Context and sequelae of food insecurity in children's development.

Daniel Belsky, Terrie Moffitt, Louise Arsenault, Maria Melchior, Avshalom Caspi

Context and Consequences of Food Insecurity in Children's Development

Daniel W. Belsky, BA[1,2]
Terrie E. Moffitt, PhD,[2-5]
Louise Arsenault, PhD,[5]
Maria Melchior, ScD,[6]
Avshalom Caspi, PhD[2-5]

1. Department of Health Policy and Management, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA
2. Department of Psychology and Neuroscience, Duke University, Durham, NC, USA
3. Department of Psychiatry and Behavioral Sciences, Duke University, Durham, NC, USA
4. Institute for Genome Sciences and Policy, Duke University, Durham, NC, USA
5. Institute of Psychiatry, King's College London, UK
6. INSERM, U687, Villejuif, F-94807, France; Université Paris XI, IFR69, Villejuif, F-94807, France

Sources of Funding. The E-Risk Study is funded by the Medical Research Council (MRC grant G9806489). Additional support was provided by NICHD HD061298, NIMH MH077874, NIDA P30 DA023026, and Economic and Social Research Council RES-177-25-0013. Dr. Arseneault is supported by a Career Scientist Award from the Department of Health UK. Dr. Caspi is a Royal Society Wolfson Research Merit Award holder.

Acknowledgements. We are grateful to the study mothers and fathers, the twins, and the twins' teachers for their participation. Our thanks to Michael Rutter and Robert Plomin, to Thomas Achenbach for kind permission to adapt the Child Behavior Checklist, and to members of the E-Risk team for their dedication, hard work, and insights.

Abstract (Word Count: 194)

Objective. To examine the role of food insecurity in the etiology of children's cognitive and mental-health problems. **Method.** Data from a prospective longitudinal study of 1,116 families with twins were used to test relationships among household food insecurity, income, maternal personality, household sensitivity to children's needs, and children's cognitive, behavioral, and emotional development. **Results.** Food insecure children had lower IQs and higher levels of behavioral and emotional problems relative to their peers. After accounting for differences in household income, the personalities of children's mothers, and the sensitivity of household organization to children's needs, food insecure children showed moderately higher levels of emotional problems relative to food secure children (B=0.22, p=0.02). Differences in children's cognitive development were accounted for by household income and differences in their behavioral development were accounted for by their mothers' personalities and their households' sensitivity to children's needs. **Conclusions.** Our results suggest that food insecurity contributed to school-aged children's emotional problems, but not to their cognitive or behavioral problems after accounting for differences in the home environments in which children were reared. Mothers' personality and household sensitivity to children's needs may present challenges to improving outcomes of children with food insecurity.

Word Count: 3,500

Introduction

Children reared in poverty experience poor health outcomes and higher mortality as adults.[1-5] This health disparity is mediated partly by cognitive, behavioral, and emotional problems that emerge in childhood and are linked to a range of adverse outcomes later in life.[6-10] Developing programs to safeguard and improve children's cognitive and mental health and thereby disrupt the cycle of life-course disease and disadvantage is a public-health priority. However, opportunities for intervention remain elusive, in part due to a lack of clarity over the pathways linking socioeconomic disadvantage to cognitive and mental-health problems in childhood.

Elevated levels of cognitive, behavioral, and emotional problems among children living in poverty have been demonstrated.[11, 12] However, weak findings regarding the causal effect of household income on these dimensions of children's mental health[13-15] have lead investigators to pursue more direct measures of the privations poverty imposes on children and families. Specific "material hardships," shortages of physical resources needed for healthy development, have received attention for being more proximal to children's health than household income and more amenable to intervention than the general state of living in poverty.[16-18] Among these, material hardship related to food--food insecurity, food insufficiency, hunger (hereafter collectively referred to as "food insecurity")—stands out as a reliable correlate of cognitive, behavioral, and emotional problems among low-income children.[19, 20] Food insecurity is a growing problem in the developed world following the recent economic crisis. In the United States, the Department of Agriculture recently reported an increase in the percent of families experiencing food insecurity from 11% in 2007 to nearly 15% in 2008,[21] with nearly 17 million children affected. With the causal nature of associations between food insecurity and children's cognitive and mental-health problems still unclear, and as ethics preclude randomly assigning children to food insecurity, observational studies incorporating relevant controls are useful for informing public policy.

