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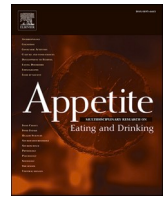
2024

The impact of the cost of living crisis and food insecurity on food purchasing behaviours and food preparation practices in people living with obesity[☆]

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A B S T R A C T

Lower income households are at greater risk of food insecurity and poor diet quality than higher income households. In high-income countries, food insecurity is associated with high levels of obesity, and in the UK specifically, the cost of living crisis (i.e., where the cost of everyday essentials has increased quicker than wages) is likely to have exacerbated existing dietary inequalities. There is currently a lack of understanding of the impact of the current UK cost of living crisis on food purchasing and food preparation practices of people living with obesity (PLWO) and food insecurity, however this knowledge is critical in order to develop effective prevention and treatment approaches to reducing dietary inequalities. Using an online survey (N = 583) of adults residing in England or Scotland with a body mass index (BMI) of ≥30 kg/m², participants self-reported on food insecurity, diet quality, perceived impact of the cost of living crisis, and their responses to this in terms of food purchasing behaviours and food preparation practices. Regression analyses found that participants adversely impacted by the cost of living crisis reported experiencing food insecurity. Additionally, food insecurity was associated with use of specific purchasing behaviours (i.e., use of budgeting, use of supermarket offers) and food preparation practices (i.e., use of energy-saving appliances, use of resourcefulness). Exploratory analyses indicated that participants adversely impacted by the cost of living crisis and who used budgeting had low diet quality, whereas use of meal planning was associated with high diet quality. These findings highlight the fragility of food budgets and the coping strategies used by PLWO and food insecurity during the cost of living crisis. Policy measures and interventions are urgently needed that address the underlying economic factors contributing to food insecurity, to improve access to and affordability of healthier foods for all.

1. Introduction

By 2035 it is predicted that approximately 24% of the global population will be living with obesity, which is almost double the prevalence recorded in 2020 (World Obesity Federation, 2023). In high-income countries, obesity is disproportionately represented in low-income groups, a trend that has become more pronounced over the past 60 years (Bann et al., 2018), and more recently during the COVID-19 pandemic (Brown et al., 2023; Robinson et al., 2021; Storz, 2020). One possible reason for this may be experiences of food insecurity.

Food insecurity refers to the limited or uncertain availability of nutritionally adequate and safe to consume food (FAO and Unicef,

2017). Those who are food insecure are more likely to be living with obesity (Brown et al., 2019), which seems paradoxical given that having limited access to food suggests a reduced amount of food intake, rather than an excess. This association has been related mechanistically to the Resource Scarcity Hypothesis (Dhurandhar, 2016) and the Insurance Hypothesis (Nettle et al., 2017). The Resource Scarcity Hypothesis proposes that overeating and subsequent adiposity are a physiological response to threatened food supplies. Similarly, the Insurance Hypothesis posits that individuals store body fat in anticipation of future shortfalls in food supplies. Additional interpretations of the obesity-food insecurity paradox are related to healthy foods being expensive (e.g., Aggarwal et al., 2011; Darmon & Drewnowski, 2015; Johnstone & Lonnie, 2023) and food insecurity being associated with poor dietary quality (e.g., Keenan et al., 2021; Leung & Tester, 2019; Ranjit et al., 2020). Low expenditure on food is associated with less-healthy food purchasing practices among low-socioeconomic groups (Douglas et al., 2015; Pechey & Monsivais, 2016). In the United Kingdom, adults on low incomes (the poorest fifth of UK households) would need to spend 50% of their disposable income to consume a healthy diet according to government guidelines, whereas the richest fifth would only need to spend 11% (Food Foundation, 2023b). This stark contrast highlights the food-insecure environment that is faced by households with low-incomes that may predispose the consumption of a low-quality diet and increase risk of developing obesity and other diet-related comorbidities.

Since late 2021, many countries have been experiencing a 'cost of living crisis' that is being driven by the rapidly increasing cost of everyday essentials like food and utilities (i.e., inflation), which has not been met with increases to household incomes (Hourston, 2022). Drivers of inflation can include climate change disasters (e.g., draughts and flooding), where extreme weather events and temperature variability can affect crop yields driving the price of goods higher than usual; conflict (e.g., the war in Ukraine) where Russia (a major oil-producing nation) can impact crude oil supply leading to supply disruptions and subsequent price escalation; or being highly reliant on imports such as food (e.g., Brexit), where trade barriers can hamper food imports and so disrupt supply chains. The COVID-19 pandemic has also added to this economic turmoil in many countries by increasing governments' and individuals' debts, as well as the prices of goods before the crisis itself. As a result, in 2022 average prices across the globe rose by 9% (International Monetary Fund, 2022) and in June 2023 in the UK, the cost of food and non-alcoholic beverages rose to 17.4% (Gooding, 2023).

High inflation rates have directly impacted the affordability of food, both directly through food price rises and indirectly through constrained budgets due to increasing utilities, housing and services costs. These cost of living pressures are leading to rises in food insecurity (i.e., having limited or uncertain availability of nutritionally adequate and safe to consume food). In the UK, the Food Standards Agency's Food and You 2 most recent survey reported that 25% of households were experiencing food insecurity (Armstrong et al., 2023), which is the highest prevalence recorded since the survey began in late 2020 where only 16% of households were experiencing food insecurity (Armstrong et al., 2021). Like obesity, the cost of living crisis has disproportionately impacted households with low-incomes who may be less resilient to sudden price increases. The current economic crisis is thereby amplifying existing challenges faced by those from poorer households and likely widening inequalities (Johnstone & Lonnie, 2023). As food is seen as a variable cost, it is likely that food quality and variety may be compromised as a means of survival (Puddephatt et al., 2020; Williams & Dienes, 2022). The consequences of low diet quality are well documented, particularly as being one of the primary risk factors for non-communicable diseases (Hyseni et al., 2017). The cost of living crisis may not only contribute to increased experiences of food insecurity, but may also perpetuate high levels of obesity producing more diet and health inequalities for those living with obesity (Robinson, 2023).

Given the challenges posed by the cost of living crisis, households

with low-incomes have responded by using 'coping strategies' to mitigate experiences of food insecurity, specifically, the ways in which households purchase and prepare food (Douglas, 2023; Eicher-Miller et al., 2023; Johnstone & Lonnie, 2023). In relation to food purchasing behaviours, Ditlevsen et al. (2023) reported that households with low-incomes often engage in bulk purchasing to benefit from bulk-buy discounting, and Adams (2023) reported that women experiencing food insecurity made use of 'bargain bins' and coupons to maximize their purchasing power. However, in the UK, the food that is on promotion has recently been flagged for its tendency to be high in fat, sugar and salt (HFSS), which has been found to contribute to excess food intake (Watt et al., 2023). Households with low-incomes also report engaging in financial budgeting as this allows households to manage limited resources effectively (Douglas, 2023; Power et al., 2018). However, given the higher cost of healthier food (relative to less healthy food), the 'healthiness' of food may be deprioritised (Puddephatt et al., 2020; Robinson et al., 2022). In relation to food preparation practices, households with low-incomes typically use batch cooking (Williams & Dienes, 2022), meal planning (Power et al., 2018), pad out meals with starchy foods (Ditlevsen et al., 2023), and use energy-saving appliances such as air fryers (Nayak & Hartwell, 2023). Taken together, although the aforementioned purchasing and food preparation practices are highly adaptive and likely to be beneficial in the immediate (i.e., to escape hunger when living with a low income), prolonged use of these strategies may negatively impact health in relation to diet quality and variety (Seligman & Berkowitz, 2019; Tarasuk, 2001).

There is a lack of understanding of the magnitude and impact of the current cost of living crisis on food purchasing behaviours and food preparation practices of PLWO and food insecurity. Better evidence is critical to highlight and inform the development of policy measures and interventions aimed at supporting this group make healthy food choices. The aim of the current study was therefore to quantify in a sample of PLWO, the perceived impact of the cost of living crisis on food insecurity, and whether food insecurity in turn is associated with the use of food purchasing behaviours and food preparation practices. It was hypothesised that (1) those adversely impacted by the cost of living crisis will be more likely to experience food insecurity, and (2) food insecurity will be associated with use of cost-effective cooking practices and purchasing behaviours.

2. Methods

2.1. Participants

The inclusion criteria were participants aged between 18 and 65-years old, who resided in England or Scotland, were the primary grocery shopper, and had a BMI of over 30 kg/m^2. Participants were recruited between February 2023 and May 2023, predominantly using the participant recruitment website, Prolific (www.prolific.com) (approximately 98% of the sample). Participants were also recruited using advertisements on social media (Twitter, now known as X) and paid advertisements on Facebook. Advertisements on Facebook were targeted to individuals between the ages of 18 and 65-years who had 'liked' Facebook pages that were related to weight management (e.g., WeightWatchers) or food insecurity (e.g., budget cooking). Participants who completed the study through Prolific were reimbursed for their time. Participants who completed the study through social media could anonymously enter into a prize drawer to win Amazon vouchers (1 × £100, 1 × £50, 1 × £25). Ethical approval was obtained from the University of Liverpool Research Ethics Committee, Ethics number 12027.

A total of 654 participants completed the survey. Data were excluded from analyses for participants who were not the primary grocery shopper (n = 10), did not have a BMI ≥30 kg/m^2 (n = 44), who failed to correctly respond to ≥ 3 attention checks (n = 2), who answered 'prefer not to say' to whether their daily functioning was affected (n = 5) or their ethnicity (n = 1). A minority of participants (n = 9) reported that

they were third-gender/non-binary and these participants were removed from data analysis because the small sample size could lead to this subgroup having a disproportionally large effect on other regression coefficients. As this study is part of a wider study using structural equation modelling to explore the barriers to purchasing healthy and sustainable food (Stone et al., 2023), *a priori* sample size calculations indicated that a minimum of 500 participants were needed for adequate power (≥80%, α = 0.05; https://doi.org/10.17605/OSF.IO/BYZKP). The analytical sample size was 583 participants (89% of original sample).

