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Abstract

In westernised countries, food insecurity (FI), poorer diet quality, and obesity are disproportionately represented in groups experiencing socio-economic disadvantage. Grocery stores are one promising arena for intervention; however how these settings can facilitate purchasing of healthier, more sustainable food in people living with obesity (PLWO) and FI remains unclear. Using an online survey (N=583), adults residing in England or Scotland with a body mass index of ≥30kg/m^2 self-reported on FI, diet quality, and their experiences of shopping in a grocery store for healthy and sustainable food. Using structural equation modelling, greater FI was directly associated with barriers from the food environment (e.g., price), food preparation practices, lower healthy diet knowledge and physical ill-health. Moreover, greater FI was indirectly associated with poorer diet quality via poorer mental health and greater experiences of self-stigma associated with being food insecure. Grocery store interventions based on price or incentivisation were ranked most helpful in supporting healthier, more sustainable purchasing. These findings highlight the challenges faced by this group when shopping and underscore the need for policy development relating to price and affordability at a population-level, and for clinicians to offer tailored, holistic approaches to obesity treatment that acknowledges and minimises stigma and mental health.

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 [1]. People experiencing FI tend to have diets that are of poorer nutritional quality compared to those who are food secure [2], and in high-income countries, those who are food insecure are also more likely to be living with obesity [3]. Despite seeming paradoxical, the Insurance Hypothesis suggests that incidences of FI lead to increased fat storage as a protective measure against potential starvation [4]. Access to cheap and healthy and environmentally sustainable food is challenging for people living with obesity (PLWO) and FI [5]; further, it remains to be seen how, when there is limited or unpredictable access to food, body fat levels increase [6]. Considering ongoing public health concern about population obesity trends [7], it is imperative to prioritise efforts aimed at enabling easier access to healthy foods for PLWO and FI. Purchasing food is a prerequisite for consumption [8], and given the majority of the UK population uses grocery stores to purchase food [9], there is a lack of understanding regarding the barriers that may hinder this groups' abilities to purchase healthy and environmentally sustainable food in retail settings.

Previous research has highlighted that the food environment might act as a barrier to healthy food purchasing, due to issues such as affordability, distance to grocery store, variety and quality of food, and transport [10]. Limited financial resources often result in food insecure shoppers relying on cheaper, energy-dense, and nutrient-poor food, which may result in imbalanced, unhealthy diets, and ultimately the development of obesity [5, 11]. Low-income neighbourhoods, where lower income families may reside, have been identified as containing fewer grocery stores [12, 13]. Instead, these neighbourhoods tend to be populated with smaller convenience/ corner stores [14] where food is priced at a premium and there is a lack of variety and quality in healthier foods, meaning the healthfulness of shopping baskets can be poor [15]. This also means that food insecure shoppers 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 [16].

There may also be barriers to healthy food purchasing relating to an individuals' personal environment. As obesity is a metabolic risk factor for non-communicable diseases, including Type 2 diabetes [17], food insecure individuals may face financial hardships in managing such health conditions [18], which may encourage the reliance placed on low-cost food to mitigate this [19]. General population studies have also highlighted the mental health impact of experiencing FI, where being food insecure is associated with distress that is then associated with emotional eating behaviours and higher body mass index (BMI) [2]. Additionally, those experiencing FI may be subject to greater stigmatisation from society for accessing food help, which may further promote unhealthy food purchasing behaviour [20, 21]. Socioeconomic deprivation has historically been associated with deficits in nutrition knowledge [22] and cooking skills [23], which is believed to increase vulnerability to modern food environments [24]. However, more recently, this belief has been contested as FI has been found to be unrelated to cooking skills [25]. Rather, the observed differences in the nutritional quality of people with FI may be attributable to the thrifty food preparation practices used (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) are met) [26]. Lastly, the amount of time available to shop for and cook fresh healthful food has also been highlighted as a barrier by those experiencing FI [10]. Indeed, this may promote the use of processed, convenience food to help mitigate this lack of time [27], with the consequence being high caloric intake. Therefore, taken together, there may be a range of individual-level barriers relating to physical health, mental health, stigma associated with the experience of being food insecure, time to shop and cook, cooking skills, and healthy diet knowledge.

