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Understanding the barriers to purchasing healthier, more environmentally sustainable food for people living with obesity and varying experiences of food insecurity in the UK

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ABSTRACT

In westernised countries, food insecurity (FI) is robustly associated with low diet quality, and obesity. Grocery stores are one promising arena for interventions to facilitate purchasing of healthier, more environmentally sustainable food. However, we currently lack understanding of the barriers experienced by people living with obesity (PLWO) and FI when shopping for such food. Using an online survey (N = 583), adults residing in England or Scotland with a body mass index of ≥ 30 kg/m^2 self-reported on FI, diet quality, and their experiences of shopping in a grocery store for healthy and environmentally sustainable food. Participants also ranked different grocery store interventions on their helpfulness in supporting healthier, more environmentally sustainable purchasing. Structural equation modelling revealed that greater experiences of FI were directly associated with greater experiences of barriers from the food environment (e.g., price), food preparation practices, lower healthy diet knowledge and physical ill-health. Moreover, greater experiences of FI were indirectly associated with lower diet quality via mental ill-health and greater experiences of anticipated stigma associated with being food insecure. Grocery store interventions based on price/ incentivisation were ranked most helpful in supporting healthier, more environmentally sustainable purchasing. These findings highlight the challenges faced by PLWO and with greater experiences of FI when shopping for healthy and environmentally sustainable food. Findings also underscore the need for policy development relating to price and affordability at a population-level, and for policymakers and healthcare professionals to consider how to address mental health and how to minimise anticipated stigma experienced by this vulnerable group.

1. Introduction

Food insecurity (FI) is a multifaceted issue that relates to the inability to access and acquire nutritionally adequate and safe to consume food (Food and Agriculture Organization, 2009). People experiencing FI tend to have diets that are of lower nutritional quality compared to those who are food secure (Keenan et al., 2021), and in high-income countries, FI is robustly associated with obesity and diet-related adverse health conditions such as type 2 diabetes (e.g., Brown et al., 2019; Hyseni et al., 2017; Robinson, 2023). Considering ongoing public health concerns about population obesity trends (Safaei et al., 2021) and that the United Nations has pledged to end world hunger and ensure food security for all by 2030 (United Nations, 2015), policymakers need to prioritise efforts aimed at enabling easier access to healthier diets for people living with obesity (PLWO). This is particularly important for those who are living with both obesity and FI who are at increased risk of a double burden of poor health (Johnson & Lonnie, 2023). In the UK, the majority of the population uses grocery stores to purchase food (CHL UK, 2020), therefore grocery stores are one promising arena for interventions. However, we currently lack understanding of the barriers experienced

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by PLWO and FI when shopping for food and this hampers current intervention and policy efforts aimed at supporting this vulnerable group. Consuming a healthier diet is often also more environmentally sustainable for the planet (and vice-versa) (e.g., reducing meat consumption, increasing intake of local and seasonal fruit and vegetables) (The Carbon Trust, 2016), which is pertinent given that the food system is not viable in its current form (One Blue Dot, 2019). Therefore, in addition to encouraging people to consume a healthier diet, efforts are also needed to support food choices that are more environmentally sustainable.

Previous research has highlighted how the household food environment can act as a barrier to healthier food purchasing. For example, Karpyn et al. (2020b) found that, in urban low-income communities, several household "food challenges" were associated with lower Healthy Eating Index scores and lower vegetable consumption (e.g., lower household grocery spending and fruit and vegetable spending per person, greater unhealthy food availability in the home, lack of access to a vehicle to get to the household's main store). Complementary to this, Wolfson et al. (2019) found that barriers within the wider food environment (affordability, distance to grocery store, variety and quality of food, transport) were significantly associated with lower diet quality for low-income populations. Low-income neighbourhoods can be described as food deserts (Burgoine et al., 2017; Huang et al., 2024) because they tend to contain fewer large grocery stores and instead are populated with smaller convenience stores (Zenk et al., 2006) where food is priced at a premium and there is a lack of variety and quality in healthier foods (Cannuscio et al., 2013). This also means that shoppers in such food deserts are required to travel further to access larger grocery stores, which is not always possible without means of transportation or finances to use public transport (MacNell, 2018). Taken together, there are multiple barriers to healthier eating within food environments in lower income neighbourhoods where many people experience FI. To date, there has been little research specifically focused on barriers in the food environment experienced by PLWO and FI. However, in a qualitative and quantitative review of the lived experience of FI with obesity, Briggs et al. (2024) found that living with obesity further hindered access to a healthy diet, for example due to weight-related mobility issues, individuals had to pay for transport to the grocery store as they could not walk, which further reduced their already tight food budgets.

Other barriers to consuming healthier diets may relate to low nutritional knowledge and cooking skills in communities experiencing socioeconomic deprivation (Parmenter et al., 2000; Wrieden et al., 2007); however, this is a contested area (Douglas, 2023). More recently, FI was found to be unrelated to cooking skills (Pepetone et al., 2021). In a sample of PLWO, FI was instead associated with thrifty food purchasing practices (e.g., greater use of household budgeting) where food is a flexible cost that can be sacrificed to ensure other fixed costs (e.g., mortgage, household bills) are met (Stone et al., 2024). However, this often occurs to the detriment of diet quality due to the, on average, higher cost of healthier foods relative to less healthy foods (Darmon & Drewnowski, 2015). The amount of time available to shop for and prepare fresh healthful food has also been highlighted as a barrier for those experiencing FI (Wolfson et al., 2019). Therefore, time constraints may promote the use of convenience food (Monsivais et al., 2014) which are often higher in energy content.

