Appetite 212 (2025) 108007

Contents lists available at ScienceDirect

Appetite

journal homepage: www.elsevier.com/locate/appet

Understanding the association between household food insecurity and diet quality: The role of psychological distress, food choice motives and meal patterning

Rebecca Evans [a,*], Paul Christiansen [a], Melissa Bateson [b], Daniel Nettle [c,e], Gregory S. Keenan [d], Charlotte A. Hardman [a]

[a] Department of Psychology, University of Liverpool, L69 7ZA, UK
[b] Biosciences Institute, Newcastle University, NE2 4HH, UK
[c] Institut Jean Nicod, Département D'Etudes Cognitives, Ecole Normale Supérieure, Université PSL, EHESS, CNRS, 75005, Paris, France
[d] Department of Psychology, Liverpool John Moores University, L33AF, UK
[e] Department of Social Work, Education and Community Wellbeing, Northumbria University, Newcastle Upon Tyne, NE7 7XA, UK

A B S T R A C T

Household food insecurity – a lack of reliable access to food that is safe, nutritious, and sufficient for normal growth – is associated with physical and mental ill-health. In the UK and many countries worldwide, food insecurity has been exacerbated by the cost-of-living crisis and is a major public health concern. To identify potential points of intervention, it is important to understand how food insecurity is associated with individual-level factors, including behaviours and motivations towards food. This study therefore examined the associations between household food insecurity (HHFI), psychological distress, motives underlying food choices and meal patterning behaviours in a sample of UK adults (N = 594, mean age = 40.6 years, 96 % female). Key variables were quantified using questionnaires and structural equation modelling was used to determine the associations between them. HHFI was directly associated with higher food choice motives based on price, but not directly with other food choice motives. HHFI was indirectly associated with poorer diet quality via price motives. There were also significant serial indirect associations between HHFI and diet quality via distress and food choice motives. Specifically, HHFI was associated with greater distress, which in turn was associated with higher convenience motives and lower health motives, which were then both associated with poorer diet quality. Exploratory analyses indicated that HHFI was directly associated with lower meal frequency, and this in turn was associated with poorer diet quality. Findings demonstrate how experiences of general psychological distress, certain food choice motives, and meal frequency may play a role in the relationship between food insecurity and diet quality.

1. Introduction

Household food insecurity (HHFI) refers to having a lack of reliable access to food that is safe, nutritious, and sufficient for normal growth and development (Food and Agriculture Organization of the United Nations, 2021). HHFI is a major public health concern because of its association with multiple adverse mental and physical health outcomes, including obesity and its associated comorbidities (e.g., cardiovascular disease, diabetes) (Bergmans et al., 2019; Nettle et al., 2017; Yau et al., 2020). In 2023, approximately 10 % of UK households were food insecure (low or very low food security) – a 2 % increase from 2020 (Department for Environment, Food & Rural Affairs, 2024). Alongside this, 7 % of UK households accessed food aid, such as from a food bank or social supermarket (Bull et al., 2023). Rates of food insecurity had been a concern prior to the Covid-19 pandemic, and income disruptions from early 2020 and the subsequent increases in living costs have only exacerbated this further, leading to a doubling in food aid requirements from 2017/18 to 2022/23 (Bull et al., 2023; From Purse to Plate: Implications of the Cost of Living Crisis on Health, 2023). Importantly, many who are food insecure do not use food banks, and therefore food bank usage is likely an underestimate of population-level food insecurity (Loopstra & Tarasuk, 2015).

Food banks are designed to provide short-term relief in times of crisis, and are therefore not a long-term solution to food insecurity (Taylor et al., 2024). According to market/government failure theory, market and government failures create conditions under which food insecurity and food bank use proliferate (Salamon, 1987). Market failure happens due to a lack of efficient provision of public goods. Types of market failure include unemployment, underemployment, and income inequality. Government failure is characterized as the inability of

This article is part of a special issue entitled: Food insecurity & obesity published in Appetite.

* Corresponding author.
E-mail address: r.k.evans@liverpool.ac.uk (R. Evans).

https://doi.org/10.1016/j.appet.2025.108007
Received 20 December 2024; Received in revised form 13 March 2025; Accepted 5 April 2025
Available online 12 April 2025

government to meet this unsatisfied demand (e.g., through policy changes). Consequently, individuals rely on the voluntary sector (e.g., food banks) to obtain goods which are not provided sufficiently through the market or government. A recent systematic review confirmed that factors associated with food bank use include unemployment and low income, which can be traced back to market and government failure, as opposed to individual-level behaviour and motivation (Taylor et al., 2024). Nevertheless, it is important to understand how individuals behave within these environmental constraints to inform effective interventions and systemic, upstream policy change.

A considerable body of evidence from non-human animals – which has more recently been extended to humans - has shown that fat reserves increase under conditions of limited and unpredictable access to food (Epstein et al., 2024; Nettle et al., 2017). According to the Insurance Hypothesis (Nettle et al., 2017), this greater fat storage is an adaptive strategy because it protects the organism against starvation. However, in westernized "obesogenic" environments where (i) energy-dense, nutrient-poor food is more accessible, affordable, and heavily marketed than healthier options and (ii) physical activity is limited by car-centric infrastructure, sedentary jobs, and time constraints, it increases risk of developing obesity (Allen, 2023; Eskandari et al., 2022). There is a well-established relationship between food insecurity and obesity in women, but the specific biological and behavioural mechanisms which account for it are not well understood (Bateson & Pepper, 2023; Kowaleski-Jones et al., 2019). They may include shifts in diet composition under conditions of food insecurity. Indeed, persons on low incomes tend to substitute more expensive, healthy foods (i.e. nutrient-rich options such as fruits, vegetables, fish) with cheaper unhealthy foods (i.e., energy-dense but nutrient-poor options) (Jones et al., 2018; Morales & Berkowitz, 2016).

