

# Hunger and overweight in Canadian school-aged children: A propensity score matching analysis

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## ABSTRACT

**OBJECTIVE:** The last decade saw a higher prevalence of overweight reported among food-insecure families in Canada, but no robust evidence exists on the covariate-adjusted association in children. In this study, we examined the association between hunger and overweight in Canadian students, using a propensity score matching analysis to reduce confounding.

**METHODS:** This research used data from the 2009/2010 Canadian Health Behaviour in School-aged Children study on a representative national sample of students in Grades 6 through 10. Students self-reported their height and weight and how often they have gone to school or to bed hungry due to a lack of food at home. Multivariate logistic regression modeling was conducted on the total sample ( $N = 17,694$ ) and on the sample matched on propensity scores ( $n = 7,788$ ).

**RESULTS:** The overall prevalence of overweight among students was 20.2% with a significant difference between students who reported hunger (24.0%; 95% CI: 22.1–26.0) and students who did not (19.0%; 95% CI: 17.9–20.2). Analysis on the matched sample revealed a significant association between hunger and overweight in children (adjusted odds ratio: 1.30; 95% CI: 1.12–1.50).

**CONCLUSIONS:** A substantial number of Canadian students have reported being hungry because of a lack of food at home. These students are at increased risk of overweight, regardless of their social class. Child hunger and household food insecurity exist in Canada and constitute a call for policy action at a national level.

**KEY WORDS:** Overweight; child; adolescent; hunger; propensity score; food

La traduction du résumé se trouve à la fin de l'article.

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Overweight and obesity are now a global health problem and the prevalence of childhood overweight and obesity in North America remains the highest among high-income countries.<sup>1</sup> In Canada, obesity has been reported in 7.9% and 8.9% of children aged 5–11 years and 12–17 years respectively, while 19.8% of youths were classified as overweight in 2011 (based on International Obesity Task Force [IOTF] cut-offs).<sup>2</sup> Excess weight contributes to mental and physical health problems in children and is a key predictor for persistent weight problems in adulthood.<sup>3</sup> The research on contributors to childhood overweight and obesity suggests complex interactions between individual factors (e.g., genetic predisposition), social factors (e.g., family characteristics), lifestyle factors (e.g., food habits and sedentary activities) and environmental factors (e.g., neighbourhood characteristics).<sup>4</sup>

In the last two decades, studies have investigated the paradoxical association between food insecurity and overweight. A proposed definition of food insecurity is “the inability to acquire or consume an adequate diet quality or sufficient quantity of food in socially acceptable ways, or the uncertainty that one will be able to do so”.<sup>5</sup> Hunger is a common consequence and indicator of household food insecurity. Although the intuitive hypothesis is that persons who are hungry weigh less because they consume less food, the reverse relationship was found in adults.<sup>6</sup> One hypothesis is that food insecurity leads to a cycle of hunger followed by caloric overconsumption, particularly from cheaper and energy-dense

foods.<sup>7–10</sup> Specific parenting practices have been observed in families that experience food insecurity, with mothers being more likely to encourage overeating in their children.<sup>11</sup>

Evidence on the associations among household food insecurity, hunger and overweight during childhood has been inconsistent.<sup>9,10,12,13</sup> To our knowledge, the association between hunger and overweight in childhood has not been examined among a nationally representative sample of Canadian school-aged children. The aim of our study was to investigate the association between hunger and overweight in Canadian children using data from the Canadian Health Behaviour in School-aged Children (HBSC) study. We adjusted for confounding using both a

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conventional multivariate regression analysis and a propensity score (PS) matching approach. The PS approach controls for confounding by identifying and then matching children who have similar levels of confounders, which may be useful in hunger research where the socio-economic circumstances of children who go hungry may be markedly different from those of children who do not.

## **METHODS**

### **Study population**

The study used data that were collected in the 2009/2010 Canadian Health Behaviour in School-aged Children (HBSC) study, a cross-sectional survey conducted in collaboration with the World Health Organization. A nationally representative sample of students in Grades 6 through 10 was recruited through a two-stage cluster process to select whole classes of students. Standardized population weights were used to account for oversampling and stratification. Students from Prince Edward Island and New Brunswick, and those attending private and special schools were not included in the sample.<sup>14</sup> Response rate at the student level was 77.0%. The self-reported questionnaire, developed internationally by an interdisciplinary research group,<sup>15</sup> was administered anonymously in classrooms to 26,078 students in 436 schools. The questionnaire covered various topics related to health and its determinants in school-aged children.

The study protocol was approved by the Queen's University General Research Ethics Board. Written parental consent or passive consent was obtained, according to local school board customs.