Personal health may also act as a further barrier, exacerbating the above issues with food access and preparation. As noted above, both obesity and FI are associated with increased risk of diet-related adverse health conditions including Type 2 diabetes (Lin & Li, 2021), and also greater prevalence of common mental disorders (Smith et al., 2024). Living with chronic physical and/or mental health conditions can act as a barrier to consuming a healthier diet by curtailing a person's ability to travel to shops and plan and prepare food (Puddephatt et al., 2020). People living with both obesity and FI may also face financial hardships in managing health conditions (Liese et al., 2022), which could encourage the reliance placed on low-cost food (Papan & Clow, 2015). Stigma towards PLWO is also pervasive and known to have a negative impact on mental and physical health (Brown et al., 2022). PLWO who concurrently live with FI may experience even greater societal stigmatisation due to needing to access food support. In this way, the combined impact of weight stigma and FI stigma may be internalised and further promote unhealthier food purchasing behaviour (Gombert et al., 2017; Hunter et al., 2025; Leone et al., 2022). For example, in a qualitative study of PLWO and FI, participants described feeling judged by others when shopping for food in the grocery store, which resulted in participants engaging in fast-shopping practices (i.e., shopping as fast as possible) to escape (Hunter et al., 2025).

Given the health and wellbeing impacts of living with both obesity and FI, it is therefore of key importance to develop understanding of the range of barriers at the individual/household level and in the wider food environment that may make it particularly difficult for this group to consume a healthier diet. This new knowledge will ultimately help to steer and inform policy on how to effectively support access to healthier and more environmentally sustainable diets for PLWO and greater experiences of FI. The current study addressed this gap by recruiting a sample of PLWO with varying experiences of FI to 1) quantify the associations between FI and multiple barriers to purchasing/consuming a healthier and more environmentally sustainable diet, and 2) understand what interventions, in practice, do PLWO think would be most/least helpful to support them with purchasing these foods in the grocery store (online or in-store). It was hypothesised that, in a sample of PLWO, greater experiences of FI will be associated with lower diet quality, and this relationship will be accounted for by barriers which include food environment and personal factors (pre-registration: https://doi.org/10.17605/OSF.IO/BYZKP).

2. Method

2.1. Participants

The participants in the current study are from a dataset that has been described in full elsewhere (Stone et al., 2024). Briefly, participants were recruited from March 2023 to May 2023 using the recruitment website, Prolific (98 %) and through paid, targeted advertisements on Facebook, and advertisements on X. To be eligible, participants had to be between 18–65-years-old, reside in England or Scotland, with a BMI of $\geq$ 30 kg/m^2 (BMI scores of $\geq$ 29.50 kg/m^2 were rounded up to the nearest whole number (n = 12)). Ethical approval for the study was granted by the University of Liverpool Research Ethics Committee. Of the 654 participants who completed the survey, 583 were entered into data analysis due to the exclusion criteria.[1] Using *a priori* sample size calculations, a minimum of 500 participants were needed for adequate power ($\geq$80 %, $\alpha = 0.05$; https://doi.org/10.17605/OSF.IO/BYZKP).

2.2. Procedure

The study questionnaires were hosted on Qualtrics. For participants accessing the questionnaires via social media advertisements, a reCAPTCHA was used at the start of the study to protect against bots (i.e., an autonomous computer program on the internet that can interact with surveys). Those who completed the study via Prolific have already been authenticated as not a bot when signing up to the platform

[1] Data were excluded from analyses for participants who were: not the primary grocery shopper (n = 10), had a BMI $\leq$30 kg/m^2 (n = 44), who failed $\geq$ 3 attention checks (n = 2), and 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.

(Prolific, 2018). After providing informed consent electronically, participants were asked a series of screening questions to assess eligibility. All participants then completed a series of questionnaires (in the following order) about their demographics, FI, mental health (depression and anxiety), diet quality, stigma from being food insecure, barriers to purchasing healthy and environmentally sustainable food, and knowledge of healthy and sustainable diets. Finally, to address Aim 2 of the current study, they were asked about what grocery store interventions (either online or in-store) they perceived as the most/least helpful to support them to purchase healthy and environmentally sustainable food.

2.3. Measures

2.3.1. Demographic information

Demographic information included the following: age, country of residence, height and weight, gender, ethnicity, daily functioning (i.e., limited/ not limited, to depict physical health), dietary preference (i.e., vegan, vegetarian etc.), household size, education, household income, the grocery store frequented the most, use of the grocery store (i.e., in store or online), and whether the participant was a solo shopper (see Stone et al., 2024 for further detail of these items).

2.3.2. Household food security

The 10-item United States Department of Agriculture Household Food Security Survey Model (USDA, 2012) was used to measure experience of FI. This scale asked questions about food accessibility in the past 30 days in order to compute an FI score. For example, "In the last 30 days, did you ever cut the size of your meals or skip meals because there wasn't enough money for food?" with Likert response options of "Yes", "No", and "Do not Know"; and "How often did this happen?" with Likert response options of "Almost Every Day", "Some Days but not Every Day", "Only 1 or 2 Days" or "Do not Know". Responses of 'Yes', 'Often', 'Sometimes', 'Almost every day, and 'Some days but not every day 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 FI score. Higher scores on the USDA-10 were indicative of greater experiences of FI (possible range: 0–10). Scale reliability using McDonald's Omega (ω_T) indicated that this measure had excellent reliability in the current study ($\omega_T = 0.95$).

2.3.3. Mental health

The four-item Patient Health Questionnaire (PHQ-4) is a scale that combines two validated scales of depression (PHQ-2; two items) and anxiety (GAD-2; two items) (Kroenke et al., 2009). Response options are: 1 = Not at all, 2 = Several days, 3 = More than half the days, 4 = Nearly every day). Reliability of the PHQ-4 in the current sample was excellent ($\omega_T = 0.93$).

2.3.4. Diet quality

Diet quality was measured using a validated, short (20-item) food frequency questionnaire (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 used a 10-item Likert scale to rate the frequency that they consumed 19 foods in the last three months (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). Likert scores were rated: 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. To estimate diet quality, the following steps were undertaken (1) recoding frequencies eaten per day 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 ($\geq$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.