On an individual-level, food choice motives may play a role in the association between food insecurity and lower diet quality. The Food Choice Questionnaire (Steptoe et al., 1995) quantifies a range of factors that influence people's dietary choices, including convenience, price, health, weight control, and ethical concern. Given that not having enough money to buy food is a key component of HHFI, and food insecure individuals mostly have a lower income (Bull et al., 2023; Drewnowski, 2022; The Food Foundation, 2025), it makes sense that higher HHFI would be associated with food choice motives based on price. Furthermore, given that healthier foods tend to be relatively more expensive than less healthy foods (The Food Foundation, 2025), people may have to make trade-offs between price and health. Indeed, the high and increasing price of food is the most frequently cited barrier to adopting healthier diets (Drewnowski, 2022). HHFI may therefore be associated with lower food choice motives based on health and weight control. This is supported by previous findings that lower socioeconomic position is associated with being less motivated by health and weight control when making food choices (Robinson et al., 2022). It is important to acknowledge a wealth of qualitative evidence showing that people living on low incomes and with food insecurity are often knowledgeable about healthy eating, and would like to be able to consume foods that are healthy and ethically produced (e.g., in an environmental and politically conscious way) (A. Evans et al., 2015; Hunter et al., 2025; Puddephatt et al., 2020). However, their food choices are highly constrained by limited income which makes price and affordability the focus of food choices, and other motives such as health are deprioritized (Hunter et al., 2025; Puddephatt et al., 2020). Moreover, people living with food insecurity are often "time-poor" (i.e., have limited time to plan, shop for and prepare healthy meals) and may also lack access to cooking facilities (or avoid using them to reduce energy costs), which may increase choices of convenience foods (Hunter et al., 2025; Puddephatt et al., 2020; Stone et al., 2025).

Negative affect may also play a mediating role in the relationship between food insecurity, food choice motives and diet. For example, food insecurity is associated with general psychological distress (stress, anxiety, depression), and distress in turn is associated with eating as a coping mechanism and higher BMI (Keenan et al., 2021). Perceived stress might also bias people's decisions towards choosing foods that are low-cost and convenient as a stress-reduction strategy (Shen et al., 2020); for example when people are stressed they may lack the psychological resources needed to prepare and cook food from scratch (Hunter et al., 2025). Stress is associated with weight gain and also increases appetite for high-calorie, rewarding foods (Sominsky & Spencer, 2014). In a systematic review and meta-analysis of studies in healthy adults, stress was associated with increased consumption of unhealthy foods and decreased consumption of healthy foods (Hill et al., 2022). This may be because stress biases choices towards less healthy foods and away from foods that are healthy, beneficial for weight management, and potentially those that are ethically produced, leading to poorer overall diet quality. A recent qualitative study with food bank clients found initial support for this effect (Puddephatt et al., 2020) but evidence from larger quantitative studies is currently lacking.

In existing research, HHFI is commonly operationalized using quantitative tools such as the United States Department of Agriculture (USDA) Household Food Security Survey Module (Economic Research Service, USDA, 2012) and the Food Insecurity Experience Scale (FIES) (Cafiero et al., 2018). These scales primarily ask about not having enough money to afford sufficient food for the household. However, they do not provide quantitative information on *how* people are eating and their patterns of food intake (i.e., timing and frequency of eating occasions, portion sizes). It is important to capture these aspects of eating because, in the general population, meal frequency (defined based on energy contribution and timing) is positively associated with a healthy diet (Murakami & Livingstone, 2016). Moreover, research has found that, compared to food-secure women, food-insecure women had more variable time gaps between eating, and more variable day-to-day (i) hunger, (ii) time of first consumption, and (iii) number of eating occasions (Neal et al., 2025; Nettle & Bateson, 2019; Shinwell et al., 2022). Food-insecure women also ate a smaller and less variable number of distinct foods per eating occasion (Nettle & Bateson, 2019). However, overeating has also been observed among food-insecure individuals in a controlled laboratory setting when food access was unlimited (Stinson et al., 2018). This may suggest that unpredictable food availability could lead to higher energy intake (e.g., via larger meals) in food-insecure individuals during times of greater food access (e.g., after receiving food aid).

The current study was a cross-sectional observational study of UK adults (mostly women). We aimed to understand the associations between HHFI, psychological distress, motives underlying food choices, meal patterning behaviours and diet quality. All hypotheses were pre-registered on AsPredicted.org (https://aspredicted.org/blind.php?x=j8ui5j). We predicted that:

1. HHFI would be associated with higher food choice motives based on convenience and price (as measured by the Food Choice Questionnaire) which, in turn, would be associated with poorer diet quality.
2. HHFI would be associated with lower food choice motives based on health, weight control and ethical concern (as measured by the Food Choice Questionnaire) which, in turn, would be associated with poorer diet quality.
3. Psychological distress (depression, anxiety, stress) will mediate the above associations between HHFI and food choice motives.

We also conducted pre-registered exploratory analyses to determine the nature of associations between HHFI and eating patterns. Based on previous findings, we predicted that HHFI would be associated with less frequent meals, more frequent snacking, and more variable time gaps between eating (Nettle & Bateson, 2019), and tentatively with larger habitual meal sizes (Stinson et al., 2018).

2. Method

2.1. Participants

Adult participants were recruited from the city of Liverpool and the wider North West region of the United Kingdom (UK). Specific inclusion criteria were: 18-65-years-old, currently living in the Liverpool/Merseyside area, and fluent in English. Participants were recruited via paid advertisements posted on social media (e.g., Facebook). Consistent with Keenan et al. (Keenan et al., 2021), our recruitment plan involved recruiting participants during an on-site visit at a food bank in Liverpool with the aim to ensure sufficient variability in levels of HHFI. Uptake was lower than anticipated and this resulted in N = 3 participants. However, variability in participant HHFI levels was achieved regardless (40 % experiencing some form of food insecurity). As reimbursement for their time and effort to complete the questionnaire measures, participants could opt to be entered into a prize draw to win an Amazon voucher (1 x £100, 1 x £50, 2 x £25 prizes). Based on the protocols described by MacCallum et al. (MacCallum et al., 1996) and Kim (Kim, 2005), a power analysis for the hypothesized structural model (DF = 30), indicated that 406 participants were needed for 90 % power at alpha 0.05, for an acceptable RMSEA ($\leq$0.08). To account for a dropout rate of 20 %, we aimed to recruit a minimum of 488 participants. Ethical approval was obtained from the University of Liverpool ethics committee (reference number: IPHS-1516-LB-174), and informed consent was obtained from all participants before they took part in the study.

2.1.1. Measures

McDonald's Omega (ωt) was calculated to assess the internal reliability of relevant measures. Internal reliability was deemed acceptable at ωt $\geq$ 0.7 (McDonald, 2013). The full survey is accessible at https://osf.io/fu94n/.

Household food insecurity (HHFI). The USDA Household Food Insecurity Survey Module (Economic Research Service, USDA, 2012) measures the difficulties individuals and household members experienced in the previous 12 months in accessing sufficient nutritionally adequate food. Participants answered questions from modules 1, 2, and 3, amounting to 10 questions in total (i.e., the 10-item Adult Food Security Survey Module). Responses of "sometimes true", "often true", "some months but not every month", "almost every month" and "yes" were coded as 1, and all other answers were coded as 0. The sum indicates household food insecurity with scores ranging from 0 (high food security) to 10 (low food security). Individuals can be categorised as high (0), marginal (1–2), low (3–5), and very low (6–10) food security.

