




Household food insecurity: associations with disordered eating behaviours and overweight in a population-based sample of adolescents

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Abstract

Objective: To examine how household food insecurity is related to adolescent weight status and disordered eating.

Design: Cross-sectional, population-based study. Adolescents self-reported unhealthy weight control behaviours, binge eating and meal frequency; weight status was measured. Household food insecurity was assessed by asking parents to respond to the validated six-item US Household Food Security Survey Module.

Setting: Adolescents surveyed within Minneapolis/St. Paul public middle and high schools completed surveys at school, and their parents/guardians were surveyed by mail during the 2009–2010 academic year.

Participants: Ethnically/racially diverse, primarily low-income adolescents (mean age: 14.4 years, range: 10–22 years) and their parents/guardians (n 2285 dyads).

Results: More than one-third (38.9%) of the adolescents experienced past-year household food insecurity, 43.2% reported disordered eating and 39.6% were overweight. Generalised regression models showed that food insecure (FI) compared with food secure (FS) adolescents had higher prevalence of overweight (FI: 42.3% *v.* FS: 37.9%, $P = 0.039$), lower breakfast consumption (FI: 4.1 times/week *v.* FS: 4.4 times/week, $P = 0.005$) and greater use of unhealthy weight control behaviours (FI: 49.0% *v.* FS: 39.5%, $P < 0.001$) in unadjusted models. Models adjusted for parental education, ethnicity/race, sex and age found that food insecurity was associated with higher prevalence of unhealthy weight control behaviours (FI: 44.5% *v.* FS: 37.8%, $P = 0.007$), but not with weight status or other eating behaviours.

Conclusions: These results suggest that food insecurity may be an independent risk factor for unhealthy weight control behaviours, indicating a need to approach these intersecting issues in a comprehensive manner.

Keywords
Food insecurity
Disordered eating
Obesity
Adolescents
Eating behaviour

Food insecurity is defined as inconsistent or unpredictable access to affordable, nutritionally adequate food⁽¹⁾. Food insecurity has historically been associated with underweight status, but is now increasingly associated with obesity^(2–4). This association with obesity may be explained by the fact that low-nutrient, low-fibre, energy-dense foods tend to be cheaper than nutrient-dense, fibre-rich, lower-energy foods^(5,6). Thus, food insecure (FI) individuals may disproportionately depend on these low-cost, less nutritious foods, contributing to their risk for obesity. Another possible explanation for the food insecurity–obesity association is that food insecurity is linked to fluctuating

food availability, which may increase the risk for cycles of energetic restriction followed by binge eating, a pattern which, if repeated over time, may increase the propensity for weight gain⁽⁷⁾.

Several epidemiological studies have investigated the relationship between food insecurity and weight status in adults and children. A 2017 meta-analysis included 123 cross-sectional and seven longitudinal studies and found an overall positive association between food insecurity and elevated weight status in analyses unadjusted and adjusted for socio-economic status⁽⁴⁾. When looking at specific populations, this meta-analysis found that the

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food insecurity–obesity association was stronger in adult females than in children (defined as <16 years of age) or adult males.

Food insecurity is of particular concern for adolescents because they have high energy and nutrient needs to fuel their rapid growth and development. Reliable access to food that is familiar, of acceptable quality, and nutritionally adequate is foundational to healthful eating patterns for adolescents^(8,9). Consequently, any disruption to that foundation – including food insecurity – may put adolescents at increased risk for appetite dysregulation, inconsistent eating patterns and disruption to predictable growth and development patterns, including accelerated weight velocity^(8,10). When investigating the food insecurity–weight status relationship in adolescents, findings have been mixed^(11–15). A notable study by Lohman and colleagues examined the association of food insecurity with BMI gain over a 16-year period through prospective growth curve analysis⁽¹⁵⁾. At baseline, participants were 15 years old, primarily non-Hispanic white and residing in the rural Midwest. Investigators found that household food insecurity at 15 years of age predicted more rapid BMI gain from 16 to 31 years of age. However at baseline, there was no cross-sectional association between household food insecurity and BMI⁽¹⁵⁾.