### **Measures**

#### *Overweight*

Weight and height were self-reported and body mass index (BMI) was computed as an individual's body weight divided by the square of the individual's height. Stata's *egen* function *zanthro* was used to identify underweight, healthy weight, overweight, or obesity using age- and gender-adjusted criteria corresponding to adult BMI cut-off points ( $\text{kg}/\text{m}^2$ ) endorsed by the World Health Organization international child growth standards.<sup>16</sup> For the current analysis, overweight was defined as being overweight or obese ( $\geq 25 \text{ kg}/\text{m}^2$ ) compared with non-overweight ( $< 25 \text{ kg}/\text{m}^2$ ).

#### *Hunger*

The perception of hunger was measured through the following question: "Some young people go to school or to bed hungry because there is not enough food at home. How often does this happen to you?" Students rated the item using a four-point Likert scale with the following response options: 1) Always, 2) Often, 3) Sometimes and 4) Never. The experience of hunger was defined as being the case when the respondent replied affirmatively (sometimes/often/always).<sup>17</sup>

#### *Potential Confounders and Covariates*

Potential confounders of the association between going to bed hungry and child overweight were taken into account. Data on child and family socio-demographic variables were collected, including gender, grade, ethnicity, immigration status, family affluence, family structure (single-parent families vs. others), and residential province/territory. Family affluence was assessed using the HBSC Family

Affluence Scale, which is a composite measure of material affluence based on four common household assets or activities that reflect affluence (i.e., number of computers, number of cars, having one's own bedroom, and holidaying abroad). A summary score ranging from 0 to 9 was then used to categorize children as living within a low (0–3), middle (4–5) or high (6–9) family affluence.<sup>18</sup> Child lifestyle was measured through the level of vigorous physical activity outside of school per week ( $\geq 2$  hours vs.  $< 2$  hours), dieting to lose weight (yes vs. no), time dedicated to sedentary screen-based activities during the week (TV and video games separately;  $> 2$  hours per day vs.  $\leq 2$  hours), the number of dinners per week with family (0–7), fast-food consumption per week (0 vs.  $\geq 1$  meal), and conflict with parents (strong agreement to "I have lots of arguments with my parents"). The school neighbourhood environment was also used to estimate the PS (average family income and unemployment rate within 1 km circular buffer of the school, and rural/urban school area from 2006 census data).

### **Statistical analysis**

Data analyses were conducted using Stata 13.0.<sup>19</sup> Chi-square tests were used to compare socio-demographic characteristics between students according to their perception of hunger.

Multivariate logistic regression modeling was conducted to explore the association between hunger and overweight on the total sample and on the sample matched on the PS. PS matching is a method of confounder control that matches together individuals with a similar likelihood to experience hunger given their household and individual characteristics.<sup>20</sup> The PS matching method is useful where comparison groups may have very different distributions of covariates, potentially leading to faulty inferences based partly on model extrapolation. The PS matching method tends to mimic some characteristics of randomized controlled trials in balancing both comparison groups on a set of covariates. PS were computed using logistic regression with hunger as dependent variable (1 = went to school or bed hungry; 0 = did not go to school or bed hungry). Potential confounders and others covariates were included in the predictive model (the list is shown in Supplementary Table 1; all supplementary material in this article can be accessed in the ARTICLE TOOLS section on the journal site) as well as their squares and interactions terms when they improved the predictive power of the model. We checked visually the overlap of the density distribution of the estimated PS among exposed and non-exposed groups, before and after matching. Given the skewed distribution of the PS, the matching was performed on the estimate of the logit of the PS (Austin 2011) with a 1:1 nearest neighbour matching algorithm without replacement within caliper equal to 0.2 times the standard deviation of the logit of the PS. The balance in both groups of the covariates was examined through the standardized difference indicator.<sup>20</sup> We checked mean differences of covariates before and after matching using a two-sample *t*-test. Balancing between covariates was considered satisfying when the standardized difference value was less than 10%. Matching of PS was carried out using the Stata's *psmatch2* package.

Two models were implemented on the total sample and the matched sample. A first model (Model 1) adjusted for child and family socio-demographic factors and a second model (Model 2) adjusted for child and family socio-demographic factors and child lifestyle factors. An interaction term was tested in Model 1 to

examine whether the association between hunger and overweight differed by gender. Sampling weights were taken into account in the PS model (as predictor) and for analyses conducted on the outcomes on the total and the matched samples.<sup>21</sup> All standard errors were adjusted for cluster sampling design using the svy command.

