Household Food Insecurity, Diet Quality, and Obesity: An Explanatory Model

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Objective: Food insecurity (a lack of stable access to nutritious food) is reliably associated with poor diet, malnutrition, and obesity; however, the underlying mechanisms are unclear. In this study, the hypothesis that these relations are explained by higher levels of distress, which are due to the experience of food insecurity, and unhealthy coping behaviors (eating high-calorie foods, drinking alcohol) was tested.

Methods: Adults from the United Kingdom ($N=604$), who were recruited online and at food banks, completed questionnaire measures of household food insecurity, physical stress, psychological distress, eating to cope, drinking to cope, diet quality, and self-reported height and weight to calculate BMI.

Results: Structural equation modeling was used to test the hypothesized relationships, including a multilevel structural model controlling for the effect of income. As predicted, food insecurity was indirectly associated with higher BMI via greater distress and eating to cope. Food insecurity was directly associated with poorer diet quality, but this relationship was not explained by distress and eating to cope

Conclusions: Our data provide novel insight into the psychological experience of being food-insecure and how maladaptive coping mechanisms might play some role in the association between food insecurity, diet, and obesity.

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Study Importance

What is already known?

- Food insecurity (a lack of stable access to nutritious food) is reliably associated with obesity and a less nutritious diet, but the underlying mechanisms are not yet clear.
- Research has identified links between food insecurity and increased distress and between distress and maladaptive coping mechanisms (e.g., eating to cope). However, no studies to date have explored whether household food insecurity might be associated with elevated BMI via the mediating pathway of increased distress and eating to cope.

What does this study add?

- Household food insecurity was indirectly associated with higher BMI via greater experienced distress and the use of food as a coping mechanism.
- Food insecurity was directly associated with poorer diet quality, but this relationship was not explained by distress and eating to cope.

How might these results change the direction of research or focus of clinical practice?

- Interventions seeking to reduce obesity prevalence in food-insecure populations will likely benefit from targeting sources of distress and subsequent coping mechanisms.
- Further investigation of the psychological mechanisms that might drive eating behavior in response to household food insecurity will be of benefit in the future.

Introduction

Food insecurity refers to unreliable access to nutritionally adequate and safe foods, which is usually the result of a lack of financial resources. On a global scale, over 2 billion people are estimated to experience food insecurity, including 8% of the population in North America and Europe, with this number currently rising (1). In addition to food insecurity being associated with many noncommunicable diseases (2,3), it is a robust predictor of obesity in children and adults (4).

According to the Insurance Hypothesis, greater fat storage occurs in response to food insecurity because it is an adaptive strategy to protect against starvation (5). Indeed, in nonhuman animals, fat reserves have been shown to increase under conditions of food restriction (5). However, it is unclear how increases in body fat are achieved when access to food is limited or unpredictable (6).

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In humans, the greater availability of low-cost, energy-dense foods in neighborhoods where food insecurity is high is thought to play a key role in the association between food insecurity and BMI (7,8). Food insecurity is also robustly associated with anxiety and depression (9,10), and emotional distress may be fundamental in explaining the relationship between socioeconomic disadvantage and obesity (11,12). Emotional distress is associated with increased food intake and higher BMI (13,14). More specifically, individuals may seek to alleviate distress through maladaptive coping behaviors, such as eating energy-dense palatable foods or consuming alcohol. Consistent with this, lower socioeconomic status is indirectly associated with higher BMI via increased emotional distress and subsequent emotional eating (15). Although socioeconomic disadvantage and food insecurity are closely related, they are distinct constructs (16,17), and the potential for psychological distress and unhealthy coping behaviors to explain the food insecurity–obesity association has not been examined previously.

In the current study, we collected primary data and used structural equation modeling to test a theoretical model of the associations between household food insecurity (HHFI), poor diet quality, and obesity. Distress plays a central role in the model and was operationalized as both physical symptoms of stress (including wear and tear on the body, or "allostatic load") and psychological distress (depression, stress, anxiety). Maladaptive coping via eating unhealthy foods and drinking alcohol were included as both and are associated with more frequent consumption of unhealthy foods and increased BMI (15,18,19). Adults from the United Kingdom (UK) completed online questionnaire measures of the target constructs.

We predicted that HHFI would be indirectly associated with higher BMI and poorer diet quality via distress and subsequent eating and drinking to cope. Specifically, greater HHFI would be associated with greater distress (emotional and physical stress); greater distress would be associated with greater eating and drinking to cope; and greater eating and drinking to cope would be associated with higher BMI and poorer diet quality.