Food insecurity may also be linked to disordered eating. Cross-sectional studies in adults have found positive associations between food insecurity and disordered eating^(16–21). One US-based study of adults found that food insecurity was more prevalent in the group with bulimia nervosa pathology in comparison with binge eating and control groups⁽²¹⁾. Another study in adult patrons of food pantries in San Antonio, TX found that participants with the least food security reported higher levels of binge eating and overall eating disorder pathology compared with more food secure (FS) participants⁽²⁰⁾. Despite the high prevalence of disordered eating behaviours in adolescents^(22–25), studies examining the relationship between food insecurity and disordered eating behaviours and attitudes in this population are limited^(26,27). We identified only three studies, a qualitative study⁽²⁶⁾ and a study which examined food insecurity as one potential risk factor for disordered eating⁽²⁷⁾, and one which examined food insecurity and body dissatisfaction⁽²⁸⁾. These studies found that food insecurity was associated with disordered eating or body dissatisfaction in adolescents. Our study builds on these data by specifically investigating whether household food insecurity, reported by parents/guardians, is associated with measured adolescent weight status and a comprehensive panel of problematic eating behaviours, reported by adolescents, in an ethnically diverse sample. Household food insecurity reported by parents/guardians was chosen as the exposure variable because of our goal to improve understanding of how the home food environment, not just the individual perceptions of adolescents regarding their food insecurity, may

support or disrupt the foundation of healthful eating patterns for adolescents. We chose parent/guardian report because it is likely the more accurate measure of household-level food security status.

The current study expands upon the extant literature on food insecurity and weight status and disordered eating behaviours to explore these associations in a large population-based sample of adolescents. The study explores cross-sectional associations both with and without adjustment for socio-economic status and ethnicity/race, given the interconnectedness of food insecurity with household income⁽²⁹⁾. We hypothesised that food insecurity would be associated with higher prevalence of overweight status, meal skipping, binge eating and unhealthy weight control behaviours (i.e. fasting, eating very little food, using food substitutes, skipping meals, smoking more cigarettes, volitional vomiting, laxative, diet pill or diuretic use) in unadjusted analyses. Lower socio-economic status is associated with higher prevalence of food insecurity⁽³⁰⁾, less frequent breakfast intake^(31,32), higher prevalence of disordered eating⁽³³⁾ and higher BMI^(32,34,35). Additionally, the existing literature suggests that persons who identified with an ethnicity/race other than non-Hispanic white experience higher prevalence of food insecurity⁽³⁰⁾ and tend to have less frequent breakfast intake⁽³¹⁾, higher prevalence of disordered eating⁽³⁶⁾ and higher BMI⁽³⁶⁾. We were interested in understanding the independent effect of food insecurity on disordered eating and BMI; thus, we examined models adjusted for ethnicity/race and our measure of socio-economic status and parental education. We hypothesised that parental education and ethnicity/race would account for some of the association between food insecurity and weight status, meal skipping and disordered eating, and therefore, associations observed in unadjusted models would be attenuated in the adjusted models. To the best of our knowledge, this study is the first to examine associations between food insecurity, using a strong measure of household food insecurity, with both weight status and disordered eating in a population-based sample of urban adolescents.

Methods

Study design and sample

EAT 2010 (Eating and Activity in Teens) was designed to examine dietary intake, physical activity, weight control behaviours, weight status and factors associated with these outcomes in adolescents^(37–39). Project F-EAT (Families and Eating and Activity Among Teens) was designed to examine factors within the family and home environment of potential relevance to these weight-related behaviours^(16,40,41). Data for this analysis are from these two coordinated, population-based studies.

For EAT 2010, surveys and anthropometric measures were completed by 2793 adolescents during the 2009–2010



academic year. The study population included adolescents from twenty public middle and high schools in the Minneapolis–St. Paul metropolitan area of Minnesota, which serve ethnically/racially diverse and largely low-income communities.

For Project F-EAT, data were collected by surveying up to two parents/guardians (n 3709) of the adolescents in EAT 2010. For the purpose of simplicity throughout the remainder of this article, both parents and guardians will be referred to as ‘parents.’ Approximately 70 % of adolescents provided information for two parents and 30 % provided contact information for one parent. In total, 2382 adolescent participants in EAT 2010 (85.3 %) had at least one parent respondent and there were two parent respondents for 1327 adolescents. Because our analyses depended on household variables obtained from the parents, adolescent participants whose parents did not participate in the study were excluded. Only data from the adolescent’s primary parent were used in the current analysis to ensure the most accurate information on the usual home environment. When two parents responded, primary parent status was determined using an algorithm that accounted for the family living situation (preference to parents who lived with their child more than half the time), relationship to the adolescent (preference to biological and adoptive parents over step-parents) and the parent’s sex (preference to female because of literature indicating that female parents are more likely to be responsible for household food purchasing and preparation)⁽³⁹⁾. Pairing adolescents with the primary parent resulted in a final analytic sample of 2285 adolescent–parent dyads.

