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A randomised control trial on the impact of nudges, information and incentives on food choices of vulnerable families

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ABSTRACT

This study examines the impact of information, nudges and cash aid on food choices among vulnerable families receiving Red Cross aid in Spain. We use data on 1429 participants of a Randomised Controlled Trial (RCT) ran across 73 branches of the Red Cross in Catalonia, a region of Spain. While all RCT participants received cash-aid food vouchers, they were randomised to the following additional treatment arms: i) informational intervention about the benefits of healthy eating; ii) "affective" nudges reminding facts about healthy food, or iii) additional cash-aids. We use food purchasing data from all these participants who were also beneficiaries in 2023 of cash-aid food vouchers. We find a positive impact of all interventions aggregated in the three standard indexes of food purchasing quality. Examining intervention heterogeneity, we find that informational interventions and affective nudge messages were more effective than cash incentives in leading to healthier food choices. They improved the nutritional content, overall purchases and the quality of purchases made by the treated groups by 9.06 %, 3.29 % and 8.43 % of the average value for the control group during the pre-treatment period.

1. Introduction

Obesity is associated with a range of preventable chronic conditions, including cardiovascular diseases, osteoarthritis, and type 2 diabetes (World Health Organization, 2015). The burden of obesity, particularly severe and moderate forms, places significant strain on the Spanish healthcare system. Mora et al. (2015) estimate that severe obesity is linked to a 26 % increase in medical costs, accounting for approximately 7 % of total healthcare spending in Spain. Several studies report socio-economic inequalities in obesity, particularly in Spain (Costa-Font and Gil, 2008; Rodríguez-Caro et al., 2016; Merino Ventosa and Urbanos-Garrido, 2016). At the same time, malnutrition is associated with increased healthcare use and costs, especially in lower socioeconomic groups (Elia, 2015). In a study of older adults in a Spanish community, 15 % were at risk of malnutrition, and 12.6 % were malnourished (Rodríguez-Sánchez et al., 2020).

Given that food choices are an essential determinant of diet quality, particularly amongst low socioeconomic groups, numerous public policies have been implemented to influence them. From an economic perspective, the design of such policies often depends on the nature of market failures, particularly those arising from information asymmetries, which may disproportionately affect more vulnerable populations. Health capital theory suggests that individuals with higher levels of education are more efficient and productive in making health-related decisions (Grossman, 1972). Meanwhile, behavioural economics highlights the possibility that individuals may misjudge the long-term health consequences of their actions or exhibit present bias in their decision-making (Loewenstein et al., 2014), suggesting nudges and informational interventions, understood as elements of the choice architecture that change individual behaviour without any economic incentive (Thaler and Sunstein, 2008) may address these issues.

In response to these challenges, public policies have sought to mitigate information asymmetries and financial barriers. For example, "5-a-day" campaigns promote healthier eating habits (Capacci and Mazzochi,

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2011), while labelling initiatives provide consumers with more explicit nutritional information (Fichera and von Hinke, 2020). Additionally, effective policies aimed at reducing income constraints, such as targeted subsidies for fruits and vegetables (Griffin et al., 2018) or taxes on sugar-sweetened beverages (Fletcher et al., 2010; Fichera et al., 2021), have been introduced to encourage healthier choices.

Previous evidence suggests mixed effectiveness of nudges (Wilson et al., 2016; Nørnberg et al., 2016; Just and Price, 2013; List and Samek, 2015; Belot et al., 2016; Loewenstein et al., 2016; Mora and Lopez-Valcarcel, 2018). The focus on vulnerable families is limited partly because of sample sizes, as most evidence uses laboratory experiments where participants are not affected by their choices, but also because the few existing field experiments focus on children (Belot et al., 2016). Previous systematic reviews on the effectiveness of nudges on lower socioeconomic groups suggest that cognitive-related nudges are less likely to alter the food choices of these individuals (Schüz et al., 2021). In contrast, Harbers et al. (2020) found that the effectiveness of information nudges may be moderated by socioeconomic status and that more substantial impacts are observed amongst lower-income individuals. Sapio and Vecchio (2024) updated this systematic review, accounting for more recent studies after 2018. They highlighted that most studies focus on cognitive nudges instead of affective nudges (i.e. those that appeal to individual emotions to change their eating habits). Evidence suggests that nudges can be effective for lower-income individuals. Still, the magnitude of these effects varies across types of nudges and methodologies, with most studies focusing on the United States. Sapio and Vecchio (2024) reported that only seven studies have previously examined different interventions or their combinations in field experiments involving low-income families. Results are mixed and depend on the type of intervention (nudges and non-nudges) and the methodology used (Randomised Controlled Trial or quasi-experiments). However, none compare nudges, informational interventions, and cash incentives for lower-income families within a Randomised Controlled Trial (RCT). This setting is well-suited to the context, as it allows us to identify the causal effects of the interventions on diet quality and to compare their relative effectiveness. Additionally, we focus on an under-studied population group—low-income families—for whom little is known about the relative effectiveness of financial versus non-financial food interventions, particularly in the Spanish context.

This paper presents the findings of an RCT conducted in Spain in 2023, targeting families experiencing extreme vulnerability and low-income status who received food cash-aid vouchers from Red Cross Catalonia. We collaborate with the Red Cross Catalonia to conduct an intervention alongside these regular vouchers. The treatment groups received either informational interventions, "affective" nudges, or additional cash aid. Our intervention addresses both information asymmetries and financial constraints, providing evidence that interventions effectively alter food choices. We evaluate the impact of these interventions on dietary choices using three complementary indices that capture nutritional content and purchase quality.