Methods

Participants

Individuals were recruited via (1) visits to food banks in the city of Liverpool (northwest of the UK), (2) a database of individuals who had given consent to be contacted about university research studies, and (3) advertisements on social media (Facebook) targeted at individuals aged between 18 and 75 years and living within a 25-mile radius of the city of Liverpool. As reimbursement for time and effort to complete the questionnaires, participants were anonymously entered into a prize drawing to win shopping vouchers (1 × £100, 1 × £50, 2 × £25 prizes). Based on the formula by Kim (20), a minimum of 467 participants were needed to observe a close-fitting root-mean-square error of approximation (RMSEA) ($df=24$, $\alpha<0.05$, 90% power). We rounded this up to 500 and aimed to recruit more than this number to account for any incomplete responses. Ethical approval for the study was granted by the University of Liverpool's Research Ethics Committee.

Measurements

Demographic information. Participants reported their age (in years), gender, ethnicity, and the first three characters of their post code. Their total household income (nine-point scale: 1=<£5,200, 2=£5,200-£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, and 9=≥£78.000) and highest level of education (eight-point scale: 1=none, 2=General Certificate of Secondary Education grade D or below, 3=General Certificate of Secondary Education grade C or above, 4=A-level or equivalent, 5=university degree or equivalent, 6=postgraduate qualification or equivalent, 7=master's degree or equivalent, 8=PhD or equivalent) were reported using ordinal scales. They also reported their employment status (employed full time, employed part time, unemployed looking for work, unemployed not looking for work, retired, student, unable to work because of health or disability, housewife/husband, voluntary employment), the number of adults living in their household (including themselves; options: one, two, three, four, five, or six or more), and the number of children (under 18 years of age) living in their household (options: none, one, two, three, four, five, or six or more). For BMI, participants provided self-reported height (in feet and inches or in centimeters) and weight (in either kilograms or stones and pounds). BMI (kg/m^2) was computed using the following formula: weight in kilograms divided by height in meters squared. Self-reported BMI has been shown to be highly correlated with objectively measured BMI (21,22).

HHFI. The United States Department of Agriculture Household Food Security Survey Module was used (23) to quantify difficulties experienced by individual households over the past 12 months in obtaining a sufficient amount of nutritionally adequate food. Participants completed a total of 10 questions from modules 1, 2, and 3. Answers of "often true," "sometimes true," "almost every month," "some months but not every month," and "yes" were coded as 1 and all other responses as zero. The sum of positive responses reflects household food insecurity with scores ranging from 0 (low food insecurity) to 10 (very high HHFI).

Psychological distress. The 21-item self-report Depression, Anxiety, and Stress Scale (DASS) (24) was administered (response options: 0=never, 1=sometimes, 2=often, 3=almost always). Cronbach α values for each of the three subscales were: depression α=0.93, anxiety α=0.84, stress α=0.88, and overall distress scale α=0.95.

Physical symptoms of stress. Participants reported the extent to which nine symptoms of physical stress had troubled or distressed them during the past month (e.g., sleep problems, headaches, constant fatigue/feeling run down). Responses ranged from 0 to 4, with 0 being "not been bothered at all" and 4 being "extreme bother." Scores were averaged across items, with higher scores indicating greater symptoms of physical stress. For the current data, α=0.83.

Allostatic load. Participants were asked about having elevated blood pressure and elevated blood glucose and whether they were currently taking medication to lower their cholesterol (response options: "yes" or "no"). Responses were coded as 1 (yes) or 0 (no). These items have been shown to be strong predictors of allostatic load (25). Participants were also asked how many times they had visited a medical general practitioner for themselves in the past month ("never," "once," "twice," "three times," "four times," or "five times or more"). Responses were scored as 1 (never) to 6 (five times or more). These scores were then summed.

Eating to cope. The coping subscale from the Palatable Eating Motives Scale was used, which has good internal reliability and validity (26). It consists of five items (e.g., "How often do you eat tasty foods to forget about your problems?") (Response options: "never/almost never," "some of the time," "half of the time," "most of the time," "almost always/always"). Scores were averaged across items, with higher scores indicating higher levels of the behavior. For the current data, $\alpha = 0.92$.

Drinking to cope. The three items from the coping subscale of the abbreviated Drinking Motives Questionnaire, which has good reliability and validity, were used (27). Participants read the statement "Thinking of all the times you consume alcohol, how often would you say that you drink for each of the following reasons?" (e.g., "To forget about your problems?") Responses were on a five-point scale ("never/almost never," "some of the time," "half of the time," "most of the time," "almost always/always"). Scores were averaged across items, with higher scores indicating higher levels of the behavior. For the current data, $\alpha = 0.86$.