2.3.5. Food insecurity stigma

To measure the anticipated stigma from being food insecure (i.e., the belief that others will discriminate against someone for being food insecure; Earnshaw & Karpyn, 2020), four items were used; three items from the Food Insecurity Self-Stigma Scale (FISS; Taylor et al., 2024) (1: because of peoples' ignorance about how difficult it can be to access food, I do not speak to anyone about the problems linked to accessing food. 2: because of people's preconceptions, I do not speak to anybody about needing help accessing food. 3: I try to avoid situations where my difficulty in accessing food might be revealed), and one item to measure "fast shopping practices" based findings from Gombert et al. (2017) (4: I do my grocery shopping as fast as I can so that people do not judge what I am buying). Response options were: 1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree, 4 = Agree, and 5 = Strongly Agree. Reliability of this scale in the current sample was good (ω_T = 0.87).

2.3.6. Barriers to purchasing healthy food

Based on the survey used in Wolfson et al. (2019), participants were asked "How often do the following situations make it difficult for you to acquire healthy, environmentally sustainable foods (healthy, environmentally sustainable foods include fresh fruit and vegetables, whole grains, beans and legumes, low-fat dairy, lean meats, and alternatives to meat and dairy)?" in relation to the following barriers: distance to the grocery store, lack of transportation to the grocery store, price of products, time available to go shopping, cooking skills, time available to prepare meals, variety of items available in grocery store (in-store or online), quality of items available in grocery store (in-store or online). Response options were on a 5-point Likert scale where 1 = Never, 2 = Rarely, 3 = Sometimes, 4 = Often, and 5 = Always. Reliability in current sample was good ($\omega_T = 0.78$).

2.3.7. Knowledge of healthy and environmentally sustainable diet

Self-perceived knowledge of healthy and environmentally sustainable diets was assessed using an existing question set from the Food Standard's Agency Healthy and Sustainable Diets: Consumer Poll (Heard & Bogdan, 2021). Participants were asked to rate the extent to which they agreed or disagreed with the following statements: "I know what healthy food purchases consist of", "I understand the impact that my food purchases have on my health", "I know what sustainable/ environmentally friendly food purchases consist of", "I understand the impact that my food purchases have on the environment". Response options used a 5-point Likert scale where 1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree, 4 = Agree, and 5 = Strongly Agree. Reliability in current sample was good ($\omega_T = 0.72$).

2.3.8. Helpful interventions for healthy and environmentally sustainable food purchasing

Twenty frequently used interventions (ten in-store, ten online) to support healthy food purchasing were generated (see Table 4). The list of interventions was compiled based on previous research (Karpyn et al., 2020a), and insights from retail-sector stakeholders. Participants were asked to rank in order of helpfulness (1 least helpful – 10 most helpful) the intervention that would support them to purchase healthier food either in-store or online (depending on how they shopped). Online shopping was included here because PLWO may be more inclined to shop online due to anticipated weight stigma (Hunter et al., 2025). Interventions were categorised by the researchers based on the behaviour

change lever they operated on as per (Hartmann-Boyce et al., 2018) for example "Price discount on healthy food products" was categorised as 'price/ incentivisation' lever. Behaviour change lever categorisation was not shown to the participant.

The above activity was then repeated but this time participants were asked to rank the helpfulness of interventions to support environmentally sustainable food purchasing using another list of twenty interventions (ten in-store, ten online, see Table 5) generated from previous research and insights from retail-sector. These interventions were also categorised based on the behaviour change lever they operated on (Hartmann-Boyce et al., 2018).

2.4. Data analysis

2.4.1. Structural equation model

A structural equation model, computed in R using the Lavaan package, was used to quantify the association between variability in FI scores and diet quality and the extent to which this association is accounted for by barriers from the food environment (including: distance to grocery store, transportation, price, variety of products, and quality of products) and personal barriers (including: food preparation barriers (i.e., cooking skills, time available to shop for food, time available to cook food)), FI stigma, mental health, physical health, healthy diet knowledge, and environmentally sustainable diet knowledge). Food environment barriers, food preparation barriers, FI stigma, and mental health were treated as latent variables and evaluated using Confirmatory Factor Analysis (CFA) (see Section 3.3).

A maximum likelihood estimator with a Satorra-Bentler correction was used for model fitting because of the non-normality of food environment barriers and personal barriers (Ullman et al., 2001). Several indices of model fit were computed: root mean square error of approximation (RMSEA) (values less than 0.08 are acceptable), comparative fit index (CFI) (values greater than 0.95 are good, greater than 0.90 are acceptable), and standardized root mean residual (SRMR) (values less than 0.08 are acceptable; Hu & Bentler, 1999). Covariances were added due to correlated residuals (i.e., the error variance in the items not explained by the common factor were correlated as this has profound effects on the model fit).

2.4.2. Ranking of interventions for healthy and environmentally sustainable food purchasing

The mean score of each intervention (for health and for environmental sustainability, in-store and online) were computed. As stated earlier, scores ranged from 1 (least helpful) – 10 (most helpful). Therefore, higher mean scores were indicative of more helpful interventions.