Our findings indicate that the interventions positively impacted these indices. When disaggregating the results by intervention type, we find that the informational intervention and affective nudges primarily drove the positive effects on the nutritional content and the quality of purchases. In contrast, the cash incentives had a comparatively smaller effect. Cash incentives did not significantly impact either index measuring the quality of purchases. Finally, we estimate the conditional average treatment effects. Our analysis suggests that individuals who received smaller cash-aid amounts during the post-treatment period, and age, played a role in moderating the treatment effects.

The remainder of the paper is organised as follows: Section 2 describes the dataset and contains detailed information on the RCT design and statistical methods. Section 3 presents the results, and Section 4 concludes with a discussion of our findings.

2. Data and methods

2.1. Participants: low-income individuals

We have access to comprehensive data on the entire population of low-income individuals who received food cash-aid vouchers provided by the Red Cross in Catalonia in 2023. These individuals and family units had incomes equal to or below the Income Sufficiency Indicator (IRSC) of €615 per month, with an additional €125 per child or dependent person without income. Eligibility for these vouchers was also based on other vulnerability criteria, such as single-parent households, older adults, health conditions, and social networks. In the next section, we will describe the design of the Randomised Controlled Trial.

Participants are provided with a data protection and informed consent sheet, and a trained fieldworker administers an initial questionnaire. This person oversees the completion of the questionnaire to address any participant questions, ensure accuracy, and prevent missing data. The questionnaire is delivered through Google Forms (see Appendix A1). Its primary aim is to assess participants' socioeconomic and educational status and eating habits.

The information collected includes gender, educational attainment, employment status, country of origin, household size, cohabitation status (whether participants live with partners or have dependents), and the primary source of income (NGOs, social benefits, family or neighbourhood support, informal economy, or salaries). Additionally, we ask about the food source (social services, NGOs, personal income, or support from family and friends). Participants are also asked about previous training in nutrition, home management, and childhood education.

In terms of dietary habits, participants are asked to report the frequency of their regular daily or weekly intake (on a scale of 1–5) of cereals and derivatives (such as pasta, rice, potatoes, bread, and grains), vegetables, fruits, dairy products (such as cheese, yoghurt, milk, and butter), meats, fish, eggs, legumes, sausages and cold cuts, sweets, sugar-sweetened soft drinks, pre-cooked dishes, and home-delivered meals.

Finally, the initial questionnaire records information about any conditions that may affect regular food intake or daily activity, with an option for open-text responses. These conditions include food allergies, digestive issues, cholesterol, diabetes, overweight, hypertension, mental health conditions, arthritis/arthrosis, neoplasms, cardiovascular diseases, thyroid issues, asthma, and disabilities.

We also have access to comprehensive food purchase information on these Red Cross Catalonia cash-aid beneficiaries, sourced from various additional data tools. This information encompasses: (i) disaggregated purchases made using pre-paid vouchers at two specific supermarket chains during 2023; (ii) data from the Red Cross platform, which details beneficiaries' prior participation in various Red Cross projects; (iii) the economic value of monthly vouchers received by beneficiaries in 2023 which depends on vulnerability criteria (households characteristics, age, health conditions, among others); and (iv) a list of the local Red Cross branches throughout Catalonia. The two supermarket chains in which beneficiaries were allowed to expend their vouchers provided item-by-item purchases during 2023 containing information on the specific products, the number of units and weight. Beneficiaries were identified by their voucher card number initially provided by the Red Cross. Then, we categorised and searched for the nutritional content of the final 5681 products into the categories we needed to construct the nutritional indices.

2.2. Measures: food purchase quality indexes

Three complementary indices are used to evaluate the quality of food purchases from different perspectives. All indices are rescaled from 0 to 100 to ensure comparability, with higher values indicating healthier purchases. These indices are: (a) the *Índice de Alimentación Saludable en España* (Healthy Eating Index for the Spanish Population, IASE) developed by Norte-Navarro and Ortiz-Moncada (2011); (b) the Healthy

Trolley Index (HETI) as defined by Taylor et al. (2015); and (c) the revised Healthy Purchase Index (r-HPI) designed by Perignon et al. (2023). IASE is specifically tailored to the Spanish context, using nutritional information relevant to the local population. HETI and r-HPI offer complementary approaches to assessing purchase quality, analysing the ratio of healthy to unhealthy foods in monthly purchases. HETI was developed for Australia and provides a general assessment of purchase quality, while r-HPI, designed for France, offers a more detailed evaluation of the nutritional quality of purchases. Both (HETI and r-HPI) were retained to capture broader and more specific perspectives on food quality. Appendix A3 details these indices.

The IASE index is used to assess the quality of dietary choices by comparing the frequency of food consumption based on nutritional recommendations by the Spanish Society for Community Nutrition (SENC) on specific food groups and dietary variety. Foods are classified into ten groups (including grains and derivatives, vegetables, fruits, dairy products, meats, legumes, cold-processed meats, sweets, beverages, and diet-variety), and each food carries a maximum score of 10. In this study, the quantities of food purchased have been converted into standard portions for adults. The final score of the IASE index is calculated by adding the scores obtained in each category, which allows a maximum score of 100 points.