2.2. Procedure

This study operated as a cross-sectional online questionnaire study hosted on Qualtrics. All participants were asked to read the Participant Information Sheet prior to providing informed consent electronically and completed a series of screening questions to ensure they met the eligibility criteria. All participants then completed a series of questions about demographics, food insecurity, diet quality, the impact of the cost of living crisis, and the use of food purchasing behaviours and food preparation practices in response to the cost of living crisis. The survey took approximately 30-min to complete.

2.3. Measures

Measures are outlined in the order that they were displayed to the participant. Within each section, items were presented in a randomised order to eliminate order bias. Built into these questions (excluding the demographic questionnaire) were attention checks such as "*It is important that I pay attention. Please select 'Strongly Agree'*". Participants who made three or more errors on the attention checks were excluded. For participants who took part via social media, a reCAPTCHA was used at the start of the study to protect against bots and malicious programs. A reCAPTCHA was not necessary for those who took part using Prolific. Despite recruiting from Prolific using our inclusion criteria, a set of parallel screening questions were used during the survey to ensure participants met the eligibility criteria.

2.3.1. Demographic questions

Participants self-reported their age (in years), the country they resided in, their height (in feet/inches or in centimetres) and weight (in kilograms or in stones/pounds). Participants' height and weight were used to compute BMI. Participants also reported their gender (three-point scale: 1 = male, 2 = female 3 = third-gender/non-binary). Gender was recoded into a binary variable: 0 = female, 1 = male, with those third-gender/non-binary removed (n = 9). Ethnicity was recorded following the UK Governments list of ethnicities (15-point scale: 1 = White British, 2 = White Irish, 3 = Other White background, 4 = Black – Caribbean, 5 = Black – African, 6 = Other Black background, 7 = Asian – Indian, 8 = Asian – Pakistani, 9 = Other Asian background, 10 = Mixed – White and Black Caribbean, 11 = Mixed – White and Black African, 12 = Other Mixed background, 13 = Chinese, 14 = Any other ethnicity not listed, 15 = Prefer not to say). Ethnicity was recorded into a binary variable: 0 = Black, Asian, and Minority Ethnic (BAME), 1 = White, with those reporting 'prefer not to say' excluded (n = 1). Participants also indicated the number of adults and children under 18-years in household (summed to give household size) and their highest level of education (six-point scale: 1 = No formal qualification, 2 = Secondary School, 3 = College/Sixth Form, 4 = Apprenticeship, 5 = Undergraduate Degree, 6 = Postgraduate Degree). Education was recoded into a binary variable: 0 = no degree, 1 = degree level. Furthermore, participants were asked to indicate their household income using a nine-point scale: 1 = < £5,200, 2 = £5200 to £10,399, 3 = £10,400 to £15,599, 4 = £15,600 to £20,799, 5 = £20,800 to £25,999, 6 = £26,000 to £36,399, 7 = £36,400 to £51,999, 8 = £52,000 to £77,999, 9 = ≥ £78,000). Participant's daily functioning was recorded by assessing how

limited it was, from limited to not limited (So et al., 2003), with those reporting 'prefer not to say' excluded (n = 5). Participants were asked to select their dietary preference from a list of: Omnivore (eats meat or fish), Vegetarian (eats no meat or fish), Pescatarian (does not eat meat but does eat fish), Vegan (eats no food/drink derived from animals), or Flexitarian (mainly vegetarian but occasionally eats meat) to assess whether dietary preference acted as a covariate for diet quality, as vegetarian diets have been shown to have higher diet quality than non-vegetarians (Parker & Vadiveloo, 2019). Lastly, participants were asked 1) which supermarket they primarily used to purchase groceries, 2) the method used to purchase foods either in-store, or online, and 3) who they did the grocery shopping with (using a six-point scale: 1 = Alone, 2 = Spouse/partner, 3 = Children, 4 = Other relative(s), 5 = Friend(s), 6 = Carer(s)).

2.3.2. Household food insecurity

Household food insecurity was assessed using the United States Department of Agriculture Household Food Security Survey Module (10-item; USDA-10) (USDA, 2012). This scale asked questions about food accessibility to assess food security score; for example, "*in the last 12 months, were you ever hungry but didn't eat because there wasn't enough money for food?*" with Likert response options of "*Yes*", "*No*" and "*Do Not Know*". Responses of '*Yes*', '*Often*', '*Sometimes*', '*Almost every month*', and '*Some months but not every month*' were coded as affirmative (i.e., given a score of 1). The sum of affirmative responses to the 10 questions were used to indicate the participant's raw food insecurity score. Higher scores on the USDA-10 were indicative of greater food insecurity (possible range: 0–10). McDonald's Omega for the current study was excellent at $\omega_T = 0.95$.

2.3.3. Diet quality

A validated 20-item food frequency questionnaire was used to assess diet quality (Robinson et al., 2017). This measure positively correlates with nutrient intake and results are comparable to a longer 129 item scale (Bingham et al., 1994). Participants were asked to think about the last three months and rate on a 10-item Likert scale their average consumption of 19 foods (1 = never, 2 = less than once/month, 3 = 1-3- per month, 4 = once a week, 5 = 2–4 per week, 6 = 5–6 per week, 7 = once a day, 8 = 2–3 per day, 9 = 4–5 per day, 10 = 6+ per day). The included foods were: white bread, brown and wholemeal bread, biscuits, apples, bananas, melon, pineapple, kiwi and other tropical fruits, green salad, garlic, marrow and courgettes, peppers, yoghurt, eggs, white fish, oily fish, bacon and gammon, meat pies, potatoes (boiled, mashed, and jacket), chips, pasta.

To estimate diet quality, several steps were conducted (1) recoding frequencies as times per week (2) standardising scores by subtracting the means and dividing by the standard deviations for each food item (3) multiplying each score by coefficients identified in Robinson et al. (2017), and (4) summing all scores for each participant. Scores of zero were indicative of a diet that conformed to healthy eating guidelines (i.e., high in fruit and vegetables and low in processed foods). Higher scores (≥0) were indicative of a diet that conformed more strongly to typical healthy eating recommendations. Scores below zero were indicative of a diet that did not conform to healthy eating guidelines. Use of this variable was not planned in the pre-registration for the analyses and was therefore included for exploratory analysis only.

2.3.4. Impact of the cost of living crisis

The impact of the cost of living crisis was assessed with five items taken from UK supermarket Sainsbury's cost of living survey (J Sainsbury PLC, 2022). These items were selected based on their relevance to assessing the impact of the cost of living crisis as no existing validated tools exist. Participants were asked to indicate how much they agreed or disagreed with each item using a five-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree): (1) My income allows me to save for the future (reverse coded), (2) I am going into debt to pay for everyday

essentials, (3) I am unable to pay for all of my bills, (4) I have cut my spending on everyday essentials, (5) I have cut my spending in other areas to be able to afford the everyday essentials. McDonald's Omega for question set used in the current study was excellent at $\omega_T = 0.85$.

2.3.5. Cost of living – food purchasing behaviours

To assess the use of food purchasing behaviours in response to the cost of living crisis, a 10-item existing questionnaire was used, also taken from Sainsbury's cost of living survey (J Sainsbury PLC, 2022), as this question set assessed whether particular food purchasing behaviours had been used in response to the cost of living crisis as no existing validated tools exist. Participants were asked to think about the last three months and to indicate how much they agreed or disagreed with 10 statements using a five-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree): (1) Cut back on the quantity of food to afford other essentials (e.g., energy bills), (2) Cut back on the quality of food to afford other essentials (e.g., energy bills), (3) Shop around supermarkets for the best deals, (4) Bought more own-brand food and drink, (5) Stuck to a strict budget when buying food and drink, (6) I have changed the days of the week/time of day I shop in order to get the best deals/prices, (7) Been to the supermarket less because I can't afford to travel there (either fuel or public transport, (8) Cut back on healthy food to afford other essentials (e.g., energy bills) (9) Bought smaller amounts of dried goods (e.g., pasta, lentils), so I only buy what I need, (10) Bought more discounted/'yellow sticker' food and drink. McDonald's Omega for the question set used in current study was excellent at $\omega_T = 0.86$.

2.3.6. Cost of living - food preparation practices

To assess use of food preparation practices in relation to the cost of living crisis, a nine-item existing questionnaire was used, also taken from the supermarket Sainsbury's cost of living survey (J Sainsbury PLC, 2022), as this question set assessed what food preparation practices might have been utilised in response to the cost of living crisis as no existing validated tools exist. Participants were asked to think about the last three months and indicate how much they agree or disagree with the following nine statements using a 5-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree) (1) Used appliances (e.g. oven, hob etc.): less for cooking to save money on energy bills, (2) Used appliances such as air-fryers more to save money on energy bills, (3) Ate cold meals or ones that don't need to be cooked to save money on energy bills, (4) Cooked meals from scratch, (5) Reduced the amount of food that I waste, (6) Padded out meals with more filling foods e.g. pasta, potatoes, (7) Plan all meals for the week in advance, (8) Batch cooked meals for the week in advance, (9) Eaten more vegetarian meals/meals without meat. McDonald's Omega for the question set used in the current study was acceptable at $\omega_T = 0.69$.

2.4. Data analysis

Hypotheses and the analytic plan were pre-registered on Open Science Framework (https://doi.org/10.17605/OSF.IO/BYZKP). IBM SPSS Statistics 28 (IBM Corp, 2021) was used for all data analyses.