3. Results

3.1. Sample characteristics

Descriptive data for the demographic variables are shown in Table 1. Briefly, most participants (90.1 %; n = 525) lived in England compared to Scotland (9.95 %; n = 58), which is representative of relative population sizes of England and Scotland (Office for National Statistics (ONS), 2021; Scottish Consensus, 2011). In the sample, 63.1 % (n = 368) were female and 36.9 % (n = 215) were male, which is a slight overrepresentation for females compared to England and Scotland's population (51 %-51.5 %; ONS, 2021; Scottish Consensus, 2011). Participants had a mean age of 40.3 years (comparable to England's population median of 40.7 years (ONS, 2021) but younger than Scotland's population median of 43 years (Scottish Consensus, 2021)), and 49.3 % (n = 287) of the sample were educated to degree level, which is an overrepresentation of those educated to degree level compared to England and Scotland's population (33.8 % – 26.1 %; ONS 2021; Scottish Consensus, 2011). For ethnicity, 90.1 % (n = 525) identified as White, which is a slight overrepresentation of White ethnicity compared to England (81.7 %; ONS, 2021) but could arguably reflect the two nations combined given Scotland's population identify as 96 % White (Scottish Consensus, 2011)). The current sample had a mean BMI of 37.92 kg/m^2, and 37.4 % (n = 218) were food insecure (determined using the USDA-10 cut-offs (USDA, 2012), where a score of 0 = high; 1–2 = marginal; 3–5 = low; 6–10 = very low food security, where food insecure reflected low and very low food security groups combined), which is higher than the UK average of FI in a sample of PLWO at 6–10 % (Brown et al., 2023). The mean household size of the sample was 3.7, which is higher than UK average of 2.36 people (Statista, 2024), and 56.7 % (n = 331) of participants reported an annual household income of ≤ £26,000 (below 60 % of the median for the United Kingdom which is often used as a measure of poverty (GOV, 2023)). Participants' mean diet quality score was 0.23, which suggested that they had a healthy diet (Robinson et al, 2017). The majority of participants were omnivores (79.2 %; n = 462), who primarily shopped in-store (69 %; n = 402), and shopped alone (34.5 %; n = 201) or with a spouse/partner (23.3 %; n = 136). In the sample, 41.5 % (n = 240) of participants reported having a health condition that limited their daily function. Therefore, the sample were relatively representative of national averages in terms of demographics, apart from in relation to education levels.

3.2. Covariate analysis

Before running the model, the effect of demographic variables on diet quality were investigated using Mann-Whitney U tests and Spearman's Rho correlations (analyses reported in full in Stone et al. (2024)). From these analyses, there was a significant difference in diet quality scores depending on gender, where scores were higher for females ($U = 29551$, $p < 0.001$), and for ethnicity, where scores were higher for those who identified as BAME ($U = 11412$, $p = 0.002$). Therefore, gender and ethnicity were controlled for in the model accordingly.

3.3. Confirmatory factor analysis: Latent variables

3.3.1. Latent variable 1 – mental health

Two measurements of mental health were taken; (i) anxiety (consisting of two items), and (ii) depression (consisting of two items) symptoms using the Patient Health Questionnaire (PHQ-4; Kroenke et al., 2009). A CFA was performed and the model was shown to be a good fit (CFI = 0.96, SRMR = 0.04), although the RMSEA was found to be poor (RMSEA = 0.26). All factor loadings were highly significant ($p < 0.001$). Modification Indices (MI) suggested correlated residuals for item 3 ("Feeling down, depressed or hopeless") and item 4 ("Little interest or pleasure in doing things") (MI = 145.98), therefore a covariance was added between these items. The covariance model was shown to be a good fit on all measures (CFI = 1.00, RMSEA = 0.000, SRMR = 0.000, ΔAIC = 137.54), and all factor loadings were highly significant ($p < 0.001$).

3.3.2. Latent variable 2 – food insecurity stigma

Three items from the FISS (Taylor et al., 2024), and one item relating to fast shopping practices' (Gombert et al., 2017) were used. A CFA was performed and the model was shown to be a good fit (CFI = 1.00, RMSEA = 0.06, SRMR = 0.02), and all factor loadings were highly significant ($p < 0.001$).

3.3.3. Latent variable 3 and 4 – food environment and food preparation barriers

Using the 8-item 'Barriers to Healthy Food Access' question set (as used in Wolfson et al. (2019)), a two-factor structure emerged. Five items were related to food environment barriers (Distance to supermarket, Transport to supermarket, Price of products, Variety of products, Quality of products) and three items were related to food preparation barriers (Cooking skills, Time available to cook, Time

available to prepare food). A CFA was performed and the model was shown to be a poor fit (CFI = 0.74, RMSEA = 0.18, SRMR = 0.11). All factor loadings were highly significant for food environment and for personal environment ($p < 0.001$). MIs suggested correlated residuals for item 1 (Distance to supermarket) and item 2 (Transport to supermarket) of the food environment factor (MI = 260.84), and for item 8 (Variety of products) and 9 (Quality of products) of the food preparation factor (MI = 233.65), therefore covariances were added between these items. The covariance model was shown to be a good fit on all measures (CFI = 0.97, RMSEA = 0.07, SRMR = 0.04, ΔAIC = 382.46), and all factor loadings were highly significant for food environment and for food preparation ($p < 0.001$).

3.4. Model evaluation

The initial model was an acceptable to poor fit to the data (CFI = 0.90, SRMR = 0.11, RMSEA = 0.07). MIs suggested correlated residuals between stigma item 1 ("because of peoples' ignorance about how difficult it can be to access food, I do not speak to anyone about the problems linked to accessing food") and stigma item 2 ("because of people's preconceptions, I do not speak to anybody about needing help accessing food") (MI = 48.77), and correlated observed variables between environmentally sustainable diet knowledge and healthy diet knowledge (MI = 91.44), correlated latent variables between food environment barriers and food preparation barriers (MI = 65.55), and correlated observed and latent variables between physical health and mental health (MI = 48.30), therefore covariance pathways were added based on this. The unadjusted model with covariances using a Maximum Likelihood Method (MLM) estimator indicated that the model was an acceptable fit for the data (CFI = 0.95, SRMR = 0.09, RMSEA = 0.06; ΔAkaike Information Criterion (AIC) = 275.12, ΔBayesian Information Criterion (BIC) = 253.28.