Diet quality. Diet quality was assessed via a short food frequency questionnaire taken from the Yorkshire Health Survey (28). Participants rated the frequency with which they consumed the following: whole wheat bread, white bread, chips, fried chicken, processed meats, beer, wine, sugary drinks, oily fish, and other fish ("more than once a day," "once a day," "4-6 times a week," "2-3 times a week," "once a month," "less than once a week," "never"). Abbreviated food frequency questionnaires of this kind have been shown to have good reliability and validity (29). Participants were also asked how many portions of fruit and vegetables, excluding potatoes, they ate on a typical day ("none," "one," "two," "three," "four," "five or more"). Scores for chips, white bread, fried chicken, processed meats, and sugary drinks were all coded as: more than once a day = 1 to never = 7, whereas scores for fish and oily fish were reverse scored (i.e., more than once a day = 7, never = 1). Daily fruit and vegetable consumption was counted as portions per day (none = 1 to five or more = 6). Scores for white bread, chips, fried chicken, processed meats, sugary drinks, oily fish (reverse scored), fish (reverse scored), fruit, and vegetables were then summed, with low values representing poorer diet quality.

Procedure

The questionnaires were hosted online via Qualtrics (Provo, Utah). Participants recruited via online methods (e.g., advertisements on social media) accessed the questionnaire via a Web link. Participants recruited at foodbanks (approximately 5% of total sample) were approached with an electronic tablet connected to the Internet or they were provided with paper copies of the questionnaire, depending on their preferred completion method. All participants read an information sheet and provided written informed consent followed by the questions on demographic information, height, and body weight. The following questionnaires were then presented in a randomized order: DASS, symptoms of physical stress, allostatic load, household food insecurity, eating to cope, drinking to cope, and diet quality. Finally, participants were debriefed and given the option to be entered into the prize draw to win shopping vouchers.

Planned analyses

A structural equation model was created to test the hypothesis that HHFI would be indirectly associated with higher BMI and poorer diet quality via distress and maladaptive coping mechanisms (eating to cope and drinking to cope). All modeling was conducted in Mplus version 8.4 (Los Angeles, California). A total of 759 responses were initiated, but only 606 completed all fields necessary to complete the analysis. A further two cases were removed for providing unfeasible weight values ≤34 kg (30); therefore, responses from 604 participants were included in the analysis.

Because of the non-normality of household food insecurity, eating to cope, drinking to cope, and BMI, a maximum likelihood estimator with a Satorra-Bentler correction was used for model fitting (31). A range of fit indices were produced to test the models. The standardized root mean residual (SRMR) absolute fit was computed, with values under 0.08 being indicative of good fit. Two baseline comparisons, the Tucker Lewis index (TLI) and Comparative Fit Index (CFI), were deemed acceptable at > 0.90 and good at > 0.95 (32). Finally, the RMSEA parsimony adjusted measure is reported with values < 0.06 being good fit and values > 0.06 but < 0.08 being acceptable (32).

Before running the model, the effects of gender and age on each variable in the model were investigated via correlations and independent samples *t* tests. When gender or age had a statistically significant influence, they were included as covariates in the model.

Results

Descriptive statistics

The sample ($N = 604$) was mostly female (90%) and white (96%); 47.2% were employed full time, 20.5% were employed part time, 32.3% were unemployed, retired, students, in voluntary work, or identified as housewives/husbands; 58.8% had achieved an undergraduate degree or higher. The level of moderate food insecurity (defined as providing a positive response to three or more instances of food insecurity on the United States Department of Agriculture Household Food Security Survey Module) was 21.5%, which is higher than the typical 6% to 10% reported in the UK (1). In terms of living circumstances, 22.5% were the only adult in the household, 53.6% lived with one other adult, 23.9% with two or more adults; 62.6% had no children under the age of 18 in the household, 18.5% lived with one child, and 18.9% with two or more children; 41.2% had an annual household income of less than £25,999 per annum, 19.4% earned between £26,000 and £36,399, 19.4% between £36,400 and £51,999, and 20% earned over £52,000 per annum. Of the sample, 22.8% ate five or more portions of fruit and vegetables a day, and mean BMI (SD) was 29.19 (7.86) kg/m^2 (scores > 25 were indicative of having overweight), with 2.8% of the sample classified as underweight, 30.8% of healthy weight, 28.6% with overweight, and 37.8 % with obesity (Table 1).