Adolescent survey development and measures

The EAT 2010 survey is a 235-item self-report instrument which assesses a range of factors of potential relevance to weight status and weight-related behaviours among adolescents. Survey development was guided by a review of previous Project EAT surveys^(42,43) to identify the most salient items; a theoretical framework, which integrates an ecological perspective with Social Cognitive Theory^(44,45); expert review by professionals from different disciplines and extensive pilot testing with adolescents^(37,39). The test–retest reliability of measures over a one-week period was also examined in a separate sample of 129 middle and high school students^(22,46).

Adolescent socio-demographic characteristics

Age, sex and ethnicity/race were self-reported by adolescents. Ethnicity/race was assessed with the following question: ‘Do you think of yourself as...? (1) White, (2) Black or African American, (3) Hispanic or Latino, (4) Asian American, (5) Native Hawaiian or Pacific Islander, (6) American Indian or Native American or (7) Other.’ Only thirty-five adolescents reported ‘Hawaiian or Pacific Islander’; therefore, they were coded as ‘Mixed or Other Race.’

Adolescent weight status

Trained research staff measured adolescents’ height and weight using standardised procedures during selected health, physical education and science classes. Measurements were completed in a private area⁽⁴⁷⁾. Height was measured to the nearest 0.1 cm using a Shorr board and weight to the nearest 0.1 kg using a calibrated scale. Centers for Disease Control and Prevention guidelines were used to calculate BMI and BMI percentile for each adolescent^(48,49). Adolescents’ BMI was then dichotomised to represent weight status; a BMI \geq 85th percentile was categorised as overweight, and a BMI $<$ 85th percentile was categorised as not overweight.

Adolescent meal frequency and disordered eating behaviours

Adolescents were asked to report how often they ate breakfast, lunch and dinner. For example, they were asked, ‘During the past week, how many days did you eat breakfast?’ Response options ranged from 0 to 7 d, and participants selected one response (test–retest $r=0.76$). The same questions and responses were repeated for lunch (test–retest $r=0.47$) and dinner (test–retest $r=0.56$).

Based on extensive pilot testing with adolescents and expert review to determine face validity^(37,42), unhealthy weight control behaviours were assessed with the following question, ‘Have you done any of the following things in order to lose weight or keep from gaining weight during the past year?’ Responses included fasted, ate very little food, used a food substitute, skipped meals, smoked more cigarettes, took diet pills, made myself vomit, used laxatives and used diuretics. In addition to reporting ‘yes/no’ in response to each of the individual unhealthy weight control behaviours, a positive response for one or more behaviour was coded as use of any unhealthy weight control behaviour. Those unhealthy weight control behaviours further categorised as extreme included took diet pills, made myself vomit, used laxatives and used diuretics. Study test–retest agreement was 85 % for unhealthy weight control behaviours and 96 % for the extreme weight control behaviour subset⁽⁴⁶⁾.

Binge eating with and without loss of control was assessed using two questions adapted from the adult version of the Questionnaire on Eating and Weight Patterns-Revised⁽⁵⁰⁾. This questionnaire has good psychometric properties in adolescents⁽⁵¹⁾. Binge eating was assessed by asking, ‘In the past year, have you ever eaten so much food in a short period of time that you would be embarrassed if others saw you (binge-eating)?’ Loss of control was assessed next by asking, ‘During the times when you ate this way, did you feel you couldn’t stop eating or control what or how much you were eating?’ Test–retest agreement for the binge question was 90, and 75 % for the loss of control question⁽⁴⁶⁾.

Parent survey development and measures

The Project F-EAT survey was designed to assess food-specific parenting practices and the home food environment.



A multi-disciplinary research team developed the Project F-EAT survey with guidance from an ecological framework^(44,52), a comprehensive review of the literature, and extensive pilot testing with parents of adolescents. Test-retest reliability was assessed in a subsample of 102 parent respondents who completed the parent survey twice within a 2-week period⁽¹⁶⁾.