Researchers have begun to elucidate neurodevelopmental mechanisms linking early childhood malnutrition to low IQ in middle childhood and subsequently to behavioral problems in adolescence.[22, 23] Yet, the relationship between food insecurity and malnutrition among school-aged children remains a topic of intense interest, but little consensus. Two recent reviews suggest food insecurity does influence children's nutritional status.[19, 24] However, a recent analysis of the National Health And Nutrition Examination Survey III found no relationship between food insecurity and direct measures of nutrition (dietary recall, blood-based micronutrient assays, BMI) in school-aged children.[25]

Leaving open the question of food insecurity's relationship to malnutrition, it remains possible that associations between food insecurity and cognitive, behavioral, and emotional problems among school-aged children[26-31] reflect the discomforts and humiliations of hunger[32] or acute attentional and self-regulatory deficits associated with missing a meal.[33-35] It is also possible that these associations are spurious, conditioned by features of children's households that contribute to both food insecurity and cognitive and mental-health problems. If cognitive, behavioral, and emotional problems among food insecure children share a common cause with food insecurity, interventions addressing children's food situations will fail to fully ameliorate poor developmental outcomes.

In the present study, we examine the effects of food insecurity on children's cognitive, behavioral, and emotional outcomes, considering household income and what we term "nonmaterial household features" as possible common causes of food insecurity and children's cognitive and mental-health problems. Low income is a material feature of households that constrains resources, affecting children's food situation, their physical environment, and their parents' stress levels.[36-39] Most studies of food insecurity and children's mental health account for the effects of income. However, household features that influence how resources are allocated may also contribute to food insecurity. We consider two such features that are plausible contributors to children's cognitive and mental-health problems: maternal personality and low household sensitivity to children's needs.

Maternal personality is a nonmaterial feature of children's households that contributes to food insecurity by affecting how money is spent and saved, the availability of social support during times of stress, and coping responses. Simultaneously, maternal personality affects children's mental health through genetic and parenting pathways. Personality includes a strong inherited component, demonstrates reasonable stability from early adulthood on,[40-42] and predicts socioeconomic and health outcomes.[43-46] Research has coalesced around a five-factor model of personality comprising Openness to Experience (imagination, creativity, cleverness), Conscientiousness (planfulness, responsibility, organization), Extraversion (outgoingness, energy, dominance), Agreeableness (empathy, generosity, cooperativeness), and Neuroticism (negativity, anxiety, insecurity).[42, 47] Persons with low levels of the traits conscientiousness, extraversion, and agreeableness, and high levels of the trait neuroticism are more likely to make impulsive purchases, fail to save money, struggle to build and maintain relationships, and cope ineffectively with stress,[48-52] all of which, in turn, influence families' success in meeting household needs when risk of food insecurity is greatest.[53-57] Interestingly, this personality profile also predicts parenting behaviors that contribute to children's cognitive, behavioral, and emotional problems.[58-61]

Household sensitivity to children's needs is a nonmaterial feature of children's households likely correlated with food insecurity. Neglectful and chaotic households are associated with parent factors linked to food insecurity, including poor parental mental health, substance abuse, cognitive impairment, and limited social support.[62-64] Household sensitivity to children's needs also influences children's development; children living in neglectful and chaotic household environments have higher levels of cognitive, behavioral, and emotional problems.[65-68]

Studies linking food insecurity to children's outcomes in nationally representative samples of school-aged children have sought to control for nonmaterial features of children's households using proxy measures such as income, presence of a father figure in the home, mother's age, and

race/ethnicity.[26, 28] While such measures help to contextualize food insecurity in children's lives, they do not address variation in resource allocation or parenting behaviors, or in the sensitivity of household organization to children's needs.

Our study tested the hypothesis that food insecurity contributes to cognitive, behavioral, and emotional problems among school-aged children independently of household features that place them at risk for food insecurity and poor developmental outcomes. We began by comparing, at age 12-years, children who were and were not exposed to food insecurity during ages 7-10 years. We next evaluated household features' associations with food insecurity and children's developmental outcomes. After establishing these relationships, we tested associations between food insecurity and children's developmental outcomes before and after statistically controlling for variation in household features. Lastly, we replicated these analyses with an additional statistical control for each of the outcomes measured when children were age 5-years in order to account for the possibility that differences in cognitive, emotional, and behavioral problems observed at age 12-years pre-dated the experience of food insecurity at ages 7-10 years.

Methods

Sample. Participants were members of the Environmental Risk (E-Risk) Longitudinal Twin Study, which tracks the development of a nationally representative birth cohort of 2,232 British children. The sample was selected from a larger birth register of twins born in England and Wales in 1994-1995[69]. Details about the sample have been reported previously.[70] Briefly, the E-risk sample was constructed in 1999-2000, when 1,116 families with same-sex 5-year old twins (93% of those eligible) participated in home-visit assessments. Families were recruited to represent the UK population of families with newborns in the 1990's, based on residential location throughout England and Wales and mother's age (i.e., older mothers having twins via assisted reproduction were under-selected and teen-aged mothers with twins

were over-selected). We used this sampling to replace high-risk families who were lost to the register via non-response and to ensure sufficient numbers of children reared in high-risk environments. Follow-ups were conducted when the children were aged 7 years (98% participation), 10 years (96% participation) and, most recently, 12 years (96% participation). Parents gave informed consent and children gave assent. The National Health Service Central Office for Research Ethics Committees (COREC) approved each phase of the study.