Psychological distress. The 21-item Depression, Anxiety & Stress Scale (DASS) (Henry & Crawford, 2005) is divided into three subscales, each containing 7 items. Response options were 0 = Never, 1 = sometimes, 2 = often, 3 = almost always, considering how much the statement applied over the past week. The sum of the three scales indicates level of distress, with a higher score indicating greater levels of psychological distress. For the current data, ωt = 0.96.

Food choice motives. The Food Choice Questionnaire (Steptoe et al., 1995) is a 36-item questionnaire which measures motives underlying people's food choices (9 sub-scales; Convenience, Price, Health, Mood, Sensory Appeal, Natural Content, Weight Control, Familiarity, Ethical Concern). Convenience, Price, Health, Weight Control and Ethical Concern were measured in this study in line with the hypotheses. Response options were 1 = Not at all important, 2 = A little important, 3 = Moderately important, 4 = Very important. Scores for each subscale were averaged, with a higher score indicating greater motive. For the current data, convenience ωt = 0.95, price ωt = 0.84, health ωt = 0.89, weight control ωt = 0.82, and ethical concern ωt = 0.77.

Diet quality. A food frequency questionnaire (FFQ) was used and adapted from the South Yorkshire Healthy survey. This measure has previously been used by Keenan et al. (Keenan et al., 2021) and Evans et al. (R. Evans et al., 2023). Participants rated the frequency of consuming unhealthy (e.g. crisps, fried chicken, processed meats) and healthy foods (e.g., fruit, vegetables, oily fish) (1 = "More than once a day", 2 = "Once a day", 3 = 4–6 times a week", 4 = "2–3 times a week", 5 = "Once a month", 6 = "Less than once a week", 7 = "Never"). Foods were categorised as healthy and unhealthy according to established relationships between their intake and health outcomes derived from extensive nutritional research (Roberts et al., 2024). Responses for healthy foods were reverse-scored, and total scores were summed and averaged, with lower values representing poorer diet quality. For the current data, ωt = 0.7.

Eating patterns. We developed a novel measure for the purpose of this study, to quantify meal frequency, snack frequency, variability in time gaps between eating, and habitual meal size.

Meal frequency was measured by asking how often participants typically eat breakfast, lunch, and dinner (evening meal). Response options were 1 = Never, 2 = Rarely, 3 = Sometimes, 4 = Nearly always, 5 = Always. The sum of scores pertaining to each meal occasion indicates the level of meal frequency with scores ranging from 3 (low meal frequency) to 15 (high meal frequency).

Snack frequency was measured as how often snacks/drinks were consumed outside of a main meal as a single snack (i) during the week and (ii) at the weekend; "How many times do you eat snacks and/or consume drinks (including tea, coffee) per day? Consider every time you eat or drink something outside of a main meal as a single snack". Response options were 1 = 1–2 snacks a day, 2 = 3–4 snacks a day, 3 – 5-6 snacks a day, 4 = more than 6 snacks a day. The sum indicates the frequency of snack consumption with scores ranging from 2 (low snacking) to 8 (high snacking).

Variability in time gaps between eating was measured by asking participants to choose a weekday and a weekend day over the past week and report each of the meals and snacks they ate along with the time which they were consumed. The mean time gap and standard deviation in time gap were calculated across the two days, as in Nettle et al. (Nettle & Bateson, 2019). A higher standard deviation indicates greater variability in time gaps between eating and was used as the outcome for this measure in the analyses.

Habitual portion size was measured by showing participants images of four foods at a standard portion size, consisting of two meals (pasta in tomato sauce, porridge), and two snacks (crisps, chocolate cake with ice cream). Foods were presented on a white plate on a plain worktop. Images were obtained from an image bank created and maintained by a researcher in our University research group to be used in portion size studies. Participants were prompted "Imagine you are going to eat the above food for [lunch/breakfast/a snack]. Please indicate what your ideal portion would be." and responded on a slider scale with anchor endpoints from 0 = "A lot smaller" to 100 = "A lot bigger". Scores were averaged across the four foods.

Demographics. Participants self-reported height in metres and weight in kilograms (for calculation of BMI). Additional demographic information collected were gender, age, ethnic group, highest education level, employment status, living situation, and household income. For the income measure, participants reported their annual household pre-tax income on a 9-point scale ranging from less than £5200 a year (less than £100 a week) to £78 000 a year or more (£1500 a week or more).

2.2. Procedure

The survey was administered online using Qualtrics. Participants accessed the questionnaire via a web link. Participants recruited at the foodbanks were provided with an electronic tablet connected to the internet or given paper copies of the questionnaire depending on their preferred completion method. Participants first read an information sheet and provided written informed consent. They were then asked to provide demographic information, height and body weight. The study questionnaires were then presented in a randomised order. Following

completion of the questionnaires, participants were debriefed and given the option to be entered into the prize draw to win Amazon vouchers.

2.2.1. Statistical analysis

The analyses were pre-registered on AsPredicted.org (https://aspredicted.org/blind.php?x=j8ui5j). Analyses were run using R. Structural equation modelling was conducted using the Lavaan package (Rosseel, 2012). The research data is accessible at https://osf.io/fu94n/.

Primary analyses. To test hypotheses 1–3, we used structural equation modelling (SEM). This allowed comprehensive exploration of direct and indirect associations between household food insecurity (HHFI) and diet quality, when mediated by stress and each of the five food choice motives (i.e. price, convenience, health, weight control ethical concern). A confirmatory factor analysis was performed for the psychological distress variable, which was made up of 21 items. As this variable and the other variables in the structural model used ordinal scales, the confirmatory factor analysis and structural model were fitted using a maximum likelihood with robust standard errors (29). Fit was assessed using the normed X^2 (X^2/df) with values below three or five indicating a good fit or acceptable fit respectively, and the comparative fit index (CFI) with values deemed as acceptable at >0.90 and good at >0.95. The root mean square error of approximation (RMSEA) parsimony adjusted measure was also used, with values between 0.06 and 0.08 considered acceptable, and <0.06 considered a good fit. Finally, the standardised root mean residual (SRMR) absolute fit index was calculated, with values < 0.08 considered a good fit (30).

Exploratory analyses. We conducted a series of regression analyses on the eating patterns variables. HHFI, age, and gender (eating patterns can vary by age and gender (Jacob & Panwar, 2023)) were entered as predictors in each model. Outcome variables were (i) meal frequency, (ii) snack frequency, (iii) variability in time gaps between eating and (iv) habitual meal size. We planned to follow up any significant associations using mediation models with HHFI as the independent variable, diet quality as the dependent variable, and the relevant eating patterns variable as the mediator.