Parental education

Parent-reported household educational attainment was used to measure socio-economic status^(16,34,38,53). Parents were asked, 'What is the highest grade or year of school that you have completed?' The same question was asked about their spouse or partner. Responses included did not finish high school, finished high school or got General Educational Development, some college or training after high school, finished college, and advanced degree (e.g. Master's degree, PhD, MD).

Household food insecurity

Past-year food security was measured as a part of the parent survey using the previously validated six-item US Household Food Security Survey Module modified for self-administration which assesses food security over the past 12 months. This scale has been shown to correctly classify 97.7% of families when compared with the full eighteen-item scale included in the Current Population Survey^(54,55). The survey module includes the following items: 'Is this statement true?: "We couldn't afford to eat balanced meals?"; 'In the past 12 months, did you or other adults in your household ever cut the size of your meals or skip meals because there wasn't enough money for food?'; 'In the past 12 months, did you ever eat less than you felt you should because there wasn't enough money for food?' and 'In the past 12 months, were you ever hungry but didn't eat because there was not enough money for food?' Affirmative responses to the items were summed according to the established guidelines, and this raw score (test-retest $r = 0.77$) was used to categorise households as FS (score = 0–1) or FI (score ≥ 2)^(16,55). We used the less severe cut-point of low food security (score ≥ 2) because we were most interested in understanding, from a population perspective, how more prevalent exposures to food insecurity were linked to more common public health problems (i.e. disordered eating behaviours). Additionally, in a supplemental sensitivity analysis, we used the more severe cut-point of very low food security (score ≥ 5)^(16,56).

Statistical analysis

Bivariate associations between household food insecurity status and key variables including socio-demographic characteristics were assessed using t tests or χ^2 tests, as appropriate. We were interested in understanding the specific effect of food insecurity on disordered eating and weight status above and beyond the effect of

socio-economic status. Therefore, crude and adjusted (parental education, race/ethnicity, sex and age) logistic regression models with robust standard errors were used to estimate marginal probabilities and 95% CI for each binary outcome (e.g. overweight status). Similarly, crude and adjusted (parental education, race/ethnicity, sex and age) linear regression models with robust standard errors were used to estimate marginal means and 95% CI for each ordinal outcome (e.g. frequency of breakfast). Adjusted models used Huber–White robust sandwich estimators to adjust for potential clustering by school. Linear regression models are appropriate for ordinal and other non-normally distributed outcomes in large sample sizes⁽⁵⁷⁾. All analyses were conducted using SAS 9.4 (copyright 2002–2012).

Results

Descriptive findings of food insecurity by socio-demographic characteristics

Participating adolescents were ethnically/racially diverse and were primarily living in low socio-economic status homes (Table 1). The mean age of adolescent participants was 14.4 years (age range 10–22 years); 45.8% were identified as male and 54.2% as female. Parent participants had a mean age of 42.3 (SD 8.6) years. The majority of parent respondents were mothers or other female guardians (62.0%). Household food insecurity was experienced in the past year by 38.9% of this ethnically/racially diverse, largely low-income, urban adolescent sample. Non-white adolescent race, lower household educational attainment and lower household income were associated with greater household food insecurity ($P < 0.001$). The data did not suggest differences in household food security status based on age or sex (Table 1).

Eating behaviours and weight status by food insecurity status in adolescents

In the unadjusted model, household food insecurity was associated with higher prevalence of overweight status (FI: 42.3% *v.* FS: 37.9%, $P = 0.039$). Adjusting for ethnicity/race, parental education, sex and age attenuated this difference, and it was no longer statistically significant (Tables 2 and 3).