Three separate measurements of distress were taken: (1) physical symptoms, (2) psychological symptoms using the DASS (23), and (3) allostatic load. A confirmatory factor analysis was performed, which showed that each measurement had a highly significant loading onto the latent variable "distress" ($\beta > 0.74$, $P < 0.001$ for all). The overall fit of the model was good to acceptable ($CFI = 0.99_{sb}$, $TLI = 0.99_{sb}$, $RMSEA_{sb} = 0.066$, $SRMR = 0.01$). When allostatic load was included, the model still showed a good fit, but the individual loading of allostatic load was substantially lower ($\beta = 0.237$, $P < 0.001$) than all other variables. Therefore, allostatic load was not included in the final latent factor.

Model evaluation

The final model (Figure 1) was a good to acceptable fit for the data ($CFI_{sb} = 0.95$, $TLI_{sb} = 0.91$, $RMSEA_{sb} = 0.072$, $SRMR = 0.032$).

TABLE 1 Sample descriptions and questionnaire scores ($N=604$)

	Mean	SD	Range
Household food insecurity[a]	1.78	2.82	0-10
DASS – Depression[a]	27.59	10.62	14-56
DASS – Anxiety[a]	23.59	8.42	14-54
DASS – Stress[a]	30.36	9.35	14-56
Physical stress symptoms[a]	2.73	.86	1-5
Allostatic load[a]	1.96	1.19	1-8
Eating to cope[a]	2.11	1.02	1-5
Drinking to cope[a]	1.63	.82	1-5
Diet quality[b]	36.88	6.66	13-52
BMI (kg/m^2)	29.19	7.86	15.0-66.8
Age (y)	39.07	12.66	18-75

[a]A high score represents greater symptoms, that is, of food insecurity as well as psychological and physiological stress.
[b]Low scores represent more frequent consumption of processed foods and less fresh produce.
DASS, Depression, Anxiety, and Stress Scale.

A covariance was added between eating to cope and drinking to cope based on modification indices. Direct associations between the variables and hypothesized indirect effects are shown in Tables 2 and 3, respectively. For ease of interpretation, the values in Figure 1 are standardized (β) coefficients, whereas those in Table 2 are regression coefficients.

HHFI, BMI, and diet quality

As can be seen in Table 2, HHFI was directly associated with distress, drinking to cope, and poorer diet quality but it did not directly contribute to eating to cope or BMI. There were no direct associations between distress and diet quality or BMI.

Consistent with predictions, distress was directly associated with increased eating to cope, which in turn was associated with increased BMI, although the association between eating to cope and poorer diet quality was not statistically significant. Distress was also associated with elevated drinking to cope, which, although not associated with diet quality, did have a marginal association with (lower) BMI.

Indirect effects were calculated for the hypothesized effect of HHFI on BMI and diet quality through distress and eating or drinking to cope (while controlling for other variables in the model; Table 3). The hypothesized indirect effect via distress and eating to cope was significant for BMI but not for diet quality. There was a marginal indirect effect through distress and drinking to cope on (lower) BMI but not on diet quality

Secondary analysis

In order to control for the effect of income on the model, we ran a multilevel structural model with the levels of weekly household income added as a random intercept (<£100, $N=21$; £100-£199, $N=43$; £200-£299, $N=48$; £300-£399, $N=45$; £400-£499, $N=77$; £500-£699, $N=110$; £700-£999, $N=110$; £1,000-£1,499, $N=82$; £1,500+, $N=32$). The smaller sample ($N=568$) in this analysis is due to 36 participants not reporting household income.

This approach enabled us to explore the effects in the model at the lower level (participants) controlling for the higher level (income). Income was instead not added as a predictor in the model due to collinearity with HHFI and ordinal measurement (necessitating generalized modeling). In addition, we were only interested in ascertaining whether the associations in the model held after controlling for income; taken together, this made the multilevel structural model the most appropriate analysis.

The model after controlling for income was a good fit (lower level SRMR=0.038). The pattern of results (Table 4) was almost the same as the single-level model (Table 2). It is notable that after removing variance associated with income there was neither direct association between drinking to cope and BMI nor between HHFI and drinking to cope.