3. Results

The final sample consisted of 594 participants. Approximately 96 % of participants were female, 98 % were white, and 40 % had children living with them. Forty-seven percent were employed full-time, 23 % part-time, 10 % students, 6 % unable to work due to health or disability, 5 % retired, 4 % housewife/husband, 2 % unemployed and looking for work, 1.5 % unemployed and not looking for work, and 1 % in voluntary employment. Regarding HHFI, 60 % were experiencing high, 15 % marginal, 11 % low, and 14 % very low food security. See Table 1 for further descriptive characteristics of the sample.

Table 1
Descriptive characteristics of the sample.

Variable	Mean	SD	Range
Age (y)	40.6	13.0	18–68
Height (m)	1.65	0.08	1.32–1.93
Weight (kg)	79.1	21.9	38.1–171.5
BMI (kg/m^2)	28.95	7.73	12.4–65.3
Annual total household income [a]	5.92	2.16	1–9
Highest educational qualification [b]	5.12	1.34	1–8
Household food insecurity[c]	1.7	2.72	0–10
Psychological distress	19.56	13.00	0–59
Convenience motives	2.84	0.70	1–4
Ethical concern motives	2.18	0.83	1–4
Health motives	2.73	0.69	1–4
Price motives	2.97	0.73	1–4
Weight control motives	2.51	0.83	1–4
Diet quality	35.82	6.17	18–53
Snack frequency	3.85	1.77	2–8
Meal frequency	12.19	2.30	5–15
Eating time gap variability (minutes)	73.76	41.30	0–502.29
Habitual portion size	54.24	14.66	4–100

[a] 9–point scale: 1 = < £5 200, 2 = £5200 - £10 399, 3 = 10 400 - £15 599, 4 = £15 600 - £20 799, 5 = £20 800 - £25 999, 6 = £26 000 - £36 399, 7 = £36 400 - £51 999, 8 = £52 000 - £77 999, 9 = >£78 000.

[b] 8-point scale: 1 = none, 2 = GCSE grade D or below, 3 = GCSE grade C or above, 4 = A-level or equivalent, 5 = university degree or equivalent, 6 = postgraduate qualification or equivalent, 7 = Masters or equivalent, 8 = PHD or equivalent.

[c] categorised as high (0), marginal (1–2), low (3–5), and very low (6–10) food security.

3.1. Primary analyses

3.1.1. Confirmatory factor analysis

A confirmatory factor analysis was conducted for the psychological distress variable. Covariances were added between items from the same subscale (e.g., depression, anxiety, stress) where modification indices were high (≥40). The confirmatory factor analysis was an acceptable-good fit for the data X^2/df = 3.63, CFI = 0.93, RMSEA = 0.07, SRMR = 0.04).

3.1.2. Structural model

Structural equation modelling was used to examine associations between HHFI, psychological distress, food choice motives, and diet quality (see Fig. 1). Covariances were added between each of the food choice motives in response to high modification indices (≥40). Theoretically, this is appropriate, as we would expect food choice motives to be related (e.g., healthy foods are usually less convenient to purchase). For ease of interpretation, the values in Fig. 1 are standardized (β) coefficients, whereas those in Table 2 are unstandardised.

The final model was an acceptable-good fit for the data (X^2/df = 2.74, CFI = 0.93, RMSEA = 0.06, SRMR = 0.04).

3.1.3. The association between HHFI and diet quality

There was a significant total association between HHFI and diet quality (B = −0.290, SE = 0.106, p = .006, CI -0.498 to −0.082). Higher levels of food insecurity were associated with poorer diet quality, considering both direct and indirect associations. HHFI was not directly associated with diet quality (see Table 2). This is likely due to the association between food insecurity and diet quality being accounted for by the significant indirect paths (see Table 3).

3.1.4. The association between HHFI and diet quality via food choice motives

As can be seen in Table 2, HHFI was directly associated with greater food choice motives based on price. However, there were no direct associations between HHFI and any other food choice motives.

As can be seen in Table 3, there was a significant indirect association between HHFI and diet quality via price motives. HHFI was associated with greater price motives, which in turn was associated with poorer diet quality.

3.1.5. The association between HHFI and diet quality via distress and food choice motives

HHFI was directly associated with higher distress, which in turn was directly associated with some food choice motives. Specifically, higher distress was associated with higher convenience, price, and weight control motives, and lower health motives, but was not directly associated with ethical motives. Food choice motives were then in turn associated with diet quality. Convenience and price motives were associated with poorer diet quality, while health and weight control were associated with better diet quality.

As can be seen in Table 3, there were significant indirect associations between HHFI and diet quality via (i) distress and health motives and (ii) distress and convenience motives. HHFI was associated with higher distress, which was associated with lower health motives, which was in

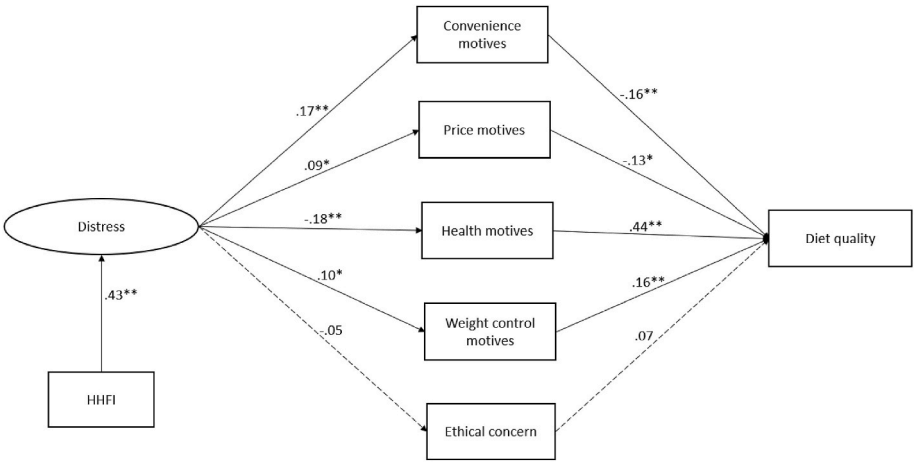

Fig. 1. The association between household food insecurity and diet quality via psychological distress and food choice motives
*p < .05, **p < .001. Values are standardized regression coefficients. For ease of interpretation, not all direct associations are shown in the figure (but are presented in Table 2), and error terms and covariances are not visually represented. A dashed line represents a non-significant path.

Table 2
Direct associations from the model.