Household food insecurity was associated in unadjusted models with less frequent adolescent breakfast consumption (FI: 4.1 times/week *v.* FS: 4.4 times/week, $P = 0.005$), greater likelihood of engaging in any unhealthy weight control behaviour (FI: 49.0% *v.* FS: 39.5%, $P < 0.001$) and the following specific unhealthy weight control behaviours: fasting, eating very little food, meal skipping, laxative use and diuretic use to control weight. There was no association between food insecurity and volitional vomiting, diet pill use, food substitute use or

**Table 1** Socio-demographic characteristics of a sample of adolescents in Minneapolis–St. Paul, Minnesota by household food security status in 2009–2010*

Characteristics	Total (n 2285)		Food secure (n 1395)		Food insecure (n 890)		P
	n	%	n	%	n	%	
Total	n/a	n/a	1395	61.1	890	38.9	n/a
Age (years)							
Mean	2.0		2.0		1.9		0.052
SD	14.5		14.5		14.4		
Sex							
Male	1047	45.8	639	45.8	408	45.8	0.987
Female	1238	54.2	756	54.2	482	54.2	
Race/ethnicity							
White	477	21.0	358	25.8	119	13.4	<0.001
Black or African American	637	28.0	390	28.1	247	27.9	
Hispanic or Latino	391	17.2	254	18.3	137	15.5	
Asian American	443	19.5	212	15.3	231	26.0	
Native American	72	3.2	42	3.0	30	3.4	
Mixed or other race	257	11.3	134	9.6	123	13.9	
Parental education							
Did not finish high school	533	23.5	270	19.5	263	29.9	<0.001
Finished high school	466	20.5	275	19.8	191	21.7	
Some college	656	28.9	366	26.4	290	32.9	
Finished college	410	18.1	298	21.5	112	12.7	
Advanced degree	204	9.0	179	12.9	25	2.8	

P-values are bolded if statistically significant at the 0.05 significance level.

* χ^2 test: % and n. T Test: mean and sd. Parental education was reported by parents and refers to the highest educational attainment of any parent or guardian in the household. All other socio-demographic characteristics were self-reported by adolescents.

Table 2 Eating behaviours and weight status by household food security status in adolescents, unadjusted estimates*

Characteristics	Food secure (n 1395)		Food insecure (n 890)		P
	n	%	n	%	
Breakfast (eaten per week)					
Mean		2.6		2.6	0.005
SD		4.4		4.1	
Lunch (eaten per week)					
Mean		1.9		1.9	0.183
SD		5.9		5.8	
Dinner (eaten per week)					
Mean		1.7		1.7	0.375
SD		6.1		6.0	
UWCB (any)	549	39.5	434	49.0	<0.001
Extreme UWCB	63	4.5	55	6.2	0.077
Binge eating	204	14.7	121	13.8	0.556
Binge with loss of control	112	8.1	67	7.7	0.715
UWCB					
Fasted	11.0		15.7		0.001
Ate very little food	30.2		35.7		0.006
Volitional vomiting	2.7		2.2		0.441
Skipped meals	26.3		32.6		0.001
Diet pill use	2.1		2.4		0.652
Laxative use	0.7		1.8		0.018
Diuretic use	0.5		1.9		0.001
Food substitute use	6.7		8.1		0.231
Smoked more cigarettes	2.1		2.2		0.907
Overweight	529	37.9	376	42.3	0.039

UWCB, Unhealthy Weight Control Behaviour.

P-values are bolded if statistically significant at the 0.05 significance level.

* χ^2 test: % and n. T test: Mean and sd.

smoking more cigarettes nor was there an association with binge eating (Table 2).

After adjusting for race/ethnicity, parental education, sex and age, associations remained statistically significant

for food insecurity with any unhealthy weight control behaviour (FI: 44.5% *v.* FS: 37.8%, $P = 0.007$), including the following specific unhealthy weight control behaviours: fasting (FI: 13.4% *v.* FS: 10.0%, $P = 0.047$) and