The HETI index was developed to determine compliance of monthly food purchases with the Australian Guide to Healthy Eating (AGHE). Foods are classified into different category description groups divided into grains and cereals, meats and alternatives, dairy foods, fruit, vegetables and discretionary foods (e.g. mixed dishes, salty snacks, confectionery, sugary drinks, alcohol, processed meats, pastries, commercial products, pasta and sauces). Some food groups, such as coffee and tea or animal and vegetable oils and fats, do not fit clearly or have no specific recommended intake, so they are excluded from the study. We have calculated the proportion of total monthly expenditure by category, corresponding to the expenditure generated by each food group, divided by the total monthly purchase expenditure generated and multiplied by 100 to obtain a percentage. To generate a HETI score, we compared the proportion of expenditure on each food group to its benchmark and calculated a score out of 10. The HETI benchmark represents the recommended servings of each food group as a proportion of the total recommended daily servings (21.5). This is calculated as: (average recommendation/21.5) $\times$ 100. If a household's monthly expenditure proportion for a food group met or exceeded the recommended proportion, it received the maximum score of 10.

Finally, the r-HPI was used to assess the nutritional quality of food purchases by examining the proportion of spending allocated to different food groups rather than focusing solely on the quantities bought. The r-HPI includes two sub-scores. The diversity sub-score consists of a score that reflects the presence of five food groups in the diet: a) fruits, b) vegetables, c) starches, d) dairy products, and e) meat, fish, and eggs. The quality sub-score evaluates the nutritional quality of purchases by analysing expenditure shares across specific food groups, including a) fruits and vegetables, b) added fats and seasonings, c) sweet snacks, d) cheese, e) sugary drinks, f) refined grains, and g) fish. The final score consisted of the sum of both sub-scores.

The IASE, HETI, and r-HPI are all measures used to assess the nutritional quality of food purchases. However, they differ in methodology, scope, and application. The IASE and HETI compare overall diet quality to specific guidelines, the former for the Spanish population and the latter for Australians. The r-HPI examines the proportion of household spending on various food groups to determine the healthiness of their purchases.

2.3. Methods: the Randomised Controlled Trial

We conducted an RCT in collaboration with the Red Cross Catalonia in which treatment groups received either informational interventions, "affective" nudges, or additional cash aid. The first treatment arm was offered an informational intervention via workshops designed and delivered by nutritionists. Through group dynamics, attendees learned about healthy eating, optimal shopping, and emotional eating. The second treatment arm offered an "affective" nudge using SMS messages prompting meal planning, reminding about eating fruit and vegetables, inexpensive and healthy eating, and recognising ultra-processed food. Three studies (Griffin et al., 2018; Gustafson et al., 2022; Kay et al., 2023) report that affective nudges providing healthy tips and motivational prompt messages moderately improved food choices for lower-income individuals. The third treatment arm instead receives an additional cash aid. The control group received food cash-aid vouchers only.

The Red Cross in Catalonia operates through a network of more than 90 regional and local branches, each responsible for setting objectives, developing work plans, and making decisions within their respective areas. Of these, 73 branches had beneficiaries participating in the cash-aid intervention project analysed in this study. The 73 Red Cross branches with cash-aid beneficiaries are consolidated into 57 branches due to their size and geographical proximity. We then cluster the branches into four groups based on the number of beneficiaries and the characteristics of individuals, using data from January to May 2023. These characteristics include gender, three age groups, and nationality. Branches within these clusters are randomly assigned to the control or intervention groups. However, three branches were randomly split across two intervention arms because of their large number of beneficiaries in a way that avoided possible contagious effects.

The Red Cross anonymised all participants in Catalonia before data analysis. The final dataset comprises 1429 participants who had previously consented to participate in the study (see Fig. 1). Of all the beneficiaries listed by the Red Cross receiving cash aid in September 2023, only 23 individuals declined to provide consent. Of the 1406 individuals who used their regular vouchers at supermarkets during 2023, 1213 did so during the pre-treatment period and 1356 during the post-treatment period. A total of 1163 beneficiaries used their vouchers in both periods (Fig. 1). Some individuals may either decide against reapplying for aid or lose eligibility after a previous award.

The monthly value of the prepaid vouchers varied depending on individual and household characteristics. The average voucher amount was €100.7 per month for those who purchased during both periods (ranging from €40 to €450). While the vouchers primarily were used for food purchases, beneficiaries could also use them to buy hygiene products (0.9 %).

We design the study with four distinct arms, including a control group and three exclusive interventions: (i) informational workshops providing nutritional guidelines, (ii) affective nudges with eight SMS messages promoting healthier food purchases, and (iii) economic incentives, specifically additional purchase credits on top of the existing voucher amount. We stratify at the branch level to prevent cross-contamination between the intervention arms.

Out of the 1163 final participating beneficiaries, the distribution across the different study arms is as follows: 345 in the control group, 180 in the workshop group, 316 in the cash-aid incentive group, and 322 in the SMS message group. The workshop arm is relatively underrepresented because we prioritised ensuring that assigned individuals received multiple training sessions, which posed logistical challenges. Coordinating availability across participants and trainers, especially in resource-constrained settings, limited our ability to include more individuals in this arm while maintaining the intended intervention fidelity. Of the 242 individuals initially assigned to the workshop arm, only 180 were observed before and after the treatment period. Similarly, out of the 431 beneficiaries assigned to the SMS intervention, 322 were observed in both periods. In comparison, 316 of the 332 individuals in the incentive group were observed during both the pre- and post-treatment periods.