For PLWO and FI, therefore, consuming a healthy diet may be particularly difficult, especially during the current economic climate. Consuming a healthy diet is often also more sustainable for the planet (e.g., reducing meat consumption, increasing intake of local and

seasonal fruit and vegetables) [28], which is pertinent given the food system is not sustainable in its current form [29]. Thus, evidence is needed on how to best support people living with FI and obesity to make healthier food choices that are also more environmentally sustainable. To address this, the current study aimed to understand what helps/hinders PLWO and FI to purchase healthier and more sustainable food in grocery stores. It was hypothesised that, in a sample of PLWO, FI will be associated with poorer diet quality. It was also hypothesised that the relationship between FI and diet quality would be accounted for by barriers from the food environment and personal factors (pre-registration: https://doi.org/10.17605/OSF.IO/BYZKP).

2. Method

2.1. Participants

The participants were from a dataset that has been described in full elsewhere [26]. 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 ≥ 30 kg/m^2. Ethical approval for the study was granted by the University of Liverpool's Research Ethics Committee, #12027. Of the 654 participants who completed the survey, 583 were entered into data analysis. Using *a priori* sample size calculations, a minimum of 500 participants were needed for adequate power (≥80%, α = 0.05; https://doi.org/10.17605/OSF.IO/BYZKP).

2.2. Procedure

As described in [26], this study was hosted on Qualtrics. After providing informed consent electronically, participants were asked a series of screening questions to assess eligibility. All participants then completed a series of questions (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 sustainable food, and knowledge of healthy and sustainable diets. Finally, 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 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 [26].

2.3.2. Household food security

The 10-item United States Department of Agriculture Household Food Security Survey Model [30] was used to measure FI. Scoring is reported in [26]. Scale reliability using McDonalds'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 for anxiety and depression (PHQ-4; [31] was used to measure anxiety and depression (response options: 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 food frequency questionnaire [32]. Participants rated the frequency that they consumed: whole wheat bread, white bread, chips, fried chicken, processed meats, beer, wine, sugary drinks, oily fish, and other fish. Higher scores were indicative of a healthier diet (i.e., one low in processed food and high in fruit and vegetables). Scoring is described in full in [26].

2.3.5. Food insecurity stigma

To measure self-stigma from being food insecure, four items were used; three items from the Food Insecurity Self-Stigma Scale (FISS) (N Taylor & CA Hardman, unpublished data) (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 [20] (4: I do my grocery shopping as fast as I can so that people do not judge what I am buying). Response options: 1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree, 4 = Agree, and 5 = Strongly Agree. Reliability of the FISS in current sample was good ($\omega_T = 0.87$).

2.3.6. Barriers to purchasing healthy food

Based on the survey used in [10], participants answered "How often do the following situations make it difficult for you to acquire healthy, sustainable foods (healthy, sustainable foods include fresh fruit and vegetables, whole grains, beans and legumes, low-fat dairy, lean meats, and alternatives to meat and dairy)?" 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 used 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 sustainable diet

Knowledge of healthy and sustainable diets were assessed using an existing question set from the Food Standard's Agency Healthy and Sustainable Diets: Consumer Poll [33]. 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 (ω_T = 0.72).

2.3.8. Helpful interventions for healthy food purchasing

Twenty interventions (ten in-store, ten online) to support healthy food purchasing were generated (listed in Table 3). Interventions were based on previous research [34], and insights from retail-sector stakeholders. Interventions were categorised by the researchers based on the behaviour change lever they operated on as per [8]. 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/online (depending on how they shopped). Behaviour change lever categorisation was not shown to the participant.

2.3.9. Helpful interventions for sustainable food purchasing

Twenty interventions (ten in-store, ten online) to support sustainable food purchasing were generated (listed in Table 4). Interventions were based on previous research and insights from retail-sector stakeholders. Interventions were categorised based on the behaviour change lever they operated on as per [8]. Participants were asked to rank the helpfulness of interventions as they did for the healthy food purchasing interventions. Behaviour change lever categorisation was not shown to the participant.