Several sensitivity analyses were conducted to explore potential bias due to BMI missing data and misclassification. Model 2 was applied in new samples matched on PS generated to explore any changes in the studied association under the following conditions: 1) all missing BMI values were set to overweight or obesity and 2) all missing BMI values were set to normal weight. Since hunger may be a risk factor for underweight, we also excluded those who were underweight from the reference group and conducted an additional PS analysis. A second set of sensitive analyses was run in which different cut-off points were tested to define hunger: 1) “Always” and “Often” grouped compared to others responses; and 2) “Always” compared to others responses. Model 2 was therefore applied on the full sample and the sample matched on new PS.

Results are shown as adjusted odds ratio (AOR) and 95% confidence interval (95% CI).

## RESULTS

### Descriptive statistics

A total of 20,206 students in Grades 6 to 10 were available for analyses and after exclusion of observations with missing data for

the hunger and overweight status (22.3%) (Supplementary Figure 1). Students who did not answer questions on weight, height and/or hunger differed significantly from others in their socio-demographic characteristics, with more girls, more students in early grades, and more students with low family affluence. Socio-demographic characteristics and BMI categories of the whole sample and by hungry status are provided in Table 1, and differences between groups were found for most variables. The prevalence of overweight among students in grades 6–10 was 20.2% with a significant difference between students who reported going to school or to bed hungry and the others: 24.0% (95% CI: 22.1–26.0) and 19.0% (95% CI: 17.9–20.2) respectively.

### Multivariate logistic regression analysis on the total sample

Results of the multivariate logistic regression analysis are shown in Table 2. Multivariate regression analyses on the total sample showed a significant association between going to school or to bed hungry and overweight among students. The odds ratio adjusted (AOR) for socio-demographic variables (Model 1 –  $n = 18,561$ ) was 1.33 (95% CI: 1.18–1.51;  $p < 0.001$ ) and remained significant after adjustment for additional potential confounders related to the child’s lifestyle (Model 2 –  $n = 17,694$ ) (AOR: 1.25; 95% CI: 1.10–1.42;  $p = 0.001$ ). No significant interaction with gender was found in the association.

**Table 1.** Characteristics of the sample according to the hunger status

Variable	All children % (n)	Never went to school/bed hungry % (n)	Went to school/bed hungry % (n)	Chi square p-value
Total	$N = 20,206$	$N = 15,311$	$N = 4895$	
Female	49.8 (10,045)	50.2 (7725)	48.5 (2320)	0.149
Grade				
Grade 6	16.3 (3314)	15.6 (2358)	18.9 (956)	<0.002
Grade 7	18.9 (3847)	18.7 (2884)	19.6 (963)	
Grade 8	20.6 (4169)	20.7 (3215)	20.2 (954)	
Grade 9	22.4 (4493)	23.3 (3508)	19.6 (985)	
Grade 10	21.8 (4383)	21.8 (3346)	21.8 (1037)	
Ethnicity				
White	79.5 (15,411)	80.6 (11,999)	76.3 (3412)	<0.001
Aboriginal	3.4 (1836)	3.0 (1132)	4.7 (704)	
East or Southeast Asian	6.9 (1218)	6.4 (863)	8.4 (355)	
South Asian	3.0 (482)	3.2 (402)	2.2 (80)	
Other ethnicity	7.2 (1114)	6.8 (809)	8.4 (305)	
Provinces/Territories				
British Columbia	12.8 (2623)	13.7 (1971)	14.3 (652)	<0.001
Alberta	11.5 (2914)	11.6 (2236)	11.2 (678)	
Saskatchewan	3.2 (2613)	3.1 (1974)	3.2 (639)	
Manitoba	3.7 (577)	3.8 (441)	3.5 (136)	
Ontario	39.8 (2931)	40.8 (2299)	36.5 (632)	
Quebec	23.1 (2614)	21.9 (1879)	26.9 (735)	
Newfoundland and Labrador	1.6 (2815)	1.7 (2358)	1.1 (457)	
Nova Scotia	3.1 (519)	3.1 (402)	2.9 (117)	
Northwest Territories	0.1 (1244)	0.1 (818)	0.2 (426)	
Nunavut	0.1 (411)	0.05 (235)	0.1 (176)	
Yukon	0.1 (945)	0.08 (698)	0.1 (247)	
Family affluence				
Low	7.6 (1349)	6.5 (841)	10.9 (508)	<0.001
Middle	36.2 (6397)	34.8 (4646)	40.4 (1751)	
High	56.3 (11,110)	58.7 (8868)	48.7 (2242)	
Family structure				
Single parent	18.2 (3589)	16.8 (2517)	22.3 (1072)	<0.001
BMI status				
Normal	70.3 (14,005)	71.5 (10,786)	66.3 (3219)	<0.001
Underweight	9.6 (1836)	9.5 (1372)	9.7 (464)	
Overweight	15.0 (3212)	14.2 (2340)	17.6 (872)	
Obese	5.2 (1153)	4.8 (813)	6.5 (340)	

