize who are the individuals that we observe the most or the least, such as class schedules, availability of meal-plan including scholarships, and students' socio-economic status. Third, in the experiment analyzed in our study, the labels did not correspond to differences in what was actually served, because vegetable plates were prepared with organic and local ingredients (whenever available) regardless of the label displayed in the menu. For students who knew or understood that the vegetable plates with a different label were actually the same, the nudging intervention would have consisted of a mere reminder or emphasis of the origins of the ingredients used at the time of purchasing. Given the peculiar context in which the study took place (UNISG), it is possible that the expected quality level of vegetable ingredients was already very high, making it difficult to notice the improvement given by the organic or local origin of the ingredients, and generating a sort of ceiling effect. Lastly, caution is advised when trying to generalize these findings since the study was conducted at a single university's canteen. More evidence needs to be collected from different settings to verify the extent to which our results generalize.

5. Conclusion

The primary aim of this study was to determine whether labeling vegetable items as *organic*, *local*, or *organic & local* tends to be associated with higher odds of purchasing at least one vegetable item for a lunch meal in a university canteen versus standard labeling. The results of our analysis suggest that the labeling of vegetable plates may have a null or very limited impact on the chance that students ordered a vegetable plate.For future studies, we recommend involving both an experimental and a control group on the same menu day, to which subjects are to be randomly allocated. Because we could not rule out the possibility of no difference between the three non-standard labels and the unlabel case, we suggest including all three non-standard labels as experimental interventions. If, however, it would not be feasible to have multiple non-standard labels, based on our empirical results from the current study and prevailing literature, we suggest using *local* as the experimental intervention.

Ethical statement

The study was approved by the Ethics Committee of UNISG (Ethics Committee Proceeding n. 2020.02). The work was carried out in accordance with the international ethical guidelines for research involving humans established in the Declaration of Helsinki. All subjects signed an informed consent.

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CRediT authorship contribution statement

Riccardo Migliavada: Conceptualization, Methodology - Study Design, Software, Investigation, Data Curation, Writing - Original Draft, Writing - Review & Editing. **Federica Zoe Ricci:** Conceptualization, Methodology - Statistical Model, Software, Data Curation, Validation, Formal analysis, Writing - Original Draft, Writing - Review & Editing, Visualization, Project administration. **Francesco Denti:** Methodology - Statistical Models, Software, Data Curation, Validation, Formal analysis, Writing - Review & Editing, Visualization. **Derenik Haghverdian:** Methodology - Statistical Models, Software, Data Curation, Formal analysis, Writing - Review & Editing, Visualization. **Luisa Torri:** Conceptualization, Methodology - Study Design, Writing - Review & Editing, Supervision.

Declaration of competing interest

The authors declare no conflicts of interest with this publication.