2.4.1. Principal component analysis (PCA)

Principal component analysis (PCA) with oblimin rotation was used as we expected components to be correlated. A PCA was used to reduce down the complex number of items into main themes, whilst retaining the same information relating to the measures of impact of the cost of living crisis, purchasing behaviours and food preparation practices, in order to create composite variables for each. Eigenvalues of ≥ 1.0 were deemed acceptable for extraction. Pattern matrixes were inspected for components with Eigenvalues of ≥ 1.0 and loadings of ≥ 0.5 were deemed strong enough for component loading. The first PCA indicated that only one component existed for the impact of the cost of living crisis measure (comprised of five individual items) explaining 63.63% of variance. This composite variable was named 'impact of cost of living

crisis' where higher scores indicated being more adversely impacted by the cost of living crisis. The second PCA on food purchasing behaviours indicated that there were two components which were labelled as follows; 1 = use of budgeting (45.50% variance explained), 2 = use of supermarket offers (11.56% variance explained). The third PCA on food preparation practices indicated that there were three components labelled as follows; 1 = use of energy-saving appliances (31.73% variance explained), 2 = use of meal planning (18.13% variance explained), 3 = cooking resourcefully (10.70% variance explained). Reliability analyses were also conducted using McDonald's Omega (ω_T) on the six components identified by the PCA to assess for scale reliability. See Supplementary Materials for full results, and Fig. 1 for a visual summary of PCA results.

2.4.2. Normality and covariates

Preliminary analyses assessed the distribution of outcome variables (food insecurity, and the six components from the PCA: impact of cost of living, budgeting, supermarket offers, energy-saving appliances, meal planning, and resourcefulness). Kolmogorov Smirnov tests indicated that outcome variables were skewed (data not shown, $p > .05$). As a result, Spearman's Rho correlations and Mann-Whitney U tests were used to assess for the presence of covariates. Spearman's Rho correlations showed that age was significantly and negatively correlated with food insecurity ($r_s = -0.256$, $p < .001$) and budgeting ($r_s = -0.148$, $p < .001$). Mann-Whitney U tests showed that there was a significant difference in food insecurity ($U = 34,112$, $p < .001$), budgeting ($U = 32,571$, $p < .001$), and energy-saving appliances ($U = 34,136$, $p < .001$) depending on level of daily functioning, where scores were higher if daily functioning was limited. There was a significant difference in use of meal planning ($U = 32,598$, $p = .043$) and resourcefulness ($U = 31,529$, $p = .009$) depending on online shopper status, where scores were higher for those were online shoppers. There was also a significant difference in use of energy-saving appliances ($U = 18085.50$, $p = .018$) depending on ethnicity, where scores were higher for those who identified as White. There was a significant difference in use of budgeting ($U = 33,424$, $p = .002$), energy-saving appliances ($U = 31,723$, $p < .001$), meal planning ($U = 34251.50$, $p = .007$), and resourcefulness ($U = 31,098$, $p < .001$) depending on gender, where scores were higher for those who were female. No other demographic variables were significantly associated with outcome variables. For each outcome variable, we selected significant covariates to be controlled for in subsequent analyses.

2.4.3. Regression analyses

For the main data analysis, a series of regressions were used to predict food insecurity and to predict each component that was generated from the PCA (budgeting, supermarket offers, energy-saving appliances, meal planning, and resourcefulness). Linear regression assumptions were assessed and no assumptions were violated. First, a hierarchical multiple regression using the 'enter' method was used to determine whether being more impacted by the cost of living crisis (component variable generated by PCA) predicted food insecurity whilst controlling for age and daily functioning (regression model 1: impact of cost of living → food insecurity). Second, a hierarchical multiple regression using the 'enter' method was used to explore whether experiences of food insecurity predicted using budgeting in response to the cost of living crisis whilst controlling for age, daily functioning, and gender (regression model 2: food insecurity → budgeting). Third, a linear regression was used to explore whether experiences of food insecurity predicted using supermarket offers in response to the cost of living crisis (regression model 3: food insecurity → supermarket offers). Fourth, a hierarchical multiple regression using the 'enter' method was used to explore whether experiences of food insecurity predicted cooking using energy-saving appliances in response to the cost of living crisis whilst controlling for ethnicity, daily functioning, and gender (regression model 4: food insecurity → energy-saving appliances). Fifth, a

Impact

Impact of Cost of Living Crisis
- My income allows me to save for the future
- I am going into debt to pay for everyday essentials
- I am unable to pay for all of my bills
- I have cut my spending on everyday essentials
- I have cut my spending in other areas to be able to afford every day essentials

Food Purchasing Behaviours

Budgeting
- Cut back on the quantity of food to afford other essentials (e.g., energy bills)
- Cut back on healthy food to afford other essentials
- Cut back on the quality of food to afford other essentials
- Been to the supermarket less because I can't afford to travel there (either fuel or public transport)
- Bought smaller amounts of dried goods (e.g., pasta, lentils) so I only buy what I need
- Stuck to a strict budget when buying food and drink

Supermarket Offers
- Shop around supermarkets for the best deals
- Bought more discounted / 'yellow sticker' food and drink
- Bought more own-brand food and drink
- I have changed the days of the week/time of day I shop in order to get the best deals/prices

Food Preparation Practices

Energy-Saving Appliances
- Used appliances (e.g., oven, hob etc) less for cooking to save money on energy bills
- Used appliances such as air fryers more to save money on energy bills
- Ate cold meals or ones that don't need to be cooked to save money on energy bills

Meal Planning
- Batch cooked meals for the week in advance
- Plan all meals for the week in advance
- Cooked meals from scratch

Resourcefulness
- Reduced the amount of food that I wasted
- Padded out meals with more filling foods e.g., pasta, potatoes
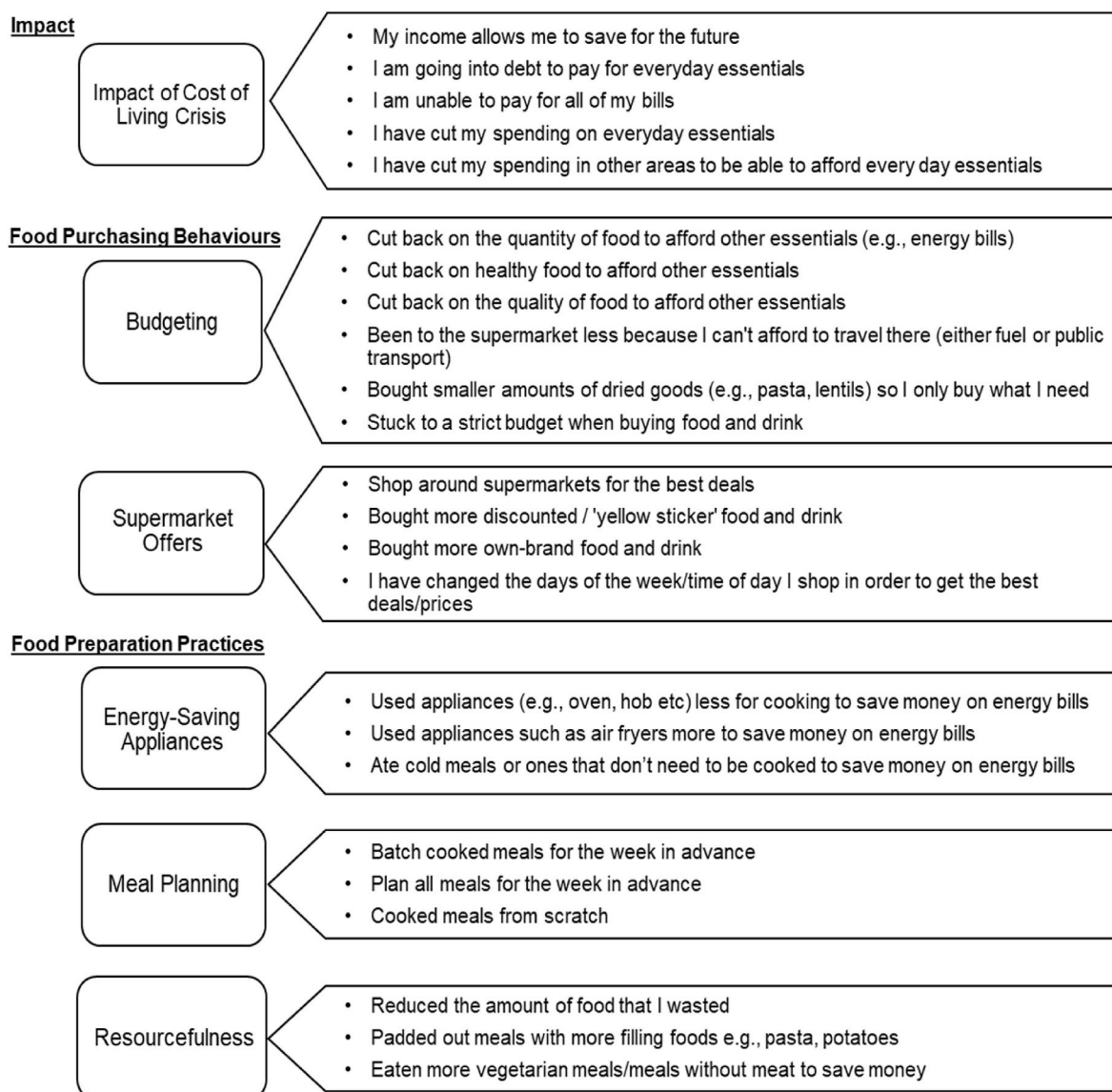- Eaten more vegetarian meals/meals without meat to save money

Fig. 1. Schematic representation of the Principle Component Analysis on survey items relating to the impact of cost of living crisis, food purchasing behaviours, and food preparation practices. The identified components for each measure are indicated by rectangular boxes, with the individual items that loaded onto each component also shown.

hierarchical multiple regression using the 'enter' method was used to explore whether experiences of food insecurity predicted using meal planning in response to the cost of living crisis whilst controlling for online shopper status and gender (regression model 5: food insecurity → meal planning). Finally, a hierarchical multiple regression using the 'enter' model was used to explore whether experiences of food insecurity predicted cooking resourcefully in response to the cost of living crisis whilst controlling for online shopper status and gender (regression model 6: food insecurity → resourcefulness).