For a comprehensive overview of the randomisation process, see Fig. 1. The study's statistical power is calculated based on the following

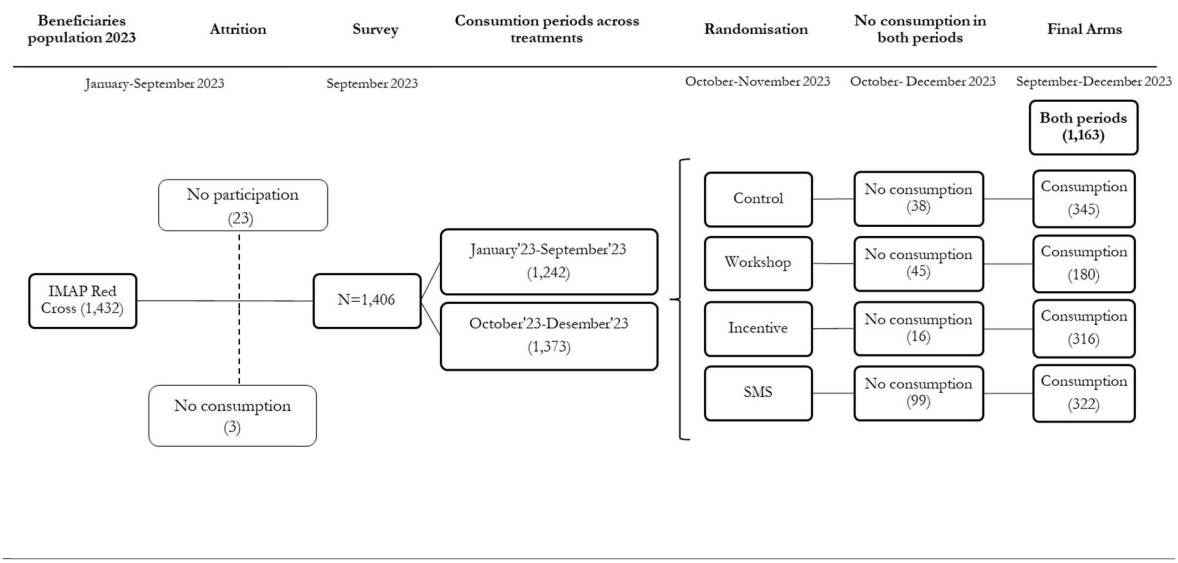

Fig. 1. Timeline intervention.

parameters: a significance level (α) of 0.05, a sample size of 1,163, an R^2 value of 0.16, and an effect size of 0.1628. Based on these inputs, the power of the study almost reaches a value of 1, indicating a high likelihood of detecting a true effect if one exists. Therefore, the Type II error (failing to detect a true effect) is almost negligible.

Table 1 shows the main descriptive characteristics by arm, which were tested for statistically significant differences based on their treatment condition to check the validity of our randomisation process. Regarding the gender dimension, the primary beneficiaries were women (78.2 %), with an average age of 48.1, mostly with primary or secondary educational attainment levels (32.0 % and 46.0 %, respectively). The average household size was around three individuals; 30.5 % of the respondents lived with their partner, and 73.5 % had any descendant/ascendant. As expected, only 17.5 % were active and 34.8 % were unemployed. They self-reported healthier regular intakes and food provenance that come mostly from NGOs (including the Red Cross) and their income. Previous training on feeding issues was low (26.9 %).

The final database contained a balanced population based on individual control characteristics (sociodemographic, income and labour status, regular intakes, food and income primary provenance and previous training experience). Very few characteristics were statistically significantly different based on their treatment condition. Indeed, a higher proportion of female and Spaniard beneficiaries (80 % and 39 %) were treated compared to the non-treated (74 % and 25 %). By chance, the share of those retired in the treatment groups (15 %) was higher than that in the control group (13 %), whereas those in the black market were overrepresented in the control group (19 %) compared to the treated (13 %). The latter was corroborated when reporting income provenance. Slightly lower frequencies were found in one recorded dietary intake in the treated arms compared to the non-treated (meats, fish and eggs). In Table A.1, we compare the characteristics of participants in the workshop arm with those in each of the other treatment arms and the control group. As we find some differences—particularly between the workshop and incentives arms—we include these baseline characteristics as controls in the regression analyses. A brief overview of the pre-intervention food purchase pattern is shown in Appendix (see Fig. A0).

The intervention was implemented between October and November 2023. The treatment period was considered to begin when individuals either attended their first workshop or received their first SMS message. Five trained specialists conducted workshops starting on October 3rd, 2023, and concluding on November 30th, 2023. In total, 79 1-h workshop sessions were delivered across three different days, with some branches offering multiple sessions on the same day to maximise participant coverage.

We tracked the number of sessions each beneficiary attended. Among the 180 participants in the workshop group, 61 (33.9 %) participated in all three sessions, 52 (28.9 %) attended two sessions, and 67 (37.2 %) attended only one. The workshops provided information on nutrition, healthy lifestyles, optimal purchasing strategies, and managing emotional eating. The first session specifically focused on identifying different food groups and understanding the nutrients they provide. For a detailed overview of the workshop content, see Appendix A2. We compared the characteristics of this arm with the rest because of its lower size (see Table A1).