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Appendix

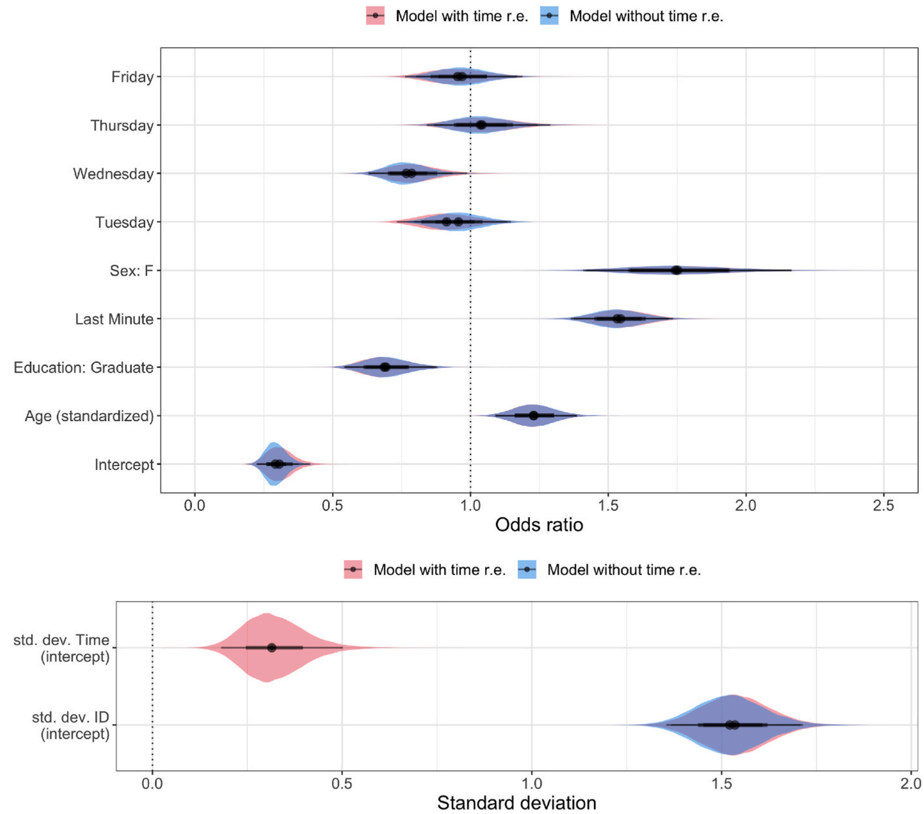

Fig. 5. Violin plots and credible intervals (thin line: 95% CI, thick line: 50% CI) summarizing the posterior distributions of the odds ratios for the coefficients of interest (top panel) and the standard deviations for the random effects (bottom panel). The two colors represent two different models, with and without the random effect (r.e.) for accounting for time.

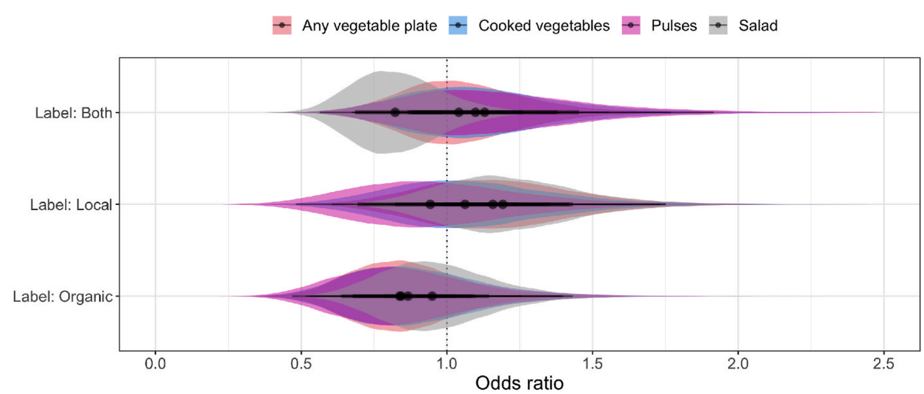

Fig. 6. Violin plots and credible intervals (thin line: 95% CI, thick line: 50% CI) summarizing the posterior distributions of the odds ratios for the coefficients of interest in the chosen statistical model (in red, original labels) compared with three identical models where the response only reflects the purchase of one of each vegetable plates.

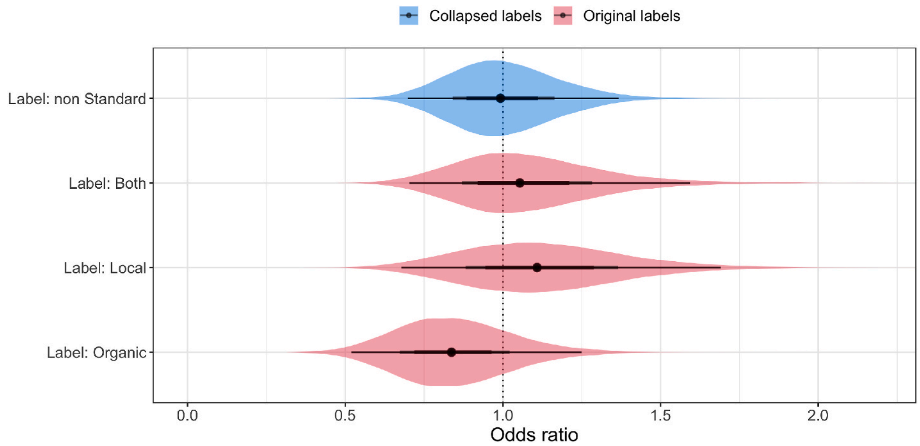

Fig. 7. Violin plots and credible intervals (thin line: 95% CI, thick line: 50% CI) summarizing the posterior distributions of the odds ratios for the coefficients of interest in the chosen statistical model (in red, original labels) compared with a similar model where the non-standards labels were collapsed together (in blue, collapsed labels).

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