2.4.4. Sensitivity analysis

A sensitivity analysis was run where primary regression analyses were re-examined with participants who were identified as extreme outliers on measures of diet quality using boxplots were removed (n = 15). Extreme outliers are data points that are more extreme than Q1 - 3 * interquartile range (IQR) or Q3 + 3 * IQR.

2.4.5. Exploratory analyses

The current study was pre-registered on the Open Science Framework (https://doi.org/10.17605/OSF.IO/BYZKP). Additional,

unplanned, hierarchical regression analyses were carried out as exploratory analyses to explore how cost of living impact scores were associated with diet quality, and the association between purchasing behaviours and food preparation practices with diet quality scores. As in Section 2.4.2., covariates were identified by using Spearman's Rho correlations and a series of Mann-Whitney U tests with diet quality (outcome variable). From these analyses, there was a significant difference in diet quality scores depending on gender, where scores were higher for females ($U = 29{,}551$, $p < .001$), and ethnicity, where scores were higher for those who identified as BAME ($U = 11{,}412$, $p = .002$). No other demographic variables were significantly associated with diet quality and consequently gender and ethnicity were controlled for in subsequent analyses that used diet quality as the outcome variable. Hierarchical regression analyses were run, and assumption checks indicated that none were violated. Using hierarchical regression, regression model 7 explored whether cost of living impact scores predicted diet quality whilst controlling for gender and ethnicity (regression model 7: cost of living impact → diet quality). Using multiple hierarchical regression, regression model 8 explored whether use of budgeting, supermarket offers, energy-saving appliances, meal

planning, and resourcefulness predicted diet quality whilst controlling for gender and ethnicity (regression model 8: food purchasing behaviours and food preparation practices → diet quality).

3. Results

3.1. Sample characteristics

Descriptive statistics of the sample characteristics are presented in Table 1. In the sample, 63.1% were female and 36.90% were male with a mean age of 40.3 years, and a mean BMI of 37.92 kg/m². Food insecurity scores indicated that 37.4% of the sample were experiencing food insecurity, which is higher than the UK average of 6–10% (Brown et al., 2023). Participants had a mean diet quality score of 0.23, which was indicative of a healthy diet (Robinson et al., 2017). Most participants resided in England (90.1%; n = 524), and described their ethnicity as White (90.1%). For education, 49.3% were educated to degree level. For annual household income, 44.3% reported an annual household income of ≤ £26,000. For health conditions, 41.5% had a health condition that limited their daily function. The majority of adults were omnivores (79.2%), who were mostly in-store shoppers (69%), with a mean household size of 3.7, and who primarily shopped alone (34.5%) or with a spouse/partner (23.3%).

3.2. Regression analyses

Fig. 2 provides a visual overview of the collective results from the eight regression analyses.

3.2.1. The association between impact of the cost of living crisis and food insecurity scores

The first step in this regression model consisted of age and daily functioning, the impact of the cost of living crisis was then added as a second step (Table 2). The overall regression model predicted 41% of variance in food insecurity scores ($R^2 = 0.41$, $F(3, 579) = 136.53$, $p < .001$). Age and daily functioning predicted approximately 9% of variance in food insecurity scores, but only age was a significant predictor with higher food insecurity in younger participants. After controlling for age and daily functioning, step two predicted approximately 33% of variance in food insecurity, with cost of living impact scores being positively associated with food insecurity scores, which is consistent with our hypothesis.

3.2.2. Experiences of food insecurity and the use of food purchasing behaviours and food preparation practices in relation to the cost of living crisis

A further four hierarchical multiple regression analyses were used to analyse the association between experiencing food insecurity and the use of budgeting, energy saving appliances, meal planning, and resourcefulness in relation to the cost of living crisis (Table 2). In the absence of any covariates, a linear regression was used to analyse the association between experiencing food insecurity and the use of supermarket offers in relation to the cost of living crisis (regression model 3, not presented in Table 3).

3.2.2.1. Food purchasing behaviours in relation to the cost of living crisis.
In regression model 2, predicting *use of budgeting*, the first step of the regression consisted of age, daily functioning, and gender, and food insecurity was added as a second step. The overall regression model predicted 44% of variance in budgeting ($R^2 = 0.44$, $F(4, 578) = 112.40$, $p < .001$). Age, daily functioning, and gender predicted approximately 8% of variance in budgeting, although only daily functioning and gender were significant predictor of budgeting, where there was higher use of budgeting for those who had limited daily functioning due to a medical problem, and who were female. After controlling for age, daily

Table 1
Means ($\pm SD$) of participant characteristics, food insecurity and the impact of the cost of living crisis (N = 583).

Measure	Mean ± SD	Min	Max
Age (years)	40.25 ± 11.66	19	65
BMI	37.92 ± 6.85	29.56	83.25
Household size	3.72 ± 1.39	2	10
Food insecurity (USDA-10[a])	2.43 ± 2.80	0	10
Diet quality score[b]	0.23 ± 1.15	−4.52	7.42

Measure	n (%)
Ethnicity:	
White:	
English/Welsh/Scottish/Northern-Irish/British	499 (85.6)
Irish	6 (1.0)
Other White background	20 (3.4)
Black:	
Caribbean	7 (1.2)
African	16 (2.7)
Mixed or Multiple ethnic groups:	
White and Black Caribbean	9 (1.5)
White and Black African	1 (0.2)
Other Mixed background	1 (0.2)
Asian or Asian British:	
Indian	5 (0.9)
Pakistani	10 (1.7)
Chinese	1 (0.2)
Other Asian background	8 (1.4)
Education:	
No formal qualification	8 (1.4)
High School	98 (16.8)
College/Sixth Form	160 (27.4)
Apprenticeship	30 (5.1)
Undergraduate Degree	191 (32.8)
Postgraduate Degree	96 (16.5)
Dietary preference:	
Omnivore (eats meat or fish)	462 (79.2)
Vegetarian (eats no fish or meat)	28 (4.8)
Pescatarian (does not eat meat but does eat fish)	15 (2.6)
Vegan (eats no food/drink derived from animals)	11 (1.9)
Flexitarian (mainly vegetarian but occasionally eats meat)	35 (6.0)
None of these	32 (5.5)
Gender:	
Female	368 (63.1)
Male	215 (36.9)
Country:	
England	525 (90.1)
Scotland	58 (9.9)
Daily functioning:	
Limited	240 (41.2)
Not limited	343 (58.8)
Household income per annum:	
< £5200	23 (3.9)
£5200 to £10,399	60 (10.3)
£10,400 to £15,599	90 (15.4)
£15,600 to £20,799	85 (14.6)
£20,800 to £25,999	73 (12.5)
£26,000 to £36,399	72 (12.3)
£36,400 to £51,999	79 (13.6)
£52,000 to £77,999	61 (10.5)
≥ £78,000	40 (6.9)
Primary supermarket:	
Aldi	135 (23.2)
Asda	105 (18.0)
Co-Op (The Co-Operative)	12 (2.1)
Lidl	56 (9.6)
M&S (Marks and Spencer)	5 (0.9)
Morrisons	51 (8.7)
Ocado	8 (1.4)
Sainsburys	52 (8.9)
Tesco	141 (24.2)
Waitrose	5 (0.9)
Iceland	10 (1.7)
Getir[c]	1 (0.2)
Heron Foods	1 (0.2)
Abel & Cole	1 (0.2)
Online shopper:	

(continued on next page)

Table 1 (*continued*)

Measure	n (%)
Yes	181 (31.0)
No	402 (69.0)
Shopping companion:	
Alone	201 (34.5)
Spouse/partner	136 (23.3)
Children	34 (5.8)
Other relative(s)	26 (4.5)
Friend(s)	2 (0.3)
Carer(s)	3 (0.5)

Note. [a] = food insecurity measure. [b] = positive scores (those above zero) reflect a healthy diet quality, with higher scores being indicative of a healthier diet. Negative scores (those below zero) reflect a lower diet quality, with lower scores being indicative of a less healthy diet (Robinson et al., 2017). [c] online grocery delivery using an app.

functioning, and gender, step two predicted approximately 36% of variance in budgeting, with food insecurity scores being positively associated with use of budgeting.

In regression model 3, predicting *use of supermarket offers*, the regression model predicted approximately 13% of variance in use of supermarket offers (Adjusted $R^2 = 0.13$, $F(1,581) = 85.97$, $p < .001$). Specifically, there was a positive association between food insecurity scores and use of supermarket offers (B = 0.11, $p < .001$, 95% CI [0.09, 0.12]).

3.2.2.2. Food preparation practices in relation to the cost of living crisis. In regression model 4, predicting *use of energy-saving appliances*, the first step of the regression consisted of daily functioning, gender, and ethnicity, and food insecurity was added as a second step. The overall regression model predicted 15% variance in use of energy-saving

appliances ($R^2 = 0.15$, $F(4, 578) = 25.36$, $p < .001$). Daily functioning, gender, and ethnicity predicted approximately 6% of variance in use of energy-saving appliances, where there was higher use of energy-saving appliances in those who had limited daily functioning due to a medical problem, were female, and who identified as White. After controlling for daily functioning, gender, and ethnicity, step two predicted approximately 9% of variance in use of energy-saving appliances, with food insecurity scores being positively associated with use of energy-saving appliances.

In regression model 5, predicting *use of meal planning*, the first step of the regression consisted of online shopper status and gender, and food insecurity was added as a second step. The overall regression model predicted 2% variance in use of meal planning ($R^2 = 0.02$, $F(3, 579) = 3.69$, $p = .012$). Only gender was a significant predictor of meal planning, where there was higher use of meal planning for those who were female. After controlling for online shopper status and gender, step two predicted approximately 0% of variance in use of meal planning, with food insecurity scores not being associated with use of meal planning in relation to the cost of living crisis.