Association	B (SE)	p	95 % CI
HHFI > Diet	0.008 (0.111)	0.942	−0.219 to 0.226
HHFI > Distress	0.063 (0.009)	<0.001	0.046 to 0.081
HHFI > Convenience	0.021 (0.011)	0.066	−0.001 to 0.044
HHFI > Price	0.105 (0.011)	<0.001	0.084 to 0.126
HHFI > Health	−0.0111 (0.012)	0.354	−0.034 to 0.012
HHFI > Weight	−0.010 (0.014)	0.443	−0.037 to 0.016
HHFI > Ethical	−0.000 (0.014)	0.972	−0.028 to 0.027
Distress > Convenience	0.301 (0.083)	<0.001	0.138 to 0.464
Distress > Price	0.162 (0.078)	0.037	0.009 to 0.315
Distress > Health	−0.307 (0.081)	<0.001	−0.466 to −0.148
Distress > Weight	0.203 (0.097)	0.037	0.009 to 0.315
Distress > Ethical	−0.112 (0.093)	0.229	−0.295 to 0.070
Convenience > Diet	−1.426 (0.326)	<0.001	−2.064 to −0.788
Price > Diet	−1.048 (0.396)	0.008	−1.824 to −0.273
Health > Diet	3.930 (0.402)	<0.001	3.142 to 4.719
Weight > Diet	1.178 (0.294)	<0.001	0.601 to 1.755
Ethical > Diet	0.538 (0.286)	0.0604	−0.02 to 1.097

Table 3
Hypothesized indirect associations.

Association	B (SE)	p	95 % CI
HHFI > Health > Diet	−0.042 (0.046)	0.352	−0.132 to 0.047
HHFI > Ethical > Diet	−0.000 (0.008)	0.972	−0.015 to 0.015
HHFI > Price > Diet	−0.110 (0.040)	0.006	−0.189 to −0.032
HHFI > Convenience > Diet	−0.030 (0.018)	0.085	−0.064 to 0.004
HHFI > Weight > Diet	−0.012 (0.016)	0.443	−0.044 to 0.019
HHFI > Distress > Health > Diet	−0.076 (0.022)	<0.001	−0.120 to −0.033
HHFI > Distress > Ethical > Diet	−0.004 (0.004)	0.325	−0.011 to 0.004
HHFI > Distress > Price > Diet	−0.011 (0.007)	0.106	−0.024 to 0.002
HHFI > Distress > Convenience > Diet	−0.027 (0.010)	0.006	−0.047 to −0.008
HHFI > Distress > Weight > Diet	0.015 (0.008)	0.063	−0.001 to 0.031

turn associated with poorer diet quality. Concurrently, HHFI was associated with higher distress, which was associated with higher convenience motives, and in turn this was associated with poorer diet quality.

3.2. Exploratory analyses

Linear regression analyses were used to examine associations between HHFI and (i) meal frequency, (ii) snack frequency, (iii) eating time gap variability, and (iv) habitual portion size. Age and gender were also included as predictors in each model.

3.2.1. HHFI and meal frequency

The overall regression model was significant, explaining approximately 21 % of variance in meal frequency, adjusted $R^2 = 0.21$, $F(3, 589) = 53.39$, $p < .001$. HHFI was associated with lower meal frequency ($B = -0.371$, $SE = 0.031$, $p < .001$, CI -0.432 to −0.309). Older age was also associated with higher meal frequency ($B = 0.017$, $SE = 0.006$, $p = .009$, CI 0.004 to 0.030).

This significant association was followed up with a mediation analysis which included HHFI as the independent variable, meal regularity as the mediator, and diet quality as the dependent variable. There was a significant indirect association between HHFI and diet quality through meal frequency ($B = -0.202$, $SE = 0.049$, $p < .001$, CI -0.298 to −0.106). HHFI was associated with lower meal frequency ($B = -0.383$, $SE = 0.031$, $p < .001$, CI -0.443 to −0.322), and this in turn was associated with poorer diet quality ($B = 0.528$, $SE = 0.120$, $p < .001$, CI 0.292 to 0.764).

3.2.2. HHFI and snack frequency

The overall regression model was non-significant (adjusted $R^2 = 0.001$, $F(3, 589) = 1.29$, $p = .279$). HHFI was not significantly associated with snack frequency ($B = -0.021$, $SE = 0.027$, $p = .432$, CI -0.075 to 0.032).

3.2.3. HHFI and eating time gap variability

The overall regression model was non-significant (adjusted $R^2 = 0.004$, $F(3, 589) = 1.70$, $p = .166$). HHFI was not significantly associated with eating time gap variability ($B = 1.288$, $SE = 0.666$, $p = .054$, CI -0.021 to 2.597).

3.2.4. HHFI and habitual portion size

The overall regression model was significant, explaining approximately 3 % of variance in habitual portion size, adjusted $R^2 = 0.03$, $F(3, 589) = 7.71$, $p < .001$). However, HHFI was not significantly associated

with habitual portion size (B = −0.243, SE = 0.220, p = .270, CI -0.674 to 0.189). The only significant predictor of habitual portion size was age, with younger age being associated with larger portion size (B = −0.220, SE = 0.046, p < .001, CI -0.310 to −0.130).

4. Discussion

The current study tested whether distress and food choice motives were mediating variables in explaining the association between food insecurity and diet quality. HHFI was indirectly associated with diet quality via only one of the food choice motives – price (higher HHFI was associated with greater price motives, which in turn were associated with poorer diet quality). HHFI was also indirectly associated with diet quality via a serial pathway that included distress and certain food choice motives. Specifically, HHFI was positively associated with distress; distress was associated with lower health/higher convenience motives; these motives were in turn associated with poorer diet quality.

Our finding that HHFI was indirectly associated with poorer diet quality via greater price motives complements broader evidence highlighting the importance of food affordability (The Food Foundation, 2025). Individuals experiencing HHFI are constrained by limited income, meaning that food choices are motivated by price, and this likely compromises health as healthier foods tend to be relatively more expensive than less healthy foods (Hunter et al., 2025; Puddephatt et al., 2020; The Food Foundation, 2025). Our findings also highlight the role of psychological distress and its associations with certain food choice motives that may also help to explain the relationship between HHFI and poorer diet quality. Specifically, we found evidence to suggest that being food-insecure, and the associated psychological distress, may bias people's decisions towards convenient food, and away from food that is healthy, which is consistent with qualitative findings from food bank clients (Puddephatt et al., 2020). Other research suggests that individuals may seek to alleviate distress by using maladaptive coping behaviours, such as consuming rewarding, highly palatable energy-dense foods (Laitinen et al., 2002), which are typically more convenient (i.e., easy to access) than healthy foods, particularly in the neighborhoods of those experiencing food insecurity (Freedman & Bell, 2009). Our findings highlight the importance of ensuring that healthy food is a convenient affordable choice, particularly for those who are food-insecure and experiencing psychological distress.