2.4. Data analysis

2.4.1. Structural Equation Model

A structural equation model, computed in R using the Lavaan package, was used to explore the effect of FI on diet quality via barriers from the food environment (i.e., distance to grocery store, transportation, price, variety of products, and quality of products) and personal barriers (i.e., 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 sustainable diet knowledge). Food preparation barriers, FI stigma, and mental health were treated as latent variables and evaluated using Confirmatory Factor Analysis (CFA); CFA model evaluations are presented in the Supplementary Material; Section 1.1.

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 [35]. Several indices of model fit were computed: root mean square error (RMSEA) (values less than .08 are acceptable), comparative fit index (CFI) (values greater than .95 are good, greater than .90 are acceptable), and standardized root mean residual (SRMR) (values less than .08 are acceptable) [36].

2.4.2. *Ranking of interventions*

The mean score of each intervention (for health and for sustainability, in-store and online) were computed.

3. Results

Descriptive data for the demographic variables are shown in Table S1. 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 [26]). From these analyses, there was a significant difference in diet quality scores depending on gender, where scores were higher for females (U = 29551, $p < .001$), and for ethnicity, where scores were higher for those who identified as BAME (U = 11412, $p = .002$). Therefore, gender and ethnicity were controlled for in the model accordingly.

3.1. Model evaluation

The structural equation model is shown in Figure 1. The initial model was an acceptable to poor fit to the data (CFI = 0.90, SRMR = 0.11, RMSEA = 0.07). Modification indices (MI) 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 latent variables between sustainable diet knowledge and healthy diet knowledge (MI = 91.44), food environment barriers and food preparation barriers (MI = 65.55), and physical health and mental health (MI = 48.30), therefore a covariance was added between residuals and latent variables. The unadjusted model with covariances using an MLM estimator indicated that the model was an acceptable fit for the data (CFI = 0.95, SRMR = .09, RMSEA = .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 = .94, SRMR = .08, RMSEA = .05; ΔAIC = 32.38, ΔBIC = 23.64.

 * INSERT FIGURE 1 HERE*

3.2.   <u>Direct and Indirect Effects</u>

As shown in Table 1, there were significant positive associations between experiences of FI and food environment barriers, food preparation barriers, FI stigma, and mental health. There were also significant negative associations between experiences of FI and healthy diet knowledge and physical health. However, there was no significant association between experiences of FI and sustainable diet knowledge.
As also shown in Table 1, 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 sustainable diet knowledge and diet quality. Additionally, there were significant negative associations between stigma from being food insecure and diet quality, and between mental ill-health and diet quality.

 * INSERT TABLE 1 HERE*

As shown in Table 2, 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 poorer diet quality. Additionally, there was a significant negative indirect effect of experiences of FI on diet quality via experiences of mental health. Specifically, greater experiences of FI were associated with greater experiences of mental ill-health, which in turn was associated with poorer diet quality. There were no other significant indirect effects. For the total effect, there was a significant negative association between experiences of FI and diet quality (B = -0.054, *SE* = 0.015, *p* < .001, 95%CI = -0.084 to -0.024).

* INSERT TABLE 2 HERE*

3.3.   Helpfulness of Interventions

3.3.1. Interventions for health

As seen in Table 3, participants indicated that interventions based on price/ incentivisation [8] would be the most helpful in supporting them to purchase healthy food, both in store and online. Whereas interventions based on awareness/education were ranked as the least helpful in supporting healthy food purchases.

* INSERT TABLE 3 HERE*

3.3.2. Interventions for sustainability

As seen in Table 4, participants indicated that interventions based on price/incentivisation [8] would be the most helpful in supporting them to purchase sustainable food, both in store and online. Whereas interventions based on awareness/education were ranked the least helpful in supporting sustainable food purchases.

* INSERT TABLE 4 HERE*

4. Discussion

This study used a UK-based sample of PLWO to test a novel model that assessed the relationship between FI and diet quality via barriers from the food environment and personal factors. To our knowledge this is the first study to find evidence that for PLWO, FI is indirectly associated with poorer diet quality via greater experiences of mental ill-health and greater experiences of stigma from being food insecure. FI was also 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 the study hypothesis, these factors did not account for the association between FI and diet quality.