In regression model 6, predicting *cooking resourcefully*, the first step of the regression consisted of online shopper status and gender, and food insecurity was added as a second step. The overall regression model predicted 10% variance in cooking resourcefully ($R^2 = 0.10$, $F(3, 579) = 20.98$, $p < .001$). Online shopper status and gender predicted approximately 4% of variance in cooking resourcefully, although only gender was a significant predictor of cooking resourcefully where higher resourceful cooking was reported in those who were female. After controlling for online shopper status and gender, step two predicted approximately 6% of variance in cooking resourcefully, with food insecurity scores being positively associated with resourceful cooking in relation to the cost of living crisis.
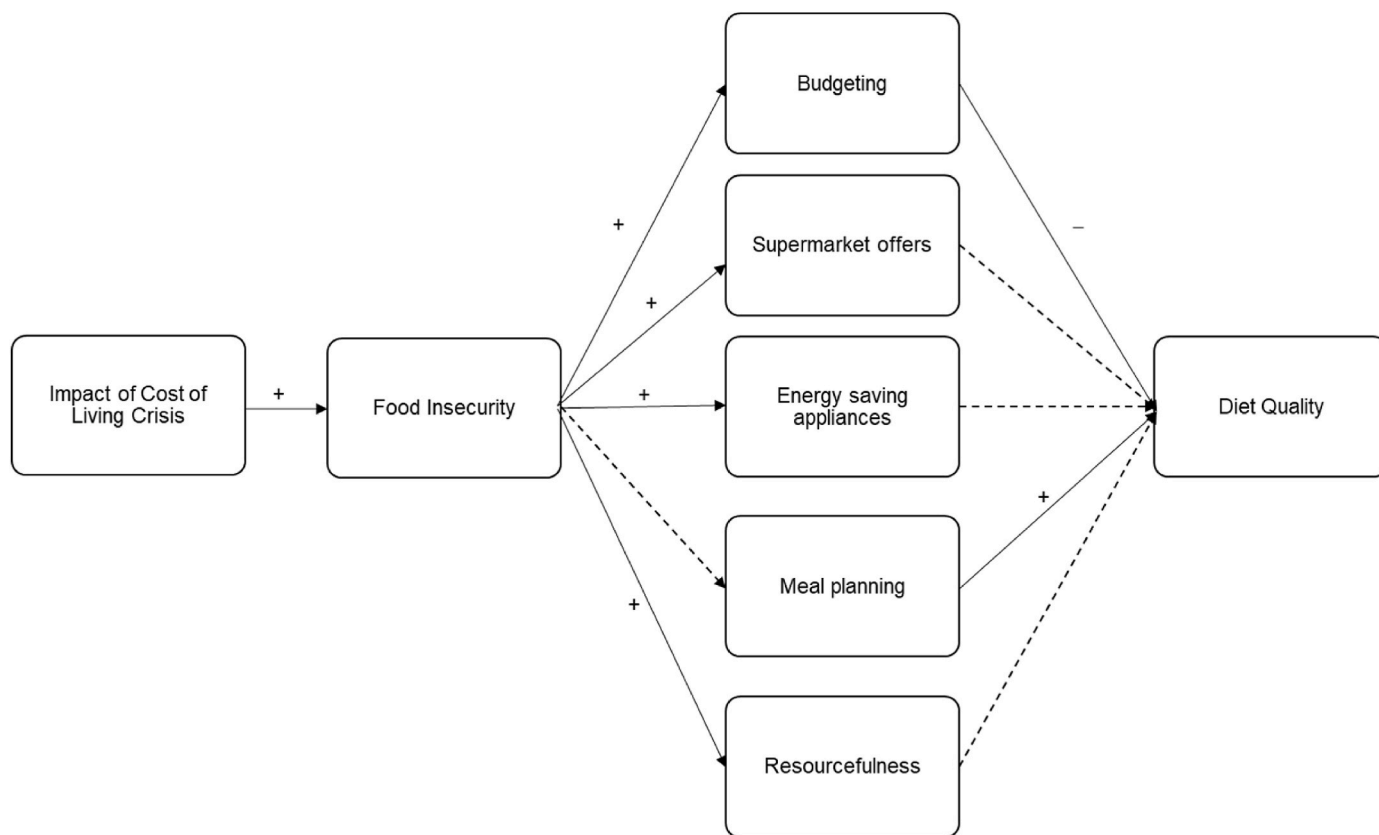

Fig. 2. Schematic representation of the results of the regression analyses. Significant associations are denoted with a solid arrow, and non-significant associations are denoted with a dashed arrow. Directionality is reflected using '+' for positive associations and '−' for negative associations. Associations with diet quality are exploratory.

Table 2

Hierarchical multiple regression analyses showing age, daily functioning, and the impact of the cost of living crisis as predictors of food insecurity.

Variable	Cumulative		Simultaneous		
	R^2-change	*F*-change	B	*p*	*95% CI*
Food insecurity (1)					
Step 1					
Age	0.09	F(2, 580) = 27.71, *p* < .001	−0.04	<.001	[−0.05, −0.02]
Limited daily functioning [yes/no]			−0.25	.189	−0.62, 0.12]
Step 2					
Impact of cost of living crisis	0.33	F(1, 579) = 323.36, *p* < .001	1.73	<.001	[1.54, 1.91]

Note. B = unstandardised regression coefficient. *(1) = regression model 1.* 95% CI = 95% confidence intervals.

3.3. Sensitivity analysis

A sensitivity analysis was conducted where primary regression analyses were re-run with extreme outliers on measures of diet quality removed. The pattern of results were consistent whereby: 1) there was a positive association between cost of living crisis impact scores and food insecurity, 2) a positive association between food insecurity and use of budgeting, supermarket offers, use of energy-saving appliances, and resourcefulness, and 3) no association between food insecurity and use of meal planning. Please see Supplementary Materials for detailed results.

3.4. Exploratory analyses

3.4.1. The association between impact of the cost of living crisis and diet quality scores

In regression model 7, predicting diet quality, the first step of the regression consisted of gender and ethnicity, and cost of living impact score was added as a second step (Table 4). The overall regression model predicted 8% variance in diet quality ($R^2 = 0.08$, F(3, 579) = 17.66, *p* < .001). Gender and ethnicity predicted approximately 5% of variance in diet quality. Gender and ethnicity were statistically significant predictors of diet quality, where those who were female and identified as BAME had a higher diet quality. After controlling for gender and ethnicity, step two predicted approximately 3% of variance in diet quality scores with cost of living impact scores being negatively associated with diet quality.

3.4.2. Use of food purchasing behaviours and food preparation practices in relation to the cost of living crisis and their association with diet quality

In regression model 8, predicting diet quality, the first step of the regression consisted of gender and ethnicity, and budgeting, supermarket offers, energy-saving appliances, meal planning, and resourcefulness were added as a second step (Table 4). The overall regression model predicted 14% of variance in diet quality ($R^2 = 0.14$, F (7, 575) = 12.86, *p* < .001). Gender and ethnicity predicted approximately 6% of variance in diet quality and, as in regression model 7, both were statistically significant predictors of diet quality. After controlling for gender and ethnicity, step two predicted approximately 8% of variance in diet quality scores, where food budgeting and meal planning were significant predictors. Use of budgeting was negatively associated with diet quality, whereas use of meal planning was positively associated with diet quality. There were no associations between use of energy-saving appliances, use of supermarket offers, and use of resourcefulness with diet quality scores.

Table 3

Hierarchical multiple regression analyses showing significant covariates and food insecurity as predictors of using budgeting, energy-saving appliances, meal planning, and resourcefulness.

Variable	Cumulative		Simultaneous		
	R^2-change	*F*-change	B	*p*	*95% CI*
Food purchasing behaviours:					
Budgeting (2)					
Step 1					
Age	0.08	F(3, 579) = 16.76, *p* < .001	−0.00	.556	[−0.01, 0.00]
Limited daily functioning [yes/no]			−0.18	.005	[−0.30, −0.05]
Gender [female/male]			−0.16	.010	[−0.28, −0.04]
Step 2					
Food insecurity	0.36	F(1, 578) = 367.51, *p* < .001	0.21	<.001	[0.19, 0.24]
Food preparation practices:					
Energy-saving appliances (4)					
Step 1					
Limited daily functioning [yes/no]	0.06	F(3, 579) = 11.22, *p* < .001	−0.21	.020	−0.38, −0.03]
Gender [female/male]			−0.32	<.001	[−0.49, −0.14]
Ethnicity [BAME/White]			0.40	.005	[0.12, 0.68]
Step 2					
Food insecurity	0.09	F(1, 578) = 64.10, *p* < .001	0.12	<.001	[0.09, 0.16]
Meal planning (5)					
Step 1					
Online shopper status [yes/no]	0.02	F(2, 580) = 4.60, *p* = .010	−0.14	.120	[−0.31, 0.04]
Gender [female/male]			−0.19	.022	[−0.36, −0.03]
Step 2					
Food insecurity	0.00	F(1, 579) = 1.85, *p* = .174	0.02	.174	[−0.01, 0.05]
Resourcefulness (6)					
Step 1					
Online shopper status [yes/no]	0.04	F(2, 580) = 11.11, *p* < .001	−0.13	.073	[−0.28, 0.01]
Gender [female/male]			−0.27	<.001	−0.40, −0.13]
Step 2					
Food insecurity	0.06	F(1, 579) = 39.26, *p* < .001	0.08	<.001	[0.05, 0.10]

Note. B = unstandardised regression coefficient. (2) = regression model 2, (4) = regression model 4, (5) regression model 5. *95% CI* = 95% confidence intervals.

4. Discussion

4.1. Key findings

We investigated, in a sample of PLWO, the perceived impact of the cost of living crisis on experiences of food insecurity, and how these experiences of food insecurity are, in turn, related to food purchasing behaviour and food preparation practices. We found that those adversely impacted by the cost of living crisis experienced food insecurity, with the composite variable that represented impact of the cost of

Table 4

Hierarchical multiple regression analyses showing gender, cost of living impact, budgeting, supermarket offers, energy-saving appliances, meal planning, and resourcefulness as predictors of diet quality.