The eight concrete SMS messages were sent weekly and in the same order to all beneficiaries assigned to this arm. The content of the different messages was about healthy eating and waste (see Annexe 2). The first message was sent at a low cost between October 27th and November 20th, 2023. We recorded the specific dates each beneficiary received a message since they were sent on different dates depending on the Red Cross branch. No beneficiaries declined to receive more messages once they received the first one. Specifically, the messages aimed to sensitise users who receive pre-loaded vouchers to buy essential products about food, making basic recommendations such as including more fruits and vegetables daily or promoting the consumption of eggs and legumes, very nutritious foods, as well included advice on planning and buying food to avoid pre-cooked products and promote fresh food.

Finally, the incentive treatment arm included a voucher with a lump-sum incentive of 70€ to be expended after November 1st, 2023. The branches recorded the concrete delivery date for each beneficiary. This incentive represented 69.6 % of the regular average monthly prepaid voucher beneficiaries received from the Red Cross in the first months of 2023. Beneficiaries received this incentive with a letter recommending healthy food products.

2.4. Statistical analysis

The specification of the model is the same for the three indices (y):

Table 1
Descriptive statistics by treatment and control arm, type of treatment arm.

	Control (N = 345)	Treatment (N = 818)	Type of treatment		
			Workshops (N = 180)	Incentives (N = 316)	SMS (N = 322)
Individual characteristics					
Individual's age	47.27	48.40	44.54	51.85	45.50
Individual is female	0.74	0.80**	0.83	0.76	0.83
Household size	3.16	3.04	3.37	2.84	3.15
Descendants/ascendents at home	0.76	0.73	0.87	0.64	0.78
Living with partner	0.32	0.30	0.32	0.31	0.28
Nationality					
Spaniards	0.25	0.39***	0.26	0.44	0.38
Arabic	0.25	0.23	0.18	0.25	0.23
American	0.40	0.32*	0.46	0.26	0.34
African	0.05	0.02*	0.02	0.02	0.02
East/European	0.04	0.04	0.07	0.03	0.03
Asian	0.01	0.00	0.01	0.00	0.00
Educational attainment level					
Illiteracy	0.06	0.10	0.08	0.11	0.09
Primary	0.29	0.33	0.28	0.35	0.33
Secondary	0.52	0.44	0.51	0.40	0.47
Tertiary	0.13	0.11	0.10	0.12	0.10
Post-tertiary	0.01	0.02	0.03	0.02	0.01
Labour market					
Unknown	0.00	0.01	0.02	0.01	0.00
Active	0.18	0.17	0.22	0.15	0.18
Inactive	0.11	0.14	0.20	0.11	0.16
Retired	0.10	0.15**	0.05	0.23	0.09
Unemployed	0.37	0.34	0.31	0.33	0.37
Black market	0.19	0.13**	0.15	0.11	0.14
Disability	0.05	0.06	0.05	0.06	0.06
Regular intakes					
Cereals and derivatives	4.49	4.32*	4.30	4.24	4.46
Vegetables	4.35	4.19	4.08	4.11	4.36
Fruit	4.43	4.29	4.26	4.21	4.43
Dairy and derivatives	4.54	4.49	4.43	4.40	4.67
Meats, fish and eggs	4.26	4.00***	4.13	3.78	4.27
Legumes	3.47	3.46	3.41	3.49	3.45
Sausages and cold cuts	2.75	2.78	2.86	2.66	2.92
Sweets	2.51	2.52	2.39	2.41	2.76
Soft drinks with sugar	2.25	2.05*	2.11	1.86	2.30
Pre-cooked dishes and home delivery	1.42	1.50	1.37	1.45	1.65
Income provenance					
Income from Red Cross and NGOs	0.49	0.55	0.52	0.52	0.60
Income from Social benefits/services	0.35	0.41**	0.29	0.50	0.34
Income from Family/Neighbourhood aid	0.16	0.12	0.19	0.10	0.11
Income from black market	0.26	0.15***	0.14	0.15	0.15
Income from salary	0.04	0.01	0.02	0.01	0.01
Training experience					
Previous training on feeding	0.33	0.25**	0.32	0.26	0.19
Previous training on home accounts	0.99	0.97*	0.95	0.96	0.99
Previous training on childhood	0.07	0.10*	0.16	0.08	0.08
Food provenance					
Food Social Services	0.15	0.18	0.14	0.24	0.12
Food Red Cross/NGOs	0.91	0.90	0.88	0.86	0.97
Food family/friends	0.13	0.10	0.15	0.09	0.08
Food own income	0.61	0.57	0.43	0.62	0.58

Note: We report average values for age, household size, and the number of ascendants/descendants, while the rest of the measures correspond to proportions.
***, **, * indicate significance at 1 %, 5 % and 10 %, respectively.
Regular intake answers were reversed (lower to higher consumption) and averaged.

$$y_{ijt} = \alpha_0 + \gamma t + \sum_{j=2}^{4} \delta_j I_j + \sum_{j=2}^{4} \mu_j tI_j + z_i'\varphi + \alpha_i + \varepsilon_{ijt} \quad [1]$$

where y is a continuous variable (the nutrition index), individuals are noted by $i = 1, \ldots n$, t = 0 at baseline (before the intervention), $t = 1$ after the intervention, $j = 1, \ldots 4$ is the arm, being j = 1 the control group (no intervention), $j = 2$ for workshop, j = 3 for SMS and j = 4 for economic incentive. I_j is the indicator (dummy) variable = 1 if the intervention group of the individual is j and 0 otherwise. z_i' is a vector of personal time-invariant characteristics. The composite random error $\alpha_i + \varepsilon_{ijt}$ includes a term for unobserved characteristics of the individual, which are assumed to be randomly distributed and independent of ε_{ijt}. The parameters of interest are μ_j (j = 2,3,4). Equation [1] is not directly estimated; instead, we focus on the change in y from the pre-treatment to post-treatment periods. The differenced version, represented by Equation [2], omits the original intercept and any time-invariant regressors, z_i' and I. The dependent variable now is the change in the nutrition index from before to after the intervention.