Recent research shows that food insecurity is related to greater barriers to consuming a healthy diet, pertaining to both the food environment (e.g., price, distance, transport, variety/quality of foods) and food preparation (time to shop and prepare food, cooking skills) (Stone et al., 2025). Indeed, currently, more than a million UK residents live in 'food deserts' – dynamic areas where people have difficulty accessing affordable, healthy food due to shifting factors such as economic conditions, reliable transport, and food retailer presence. (Karpyn et al., 2019). According to the Priority Places for Food Index, Liverpool (where the current study was conducted) currently has one of the largest numbers (relative to other UK local authorities) of 'highest priority' neighborhoods for food insecurity risk (Consumer Data Research Centre, 2022). The Index is based on food accessibility (supermarket, non-supermarket, delivery), sociodemographic barriers, need for family support (e.g., due to low income, distance to nearest food bank), and fuel poverty (Consumer Data Research Centre, 2022). Experiencing distress (stress, anxiety, depression) may exacerbate these barriers, for example people may have less energy to shop and prepare food from scratch (Puddephatt et al., 2020). Research has previously demonstrated that context-related factors (e.g., high cost and accessibility of healthy food) as opposed to personal factors (e.g., lack of efficiency in healthy lifestyle) are the greatest barriers to healthy eating in disadvantaged adults in the UK (Briazu et al., 2024). This highlights the need for systemic, upstream government policy change that makes healthy food easy to access on (i) a structural level (by ensuring grocery stores are walkable/accessible via affordable public transport) and (ii) an economic level (by addressing the underlying market failure and wider economic factors contributing to food insecurity) (Swinburn et al., 2011).

We also examined exploratory associations between HHFI and eating patterns. HHFI was found to be associated with lower meal frequency, and this in turn was associated with poorer diet quality. No significant associations were identified between HHFI, snack frequency, eating time gap variability, and habitual portion size. Our finding that HHFI was associated with lower meal frequency, and in turn poorer diet quality, is consistent with Nettle et al. (Nettle & Bateson, 2019). Reduced meal frequency in those experiencing HHFI may reflect an increased likelihood of chaotic home and work lives, or simply that food insecure individuals deliberately skip meals to save money (Neal et al., 2025). It is possible that lower meal frequency, as measured in this study as less frequent intake of three main meals (breakfast, lunch, dinner), provides less opportunity for eating a variety of foods that contribute to a healthy diet. For example, based on cultural norms around mealtime foods, skipping dinner may reduce opportunity for vegetable consumption (Myhre et al., 2015). Indeed, other research has found that food-insecure individuals consume a less diverse diet, which is driven by fewer distinct foods per meal, more carbohydrates, and less fiber and protein (Nettle & Bateson, 2019; Shinwell et al., 2022). One possible strategy could be to support community food spaces (e.g., pantries, social supermarkets, community kitchens) and initiatives (e.g., healthy start vouchers) to increase meal frequency and variety for those experiencing HHFI (Bull et al., 2023). A limitation of our meal frequency measure is it does not provide specificity about which meals were less frequent (i.e., an individual that "sometimes" consumes all three meals, and someone who "always" consumes breakfast but "rarely" lunch or dinner would receive the same score). A measure that provides further insight in this regard would help with tailoring more targeted interventions. Our finding that HHFI was not significantly associated with greater variability in eating time gaps is somewhat contradictory to existing findings, although results were in the expected direction (p = .054) (Nettle & Bateson, 2019; Shinwell et al., 2022).

The current study has several strengths, including the high percentage of individuals sampled experiencing some form of food insecurity (~40 %), and the use of structural equation modelling which allowed us to control for direct associations of HHFI while investigating indirect associations. However, there are several limitations to be acknowledged. The sample was almost exclusively white females, meaning that results cannot be generalized to males or individuals with different ethnic backgrounds who are food-insecure. Moreover, very few participants were recruited from food banks. While it is important to study HHFI on a continuum (as individuals experiencing milder HHFI can be harder to reach by research studies), we may not have captured the experience of people experiencing severe food insecurity, and further research with food bank clients specifically may be warranted. Our measure of snack frequency did not include a "0 snacks per day" option, and snacks were broadly defined as anything eaten/drank outside of a main meal, which may have impacted findings. Moreover, the current study employed a cross-sectional design, which means that evidence of associations is not evidence of causality. Relatedly, HHFI, distress, and price are overlapping constructs (i.e., HHFI is characterized as anxiety about food access, and a lack of money to buy food) and there was some semantic overlap in their respective measures, which may have driven associations. However, they also have key differences. Our measure of psychological distress covered general symptoms of stress, anxiety, and depression. Similarly, our measure of price motives does not exclusively pertain to the experiences of food-insecure individuals; indeed, food prices were found to be a top concern among a representative sample of the UK population (87 % of all respondents) (Food Standards Agency, YouGov, 2024). The value of the current study is being able to demonstrate the interrelationships between these distinct variables. Finally, we did not examine associations between variables in this study and BMI, so we can only speculate as to how the examined associations may contribute to the food insecurity-obesity relationship.

5. Conclusions

The current study found that psychological distress and certain food choice motives were mediating variables in the relationship between food insecurity and diet quality. We found HHFI was indirectly associated with poorer diet quality via price motives, and via distress and higher convenience/lower health food choice motives. We also found that HHFI was associated with lower meal frequency, and this in turn was associated with poorer diet quality. Findings provide insight into possible mediators in the relationship between HHFI and diet quality and highlight the need for upstream policy change to make healthy food accessible for all.

CRediT authorship contribution statement

Rebecca Evans: Writing – review & editing, Writing – original draft, Formal analysis, Data curation, Conceptualization. **Paul Christiansen:** Writing – review & editing, Conceptualization. **Melissa Bateson:** Writing – review & editing, Conceptualization. **Daniel Nettle:** Writing – review & editing, Conceptualization. **Gregory S. Keenan:** Writing – review & editing, Conceptualization. **Charlotte A. Hardman:** Writing – review & editing, Writing – original draft, Supervision, Project administration, Funding acquisition, Conceptualization.

Ethical statement

The study was approved by the University of Liverpool Research Ethics Committee (reference number: IPHS-1516-LB-174). All participants provided informed consent before taking part.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests. Charlotte Hardman reports a relationship with American Beverage Association that includes: funding grants. Paul Christiansen reports a relationship with American Beverage Association that includes: funding grants. Charlotte Hardman reports a relationship with International Sweeteners Association that includes: consulting or advisory. Charlotte Hardman reports a relationship with International Food Information Council that includes: consulting or advisory. Charlotte Hardman reports a relationship with The Coca Cola Company that includes: funding grants. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.appet.2025.108007.

Data availability

The research data is accessible at https://osf.io/fu94n/.