**Table 2.** Adjusted odds ratio (AOR) of the relationship between hunger and overweight

	<i>n</i>	AOR (95% CI)
Total sample		
Crude model*	20,206	1.35 (1.20–1.51)
Model 1 <sup>†</sup>	18,561	1.33 (1.18–1.51)
Model 2 <sup>‡</sup>	17,694	1.25 (1.10–1.42)
Matched sample		
Crude model*	7788	1.27 (1.11–0.46)
Model 1 <sup>†</sup>	7788	1.30 (1.13–1.50)
Model 2 <sup>‡</sup>	7788	1.30 (1.12–1.50)

\* Crude model: no adjustment.

<sup>†</sup> Model 1: adjusted for gender, grade, ethnicity, provinces/territories, family affluence and family structure.

<sup>‡</sup> Model 2: adjusted for gender, grade, ethnicity, provinces/territories, family affluence, family structure, physical activities, TV and video games activities, parent conflict, and fast food eating behaviours.

### Propensity scores matching analysis

The final predictive model computed to estimate the PS included the main effect of 19 covariates (school neighbourhood environmental covariates were squared) and 14 interaction terms (mainly with gender or grade) (Supplementary Table 1). A substantial overlap of the density distribution of the PS between groups was observed before matching and the subsequent analysis was restricted to the region of common support (Supplementary Figure 2). The average standardized differences of the means for all covariates before and after the matching procedure were compared (Supplementary Table 1). All covariates were balanced between the two groups in the matched sample, as well as the distribution of missing values. The size of the matched sample was 7,788 (3,894 students in each group).

The analysis conducted on the matched sample revealed a similar association as the full sample (Model 2 – AOR: 1.30; 95% CI: 1.12–1.50; Table 2). The results of the sensitivity analyses showed a significant association between going to school or bed hungry and overweight when missing BMI data were set to overweight (Model 2 – *n* = 10,032; AOR: 1.23; 95% CI: 1.08–1.40), and when set to normal weight (Model 2 – *n* = 10,032; AOR: 1.24; 95% CI: 1.08–1.42). When underweight students were excluded from analysis, the association still remained significant (Model 2 – *n* = 7,100; AOR: 1.37; 95% CI: 1.17–1.59). The additional analyses conducted to explore the sensitivity of the results to the definition of hunger revealed no association between being hungry and overweight for any sample when we compared children reported as being always hungry before going to school/bed to the others. However, when the students who reported always or often being hungry before going to school/bed were compared to students who did not, a significant association was found on the matched sample (Model 2 – *n* = 1,200; AOR: 1.49; 95% CI: 1.03–2.14) but not on the total sample (Model 2 – *n* = 17,694; AOR: 1.12; 95% CI: 0.87–1.44).

### DISCUSSION

Our main objective with this paper was to investigate the association between hunger and overweight among Canadian school-aged children. We found a higher prevalence of overweight among students who reported going to school or bed hungry compared to students who did not. We compared the results

obtained with a traditional multivariate regression analysis and those obtained with a matched PS analysis, a useful approach in food insecurity research to ensure comparability when contrasting those who experience hunger to those who do not. The adjusted association was found significant based on the total sample and was confirmed in the PS matching analysis.

A case report making the link between hunger and obesity in a young girl was published in 1995 and was one of the first to ask whether hunger may cause obesity in poorer families.<sup>7</sup> Since then, research has not shown a clear pattern in the relationships among hunger, food insecurity and overweight in children, with varying results depending on the age range, gender and ethnic distribution of the samples.<sup>6,9,13</sup> In Canada, a higher level of child overweight/obesity among food-insecure families compared to others was reported in Quebec,<sup>22,23</sup> among Aboriginal children,<sup>24</sup> among grade 5 students in Nova Scotia,<sup>25</sup> and among a large sample of youth aged 9–18 across Canadian provinces in 2004 (territories excluded).<sup>26</sup> Our study adds to this body of evidence by showing that hunger relates to excess body weight in children aged 11–15 years, even after controlling for potential confounders related to the socio-economic status of the child (such as family affluence and structure, ethnicity and school neighbourhood environment), and with a significant but weaker association after full adjustment for child lifestyle behaviours.