$$\Delta y_{ij} = \gamma + \sum_{j=2}^{4} \mu_j I_j + \Delta\varepsilon_{ij} \quad [2]$$

We then estimated the effects using OLS, treating changes in the indexes as outcome variables. The list of regressors included indicators for treatment and control groups. To mitigate any potential biases from

randomisation, we controlled for changes in voucher amounts between periods (excluding the voucher from the intervention arm providing an incentive) and baseline characteristics, summarised in Table 1. All statistical analyses were conducted using Stata 18.

3. Results

3.1. Average treatment effect

The changes in the computed indexes (rescaled from 0 to 100) between the pre-and post-treatment periods exhibit sufficient variability at the individual level (see Appendix, Figs. A1, A2, and A3). Specifically, the changes in IASE and HETI are moderately correlated (0.449); IASE and r-HPI show a slightly higher correlation (0.459), while HETI and r-HPI correlated 0.483. The kernel density functions were estimated for the three distributions (see Fig. A4a in the Appendix). We also examine changes in these indices by intervention arm (see Fig. 2). All arms show improvements, with the highest gains generally observed for the IASE index—except in the SMS messages arm, where the greatest increase was seen in the r-HPI index. After controlling for baseline information and other covariates, the regression analysis confirms these positive impacts.

Table 2A presents the average treatment effects (ATE) on the considered indices, with regression results controlling for baseline characteristics. Our findings show that overall, treatment significantly impacted all the indices. We report the overall explanatory power (R2) and compare fitting errors across regressions using the Bayesian Information Criteria (BIC). Our explanatory power is 3.6 % and 3.7 % for the r-HPI and the HETI regressions, whereas for the IASE, the overall explanatory power was 6.7 %. The effect sizes are 0.45, 0.18 and 0.17 standard deviations of the control group in the pre-treatment period, corresponding to increases of 4.76, 2.01 and 3.91 points on the 0–100 scale, representing 9.06 %, 3.29 % and 8.43 % of the average value for the control group at the pre-treatment period. Thus, the intervention has impacted on the nutritional content (IASE), the overall purchases (HETI) and the quality and diversity of purchases made by the treated groups.

We then estimate the average treatment effects (ATEs) while disentangling the results by intervention arm (see Table 2B). Our findings indicate that the positive impact on the IASE (nutritional content) primarily arises from the workshops and SMS messages, with a lesser contribution from cash incentives. The hierarchy of effects is as follows: training, messaging, and cash incentives.

The effective channels for the HETI and r-HPI indices are those that provide information, specifically the workshops and SMS messages. The impact of the workshops is greater than that of the SMS messages compared to the control group for the HETI index. The opposite order was evidenced for the r-HPI. In contrast, the cash incentives show no significant effect on either index related to purchases. Notably, while the SMS messages incur no cost, the training sessions yield a more substantial effect but at a higher expense. On average, each training session costs approximately €50, varying with travel distance, as they are conducted by trained nutritionists already employed by the Red Cross.

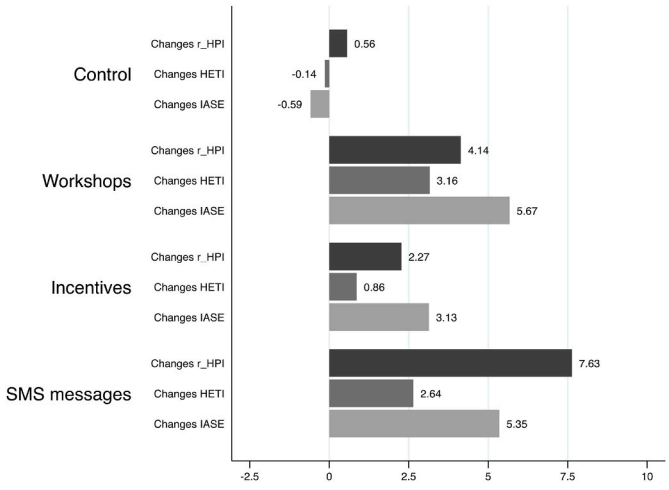

Fig. 2. Pre-post changes in the indexes by arm.

Table 2A
Overall treatment impact: ATE estimates.

	IASE	HETI	r-HPI
Treated	4.764	2.009	3.911
	(0.76)***	(0.64)**	(1.32)**
Average pre-treatment control arm (s.d.)	52.61 (10.59)	61.11 (11.00)	46.37 (22.77)
R2	0.067	0.037	0.036
BIC	9250.42	8890.74	10,639.88
N	1163	1163	1163

Note: ***, **, * indicate significance at 1 %, 5 % and 10 %, respectively. We report coefficients, standard deviation and p-values. Controls for gender, educational attainment levels, labour status, country of origin, household size, living with partners and having descendants, income primary provenance and food provenance, previous training in feeding, home accounts, and childhood; regular intakes, comorbidities and average vouchers' amount for each period.