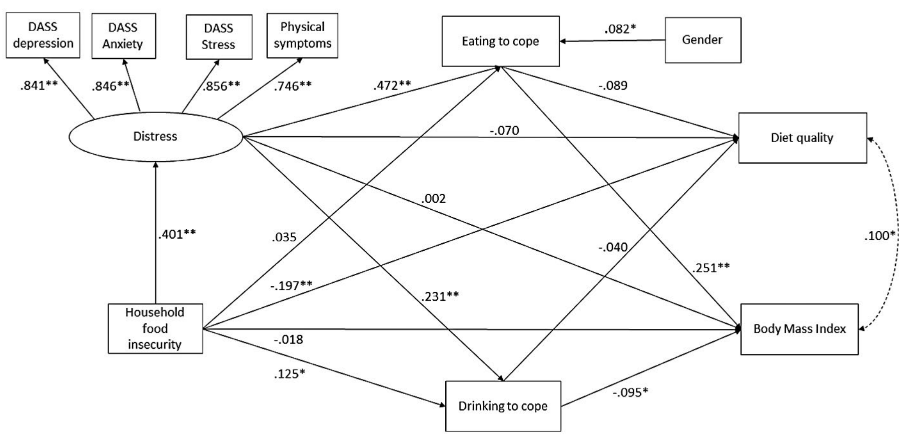

Figure 1 Associations between household food insecurity and BMI and diet quality via distress (latent variable), eating, and drinking to cope. For ease of interpretation, error terms and covariances are not visually represented (values are standardized regression coefficients) $^*P<0.025$, $^{**}P<0.001$. The dashed line between diet quality and BMI represents covariance. DASS, Depression, Anxiety, and Stress Scale.

TABLE 2 Direct associations between variables

Association	β (SE)	*P*	95% CI
HHFI → distress	0.51 (0.06)	<0.001	0.40 to 0.62
HHFI → eating to cope	0.06 (0.08)	0.441	−0.10 to 0.22
HHFI → drinking to cope	0.11 (0.05)	0.017	0.02 to 0.20
HHFI → BMI	−0.05 (0.12)	0.675	−0.28 to 0.18
HHFI → diet quality	−0.47 (0.10)	<0.001	−0.65 to −0.28
Distress → eating to cope	0.68 (0.08)	<0.001	0.53 to 0.83
Distress → drinking to cope	0.16 (0.04)	<0.001	0.08 to 0.23
Distress → BMI	−0.05 (0.10)	0.969	−0.23 to 0.24
Distress → diet quality	−0.13 (0.09)	0.176	−0.31 to 0.06
Eating to cope → BMI	0.39 (0.07)	<0.001	0.24 to 0.53
Eating to cope → diet quality	−0.12 (0.06)	0.070	−0.24 to 0.01
Drinking to cope → BMI	−0.30 (0.12)	0.015	−0.55 to −0.06
Drinking to cope → diet quality	−0.09 (0.11)	0.378	−0.30 to 0.11
Gender[a] → eating to cope	1.38 (0.61)	0.023	0.18 to 2.56

The association (covariance) between BMI and diet quality was significant (β = −5.05; SE = 1.94, *P* = 0.009)
[a]Males (0), females (1).

TABLE 3 Hypothesized indirect effects

Association	β (SE)	*P*	95% CI
HHFI → distress → eating to cope → BMI	0.13 (0.03)	<0.001	0.07 to 0.20
HHFI → distress → eating to cope→ diet quality	−0.04 (0.02)	0.076	−0.08 to 0.01
HHFI → distress → drinking to cope → BMI	−0.03 (0.01)	0.034	−0.05 to <−0.01
HHFI → distress → drinking to cope→ diet quality	−0.01 (0.01)	0.388	−0.03 to 0.01

TABLE 4 Direct associations between variables from the multilevel structural model

Association	β (SE)	*P*	95% CI
HHFI → distress	0.41 (0.06)	<0.001	0.29 to 0.53
HHFI → eating to cope	0.10 (0.07)	0.112	−0.02 to 0.23
HHFI → drinking to cope	0.12 (0.07)	0.068	0.01 to 0.23
HHFI → BMI	−0.05 (0.22)	0.811	−0.48 to 0.31
HHFI → diet quality	−0.47 (0.16)	0.003	−0.78 to −0.21
Distress → eating to cope	0.72 (0.07)	<0.001	0.58 to 0.87
Distress → drinking to cope	0.17 (0.05)	<0.001	0.08 to 0.26
Distress → BMI	0.01 (0.17)	0.971	−0.33 to 0.34
Distress → diet quality	0.17 (0.16)	0.277	−0.47 to 0.14
Eating to cope → BMI	0.38 (0.18)	0.031	0.03 to 0.73
Eating to cope → diet quality	−0.13 (0.08)	0.111	−0.28 to 0.03
Drinking to cope → BMI	−0.24 (0.21)	0.239	−0.64 to 0.16
Drinking to cope → diet quality	−0.07 (0.07)	0.284	−0.21 to 0.06
Gender[a] → eating to cope	1.19 (0.50)	0.023	0.21 to 2.18

[a]Males (0), females (1).