Variable	Cumulative		Simultaneous		
	R^2-change	*F*-change	B	*p*	95% CI
Diet quality (7)					
Step 1					
Gender [female/male]	0.05	$F_{(2, 580)} = 16.83, p < .001$	−0.47	<.001	[−0.66, −0.28]
Ethnicity [BAME/White]			−0.66	<.001	[−0.96, −0.36]
Step 2					
Cost of living impact	0.03	$F_{(1, 579)} = 18.30, p < .001$	−0.21	<.001	[−0.30, −0.11]
Diet quality (8)					
Step 1					
Gender [female/male]	0.06	$F_{(2, 580)} = 16.83, p < .001$	−0.42	<.001	[−0.61, −0.23]
Ethnicity [BAME/White]			−0.65	<.001	[−0.94, −0.35]
Step 2					
Budgeting	0.08	$F_{(5, 575)} = 10.71, p < .001$	−0.22	<.001	[−0.35, −0.10]
Supermarket offers			−0.04	.581	[−0.17, 0.10]
Energy-saving appliances			−0.06	.187	[−0.16, 0.03]
Meal planning			0.25	<.001	[0.15, 0.35]
Resourcefulness			0.07	.330	[−0.07, 0.20]

Note. B = unstandardised regression coefficient. (7) = regression model 7. (8) = regression model 8. *95% CI* = 95% confidence intervals.

living crisis explaining 33% of variance in food insecurity. While we hypothesised that food insecurity scores would be associated with use of cost-effective food purchasing behaviours and food preparation practices in relation to the cost of living crisis, this hypothesis was only partially supported in our findings. Food insecurity was associated with use of budgeting, supermarket offers, energy-saving appliances, and cooking resourcefully. Food insecurity was not found to be associated with the use of meal planning. Exploratory analyses of associations between food purchasing behaviours and food preparation practices in relation to diet quality showed that use of budgeting was negatively associated with diet quality, whereas use of meal planning was positively associated.

4.2. Impact of the cost of living crisis and food insecurity

The finding that those who were negatively impacted by the cost of living crisis experienced food insecurity is in line with previous literature that has highlighted the detrimental effects of economic hardship on food security (Brown et al., 2023; Douglas, 2023). Additionally, these findings align with recent Office of National Statistics data showing that households with the lowest incomes experience higher than average inflation rates, which is due to low-income households being more affected by high food and energy prices arising from the cost of living crisis (Office for National Statistics, 2023). The current cost of living crisis is another example of an economic shock where inflation rates, particularly food prices, are rising but wages are not. Moreover, the cost of living crisis is likely exacerbating financial pressures that were already experienced by those on low-incomes, and as a result, have made it even more challenging to afford or access a healthy diet

(Johnstone & Lonnie, 2023; Robinson, 2023). The cost of living crisis is therefore likely to continue to exacerbate social inequalities in dietary outcomes which may have short and longer-term consequences for population health but particular impact for PLWO.

Less healthy food is significantly cheaper to purchase than healthier food (Darmon & Drewnowski, 2015; Food Foundation, 2023b) and it is possible that an unintended consequence of the cost of living crisis is promoting unhealthy food choice through an individual's inability to afford a healthy diet (Food Foundation, 2023a). This finding is complemented by our exploratory analyses that indicated PLWO who were adversely impacted by the cost of living crisis were more likely to have a low quality of diet. Individuals experiencing economic hardship may prioritize more affordable energy-dense foods over diet quality as shown in previous studies prior to the current cost of living crisis (Puddephatt et al., 2020), which may contribute to an increase in body weight and exacerbate existing diet and health inequalities.

4.3. Experience of food insecurity and the use of budgeting

Our study showed a positive association between food insecurity and use of budgeting, which aligns with previous research and suggests that individuals facing food insecurity use budgeting techniques to stretch limited financial resources (Conklin et al., 2013; Laraia et al., 2017; Nieves et al., 2022; van der Velde et al., 2022). As food is seen as flexible within budgets (Ditlevsen et al., 2023; Lindow et al., 2022; Puddephatt et al., 2020), food budgets often suffer cutbacks to account for other, more pressing expenses (e.g., increased housing or energy costs). Indeed, we showed that participants reported that they reduced the quantity (35.2% of survey participants), quality (42.7% of survey participants), and healthiness of food (29.2% of survey participants) to afford rising energy bills (Table S4). As a result, budgeting may encourage cheaper, less healthy food purchases (Pechey & Monsivais, 2016), which may ultimately promote weight gain and obesity (Laraia, 2013; Patil et al., 2017). The findings from our exploratory analyses confirmed this supposition and indicated that use of budgeting strategies was associated with low diet quality.

4.4. Experience of food insecurity and the use of supermarket offers

The positive association found between food insecurity and use of supermarket offers is sensical given previous literature reporting that rising food prices are a primary food-related concern of UK consumers (Armstrong et al., 2023). Using supermarket offers allows consumers to capitalize on discounted food items thereby helping to mitigate the impact of rising food prices. While supermarket offers, such as promotions/lowering prices on seasonable fruits and vegetables, can be important policy levers for encouraging healthier diets (Piernas et al., 2022), the number of products on promotion that are HFSS far outweigh the number on healthier food (Furey, 2022). However, findings from our exploratory analyses indicate that use of supermarket offers were not associated with diet quality, which may suggest that alone, supermarket offers are not a significant driver in dietary decisions, or reflect the temporary, dynamic nature of discounts on food groups.

4.5. Experience of food insecurity and the use of energy-saving appliances

We reported a positive association between food insecurity and use of energy-saving appliances (including eating food cold). It is likely that PLWO and food insecurity use these food preparation practices as a way of reducing utility costs associated with food preparation. Additionally, energy-saving appliances, such as slow cookers and air fryers, may be used due to the convenience they offer (Callender et al., 2021; Kopetsky et al., 2021), and although air fryers are viewed by households with low-income as healthier than traditional frying methods (Adams, 2023), their use does not necessarily determine that the product chosen to be cooked is any healthier. Likewise, meals that do not require cooking

tend to be more highly processed (Parnham et al., 2022) and so consumption is likely to elicit a low quality diet (Harb et al., 2023). However, our exploratory analysis found no relationship between use of energy-saving appliances and diet quality suggesting that diet quality and use of energy-saving appliances per se may not be detrimental for adiposity in PLWO.

4.6. Experience of food insecurity and the use of resourcefulness

Food insecurity was found to be associated with use of resourceful cooking. This might be due that fact that resourceful cooking has become normalised within the food practices of households experiencing food insecurity and so has become as an essential coping strategy for stretching limited food resources, with the cost of living crisis heightening the need for such resourceful behaviours. This finding is in line with the Resource Scarcity Hypothesis (Dhurandhar, 2016), as the cost of living crisis has threatened household food supplies. However, some strategies, such as using starchy foods to pad out meals, might result in excess energy intake at the individual level (Lindberg et al., 2022). Notwithstanding this, these findings highlight the adaptive nature of individuals living with obesity in the face of food insecurity and financial challenges, which is analogous with previous research (Watson, Booth, Velardo, & Coveney, 2022). Importantly, and in contrast to our earlier supposition, exploratory analyses showed that resourceful cooking was not associated with diet quality. Therefore, this coping strategy may be beneficial for PLWO and food insecurity to reduce the financial burden of food costs, without impacting on diet quality.

4.7. Experience of food insecurity and the use of meal planning

Interestingly, we did not find a significant association in PLWO between food insecurity and the use of meal planning. Within the existing literature, the association between meal planning and the experience of food insecurity is mixed. On the one hand, previous research suggests that meal planning can be a helpful strategy for managing food insecurity in the USA (Gundersen & Garasky, 2012). Yet, on the other hand, previous literature also from the USA has found no difference between food secure and food insecure households in their use of meal planning (Ranjit et al., 2020). The lack of association found here may reflect how PLWO have different eating behaviours compared to those without obesity as research suggests that PLWO may have less structured meal plans (Ducrot et al., 2017). Another possibility is that the current study's sample already consisted of individuals who were actively engaged in meal planning, as it is common that behavioural treatments for obesity include support with meal planning (Wing, 2004). Findings from our exploratory analyses indicated that use of meal planning was associated with high diet quality, which lends support to behavioural treatments for obesity that include support with meal planning.

4.8. Implications

The current research has several practical implications. Firstly, our findings emphasise the urgent need for policies and interventions that address the underlying economic factors that contribute to food insecurity among vulnerable populations particularly for PLWO, which aligns with recommendations made elsewhere (e.g., Food Foundation, 2023a). Secondly, our findings underscore the need for comprehensive legislative reforms in ensuring that promoted foods are in favour of health, which contradicts the UK Government's recent delay on plans to ban multi-buys on HFSS and buy one get one free on HFSS products (GOV, 2023b). Thirdly, our findings highlight the fragility of food budgets and how dedicated voucher schemes, where money is ring-fenced for healthy food purchases, may be beneficial. The importance of this is underscored by other evidence that people experiencing food insecurity often prioritize foods with long-shelf lives (e.g., tins) over fresh fruit and vegetables (Shinwell & Defeyter, 2021). An example of an

active voucher scheme is the UK's 'Healthy Start' scheme, where low-income pregnant mothers (10 weeks into their pregnancy) and parents/caregivers who are responsible for at least one child under 4-years of age, can sign up to receive vouchers to purchase healthy food and vitamins. This scheme has successfully seen participating families increase the nutritional composition of their shopping baskets (Griffith et al., 2018). However, recent digitisation of the Healthy Start vouchers into pre-paid cards has received criticism where families have reported experiencing difficulties using the cards, leading to hardship and humiliation (Defeyter et al., 2022). Therefore, although voucher schemes appear a promising intervention, they must be carefully implemented to ensure they are easily accessible.