The final, adjusted model with covariances and control variables (gender and ethnicity) included, indicated that the model was a good fit for the data (CFI = 0.94, SRMR = 0.08, RMSEA = 0.05; ΔAIC = 32.38, ΔBIC = 23.64 (see Fig. 1 for the final, adjusted model with covariance pathways and control variables also shown).

3.5. Direct and indirect effects

Results for direct effects are shown in Table 2. There were significant positive associations between greater experiences of FI and greater experiences of food environment barriers, food preparation barriers, FI stigma, and mental ill-health. There were also significant negative associations between greater experiences of FI and lower healthy diet knowledge and lower physical health. There was no significant association between experiences of FI and environmentally sustainable diet knowledge.

There were no direct associations between diet quality and food environment barriers, food preparation barriers, healthy diet knowledge, or physical health. However, there was a significant positive association between greater environmentally sustainable diet knowledge and greater diet quality. There were also significant negative associations between greater experiences of stigma from being food insecure and lower diet quality, and between greater mental ill-health and lower diet quality.

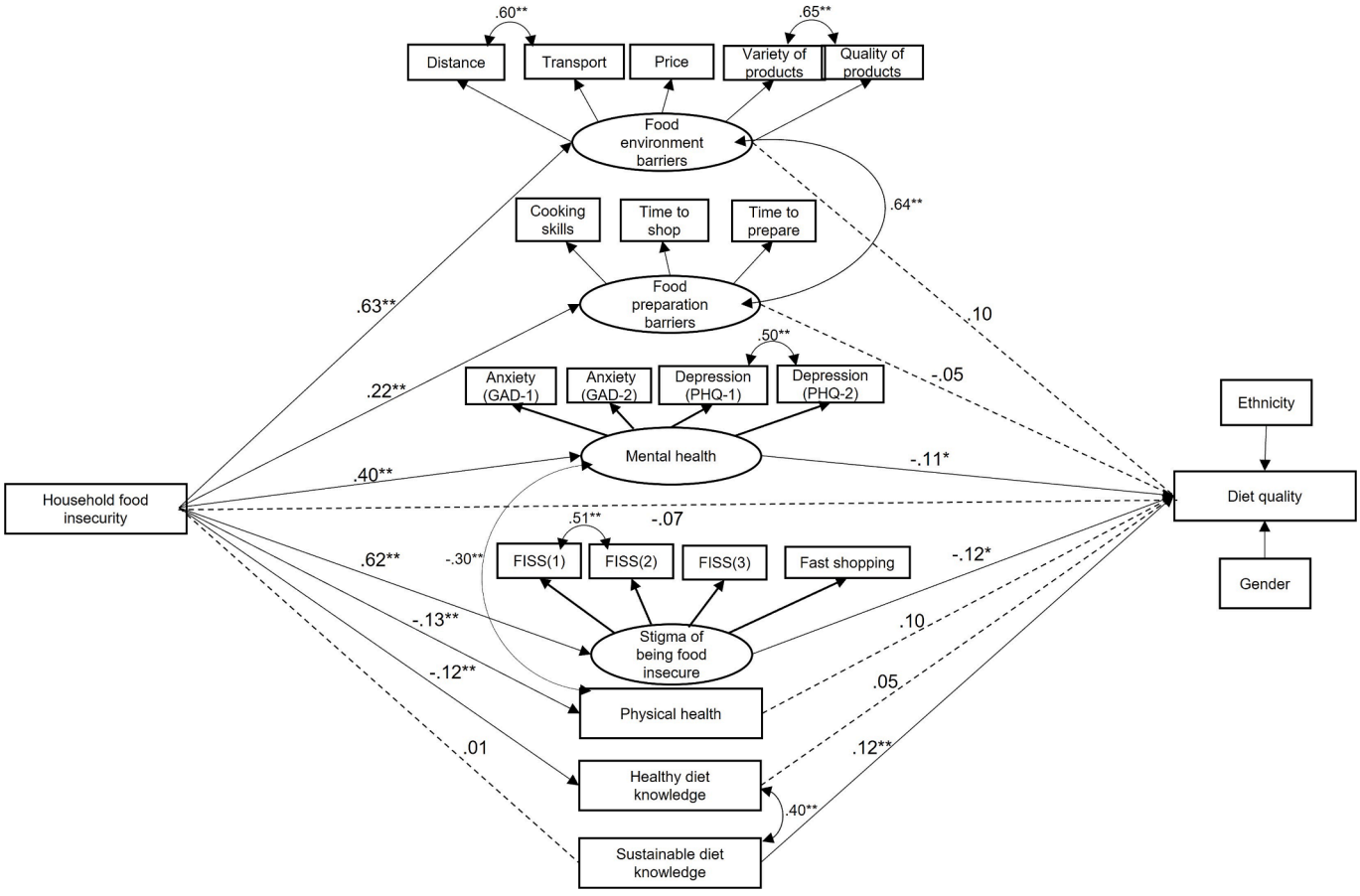

Fig. 1. Associations between food insecurity and diet quality via barriers to purchasing healthier, more environmentally sustainable food. Controlling for gender and ethnicity. Values are standardised regression coefficients, *p < 0.05, **p < 0.01. Rectangles represent observed variables and ovals represent latent variables. Curved arrows represent significant covariances, solid arrows represent statistically significant associations, and dashed arrows represent no statistically significant association. FISS = Food Insecurity Self-Stigma Scale. PHQ-2 and GAD-2 = Patient Health Questionnaire.

Table 1
Means (±*SD*) of participant characteristics (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:			
< £5,200			23 (3.9)
£5,200 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:			
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 app.

Table 2
Direct associations between variables (unstandardised regression coefficients).