References

Allen, J. (2023). The indirect effects of food insecurity on obesogenic environments. *Frontiers in Public Health, 10*, Article 1052957. https://doi.org/10.3389/fpubh.2022.1052957

Bateson, M., & Pepper, G. V. (2023). Food insecurity as a cause of adiposity: Evolutionary and mechanistic hypotheses. *Philosophical Transactions of the Royal Society B: Biological Sciences, 378*(1888), Article 20220228. https://doi.org/10.1098/rstb.2022.0228

Bergmans, R. S., Zivin, K., & Mezuk, B. (2019). Depression, food insecurity and diabetic morbidity: Evidence from the health and retirement study. *Journal of Psychosomatic Research, 117*, 22–29. https://doi.org/10.1016/j.jpsychores.2018.12.007

Briazu, R. A., Masood, F., Hunt, L., Pettinger, C., Wagstaff, C., & McCloy, R. (2024). Barriers and facilitators to healthy eating in disadvantaged adults living in the UK: A scoping review. *BMC Public Health, 24*(1), 1770. https://doi.org/10.1186/s12889-024-19259-2

Bull, R., Miles, C., Newbury, E., Nichols, A., Weekes, T., & Wyld, G. (2023). Hunger in the UK. *The trussell trust*. https://www.trusselltrust.org/wp-content/uploads/sites/2/2023/08/2023-The-Trussell-Trust-Hunger-in-the-UK-report-web-updated-10Aug23.pdf.

Cafiero, C., Viviani, S., & Nord, M. (2018). Food security measurement in a global context: The food insecurity experience scale. *Measurement, 116*, 146–152. https://doi.org/10.1016/j.measurement.2017.10.065

Consumer Data Research Centre. (2022). *Priority Places for food index* (version 1). *Consumer data research Centre*. https://doi.org/10.20390/PPFI

Department for Environment, Food & Rural Affairs. (2024). United Kingdom food security report 2024. https://www.gov.uk/government/statistics/united-kingdom-food-security-report-2024.

Drewnowski, A. (2022). Food insecurity has economic root causes. *Nature Food, 3*(8), 555–556. https://doi.org/10.1038/s43016-022-00577-w

Economic Research Service, USDA. (2012). U.S. Household food security survey module: THREE-STAGE design, with screeners. https://www.ers.usda.gov/media/8271/hh2012.pdf.

Epstein, L. H., Temple, J. L., Faith, M. S., Hostler, D., & Rizwan, A. (2024). A psychobioecological model to understand the income-food insecurity-obesity relationship. *Appetite, 196*, Article 107275. https://doi.org/10.1016/j.appet.2024.107275

Eskandari, F., Lake, A. A., Rose, K., Butler, M., & O'Malley, C. (2022). A mixed-method systematic review and meta-analysis of the influences of food environments and food insecurity on obesity in high-income countries. *Food Science and Nutrition, 10*(11), 3689–3723. https://doi.org/10.1002/fsn3.2969

Evans, A., Banks, K., Jennings, R., Nehme, E., Nemec, C., Sharma, S., Hussaini, A., & Yaroch, A. (2015). Increasing access to healthful foods: A qualitative study with residents of low-income communities. *International Journal of Behavioral Nutrition and Physical Activity, 12*(S1), S5. https://doi.org/10.1186/1479-5868-12-S1-S5

Evans, R., Christiansen, P., Masterson, T., Pollack, C., Albadri, S., & Boyland, E. (2023). Recall of food marketing on videogame livestreaming platforms: Associations with adolescent diet-related behaviours and health. *Appetite, 186*, Article 106584. https://doi.org/10.1016/j.appet.2023.106584

Food and Agriculture Organization of the United Nations. (2021). Hunger and food insecurity. https://www.fao.org/hunger/en/.

Food Standards Agency, YouGov. (2024). Consumer insights tracker. July 2024 to September 2024) https://science.food.gov.uk/article/124588-consumer-insights-tracker-july-2024-to-september-2024.

Freedman, D. A., & Bell, B. A. (2009). Access to healthful foods among an urban food insecure population: Perceptions versus reality. *Journal of Urban Health, 86*(6), 825–838. https://doi.org/10.1007/s11524-009-9408-x

From purse to plate. (2023). Implications of the cost of living crisis on health. https://foodfoundation.org.uk/sites/default/files/2023-03/TFF_Cost%20of%20living%20briefing.pdf.

Henry, J. D., & Crawford, J. R. (2005). The short-form version of the Depression Anxiety Stress Scales (DASS-21): Construct validity and normative data in a large non-clinical sample. *British Journal of Clinical Psychology, 44*(2), 227–239. https://doi.org/10.1348/014466505X29657

Hill, D., Conner, M., Clancy, F., Moss, R., Wilding, S., Bristow, M., & O'Connor, D. B. (2022). Stress and eating behaviours in healthy adults: A systematic review and meta-analysis. *Health Psychology Review, 16*(2), 280–304. https://doi.org/10.1080/17437199.2021.1923406

Hunter, E., Stone, R. A., Brown, A., Hardman, C. A., Johnstone, A. M., Greatwood, H. C., Dineva, M., & Douglas, F. (2025). "We go hunting …": Understanding experiences of people living with obesity and food insecurity when shopping for food in the supermarket to meet their weight related goals. *Appetite, 205*, Article 107794. https://doi.org/10.1016/j.appet.2024.107794

Jacob, J. S., & Panwar, N. (2023). Effect of age and gender on dietary patterns, mindful eating, body image and confidence. *BMC Psychology, 11*(1), 264. https://doi.org/10.1186/s40359-023-01290-4

Jones, N. R., Tong, T. Y., & Monsivais, P. (2018). Meeting UK dietary recommendations is associated with higher estimated consumer food costs: An analysis using the National Diet and Nutrition Survey and consumer expenditure data, 2008–2012. *Public Health Nutrition, 21*(5), 948–956. https://doi.org/10.1017/S1368980017003275

Karpyn, A. E., Riser, D., Tracy, T., Wang, R., & Shen, Y. (2019). The changing landscape of food deserts. *UNSCN Nutrition, 44*, 46.