The current study provides a unique insight into the psychological mechanisms that might operate when considering how FI is associated with obesity. Taken individually, the indirect association between FI and 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 positive association between obesity and mental ill-health [37], and between FI and mental ill-health [38]. Moreover, low socioeconomic status has been linked to a higher prevalence of comorbid depression and obesity among women [39], and FI has been indirectly associated with higher BMI via greater experiences of mental distress and the use of food as a coping mechanism [2]. Therefore, our findings reflect the emotional toll of living with obesity and FI, which may promote the consumption of unhealthy food. Indeed, in PLWO, greater experiences of depression have been linked with higher prevalence of emotional eating and unhealthy eating, providing further support for this supposition [40]. Therefore, findings from the current study have clinical implications in that weight management services might benefit from delivering tailored, holistic approaches to treatment that target mental health relating to both FI and obesity, such as third-wave psychological therapies [41].

Another novel aspect of our study is its consideration of self-stigma that is associated with FI. In this sample of PLWO, FI was indirectly associated with poorer diet quality via greater experiences of stigma from being food insecure, and this suggests that stigma is a key social determinant for health and dietary inequalities. According to The Stigma and Food Inequity Conceptual Framework [42], 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 unhealthy food to 'cope', and potentially "fast shopping practices" to minimise shopping time [20]). This finding further suggests that experiences of distress and mental ill-health may play a pivotal role in the relationship between FI and diet quality for PLWO. To ensure the promotion of food equity, policymakers should prioritise addressing the underlying structural manifestations of stigma to support PLWO and FI to purchase healthy and sustainable food, which in turn may also reduce individual manifestations of stigma and further support improvements in diet quality for this group. Similarly, findings from the current study have clinical implications in that weight management services might also benefit from delivering tailored, holistic approaches to treatment that target self-stigmatisation.

Our findings provide evidence that PLWO and FI encounter many barriers from the food environment and personal factors to purchasing healthy food. This supports previous evidence that people with FI are disproportionately affected by exposure to and burden of such barriers [5]. However, contrary to our hypothesis, barriers from the food environment (e.g., price) were not directly associated with diet quality. There is a plethora of research indicating that, among individuals in lower socioeconomic groups, limited financial resources are associated with purchasing less-healthy food [43]. However, our results may instead reflect how PLWO and FI are responding to food environment barriers. For example, people may perceive that price is a barrier but find ways to overcome this through using budgeting,

supermarket offers, or cooking resourcefully [26]. In the current study, when asking participants to rank the helpfulness of different grocery store interventions, the interventions ranked most helpful were based on the price/ incentivisation behaviour change lever [8]. Therefore, this corroborates previous research underscoring the significance of price as a barrier to purchasing healthy food [10]. We also found no evidence that food preparation barriers (e.g., cooking skills) or self-rated knowledge of heathy diets were associated with diet quality, which aligns with previous research [44]. Indeed, when participants in the current study ranked different grocery store interventions, the interventions ranked least helpful were based on education and awareness. Therefore, there is a need for upstream change to enable purchasing of healthy food in grocery stores.

Our study has several strengths, including pre-registered analyses and a large, well powered sample. However, the study has several limitations, including the use of simple measures 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 poorer diet quality. Additionally, the current study was cross-sectional by design, meaning that evidence of associations is not evidence of causality. Also, the study sample was not ethnically diverse, which may limit the generalisability of study results. However, ethnicity was controlled for in all models. 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 [45].

5. Conclusion

The current study sought to elucidate and understand the barriers that are encountered by PLWO and FI when shopping for healthy and sustainable food in the grocery

store. We found that mental ill-heath and FI stigma might begin to explain how FI is associated with poorer diet quality in PLWO. Findings underscore the need for clinicians to offer tailored, holistic approaches to obesity with a focus on minimising self-stigma and mental health. Findings also underscore the need for policy development and grocery store interventions that focus on price and incentivisation to ensure that healthy and sustainable foods are accessible for all, which in turn may reduce self-stigma.

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Figure Legends

Figure 1: Associations between food insecurity and diet quality via barriers to purchasing healthier, more sustainable food. Values are standardised regression coefficients, * $p < .05$, **$p < .01$. For ease of interpretation, residuals are not visually represented. Rectangles represent observed variables and ovals represent latent variables. Solid arrows represent statistically significant associations and dashed arrows represent no statistically significant association. FIQ = Food Insecurity Questionnaire. PHQ = Patient Health Questionnaire