Associations	B	*SE*	*p*	95 %CI
FI →Food environment barriers	0.125	0.013	**< 0.001**	0.100 to 0.150
FI →Food preparation barriers	0.059	0.014	**< 0.001**	0.032 to 0.085
FI →Healthy diet knowledge	−0.024	0.009	**0.007**	−0.042 to −0.007
FI →Physical health	−0.023	0.007	**0.001**	−0.038 to −0.009
FI →Environmentally sustainable diet knowledge	0.003	0.014	0.824	−0.024 to 0.030
FI →FI stigma	0.204	0.014	**< 0.001**	0.176 to 0.231
FI →Mental ill-health	0.133	0.013	**< 0.001**	0.108 to 0.158
Food environment barriers →Diet quality	0.210	0.243	0.388	−0.266 to 0.686
Food preparation barriers →Diet quality	−0.075	0.135	0.577	−0.339 to 0.189
Healthy diet knowledge →Diet quality	0.092	0.090	0.306	−0.084 to 0.268
Physical health →Diet quality	0.001	0.100	0.990	−0.194 to 0.196
Environmentally sustainable diet knowledge →Diet quality	0.159	0.053	**0.003**	0.055 to 0.263
FI stigma →Diet quality	−0.145	0.059	**0.013**	−0.260 to −0.030
Mental ill-health →Diet quality	−0.132	0.056	**0.020**	−0.242 to −0.021
FI →Diet quality (direct effect)	−0.027	0.034	0.431	−0.093 to 0.040
Gender[a] →Diet quality	−0.432	0.093	**< 0.001**	−0.615 to −0.249
Ethnicity[b] →Diet quality	−0.679	0.202	**0.001**	−1.076 to −0.282

Note. FI = Food insecurity. [a] Females (0), Males (1). [b] = Black, Asian, and Ethnic Minority (0), White (1).

Results for indirect effects are shown in Table 3. There was a significant negative indirect effect of experiences of FI on diet quality via experiences of stigma from being food insecure. Specifically, greater experiences of FI were associated with greater experiences of stigma from being insecure, which in turn was associated with lower diet quality. There was also a significant negative indirect effect of experiences of FI on diet quality via experiences of mental ill-health. Specifically, greater experiences of FI were associated with greater experiences of mental ill-health, which in turn was associated with lower diet quality. There were no other significant indirect effects. For the total effect, there was a significant negative association between greater experiences of FI and lower diet quality (B = −0.054, *SE* = 0.015, $p < 0.001$, 95 %CI = −0.084 to −0.024). Results remained the same when participants with a BMI that were above 29.50 kg/m^2 but below 30.0 kg/m^2 (n = 12) were excluded from analyses.

Table 3
Hypothesised indirect effects (unstandardised regression coefficients).

Associations	B	*SE*	*p*	95 %CI
FI →Food environment →Diet quality	0.026	0.030	0.386	−0.033 to 0.086
FI →Food preparation →Diet quality	−0.004	0.008	0.580	−0.020 to 0.011
FI →Healthy diet knowledge →Diet quality	−0.002	0.002	0.318	−0.007 to 0.002
FI →Physical health →Diet quality	−0.000	0.002	0.990	−0.005 to 0.005
FI →Environmentally sustainable diet knowledge →Diet quality	0.000	0.002	0.825	−0.004 to 0.005
FI →FI stigma →Diet quality	**−0.029**	**0.012**	**0.015**	**−0.053 to −0.006**
FI →Mental ill-health →Diet quality	**−0.018**	**0.008**	**0.023**	**−0.033 to −0.002**

Note. FI = Food insecurity.

Table 4
Ranked helpfulness of interventions for health.

In-store	Mean	Online	Mean
Price discount on healthy food products (*p*)	8.88	Offers/promotions on healthy products (*p*)	8.19
Personalised money off/ promotions (*p*)	6.95	Rewards on my supermarket loyalty card for buying healthy products (*p*)	6.36
Rewards on my supermarket loyalty card (*p*)	6.42	Increased stocking and availability of healthy food (*s*)	5.80
Increased stocking and availability of healthy food in supermarket (*s*)	5.62	'Healthier options' as a filter (*a*)	5.69
Healthy food samples (e.g., aisle demonstrations, taste samples) (*s*)	4.85	Suggestions for healthier swaps on items (*s*)	5.58
Nutrition inspiration in store (e.g., sample shopping lists, recipe suggestions) (*s*)	4.82	Nutrition education information (*a*)	4.90
A specific section/aisle just for healthy food (*s*)	4.67	Healthier option given when food is substituted (*s*)	4.82
Improved on pack information (*a*)	4.47	Improved healthy label/ logo for products (*a*)	4.79
Nutrition shelf labelling (shelf signs identifying healthy food) (*a*)	4.44	Recipe inspiration (*s*)	4.56
Place healthy food in aisle endcaps (end of the aisle) (*s*)	3.89	Calorie/Nutrition round up of my basket (*a*)	4.32

Note. Behaviour change levers as per Hartmann-Boyce et al. (2018): (*p*) = Price/ Incentivisation, (*s*) = Store environment, (*a*) = Awareness/ Education. Higher mean scores are indicative of more helpful interventions.

3.6. Helpfulness of interventions

For supporting purchases of healthy foods, Table 4 shows that helpfulness scores were highest for interventions based on price/ incentivisation (e.g. price discounts, offers/promotions on healthy products) and lowest for interventions based on awareness/education and changing the store environment (e.g. nutrition labelling, placement of healthy foods).

For supporting purchases of environmentally sustainable food, Table 5 show that helpfulness scores were highest for interventions based on price/incentivisation and changing the store environment (e.g. offers/promotions on environmentally sustainable food products, and for online shopping the availability of 'green' delivery slots (i.e., more fuel-efficient routes for grocery delivery)). Helpfulness scores were lowest for interventions based on awareness/education (e.g. providing environmentally sustainable information and carbon footprint round-ups of shopping basket).

Table 5
Ranked helpfulness of interventions for environmental sustainability.