Discussion

The current study tested a novel theoretical model in which distress and unhealthy coping behaviors are intervening variables, which explain the well-established associations between HHFI, poor diet quality, and obesity. For the first time, we show that HHFI is indirectly associated with higher body weight via greater distress and eating to cope (i.e., HHFI was associated with distress; distress was associated with eating to cope; eating to cope was associated with higher BMI). Importantly, these associations remained in the multilevel model that controlled for participants' level of income. This indicates that the effects are specific to HHFI rather than it acting as a proxy for more general socioeconomic disadvantage.

Our data provide new insight into the "food insecurity–obesity paradox" by providing a behavioral mechanism for how increases in body fat may be achieved under conditions of food insecurity (5,6). Our findings are also consistent with contemporary models of obesity and recent empirical data in which distress and unhealthy coping behaviors are central to explaining the association between socioeconomic disadvantage and obesity (11,12,15). Notably, in our model, distress was not directly associated with higher BMI; the indirect effect required the addition of eating to cope. This suggests it is not distress *per se* but people's coping responses that drive the association between HHFI and BMI. In line with this, previous studies have found that stress alone does not account for the relation between social disadvantage and obesity (7,33). Maladaptive coping mechanisms involving food thus appear to be critical.

Our finding that HHFI was directly associated with poorer diet quality is well-established (34,35); however, contrary to prediction and our findings for BMI, this relationship was not explained by distress and eating to cope. One possibility is that eating as a coping mechanism is more strongly associated with larger portion sizes and binge eating (36) as opposed to frequency of intake *per se* of unhealthy foods. Further research is needed to understand specific patterns of eating that are associated with food insecurity and obesity. In the single-level model, there was also a significant indirect effect of HHFI via distress and drinking to cope on lower BMI. Given the strong associations between alcohol and disease burden, especially in socially disadvantaged groups (37), further consideration of motivations for alcohol use in the context of HHFI is warranted. However, the direct association between drinking to cope and lower BMI was no longer statistically significant in the multilevel model that controlled for participants' level of income.

Our findings have practical implications for interventions and policy agendas to tackle HHFI. Transitioning people to more healthy and sustainable plant-based diets and reducing socioeconomic inequities in diet-related noncommunicable diseases, including obesity, is high on international agendas (1,38). However, to effectively intervene and change consumer behavior, it is critical to first understand the broader context and drivers of dietary intake in populations characterized by high levels of HHFI. Interventions must also be tailored to the needs of high-risk groups (39). Although environmental and socioeconomic characteristics such as food availability, price, and sociocultural norms in addition to individual-level factors (e.g., knowledge and attitudes) are known to be important drivers of dietary inequalities (8,9,40), our data highlight the need to consider and target distress and unhealthy coping behaviors. Provision of psychological support to reduce distress and support the development of positive coping strategies may be an effective intervention strategy. The necessity of these interventions is all the more timely in light of the coronavirus disease 2019 global pandemic in 2020, which increased HHFI, widened inequalities in access to safe, nutritious foods, and had a profound impact on mental health (41,42).

Our study recruited a broad spectrum of participants, including those who were visiting food banks, to ensure sufficient representation of individuals experiencing HHFI. However, the data are cross-sectional, therefore, it is not possible to infer direct causal relations between variables; longitudinal data sets will be informative on this issue. The relationships between variables are relatively modest, which likely reflects the myriad of factors that influence the association between food insecurity and eating behavior (e.g., exercise, genetic factors) (e.g., 5, 8, 9). Future research should include such variables to establish how they influence the relationships observed in this study. Future research should, therefore, consider these alternative pathways that link HHFI with higher body weight. Because the sample was predominantly female (90%), it was not possible to test the gender differences observed in previous studies (5,43) whereby food insecurity is associated with higher BMI in females but not males. However, gender was controlled for in the model. Our sample was also predominantly white, and it is not clear if the same pathways and associations would exist across all ethnic groups. Finally, although the hypotheses and analyses were based on previous research (15), they were not formally preregistered, and preregistration is recommended for future studies in this area to enhance transparency and reproducibility (44).