**Table 3** Eating behaviours and weight status by household food security status in adolescents, adjusted estimates*

Characteristics	Food secure (n 1395)		Food insecure (n 890)		P
	%	95 % CI	%	95 % CI	
Breakfast (eaten per week)					
Mean	4.3		4.1		0.227
95 % CI	4.2, 4.5		3.9, 4.4		
Lunch (eaten per week)					
Mean	5.9		5.8		0.361
95 % CI	5.8, 6.0		5.6, 6.0		
Dinner (eaten per week)					
Mean	6.0		6.1		0.601
95 % CI	5.9, 6.2		5.9, 6.3		
UWCB (any)	37.8	35.4, 40.2	44.5	39.9, 49.1	0.007
Extreme UWCB	3.2	2.3, 4.5	4.1	3.0, 5.6	0.094
Binge eating	14.0	12.5, 15.6	12.9	11.4, 14.5	0.143
Binge with loss of control	7.5	6.4, 8.7	6.9	5.2, 9.1	0.645
UWCB					
Fasted	10.0	8.4, 11.8	13.4	10.6, 16.9	0.047
Ate very little food	29.1	27.0, 31.3	32.0	27.7, 36.6	0.184
Volitional vomiting	1.9	1.3, 3.0	1.5	0.7, 3.2	0.472
Skipped meals	24.5	22.0, 27.1	28.6	25.3, 32.1	0.075
Diet pill use	1.2	0.8, 1.8	1.4	0.9, 2.1	0.592
Laxative use	0.3	0.1, 0.9	0.8	0.3, 2.0	0.005
Diuretic use	†	†	†	†	†
Food substitute use	6.3	5.3, 7.5	6.8	5.4, 8.5	0.599
Smoked more cigarettes	1.7	1.0, 2.8	2.0	1.4, 2.9	0.553
Overweight	35.6	32.7, 38.5	37.6	33.4, 42.1	0.391

UWCB, Unhealthy Weight Control Behaviour.

P-values are bolded if statistically significant at the 0.05 significance level.

*Logistic regression models with robust standard errors were used to estimate marginal probabilities and 95 % CI for each binary outcome variable adjusted for parental education, race/ethnicity, age, sex and potential clustering by school. Similarly adjusted multiple regression models with robust standard errors were used to estimate means and 95 % CI for mean number of breakfast, lunch and dinner outcomes.

†Prevalence is too low to estimate result.

laxative use (FI: 0.8% *v.* FS: 0.3%, $P=0.005$) (Table 3). Observed relationships were similar when we used the more severe cut-point value of very low food security from the six-item US Household Food Security Survey Module (data not shown).

Discussion

In this population-based sample of ethnically diverse, largely low-income, urban adolescents, we found that household food insecurity was associated with higher prevalence of overweight and several unhealthy eating behaviours in unadjusted models. After adjustment for ethnicity/race, parental education, sex and age, associations remained between food insecurity and unhealthy weight control behaviours such as fasting and laxative use. Household food insecurity, overweight and disordered eating behaviours were all common in this adolescent sample, with 43% reporting unhealthy weight control behaviours, 40% experiencing overweight and 39% living in FI homes. These findings highlight the complex nature of prevalent nutrition-related problems experienced by adolescents.

Studies examining the food insecurity-eating behaviour relationship have generally not focused on the adolescent age group. To our knowledge, only three

studies have investigated associations between food insecurity and disordered eating behaviours and attitudes in adolescents⁽²⁶⁻²⁸⁾. The first was a qualitative study by Tester and colleagues in low-income children and adolescents enrolled in an outpatient weight management programme (mean age: 11 years old)⁽²⁶⁾. Using the US Core Food Security Model to characterise food insecurity and Diagnostic and Statistical Manual of Mental Disorders, 5th Edition criteria for binge eating disorder and other specified feeding and eating disorders to characterise disordered eating, participants' disordered eating emerged as a theme in the FI group but not in the FS group⁽²⁶⁾. The second study by West and colleagues was a longitudinal population-based study in adolescents that explored various risk factors for disordered eating, one of which was food insecurity. This study found that self-reported food insecurity during adolescence independently predicted binge eating 5 years later, but only in adolescents from low socio-economic status backgrounds⁽²⁷⁾. Our results are consistent with both of these studies in that we found positive associations between household food insecurity and disordered eating behaviours in adolescents. A third study by Altman and colleagues found that food insecurity was cross-sectionally associated with higher odds of body dissatisfaction in children and adolescents ($n=14\,768$, mean age = 10.2 years)⁽²⁸⁾. Their results were consistent across all racial/ethnic groups and BMI



categories even after adjusting for age, sex, free/reduced price meal eligibility, BMI and race/ethnicity⁽²⁸⁾. More studies are needed to further understand the relationships between food insecurity and eating behaviours, body satisfaction and weight status in young people.

When investigating the food insecurity-eating behaviour relationship in adolescents, it is important to consider the complex nature of the food environments that FI adolescents occupy. For example, FI adolescents may be attempting to control their weight while also navigating various food environments at home, school, with peers, at work and/or extracurricular activities. Furthermore, adolescents may engage not only in disordered eating to control weight but also for other reasons. For example, a 2016 report found that in FI households, parents generally try to protect both children and adolescents from experiencing hunger. Adolescents also routinely take on this role by restricting their food intake to ensure younger siblings have enough to eat⁽⁵⁸⁾. Therefore, future research on this topic should investigate competing motivations for adolescent disordered eating behaviours. It may also be useful to explore whether birth order and/or the specific age during which food insecurity is most acute plays a role in eating behaviour within the context of a FI household.