In-store	Mean	Online	Mean
Offers/promotions on environmentally sustainable food products (*p*)	7.10	Availability of 'green' delivery slots (*s*)	7.83
Rewards on my supermarket loyalty card for buying environmentally sustainable/ eco-friendly products (*p*)	6.84	Rewards on my supermarket loyalty card for buying environmentally sustainable/ eco-friendly products (*p*)	6.45
Locally grown/produced (*s*)	6.82	Offers/promotions on environmentally sustainable/ eco-friendly products (*p*)	6.31
Refillable options (*s*)	6.31	Environmentally sustainable/ eco-friendly option for substitutes (*s*)	5.85
Removal of all plastic packaging (*s*)	6.11	Bagless delivery option (*s*)	5.78
A specific section/ aisle for environmentally sustainable/ eco-friendly options (*s*)	4.53	Environmentally sustainable/ eco-friendly swaps offered (*s*)	5.72
Removing plastic bags at checkout (*s*)	4.42	Environmentally sustainable/ eco-friendly options filter (*a*)	5.28
Has an ethical trading accreditation e.g., Fair Trade, Rainforest Alliance, Soil Association, Quality Meat Scotland etc. (*a*)	4.36	Environmentally sustainable education information (*a*)	4.15
Environmentally sustainable/ eco-friendly label/logo (*a*)	4.35	Environmentally sustainable/ eco-friendly label/logo (*a*)	4.13
Environmentally sustainable education information (*a*)	4.15	Carbon footprint information/ round up of my basket (*a*)	3.49

Note. Behaviour change levers as per Hartmann-Boyce et al. (2018): (*p*) = Price/ Incentivisation, (*s*) = Store environment, (*a*) = Awareness/ Education. Higher mean scores are indicative of more helpful interventions.

4. Discussion

4.1. Key findings

This study used a UK-based sample of people living with obesity (PLWO) to understand how variability in FI is associated with diet quality and the extent to which this association might be accounted for by barriers within the food environment and personal factors. Greater experiences of FI were found to be indirectly associated with lower diet quality via greater experiences of mental ill-health and stigma from being food insecure. Greater experiences of FI were directly associated with greater experience of barriers pertaining to the food environment (i.e., price, distance, transport, variety and quality of products) and food preparation (i.e., time to shop and prepare food, cooking skills), and also with physical ill-health, and lower self-rated knowledge of healthy diets. However, contrary to predictions, these factors did not account for the association between FI scores and diet quality.

A second aim was to explore which grocery store interventions PLWO thought would be most/least helpful to support them with purchasing healthier and more environmentally sustainable food. Participants ranked the most helpful interventions as those relating to the price/incentivisation behavioural change lever (e.g., price discounts) (Hartmann-Boyce et al., 2018), whereas the interventions ranked the least helpful were interventions relating to education and awareness behaviour change levers (e.g., nutrition labelling).

4.2. The association between food insecurity, diet quality, and barriers from the food environment and personal factors in people living with obesity

The current study provides a unique insight into the underpinning mechanisms that might operate when considering how greater

experiences of FI are associated with diet quality in PLWO. The indirect association between FI and lower diet quality via mental ill-health supports a wealth of literature regarding the psychosocial burden of obesity and its comorbidities. There is a well-established association between obesity and mental ill-health (Onyike, 2003), and between FI and mental ill-health (Fang et al., 2021). In PLWO, depression is linked with higher prevalence of emotional eating (Dakanalis et al., 2023), and FI has been indirectly associated with higher BMI via greater experiences of mental distress and use of food as a coping mechanism (Keenan et al., 2021). The novelty of our study lies in its focus on *variability* in FI within a sample *exclusively* of PLWO and our findings likely reflect the emotional toll of living with both obesity and experiencing greater FI, which may in turn promote dysregulated eating behaviours and consumption of unhealthier food. These findings have clinical implications in that weight management services might benefit from delivering tailored, holistic treatments (e.g. third-wave psychological therapies (Mueller et al., 2023)) that target mental health relating to both FI and obesity.

A further novel aspect of our study is its consideration of the anticipated stigma that is associated with greater experiences of FI. In this sample of PLWO, greater experiences of FI were indirectly associated with lower diet quality via greater experiences of stigma from being food insecure, and this suggests that stigma may be a key social determinant for health and dietary inequalities. According to The Stigma and Food Inequity Conceptual Framework (Earnshaw & Karpyn, 2020), poverty is a source of stigma that can manifest at the structural level (e.g., food policy, neighbourhood infrastructure) and the individual level (e.g., prejudice, discrimination). Structural manifestations may translate into limited access to healthy food, and individual manifestations of stigma may translate into psychological stress which may lead individuals to engage in less healthy eating behaviours (e.g., eating unhealthier food to 'cope', and potentially "fast shopping practices" to minimise shopping time (Gombert et al., 2017)). Our finding further supports the premise that experiences of distress and mental ill-health may play a role in the relationship between FI and diet quality for PLWO. However, it must be acknowledged that other forms of stigma (such as enacted, internalized, and stereotype threat) exist but were not included in the current study. Future research would benefit from exploring the role of different forms of stigma, other than anticipated stigma, on the relationship between FI scores and diet quality in PLWO.

Our findings provide evidence that PLWO who are experiencing greater FI perceive multiple barriers to purchasing healthy and sustainable food; these include barriers in the food environment (quantified in our analyses as a latent variable comprising distance, transport, price, variety and quality of products) as well as barriers pertaining to personal factors (e.g. food preparation barriers, knowledge, physical and mental health, stigma). Previous population-level evidence indicates that food insecure individuals experience multiple barriers to consuming healthy diets (Johnstone & Lonnie, 2024). However some of these identified barriers may be amplified for people living with both obesity and FI (e.g., double-burden of mental ill-health and stigma associated with both weight and FI status). Our findings thus highlight the potentially co-occurring, complex, contextual factors for PLWO and FI that are associated with purchasing a healthier diet and that need to be addressed by policy to support population level initiatives to create a fairer food environment for all.