Conclusion

In this study of UK-based adults, we show that HHFI was indirectly associated with higher body weight via greater distress and eating to cope. HHFI was directly associated with poorer diet quality; however, this relationship was not explained by distress and eating to cope. Interventions seeking to reduce obesity prevalence in food-insecure populations will likely benefit from targeting sources of distress and subsequent coping mechanisms.**O**

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References

1. FAO, IFAD, UNICEF, WFP, WHO. *The State of Food Security and Nutrition in the World 2019. Safeguarding Against Economic Slowdowns and Downturns*. Rome: FAO; 2019. Accessed May 10, 2020. https://www.unicef.org/media/55921/file/SOFI-2019-full-report.pdf
2. Essien UR, Shahid NN, Berkowitz SA. Food insecurity and diabetes in developed societies. *Curr Diab Rep* 2016;16:79. doi:10.1007/s11892-016-0774-y
3. Saiz AM Jr, Aul AM, Malecki KM, et al. Food insecurity and cardiovascular health: findings from a statewide population health survey in Wisconsin. *Prev Med* 2016;93:1-6.
4. Franklin B, Jones A, Love D, Puckett S, Macklin J, White-Means S. Exploring mediators of food insecurity and obesity: a review of recent literature. *J Community Health* 2012;37:253-264.
5. Nettle D, Andrews C, Bateson M. Food insecurity as a driver of obesity in humans: the insurance hypothesis. *Behav Brain Sci* 2017;40:e105. doi:10.1017/S0140525X16000947.
6. Kowaleski-Jones L, Wen M, Fan JX. Unpacking the paradox: testing for mechanisms in the food insecurity and BMI association. *J Hunger Environ Nutr* 2019;14:683-697.
7. Aggarwal A, Monsivais P, Cook AJ, Drewnowski A. Does diet cost mediate the relation between socioeconomic position and diet quality? *Eur J Clin Nutr* 2011;65:1059-1066.
8. Drewnowski A. Obesity, diets, and social inequalities. *Nutr Rev* 2009;67(suppl 1):S36-S39.
9. Arenas DJ, Thomas A, Wang J, DeLisser HM. A systematic review and meta-analysis of depression, anxiety, and sleep disorders in US adults with food insecurity. *J Gen Intern Med* 2019;34:2874-2882.
10. Stuff JE, Casey PH, Szeto KL, et al. Household food insecurity is associated with adult health status. *J Nutr* 2004;134:2330-2335.
11. Hemmingsson E. A new model of the role of psychological and emotional distress in promoting obesity: conceptual review with implications for treatment and prevention. *Obes Rev* 2014;15:769-779.
12. Hemmingsson E. Early childhood obesity risk factors: socioeconomic adversity, family dysfunction, offspring distress, and junk food self-medication. *Curr Obes Rep* 2018;7:204-209.
13. Gibson EL. The psychobiology of comfort eating: implications for neuropharmacological interventions. *Behav Pharmacol* 2012;23:442-460.
14. Laitinen J, Ek E, Sovio U. Stress-related eating and drinking behavior and body mass index and predictors of this behavior. *Prev Med* 2002;34:29-39.
15. Spinosa J, Christiansen P, Dickson JM, Lorenzetti V, Hardman CA. From socioeconomic disadvantage to obesity: the mediating role of psychological distress and emotional eating. *Obesity (Silver Spring)* 2019;27:559-564.
16. Gundersen C, Kreider B, Pepper J. The economics of food insecurity in the United States. *Appl Econ Perspect Policy* 2011;33:281-303.
17. Laraia BA, Siega-Riz AM, Gundersen C, Dole N. Psychosocial factors and socioeconomic indicators are associated with household food insecurity among pregnant women. *J Nutr* 2006;136:177-182.
18. Boggiano MM, Wenger LE, Turan B, Tatum MM, Morgan PR, Sylvester MD. Eating tasty food to cope. Longitudinal association with BMI. *Appetite* 2015;87:365-370.
19. Boggiano MM, Wenger LE, Turan B, et al. Real-time sampling of reasons for hedonic food consumption: further validation of the Palatable Eating Motives Scale. *Front Psychol* 2015;6:744. doi:10.3389/fpsyg.2015.00744
20. Kim KH. The relation among fit indexes, power, and sample size in structural equation modelling. *Struct Equ Modeling* 2005;12:368-390.
21. Pursey K, Burrows TL, Stanwell P, Collins CE. How accurate is web-based self-reported height, weight, and body mass index in young adults? *J Med Internet Res* 2014;16:e4. doi:10.2196/jmir.2909
22. Ng SP, Korda R, Clements M, et al. Validity of self-reported height and weight and derived body mass index in middle-aged and elderly individuals in Australia. *Aust N Z J Public* 2011;35:557-563.
23. Bickel G, Nord M, Price C, Hamilton WL, Cook JT. *Guide to Measuring Household Food Security, Revised 2000*. United States Department of Agriculture, Food and Nutrition Service; 2000.
24. Henry JD, Crawford JR. The short-form version of the Depression Anxiety Stress Scales (DASS-21): construct validity and normative data in a large non-clinical sample. *Br J Clin Psychol* 2005;44:227-239.
25. McCaffery JM, Marsland AL, Stohacker K, Muldoon MF, Manuck SB. Factor structure underlying components of allostatic load. *PLoS One* 2012;7:e47246. doi:10.1371/journal.pone.0047246
26. Burgess EE, Turan B, Lokken KL, Morse A, Boggiano MM. Profiling motives behind hedonic eating. Preliminary validation of the Palatable Eating Motives Scale. *Appetite* 2014;72:66-72.
27. Kuntsche E, Kuntsche S. Development and validation of the Drinking Motive Questionnaire Revised Short Form (DMQ-R SF). *J Clin Child Adolesc Psychol* 2009;38:899-908.
28. Green MA, Li J, Relton C, et al. Cohort Profile: The Yorkshire Health Study. *Int J Epidemiol* 2016;45:707-712.
29. Schaffer DM, Coates AO, Caan BJ, Slattery ML, Potter JD. Performance of a shortened telephone-administered version of a quantitative food frequency questionnaire. *Ann Epidemiol* 1997;7:463-471.
30. Das SR, Kinsinger LS, Yancy WS Jr, et al. Obesity prevalence among veterans at Veterans Affairs medical facilities. *Am J Prev Med* 2005;28:291-294.
31. Ullman JB. Structural equation modelling. In: Tabachnick BG, Fidell LS, eds. *Using Multivariate Statistics*. 4th ed. Allyn & Bacon; 2001:653-771.
32. Hu LT, Bentler PM. Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives. *Struct Equ Modeling* 1999;6:1-55.
33. Ball K, Schoenaker D, Mishra GD. Does psychosocial stress explain socioeconomic inequities in 9-year weight gain among young women? *Obesity (Silver Spring)* 2017;25:1109-1114.
34. Bocquier A, Vieux F, Lioret S, Dubuisson C, Caillavet F, Darmon N. Socio-economic characteristics, living conditions and diet quality are associated with food insecurity in France. *Public Health Nutr* 2015;18:2952-2961.
35. Leung CW, Epel ES, Ritchie LD, Crawford PB, Laraia BA. Food insecurity is inversely associated with diet quality of lower-income adults. *J Acad Nutr Diet* 2014;114:1943-1953.e2.
36. Boggiano MM, Burgess EE, Turan B, et al. Motives for eating tasty foods associated with binge-eating. Results from a student and a weight-loss seeking population. *Appetite* 2014;83:160-166.