4.9. Strengths and limitations

Our study has several strengths, including pre-registered analyses, well powered regression analyses, and rigorous sensitivity analyses. Further, individuals with low-incomes are characteristically hard to reach. Nevertheless, our sample consisted of a variety of household incomes, with over half of the sample reporting an income below 60% of the median for the United Kingdom which is often used as a measure of poverty (GOV, 2023a). However, there are several limitations to the study. Our study is constrained by its cross-sectional design as only associations can be inferred. Future research should consider using a longitudinal design to assess changes in food insecurity, food purchasing behaviours, and food preparation practices in line with changing inflation rates, or by using Directed Acyclic Graphs to assess causal inference rather than associations (Van Cauwenberg et al., 2023). Additionally, it is important to acknowledge the presence of low R^2 values for some regression analyses, which may suggest that there are other variables that have not been explored in this paper. Furthermore, the sample was predominately White ethnicity, despite a concerted effort to recruit diversely. One of the key indicators of obesity is ethnicity (NHS Digital, 2022), and so it would be beneficial to explore whether findings differed between ethnicities. However, it could be argued that the sample is representative of the relative population sizes of England and Scotland (Office for National Statistics, 2021; Scottish Consensus, 2011). In this respect, however, the sample would benefit from being recruited from all nations of the UK rather than solely England and Scotland, given the cost of living crisis has been experienced across the UK (Food Foundation, 2023a). Finally, our data were self-reported and some measures, such as the diet quality measure, may suffer from inaccuracies and response bias. Notably, a parallel qualitative study is currently underway within the wider project that is exploring the lived experiences of PLWO and food insecurity in relation to their experiences of shopping in a supermarket for healthy food. Therefore, these qualitative data may shed further light on some of the outstanding questions arising from the current work.

5. Conclusion

This paper illuminates the disproportionate impact economic crises have on people experiencing food insecurity and has added to this understanding, from the perspective of PLWO. These data support fiscal and governmental environmental measures to transform the food system in the UK, to address these diet and health inequalities.

Ethical statement

Ethical approval for the involvement of human subjects in this study was granted by University of Liverpool Research Ethics Committee, Ethics number 12027, Dated 06/02/2023.

System for Healthy People and a Healthy Environment SPF Programme, delivered by UKRI, in partnership with the Global Food Security Programme, BBSRC, ESRC, MRC, NERC, Defra, DHSC, OHID, Innovate UK and FSA.

CRediT authorship contribution statement

Rebecca A. Stone: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Writing – original draft. **Adrian Brown:** Conceptualization, Methodology, Writing – review & editing. **Flora Douglas:** Funding acquisition, Methodology, Writing – review & editing. **Mark A. Green:** Formal analysis, Writing – review & editing. **Emma Hunter:** Methodology, Writing – review & editing. **Marta Lonnie:** Methodology, Visualization, Writing – review & editing. **Alexandra M. Johnstone:** Funding acquisition, Methodology, Writing – review & editing. **Charlotte A. Hardman:** Conceptualization, Formal analysis, Funding acquisition, Methodology, Supervision, Writing – review & editing.

Declaration of competing interest

AB reports honoraria from Novo Nordisk, Office of Health Improvement and Disparity, Johnson and Johnson and Obesity UK outside the submitted work and is on the Medical Advisory Board and shareholder of Reset Health Clinics Ltd. CAH reports research funding from the American Beverage Association, and honoraria from International Sweeteners Association and International Food Information Council for work outside of the submitted manuscript. RAS, AMJ, MAG, EH, FD and ML report no declarations of interest.

Data availability

I have shared the link to the data on the Open Science Framework within the manuscript.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.appet.2024.107255.

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Supplementary Materials

1. Principle component analysis

1.1. Cost of living impact

1.1.1. Pre-analysis checks and data preparation

The sampling adequacy was acceptable (Kaiser–Meyer–Olkin (KMO) = .78) and Bartlett's test of sphericity demonstrated that correlations between items were large enough for PCA ($\chi^2(10) = 1454.58$, $p < .001$. Therefore, a Principal Component Analyses (PCA) was performed using Oblimin rotation with Kaiser Normalization. The PCA revealed one component that explained 63.63% of variance; component one Eigenvalue = 3.18.

1.1.2. Results

The means and standard deviations of measures of the impact of the cost of living scores are displayed in Table S1.

Table S1: Responses to cost of living impact questions. Values represent percentages of completed responses for each question.

	N	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
My income allows me to save for the future	583	3.3	17.2	11	27.3	41.3
I am going into debt to pay for everyday essential	583	22	31.7	14.6	22	9.8
I am unable to pay for all of my bills	583	25	34	10.1	21.3	9.6
I have cut my spending on everyday essentials	583	3.8	13.4	11.3	46.5	25

I have cut my spending in other areas to be able to afford everyday essentials	583	4.8	9.9	10.5	45.6	29.2

As seen in Table S2, all measures loaded onto one component and this was termed 'impact of cost of living crisis'.

Table S2: Principal component analysis for measures of the impact of the cost of living crisis

	Component Matrix
Variable	Component 1 (impact of cost of living crisis)
My income allows me to save for the future	.783
I am going into debt to pay for everyday essentials	.828
I am unable to pay for all of my bills	.810
I have cut my spending on everyday essentials	.777
I have cut my spending in other areas to be able to afford everyday essentials	.790

1.2. Food purchasing behaviours

1.2.1. Pre-analysis checks and data preparation

The sampling adequacy was acceptable (KMO = .89) and Bartlett's test of sphericity demonstrated that correlations between items were large enough for PCA ($\chi^2(45)$ = 2242.49, $p < .001$. Therefore, a Principal Component Analyses (PCA) was performed using Oblimin rotation with Kaiser Normalization. The PCA revealed two components that explained 56.68% of variances; component one Eigenvalue = 4.55 (variance explained = 45.50%), and component two Eigenvalue = 1.16 (variance explained = 11.56%).

1.2.2. Results

The means and standard deviations of measures of food purchasing behaviours in response to the cost of living crisis are displayed in Table S3.

Table S3: Responses to food purchasing behaviours in response to the cost of living crisis questions. Values represent percentages of completed responses for each question.

	N	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Cut back on the quantity of food to afford other essentials (e.g., energy bills)	583	12.2	24.9	12.7	35.2	15.1
Cut back on the quality of food to afford other essentials (e.g., energy bills)	583	9.3	17.5	9.4	42.7	21.1
Shop around supermarkets for the best deals	582	5	11.8	9.6	41.2	32.2
Bought more own-brand food and drink	583	3.8	4.3	8.2	41.9	41.9
Stuck to a strict budget when buying food and drink	583	5.3	18.9	16.1	38.9	20.8
I have changed the days of the week/time of day I shop in order to get the best deals/prices	583	20.8	41.9	13.4	16.8	7.2

Been to the supermarket less because I can't afford to travel there (either fuel or public transport)	583	32.4	30.7	12.2	14.2	10.5
Cut back on healthy food to afford other essentials (e.g., energy bills)	583	13.4	27.4	13.2	29.2	16.8
Bought smaller amounts of dried goods (e.g., pasta, lentils) so I only buy what I need	582	12.9	24.5	13.9	37.7	10.8
Bought more discounted / 'yellow sticker' food and drink	583	8.2	16.1	16	30.9	28.8

As seen in Table S4, all measures loaded onto one of two components. Component one, labelled '*Budgeting'* was made up of 'cut back on the quantity of food to afford other essentials (e.g., energy bills)', 'cut back on healthy food to afford other essentials (e.g., energy bills)', 'cut back on the quality of food to afford other essentials (e.g., energy bills)', 'been to the supermarket less because I can't afford to travel there (either fuel or public transport)', 'bought smaller amounts of dried goods (e.g., pasta, lentils) so I only buy what I need', and 'stuck to a strict budget when buying food and drink'. The second component, labelled '*Supermarket Offers'* was made up of 'shop around supermarkets for the best deals', 'bought more discounted / 'yellow sticker' food and drink', 'bought more own-brand food and drink', and 'I have changed the days of the week/time of day I shop in order to get the best.

Table S4: Principal component analysis pattern matrix for measures of food purchasing behaviours in response to the cost of living crisis (significant loadings in bold)

	Rotated Component	
Variable	Component 1 (*Budgeting*)	Component 2 (*Supermarket offers*)
Cut back on the quantity of food to afford other essentials (e.g., energy bills)	**.906**	-.096
Cut back on healthy food to afford other essentials (e.g., energy bills)	**.846**	.030
Cut back on the quality of food to afford other essentials (e.g., energy bills)	**.841**	.005
Been to the supermarket less because I can't afford to travel there (either fuel or public transport)	**.634**	-.025
Bought smaller amounts of dried goods (e.g., pasta, lentils) so I only buy what I need	**.526**	.221
Stuck to a strict budget when buying food and drink	**.446**	.358
Shop around supermarkets for the best deals	-.220	**.928**
Bought more discounted / 'yellow sticker' food and drink	.171	**.658**
Bought more own-brand food and drink	.251	**.580**
I have changed the days of the week/time of day I shop in order to get the best deals/prices	.091	**.564**

1.3.   Food Preparation Practices

1.3.1. *Pre-analysis checks and data preparation*

The sampling adequacy was acceptable (KMO = .73) and Bartlett's test of sphericity demonstrated that correlations between items were large enough for PCA ($\chi^2(36) = 1103.17$, $p < .001$. Therefore, a Principal Component Analyses (PCA) was performed using Oblimin rotation with Kaiser Normalization. The PCA revealed three components that explained 60.56% of variances; component one Eigenvalue = 2.86 (variance explained = 31.73%), component two Eigenvalue = 1.63 (variance explained = 18.13%), component three Eigenvalue = 1.01 (variance explained = 10.70%).

1.3.2. Results

The means and standard deviations of measures of food preparation practices in response to the cost of living crisis are displayed in Table S5.

Table S5: Responses to food preparation practices in response to the cost of living crisis questions. Values represent percentages of completed responses for each question.