Although obesity involves a myriad of social and behavioural determinants, frequent consumption of fast food and high-carbohydrate food (e.g., sweeteners, snacks, cookies or pizza) is a strong risk factor, and recent studies go further, suggesting that hunger might be a direct response to a high-sugar and low-fat meal, through the hyperstimulation of postprandial response that snares consumers in a vicious cycle of hunger and weight gain.<sup>27</sup> Moreover, it was also reported that consuming foods with high levels of fat and/or refined carbohydrates relates more closely to the type of addictive-like eating behaviours associated with those who take illicit drugs.<sup>28</sup> Indirect pathways might be relevant to consider in the context of child obesity. Stress is a common risk factor for obesity, and unhealthy eating behaviours have been described as one way to cope with stress.<sup>29</sup> Children who experience hunger may face other stressors, such as the awareness of financial difficulties for their family or the mental health problems more common among low-income mothers.<sup>30</sup>

### Strengths and limitations

These findings are based on standardized research methods that had been tested many times in previous HBSC studies. Another strength of the study is the PS approach, which balanced groups on a maximum of measured covariates that might confound the relationship between hunger and child overweight. This method is recommended when imbalance reduction is needed and the matched sample is still sufficiently large. However, the study also had several limitations. All the data were self-reported. Hunger is an aspect of household food insecurity, but food insecurity itself was not measured in the HBSC study. The Family Affluence Scale was developed in 2002 and subsequent changes in consumption and lifestyle patterns might have decreased its ability to discriminate socio-economic conditions. Furthermore, because the scale measures consumption instead of income, it may not have been sensitive to economic constraints on food availability in the home.

Additional individual socio-economic factors such as parent's educational status and family income would have been useful. Furthermore, residual confounding due to unmeasured covariates may persist both in the regression analysis and in the PS-matched method. The high level of missing BMI data (22.2%) could have biased the results. Overall, however, results were robust in sensitivity analyses using imputed BMI data. Our analyses combined data from all Canadian provinces and territories, but provincial differences in physical and social contexts may exist and affect associations. Moreover, reverse causation may take place. As discussed above, children who are overweight may experience hunger more frequently because they have greater caloric needs than those who are not overweight. Finally, we could not make any causal inference with our results given the cross-sectional design of our study.

## CONCLUSION

Numbers of Canadian school-aged children experience going to school or to bed hungry, a condition that appears to be associated with a higher rate of child overweight. Our study supports previous evidence that suggests an inverse association between aspects of food insecurity and overweight in Canadian children. Further research into the social and material mechanisms that underlie this relationship is warranted.

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## RÉSUMÉ

**OBJECTIF :** Au cours des 10 dernières années, la prévalence du surpoids déclarée chez les familles aux prises avec l'insécurité alimentaire au Canada a augmenté, mais il n'existe aucune donnée probante solide sur une association pondérée en fonction des covariables chez les enfants. Dans notre étude, nous avons examiné l'association entre la faim et le surpoids chez les élèves canadiens à l'aide d'une analyse d'appariement sur le score de propension pour réduire la confusion.

**MÉTHODE :** Nous avons appliqué les données du cycle 2009-2010 de l'Étude canadienne « Health Behaviour School-aged Children » (HBSC) à un échantillon national représentatif d'élèves de la 6<sup>e</sup> à la 10<sup>e</sup> année. Les élèves ont rapporté leur taille et leurs poids et si ils sont souvent allés à l'école ou au lit en ayant faim par manque de nourriture à la maison. Nous avons appliqué un

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modèle de régression logistique multivariée à l'échantillon total ( $N = 17\ 694$ ) et à l'échantillon apparié sur le score de propension ( $n = 7\ 788$ ).

**RÉSULTATS** : La prévalence globale du surpoids chez les élèves était de 20,2 %, avec un écart significatif entre les élèves ayant connu la faim (24,0 %; IC de 95 % : 22,1–26,0) et les autres élèves (19,0 %; IC de 95 % : 17,9–20,2). L'analyse de l'échantillon apparié a révélé une association significative entre la faim et le surpoids chez les enfants (rapport de cotes ajusté : 1,30; IC de 95 % : 1,12–1,50).

**CONCLUSIONS** : Un nombre considérable d'élèves canadiens a déclaré avoir connu la faim en raison du manque de nourriture à la maison. Ces élèves présentent un risque accru de surpoids, peu importe leur classe sociale. La faim des enfants et l'insécurité alimentaire des ménages existent au Canada et constituent un appel à l'action des pouvoirs publics à l'échelle nationale.

**MOTS CLÉS** : surpoids; enfant; adolescent; faim; score de propension; nourriture