37. Rehm J, Mathers C, Popova S, Thavorncharoensap M, Teerawattananon Y, Patra J. Global burden of disease and injury and economic cost attributable to alcohol use and alcohol-use disorders. *Lancet* 2009;373:2223-2233.
38. Haddad LJ, Hawkes C, Achadi E, et al. *Global Nutrition Report 2015: Actions and Accountability to Advance Nutrition and Sustainable Development*. International Food Policy Research Institute; 2015.
39. Peeters A, Blake MR. Socioeconomic inequalities in diet quality: from identifying the problem to implementing solutions. *Curr Nutr Rep* 2016;5:150-159.
40. McLeod ER, Campbell KJ, Hesketh KD. Nutrition knowledge: a mediator between socioeconomic position and diet quality in Australian first-time mothers. *J Am Diet Assoc* 2011;111:696-704.
41. Power M, Doherty B, Pybus K, Pickett K. How Covid-19 has exposed inequalities in the UK food system: the case of UK food and poverty [published online May 13, 2020]. *Emerald Open Res* 2020;2:11. doi:10.35241/emeraldopenres.13539.2
42. Shevlin M, McBride O, Murphy J, et al. Anxiety, depression, traumatic stress, and COVID-19 related anxiety in the UK general population during the COVID-19 pandemic. BJPsych Open 2020;6:e125. doi:10.1192/bjo.2020.109
43. Townsend MS, Peerson J, Love B, Achterberg C, Murphy SP. Food insecurity is positively related to overweight in women. *J Nutr* 2001;131:1738-1745.
44. Nosek BA, Alter G, Banks GS, et al. Promoting an open research culture. *Science* 2015;348:1422-1425.