Household food insecurity, overweight and disordered eating behaviours were each highly prevalent in our sample of adolescents from diverse ethnic/racial and socioeconomic backgrounds. These findings are concerning, given the well-established individual health risks associated with obesity^(59,60), food insecurity⁽⁶¹⁻⁶⁴⁾ and disordered eating⁽⁶⁵⁻⁶⁹⁾. Previous results reported by our team and others reveal that both binge eating^(33,49,70) and restrictive eating^(33,36,71) are positively associated with overweight. Despite these findings, food insecurity, disordered eating and overweight are most often investigated and addressed as separate and unrelated^(33,72-77). In recent years, some attention has been paid to the overlap between overweight and disordered eating in adolescents, but the role of food insecurity is generally not included in such discussions^(33,72-77). Healthcare providers who work with adolescents should be aware that disordered eating, food insecurity and overweight are prevalent problems that can co-occur and may perhaps exacerbate one another. Given the high prevalence of food insecurity, disordered eating and overweight, and their potential to negatively impact health outcomes for adolescents, understanding how to best address all three of these problems in a comprehensive manner should be the focus of future research.

Our study has several strengths. To our knowledge, it is the first quantitative study to investigate the relationship between household food insecurity and a range of weight-related outcomes in adolescents: meal frequency, disordered eating and weight status. Our population-based sample was large and ethnically diverse. Adolescents' height and weight were measured by trained research

staff using standardised procedures. We were able to survey adolescents about their own eating behaviours, survey parents about household food security status and then link parent data to adolescent data. We investigated a wide variety of eating behaviour and socio-demographic variables in the adolescents. Finally, the survey's extensive pilot testing and test-retest reliability testing ensured that questions were developmentally appropriate for adolescents. Despite our study's strengths, it also has important limitations. Because the causes of disordered eating and food insecurity are multifactorial, there may have been confounding or causal variables that we did not include in our statistical models. Our study relied on several self-reported measures, so recall bias may have affected our results. Due to our cross-sectional design, we were unable to draw conclusions about a temporal or causal relationship between household food insecurity and adolescent eating behaviours or weight status. It is possible that parent-reported food security may not accurately reflect the food security experienced by the adolescent. Carlos Chavez and colleagues found discordance in reports of food insecurity in 51 % of 70 Latino adolescent-parent dyads⁽⁷⁸⁾. However, it is worth considering that developmental factors may play a role in such discordance. Furthermore, our specific research question focused on the home food environment, rather than adolescent perceptions of food security; thus, we determined parental report of food security was the most appropriate exposure for our study. Finally, these data were collected in 2010, shortly after the Great Recession of 2008, and the median household income range in this sample (\$20 000-34 999) was much lower than that of households with families in 2010 in Minneapolis and St. Paul of \$61 725 and \$55 254, respectively⁽⁷⁹⁾. These factors may explain the high prevalence of food insecurity in our sample and may impact the generalisability of our results. However, the high prevalence of food insecurity in this sample provided a unique opportunity to improve understanding of the role of food insecurity in adolescent nutrition-related health outcomes.

Our study builds on a small amount of published literature showing a positive association between household food insecurity and adolescent disordered eating⁽²⁶⁻²⁸⁾. Our findings point to the need for well-designed longitudinal studies to investigate the aetiological nature of these relationships. Furthermore, these results draw attention to health disparities that may exist for youth who are overweight and/or FI. Clinicians and public health practitioners should be aware that all adolescents, including those who are overweight or FI, are at high risk for disordered eating behaviours and the accompanying negative health consequences. Given the high prevalence and poor health outcomes associated with food insecurity, overweight and disordered eating in adolescents, future research should focus on elucidating these relationships and understanding





how to intervene with individuals who are at the highest risk. This study highlights the varied and intersecting barriers adolescents face to achieving nutritionally adequate, balanced and healthful eating patterns. More research is needed to confirm these findings and further understand these multifaceted problems.

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