Measures. All child outcomes were measured when children were ages 5- and 12-years. We chose these measures because they are commonly used in research on children's cognitive and mental-health problems. *Children's IQ* was assessed using the Wechsler Intelligence Scale for Children[71] prorated using procedures described by Sattler.[72] *Children's behavioral problems* were measured using the externalizing scale in the Teacher Report Form (TRF),[73] completed by children's teachers, and a conduct problems scale,[74, 75] completed by the child. (The composite behavioral problems measure was constructed by averaging standardized scores on these scales.) *Children's emotional problems* were measured using the internalizing scale in the TRF, completed by children's teachers and, for the age 12 measure only, the Multidimensional Anxiety Scale for Children (MASC)[76] and the Children's Depression Inventory (CDI),[77] both of which were completed by the child. (The composite emotional problems measure was constructed by averaging standardized scores on these scales.)

Food insecurity: Family food situation was reported by the mother to a clinical interviewer when children were ages 7-10 years using a seven-item scale developed by the USDA (**Appendix Table 1**).[78] This scale distinguishes families that are a) food-secure (i.e. no evidence of food insecurity; 0-1 positive responses), b) food-insecure without hunger (i.e. food insecurity is evident, but there is no reduction in the family's food intake; 2-4 positive responses) or c) food-insecure with hunger (i.e. food intake is reduced; 5-7 positive responses). In the E-Risk sample, < 2% of families experienced food insecurity with hunger, so we combined them with the other food-insecure families. Using both assessments available

to us, we identified families that were 'ever food-insecure' (food-insecure at age-7 and/or age-10 assessments) and compared them to those that were always food secure.

Features of Children's Households: We measured three household features, one material (household income) and two nonmaterial (maternal personality and household sensitivity to children's needs):

Household income was reported by the mother to a clinical interviewer when children were ages 5-7 years. We adjusted household income for household size and composition using Cutler and Katz's[79] weighting to account for differential consumption of resources by adults and children. We then standardized household income to a family of two adults and two children and grouped families into quartiles bounded by £10,000, £18,000, and £26,000 per year.

Maternal Personality was assessed when children were ages 5-7 years. At the end of the interview session, interviewers rated the mother using the 44-item version of the Big Five Inventory (BFI) which measures five dimensions of personality: Openness to Experience, Conscientiousness, Extraversion, Agreeableness, and Neuroticism.[80] Scores were standardized and averaged across measurements.

Household Sensitivity to Children's needs was assessed using a scale derived from interviewer ratings when children were ages 7-10 years. After visiting with families, interviewers coded their perceptions of the home using a selection of items based on the Home Observation for Measurement of the Environment (HOME)[81, 82] and the University of Washington Parenting Clinic Parent-Child Observations Questionnaire.[83] Scale items evaluate parents' attention to children's needs as well as maintenance and organization of the home environment to support child development. Items were selected that were not directly dependent on households' material resources. Items were summed and the resulting score was standardized to create a continuous measure. This scale demonstrated strong

internal consistency reliability (Cronbach's α=0.803). Because it is a new scale developed for this study, scale items are listed in **Table 1**, by food insecurity status.

Data Analysis. Our study tested the hypothesis that food insecurity contributes to cognitive, behavioral, and emotional problems among school-aged children independently of features of their households that place them at risk for both food insecurity and poor developmental outcomes. We first compared the means of our mental-health measures across children who experienced food insecurity and those who did not. We next tested whether income, maternal personality, and household sensitivity to children's needs predicted food insecurity and children's mental-health outcomes independently of household income. Finally, we tested the relationship between food insecurity and each of the outcomes in a series of regression models beginning with a bivariate model and subsequently adding material and nonmaterial household features as covariates. Logistic regression models were used to predict food insecurity. Ordinary least squares regression models were used to predict children's developmental outcomes. All models account for the study's twin design and resulting dependency among observations within a household using the procedure described by Williams.[84] All analyses were conducted using Stata 10.1.[85]

Data on food insecurity status and at least one outcome measure were available for over 95% of the original E-Risk sample of children and families (n=2,125 children in 1,063 families). For regression modeling, missing data on household income and household sensitivity to children's needs were imputed for 56 children and 2 children, respectively, using the multiple imputation routine *ICE*.[86] No data were missing for maternal personality.