Table 2B
Treatment's arm impact: ATE estimates.

	IASE	HETI	r-HPI
Workshops	6.570	3.249	4.076
	(0.12)***	(1.05)**	(1.90)**
Incentives	2.623	0.541 (0.75)	0.279 (1.60)
	(0.91)**		
SMS messages	5.742	2.677	7.268
	(0.94)***	(0.79)***	(1.71)***
Average pre-treatment control arm (s.d.)	52.61 (10.59)	61.11 (11.00)	46.37 (22.77)
R2	0.079	0.045	0.050
BIC	9249.08	8894.99	10,637.40
N	1163	1163	1163

Note: ***, **, * indicate significance at 1 %, 5 % and 10 %, respectively. We report coefficients, standard deviation and p-values. Controls for gender, educational attainment levels, labour status, country of origin, household size, living with partners and having descendants, income primary provenance and food provenance, previous training in feeding, home accounts, and childhood; regular intakes, comorbidities and average vouchers' amount for each period.

3.2. Conditional average treatment effects

Following the estimation of the average treatment effect (ATE), the identification of conditional average treatment effects (CATEs) across relevant covariates is of substantial policy interest. Heterogeneity in treatment effects may arise among subpopulations defined by specific characteristics, warranting further investigation. We estimate the CATEs using locally weighted regression conditional on the quantile of the observable variable of interest, as proposed by Robson et al. (2019). This approach allows us to examine treatment effects without stratifying continuous covariates such as age and average voucher amount over the pre-post treatment periods.

Fig. 3A and B displays these results for the IASE since it is the specific one for the Spanish population. Individuals experiencing smaller changes in the value of their vouchers show a greater impact from the intervention than those with larger changes in aid. However, confidence interval analysis reveals no statistically significant differences across quantiles. Accordingly, we do not find evidence of heterogeneous effects across age groups or levels of voucher change.

These findings are supported by a stratification method using the Honest Random Forest algorithm for estimating heterogeneous treatment effects (Athey and Imbens, 2016). This method identifies

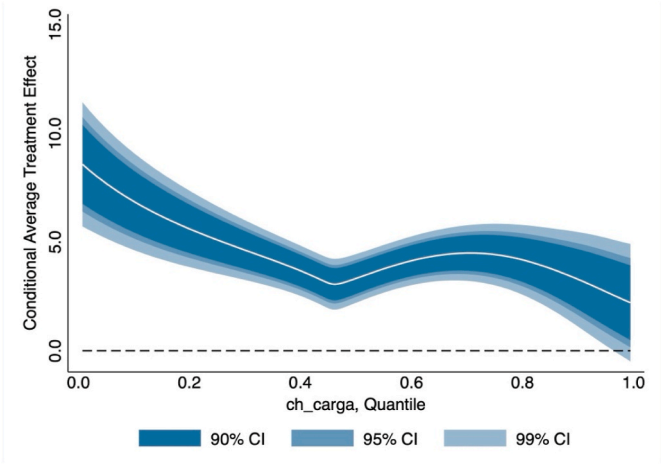

Fig. 3A. CATE: changes in vouchers' amount impact on IASE changes.

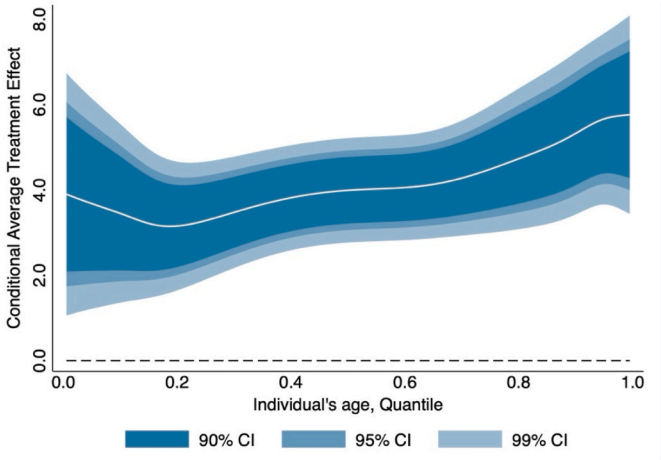

Fig. 3B. CATE: age distribution impact on IASE changes.

subgroups by selecting features and splitting decision trees based on predictor variables that maximise variation in treatment effects. As shown in Fig. A5 (Appendix), participants who experience a decrease in the average value of their vouchers during the treatment period exhibit a treatment effect of 4.2 points on the IASE score, compared to the average treatment effect (ATE) of 2.9 points.

Although variation in CATEs by age is observed, the overlapping confidence intervals suggest these differences are not statistically significant. As a robustness check, we also implement the broader Honest Machine Learning framework, which aims to improve model reliability across machine learning tasks. This approach similarly indicates that individuals under the age of 45 with increasing voucher amounts exhibit the smallest treatment effect (2.9 points).

All analyses using Honest Random Forest and Honest Machine Learning methods are conducted in the R programming language.

3.3. *Sensitivity of results*

We test the sensitivity of our results to excluding consumption in December and January, as these months include the Spanish Christmas holidays (December 23 to January 6), during which consumption patterns differ from the rest of the year. Fewer beneficiaries (837 individuals) were kept in the database since we have excluded a complete month period post-treatment. Our results indicate that the intervention impact is higher when not accounting for these months. The coefficient for the effect of the intervention on changes in IASE increases to 9.06, to 6.32 for the HETI, and 10.24 for the r-HPI, which accounts for the quality of purchases.