Keenan, G. S., Christiansen, P., & Hardman, C. A. (2021). Household food insecurity, diet quality, and obesity: An explanatory model. *Obesity, 29*(1), 143–149. https://doi.org/10.1002/oby.23033

Kim, K. H. (2005). The relation among fit indexes, power, and sample size in structural equation modeling. *Structural Equation Modeling: A Multidisciplinary Journal, 12*(3), 368–390. https://doi.org/10.1207/s15328007sem1203_2

Kowaleski-Jones, L., Wen, M., & Fan, J. X. (2019). Unpacking the paradox: Testing for mechanisms in the food insecurity and BMI association. *Journal of Hunger & Environmental Nutrition, 14*(5), 683–697. https://doi.org/10.1080/19320248.2018.1464997

Laitinen, J., Ek, E., & Sovio, U. (2002). Stress-related eating and drinking behavior and body mass index and predictors of this behavior. *Preventive Medicine, 34*(1), 29–39. https://doi.org/10.1006/pmed.2001.0948

Loopstra, R., & Tarasuk, V. (2015). Food Bank usage is a poor indicator of food insecurity: Insights from Canada. *Social Policy and Society, 14*(3), 443–455. https://doi.org/10.1017/S1474746415000184

MacCallum, R. C., Browne, M. W., & Sugawara, H. M. (1996). Power analysis and determination of sample size for covariance structure modeling. *Psychological Methods, 1*(2), 130–149. https://doi.org/10.1037/1082-989X.1.2.130

McDonald, R. P. (2013). *Test theory: A unified treatment* (0 ed.). Psychology Press. https://doi.org/10.4324/9781410601087

Morales, M. E., & Berkowitz, S. A. (2016). The relationship between food insecurity, dietary patterns, and obesity. *Current Nutrition Reports, 5*(1), 54–60. https://doi.org/10.1007/s13668-016-0153-y

Murakami, K., & Livingstone, M. B. E. (2016). Associations between meal and snack frequency and diet quality and adiposity measures in British adults: Findings from the National Diet and Nutrition Survey. *Public Health Nutrition, 19*(9), 1624–1634. https://doi.org/10.1017/S1368980015002979

Myhre, J. B., Løken, E. B., Wandel, M., & Andersen, L. F. (2015). Meal types as sources for intakes of fruits, vegetables, fish and whole grains among Norwegian adults. *Public Health Nutrition, 18*(11), 2011–2021. https://doi.org/10.1017/S1368980014002481

Neal, C., Pepper, G. V., Shannon, O. M., Allen, C., Bateson, M., & Nettle, D. (2025). The daily experience of hunger in UK females with and without food insecurity. *Appetite, 204*, Article 107732. https://doi.org/10.1016/j.appet.2024.107732

Nettle, D., Andrews, C., & Bateson, M. (2017). Food insecurity as a driver of obesity in humans: The insurance hypothesis. *Behavioral and Brain Sciences, 40*, Article e105. https://doi.org/10.1017/S0140525X16000947

Nettle, D., & Bateson, M. (2019). Food-insecure women eat a less diverse diet in a more temporally variable way: Evidence from the US national health and nutrition examination survey, 2013-4. *Journal of Obesity*, 1–9. https://doi.org/10.1155/2019/7174058, 2019.

Puddephatt, J.-A., Keenan, G. S., Fielden, A., Reaves, D. L., Halford, J. C. G., & Hardman, C. A. (2020). 'Eating to survive': A qualitative analysis of factors influencing food choice and eating behaviour in a food-insecure population. *Appetite, 147*, Article 104547. https://doi.org/10.1016/j.appet.2019.104547

Roberts, K., Stephenson, J., Holdsworth, M., Relton, C., Williams, E. A., & Cade, J. E. (2024). Inequalities in diet quality by socio-demographic characteristics, smoking, and weight status in a large UK-based cohort using a new UK diet quality questionnaire-UKDQQ. *Journal of Nutritional Science, 13*, e59. https://doi.org/10.1017/jns.2024.60

Robinson, E., Jones, A., & Marty, L. (2022). The role of health-based food choice motives in explaining the relationship between lower socioeconomic position and higher BMI in UK and US adults. *International Journal of Obesity, 46*(10), 1818–1824. https://doi.org/10.1038/s41366-022-01190-4

Rosseel, Y. (2012). lavaan: An *R* package for structural equation modeling. *Journal of Statistical Software, 48*(2). https://doi.org/10.18637/jss.v048.i02

Salamon, L. M. (1987). Of market failure, voluntary failure, and third-party government: Toward a theory of government-nonprofit relations in the modern welfare state. *Journal of Voluntary Action Research, 16*(1–2), 29–49. https://doi.org/10.1177/089976408701600104

Shen, W., Long, L. M., Shih, C.-H., & Ludy, M.-J. (2020). A humanities-based explanation for the effects of emotional eating and perceived stress on food choice motives during the COVID-19 pandemic. *Nutrients, 12*(9), 2712. https://doi.org/10.3390/nu12092712

Shinwell, J., Bateson, M., Nettle, D., & Pepper, G. V. (2022). Food insecurity and patterns of dietary intake in a sample of UK adults. *British Journal of Nutrition, 128*(4), 770–777. https://doi.org/10.1017/S0007114521003810

Sominsky, L., & Spencer, S. J. (2014). Eating behavior and stress: A pathway to obesity. *Frontiers in Psychology, 5*. https://doi.org/10.3389/fpsyg.2014.00434

Steptoe, A., Pollard, T. M., & Wardle, J. (1995). Development of a measure of the motives underlying the selection of food: The food choice questionnaire. *Appetite, 25*(3), 267–284. https://doi.org/10.1006/appe.1995.0061

Stinson, E. J., Votruba, S. B., Venti, C., Perez, M., Krakoff, J., & Gluck, M. E. (2018). Food insecurity is associated with maladaptive eating behaviors and objectively measured overeating. *Obesity, 26*(12), 1841–1848. https://doi.org/10.1002/oby.22305

Stone, R. A., Christiansen, P., Johnstone, A. M., Brown, A., Douglas, F., & Hardman, C. A. (2025). Understanding the barriers to purchasing healthier, more environmentally sustainable food for people living with obesity and varying experiences of food insecurity in the UK. *Food Policy, 131*, Article 102798. https://doi.org/10.1016/j.foodpol.2025.102798

Swinburn, B. A., Sacks, G., Hall, K. D., McPherson, K., Finegood, D. T., Moodie, M. L., & Gortmaker, S. L. (2011). The global obesity pandemic: Shaped by global drivers and local environments. *The Lancet, 378*(9793), 804–814. https://doi.org/10.1016/S0140-6736(11)60813-1

Taylor, N., Boyland, E., & Hardman, C. A. (2024). Conceptualising food banking in the UK from drivers of use to impacts on health and wellbeing: A systematic review and directed content analysis. *Appetite, 203*, Article 107699. https://doi.org/10.1016/j.appet.2024.107699

The Food Foundation. (2025). The broken plate 2025. https://foodfoundation.org.uk/publication/broken-plate-2025.

Yau, A., White, M., Hammond, D., White, C., & Adams, J. (2020). Socio-demographic characteristics, diet and health among food insecure UK adults: Cross-sectional analysis of the International Food Policy Study. *Public Health Nutrition, 23*(14), 2602–2614. https://doi.org/10.1017/S1368980020000087