While FI was directly associated with greater experiences of barriers from the food environment, contrary to predictions, food environment barriers were not directly associated with diet quality. Previous evidence suggests that, among individuals in lower socioeconomic groups, limited financial resources are associated with purchasing less-healthy food (Pechey & Monsivais, 2016). However, our results may instead be explained by how PLWO and greater experiences of FI are responding to and coping with food environment barriers. For example, Stone et al. (2024) found that, in PLWO, greater experiences of FI were associated with use of coping strategies to mitigate against the impact of the cost-of-living crisis, included using budgeting, supermarket offers, or cooking resourcefully (e.g., batch cooking). Therefore, in our sample, while price may be perceived as a barrier along with other factors in the food environment, some individuals may find ways to overcome this without impacting their diet.

4.3. Perceived most and least helpful grocery store interventions for people living with obesity

When asked to rank the helpfulness of different grocery store interventions for supporting healthy and environmentally sustainable food purchasing, the interventions ranked most helpful were predominantly based on price/ incentivisation (Hartmann-Boyce et al., 2018). Whilst this may seem contradictory to the above finding that food environment barriers (which included price) were not directly associated with diet quality, it is important to consider that participants were simply asked to rank the interventions they would find the *most helpful* in supporting purchase of healthy and environmentally sustainable food. Given that, as evidenced above, PLWO and FI use coping strategies to mitigate against the price of food (e.g., budgeting), and that use of these strategies is considered effortful (Hunter et al., 2025), it is conceivable that if price were removed as a barrier by grocery stores, this would remove the need for effortful coping strategies. Additionally, when participants ranked the least helpful grocery store interventions, these were predominantly based on education and awareness behaviour change levers. This finding complements our structural equation modelling findings where we found no evidence that food preparation barriers (e.g., cooking skills) or self-rated knowledge of heathy diets were directly associated with diet quality. These findings align with other evidence that PLWO and/or FI possess the knowledge and skills required to purchase and prepare a healthier diet (Hunter et al., 2025). Together, these findings speak to the outdated rhetoric regarding the personal responsibility attributed to obesity and food insecurity, indicating that a reorientation of the food system so that it supports individuals to access affordable healthier food is needed (Food Foundation, 2023).

4.4. Policy implications

Our study adopts a systemic approach to examine a broad range of barriers at an individual level and within the wider food environment, which consequently lays an important foundation with regards to how/ where policymakers could intervene to support the purchasing of healthier, more environmentally sustainable diets in PLWO who are experiencing greater FI. Our findings further underscore that current policy regarding the use of education/awareness to improve diets and reduce obesity (e.g., nutritional labelling) may be futile and ineffective for PLWO, and especially for those who concurrently live with FI. Upstream interventions to transform the food system to address diet and health inequalities are therefore urgently needed and these could include changes to pricing of healthier foods so that they are affordable for available household budgets. Our findings also suggest that policymakers should prioritise addressing stigma to support PLWO who are experiencing greater FI to purchase healthier and more environmentally sustainable food.

4.5. Strengths and limitations

Our study has several strengths, including pre-registered analyses and a large, well powered sample. However, limitations include the use of a limited set of questions to capture participants' experience of barriers. Physical health was measured in reference to a participants' daily functioning being limited because of a health problem or disability, however this only captured the perceived impact rather than the presence of a health condition per se. Indeed, this limitation may help to explain why we did not find evidence that physical ill-health was

associated with lower diet quality. Additionally, the current study was cross-sectional by design, meaning that evidence of association is not evidence of causality. Likewise, it is conceivable that the relationship between FI and experiences of food environment barriers is bi-directional whereby experiencing barriers in the food environment may cause or further exacerbate FI. Therefore, subsequent work using causal inference and randomised controlled trial designs is needed to extend the findings. Additionally, whilst not assessed in the current research, it is possible that other factors, such as poverty (Taylor et al., 2024), may underpin the associations reported. Despite efforts, the study sample were not ethnically diverse, and whilst we controlled for ethnicity in all models, it is important that future research captures the experiences of seldom heard groups, such as ethnic minorities, where experiences of FI and obesity are becoming increasingly common (Hernandez et al., 2017; Power et al., 2018). It is also important to note that measures of diet quality were self-rated, which may not accurately reflect participants' actual consumption. However, the diet quality measure used in the current study has been found to positively correlate with nutrient intake and is comparable to a longer 129-item questionnaire (Bingham et al., 1994).

5. Conclusion

The current study sought to elucidate and understand the barriers that might be encountered by PLWO with greater experiences of FI when shopping for healthier and more environmentally sustainable food in the grocery store. We found that mental ill-heath and FI stigma might begin to explain how greater experiences of FI are associated with lower diet quality in PLWO. Findings underscore the need for policymakers and healthcare professionals to consider how to address mental health and on how to minimise anticipated stigma experienced by this vulnerable group. Findings also support the need for policy development and grocery store interventions that focus on price and incentivisation to ensure that healthier and more environmentally sustainable foods are accessible for all.

CRediT authorship contribution statement

Rebecca A. Stone: Writing – original draft, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Paul Christiansen:** Writing – review & editing, Methodology, Formal analysis. **Alexandra M. Johnstone:** Writing – review & editing, Methodology, Funding acquisition. **Adrian Brown:** Writing – review & editing, Methodology, Conceptualization. **Flora Douglas:** Writing – review & editing, Methodology, Funding acquisition. **Charlotte A. Hardman:** Writing – review & editing, Supervision, Methodology, Funding acquisition, Formal analysis, Conceptualization.

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Declaration of competing interest

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Data availability

Data will be made available on request.

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