As an additional robustness check, we restrict the analysis to the period from June onward to ensure a more balanced distribution of months between the pre- and post-intervention periods. This adjustment results in more comparable distributions across the indexes (see Fig. A4b). The new estimates continue to show significant effects for the workshop and SMS message interventions, but not for incentives. Notably, unlike the earlier analysis, the workshops no longer have a statistically significant effect on the r-HPI.

The estimated impact of the intervention on the IASE index decreases to 3.70 and 3.05, while the coefficients for the HETI index fall to 2.29 and 2.35. The effect of the SMS messages on the r-HPI remains strong, with a coefficient of 5.59. We confirm the robustness of this SMS effect on the r-HPI across all starting points from April onward.

Finally, we examine the number of workshops attended to refine the workshop intervention, since not all participants attended all three sessions. However, this interaction term is not statistically significant, and the results remain unchanged.

4. Discussion & conclusion

This study provides new insights into the effects of different interventions on food purchase quality among vulnerable families in Spain. The findings show that workshops and SMS messages improved the Healthy Feeding Index (IASE), the Healthy Trolley Index (HETI) and, to a lesser extent, the revised Healthy Purchase Index (r-HPI). Our results align with previous research with limited sample sizes (Griffin et al., 2018; Gustafson et al., 2022; Kay et al., 2023), supporting the role of informational interventions and "affective" nudges in promoting healthier purchasing behaviours.

Our evidence also suggests that workshops and behavioural nudges—particularly SMS messages—enhance the nutritional quality of food purchases more effectively than cash incentives alone. This is especially relevant for organisations such as the Red Cross and public health agencies, as it indicates that simple, low-cost educational tools can be more impactful than financial support when aiming for long-term dietary improvement. Although cash assistance provides immediate relief, it appears less effective at promoting lasting changes in food quality. Interventions with an educational or behavioural component should, therefore, be prioritised. Workshops achieved the most notable improvements, albeit with higher costs, while SMS nudges, though less intensive, showed positive and scalable results.

A key question arising from the study is whether the impact of cash incentives could be increased by tailoring them to household needs rather than distributing a flat amount. Proportional support—aligned with food aid already received or specific nutritional needs—may encourage more mindful and nutritious purchases. Future research should examine whether customised financial assistance leads to better dietary outcomes than standardised cash transfers.

Several practical strategies could strengthen similar interventions. Extending the duration of interventions would help assess whether improvements in dietary behaviour persist over time. Moreover, integrating elements of social support, such as cooking groups or peer-based programs, could help participants reinforce what they learn and maintain motivation. Personalising SMS nudges to reflect household preferences or dietary goals may improve engagement and effectiveness.

Another aspect worth considering is the influence of peer interaction in workshops. These sessions provided a social space for participants to share experiences, learn from one another, and support behavioural change collectively. This peer influence may have played a significant role in the observed outcomes. Future research could explore the extent to which group dynamics, social norms, and shared accountability contribute to success in such settings.

While this study offers meaningful contributions, some limitations must be acknowledged. First, the number of participants assigned to

workshops was smaller than in the other study arms due to the logistical difficulty of coordinating multiple in-person sessions. While this ensured intervention fidelity, it may have introduced bias if those who could attend differed systematically from those who could not, for example, in motivation or availability. This should be considered when interpreting the results for this group. Second, its short duration limits the ability to assess long-term sustainability. Additional studies with longer follow-up periods are needed to determine whether changes in purchasing habits are maintained. Third, as participants were Red Cross beneficiaries, their dependence on food aid may have influenced their behaviour. Some may have altered their choices out of concern that it could affect their continued eligibility for support. Future research should include populations not reliant on food aid or compare results across diverse settings to account for this potential bias. Fourth and finally, the study did not fully address wider social and environmental factors that shape food choices, such as access to healthy foods, local pricing, or neighbourhood food environments. These variables can significantly affect purchasing behaviour in low-income populations. Incorporating such factors in future analyses would provide a more comprehensive picture of the drivers of food choice.

In conclusion, this study highlights that educational and behavioural interventions, particularly workshops and SMS messages, can improve the nutritional quality of food purchases among vulnerable families. In contrast, financial incentives appear insufficient when focusing on food quality rather than quantity. For policymakers and service providers aiming to support healthier food choices in low-income communities, a combination of informational strategies and behavioural nudges should be prioritised. Further work is needed to examine these interventions' long-term impact and explore whether tailored cash support based on household needs could strengthen outcomes.

CRediT authorship contribution statement

Toni Mora: Writing – review & editing, Writing – original draft, Visualization, Software, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Eleonora Fichera:** Writing – review & editing, Writing – original draft, Validation, Methodology, Investigation. **Beatriz G. López-Valcárcel:** Validation, Methodology, Investigation, Formal analysis, Conceptualization. **Blanca Raidó-Quintana:** Validation, Supervision, Investigation, Data curation, Conceptualization. **Pedro Rey-Biel:** Writing – review & editing, Writing – original draft, Validation, Supervision, Investigation, Formal analysis.

Ethics statement

The Ethical Review Board approved the study at Universitat Internacional de Catalunya (Spain).

Conflict of interest statement

None.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.socscimed.2025.118315.

Data availability

The data that has been used is confidential.

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