	N	Strongly disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly agree
Used appliances (e.g. oven, hob etc.) less for cooking to save money on energy bills	583	10.1	17.2	8.4	41.2	23.2
Used appliances such as air-fryers more to save money on energy bills	583	20.6	16	7.5	23.7	32.2
Ate cold meals or ones that don't need to be	583	19	30.4	10.1	28.8	11.7

cooked to save money on energy bills					
Cooked meals from scratch	583	5.8	10.1	14.1	43.6	26.4
Reduced the amount of food that I waste	583	3.6	6.3	11.5	48	30.5
Padded out meals with more filling foods e.g. pasta, potatoes	583	8.1	14.6	12.9	42.2	22.3
Plan all meals for the week in advance	583	16.8	24.7	13	26.6	18.9
Batch cooked meals for the week in advance	583	19.9	31	14.9	25.7	8.4
Eaten more vegetarian meals / meals without meat	583	22.8	25	13.6	26.8	11.8

As seen in Table S6, all measures loaded onto one of three components. Component one, labelled '*Energy Saving Appliances'* was made up of 'used appliances (e.g. oven, hob etc.) less for cooking to save money on energy bills', 'used appliances such as air-fryers more to save money on energy bills', and 'ate cold meals or ones that don't need to be cooked to save money on energy bills'. The second component, labelled '*Meal Planning'* was made up of 'batch cooked meals for the week in advance', 'plan all meals for the week in advance', and 'cooked meals from scratch'. The third component, labelled '*Resourcefulness'* was made up of 'reduced the amount of food that I waste', 'padded out meals with more filling foods e.g. pasta, potatoes', and 'eaten more vegetarian meals / meals without meat.'

Table S6: Principal component analysis pattern matrix for measures of food preparation practices in response to the cost of living crisis (significant loadings in bold)

Variable	Rotated components		
	Component 1 (*Energy saving appliances*)	Component 2 (*Meal planning*)	Component 3 (*Resourcefulness*)
Used appliances (e.g. oven, hob etc.) less for cooking to save money on energy bills	**.825**	-.008	.147
Used appliances such as air-fryers more to save money on energy bills	**.800**	.265	-.217
Ate cold meals or ones that don't need to be cooked to save money on energy bills	**.699**	-.174	.239
Batch cooked meals for the week in advance	.141	**.806**	-.014
Plan all meals for the week in advance	.000	**.799**	.034
Cooked meals from scratch	-.131	**.518**	.377
Reduced the amount of food that I waste	.111	.036	**.730**
Padded out meals with more filling foods e.g. pasta, potatoes	.333	-.051	**.648**

Eaten more vegetarian meals / meals without meat	-.131	.131	**.590**

1.4. <u>Reliability analysis</u>

The scale reliability of each construct identified by the PCA was assessed using McDonald's Omega (ω_T). McDonald's Omega was high for impact of cost of living crisis (0.85), budgeting (0.85), supermarket offers (0.71) and energy saving (0.73), and moderate for meal planning (0.66) and resourcefulness (0.52) (Hinton et al., 2014).

2. Sensitivity analysis

Main regression analyses were re-run with extreme outliers excluded (n = 15, N = 268).

2.1. <u>The association between impact of the cost of living crisis and food insecurity scores</u>

As seen in Table S7, hierarchical multiple regression analysis was used to analyse the effect of being impacted by the cost of living crisis on experiences of food insecurity. The first step in this regression model consisted of age and daily functioning, the impact of the cost of living crisis was then added as a second step. The overall regression model predicted 41% of variance in food insecurity scores (R^2 = .41, F(3, 564) = 132.35, p < .001). Age and daily functioning predicted approximately 9% of variance in food insecurity scores, but only age was a significant predictor with higher food insecurity in younger participants. After controlling for age and daily functioning, step two predicted approximately 32% of variance in food insecurity, with higher cost of living impact scores being associated with higher food insecurity scores, which is consistent with our hypothesis.

<u>Table S7</u>: Hierarchical multiple regression analyses showing age, daily functioning, and the impact of the cost of living crisis as predictors of food insecurity

Variable	Cumulative	Simultaneous

	R^2-change	F-change	B	p	95% CI
Food insecurity (1)					
<u>Step 1</u>					
Age	0.09	F(2, 565) = 26.98, p < .001	-.04	< .001	[-.05, -.02]
Daily functioning			-.27	.163	[-.65, .11]
<u>Step 2</u>					
Impact of cost of living crisis	0.32	F(1, 564) = 313.26, p < .001	1.75	< .001	[1.55, 1.94]

Note. B = unstandardised regression coefficient. *(1) = regression model 1.*

1.1.1. *Experiences of food insecurity and the use of food purchasing behaviours and food preparation practices in relation to the cost of living crisis*

A further four hierarchical multiple regression analyses were used to analyse the association between experiencing food insecurity and the use of budgeting, energy saving appliances, meal planning, and resourcefulness in relation to the cost of living crisis (Table S8). In the absence of any covariates, a linear regression was used to analyse the association between experiencing food insecurity and the use of supermarket offers in relation to the cost of living crisis (regression model 3, not presented in Table S8).

<u>Table S8:</u> Hierarchical multiple regression analyses showing significant covariates and food insecurity as predictors of using budgeting, energy-saving appliances, meal planning, and resourcefulness

Variable	Cumulative		Simultaneous		
	R^2-change	F-change	B	p	95% CI

Food purchasing behaviours:

Budgeting (2)

Step 1

Age	0.08	F(3, 564) = 16.71, p < .001	-.00	.545	[-.01, .00]
Limited daily functioning [yes/no]			-.17	.006	[-.30, -.05]
Gender [female/male]			-.17	.007	[-.29, -.05]

Step 2

Food insecurity	0.35	F(1, 563) = 353.68, p < .001	.21	< .001	[.19, .24]

Food preparation practices:

Energy-saving appliances (4)

Step 1

Daily functioning	0.05	F(3, 564) = 10.68, p < .001	-.21	.022	[-.38, -.03]
Gender			-.31	< .001	[-.49, -.13]
Ethnicity [BAME/White]			.39	.009	[.10, .68]

Step 2

Food insecurity	0.09	F(1, 563) = 60.98, p < .001	.12	< .001	[.09, .15]

Meal planning

(5)

<u>Step 1</u>

Online shopper status [yes/no]	0.02	$F(2, 565) = 3.91, p = .021$	-.12	.190	[-.29, .06]
Gender			-.19	.029	[-.35, -.02]

<u>Step 2</u>

Food insecurity	0.00	$F(1, 564) = 1.40, p = .237$	.02	.237	[-.01, .05]

Resourcefulness

(6)

<u>Step 1</u>

Online shopper status	0.04	$F(2, 565) = 11.25, p < .001$	-.14	.069	[-.28, .01]
Gender			-.27	< .001	[-.41, -.13]

<u>Step 2</u>

Food insecurity	0.06	$F(1, 564) = 36.45, p < .001$	.07	< .001	[.05, .10]

Note. B = unstandardised regression coefficient. (2) = regression model 2, (4) = regression model 4, (5) regression model 5.

<u>Food purchasing behaviours in relation to the cost of living crisis</u>

In regression model 2, predicting *use of budgeting*, the first step of the regression consisted of age, daily functioning, and gender, and food insecurity was added as a second step. The overall regression model predicted 43% of variance in budgeting ($R^2 = .43$, $F(4, 563) = 108.79$, $p < .001$). Age, daily functioning, and gender predicted approximately 8% of variance in budgeting, although only daily functioning and gender were significant predictor of budgeting, where there was higher use of budgeting for those who had limited daily functioning due to a medical problem, and who were female. After controlling for age, daily

functioning, and gender, step two predicted approximately 35% of variance in budgeting, with higher food insecurity scores being associated with higher use of budgeting.

In regression model 3, predicting *use of supermarket offers*, the regression model predicted approximately 12% of variance in use of supermarket offers, Adjusted R^2 = .12, $F(1, 566)$ = 81.62, *p* < .001). Specifically, there was a positive association between food insecurity scores and use of supermarket offers (B = 0.11, *p* < .001, 95%CI [.08, .13]).

Food preparation practices in relation to the cost of living crisis

In regression model 4, predicting *use of energy-saving appliances*, the first step of the regression consisted of daily functioning, gender, and ethnicity, and food insecurity was added as a second step. The overall regression model predicted 14% variance in use of energy-saving appliances (R^2 = .14, F(4, 563) = 24.10, *p* < .001). Daily functioning, gender, and ethnicity predicted approximately 5% of variance in use of energy-saving appliances, where there was higher use of energy-saving appliances in those who had limited daily functioning due to a medical problem, were White, and who were female. After controlling for daily functioning, gender, and ethnicity, step two predicted approximately 9% of variance in use of energy-saving appliances, with higher food insecurity scores being associated with higher use of energy-saving appliances.

In regression model 5, predicting *use of meal planning*, the first step of the regression consisted of online shopper status and gender, and food insecurity was added as a second step. The overall regression model predicted 2% variance in use of meal planning (R^2 = .02, F(3, 564) = 3.08, *p* = .027). Only gender was a significant predictor of meal planning, where there was higher use of meal planning for those who were female. After controlling for online shopper status and gender, step two predicted approximately 0% of variance in use of meal planning, with food insecurity scores not being associated with use of meal planning in relation to the cost of living crisis.

In regression model 6, predicting *cooking resourcefully*, the first step of the regression consisted of online shopper status and gender, and food insecurity was added as a second step. The overall regression model predicted 10% variance in cooking

resourcefully (R^2 = .10, $F(3, 564)$ = 20.12, p < .001). Online shopper status and gender predicted approximately 4% of variance in cooking resourcefully, although only gender was a significant predictor of cooking resourcefully where higher resourceful cooking was reported in those who were female. After controlling for online shopper status and gender, step two predicted approximately 6% of variance in cooking resourcefully, with higher food insecurity scores being associated with higher resourceful cooking in relation to the cost of living crisis.