Results

Children reared in households experiencing food insecurity (n=278) had significantly lower IQs and higher levels of behavioral and emotional problems at age 12 years than their food-secure counterparts (**Figure 1**, p<0.001 for all). Food-insecure households had lower incomes than food-secure

households (χ^2=204.47, p<0.001). In addition, mothers in food-insecure households were more likely to have high-risk personality profiles (low conscientiousness, extraversion, and agreeableness, and high neuroticism) and their households were less sensitive to children's needs (**Figure 2**) (p<0.001 for all).

Table 2 shows that children living in poor households, whose mothers had high-risk personality profiles, and whose households were insensitive to children's needs were significantly more likely to experience food insecurity (p<0.001 for all). Such children also had low IQs and high levels of behavioral and emotional problems (p<0.001 for all).

These features of children's households fully explained statistical associations between food insecurity and children's IQ and behavioral problems, and reduced the association between food insecurity and children's emotional problems by half, although the latter association remained statistically significant (**Table 3**). Household income accounted for the association between food insecurity and IQ. In the bivariate model (**I**), food insecurity predicted lower IQ, but once income was added to the model (**II**), this association was attenuated below the α=.05 level of statistical significance. The relationship between food insecurity and children's behavioral problems was largely independent of household income, but was fully accounted for by differences in nonmaterial features between food-insecure and food-secure households (**III**). In contrast, neither income nor nonmaterial features of households, nor their combination, fully accounted for the association between food insecurity and children's emotional problems (**IV**), although nonmaterial features of children's households accounted for about half of this relationship. Complete results for all models are included in the Appendix (Table 2).

We conducted two sensitivity analyses to test the robustness of these findings. First, to evaluate potential confounding due to differences in children's cognitive and mental health pre-dating experience of food insecurity at ages 7-10 years, we re-estimated the models presented in **Table 3** after adding statistical controls for the same measures of children's cognitive and mental health collected at

age 5 years. Second, to evaluate how the effects of food insecurity might be influenced by unequal distributions of covariates among food insecure and food secure children, we conducted analyses parallel to those in the final row of Table 3 using propensity-score matching techniques[87] implemented with the routine *psmatch2*.[88] Results were consistent with those presented in **Table 3** and are available from the authors.

Discussion

Findings from this study enhance understanding of the role that food insecurity plays in the etiology of childhood cognitive and mental-health problems in two ways. First, food insecurity is implicated as a source of lasting emotional distress for children independent of their families' incomes, their mothers' personalities, and their households' sensitivity to children's needs. The emotional problems measure we used tapped childhood anxiety and depression, which are known to predict maladjustment in adulthood,[10, 89] including major depressive disorder, a leading cause of disability and health burden worldwide.[90] Children living in food insecure households at ages 7-10 years experienced greater emotional problems at age 12 years relative to peers living in households that were similar but food-secure, although the difference was small. This finding, coming from an epidemiologically sound sample and identified within a longitudinal design accounting for household features unmeasured in previous studies, constitutes the strongest evidence to date that food insecurity, and not just impoverished, chaotic, and neglectful households that are prone to disrupted food situations, can influence children's mental health.

Second, while exposure to food insecurity appears to make some contribution to children's emotional distress, it was primarily other features of children's households that explained differences in cognitive, behavioral, and emotional problems between food-insecure children and their peers in this study. Specifically, children who experience food insecurity are cared for by mothers with poor self-control and depressive and antisocial tendencies (low conscientiousness, high neuroticism, and low agreeableness), and live in households providing less structure and nurturance. These characteristics of mothers and the household environments they provide appear to function as risk factors for both food insecurity and cognitive and mental-health problems among children, above and beyond the general risk imposed by poverty. However, our data do not permit us to exclude the possibility that household features were caused by food insecurity predating our baseline assessments.

Our study has several strengths. First, the longitudinal design allowed temporal ordering of measurement for household features, food insecurity, and children's cognitive and mental-health outcomes that parallels the hypothesized causal model, with the exception that sensitivity to child needs was measured concurrently with food insecurity. Most previous studies relied on cross-sectional data, raising concerns over possible reverse causality. Second, food insecurity was reported by mothers while child outcomes were reported by teachers and children themselves, minimizing risk of reporter bias. Previous studies obtained information about food insecurity and children's outcomes from mothers, potentially inflating correlations among these measures. Third, measurements of mother's personalities and household organization allowed us to account for potential common causes of food insecurity and children's outcomes, other than low income. Previous studies lacked such measures or relied on proxies such as household composition. Finally, use of a nationally representative sample with exceptional retention across 7 years of follow-up permits inference regarding the general population. Previous studies using longitudinal data or measures of nonmaterial household features relied on high-risk samples drawn from limited geographic areas, constraining the external validity of findings.

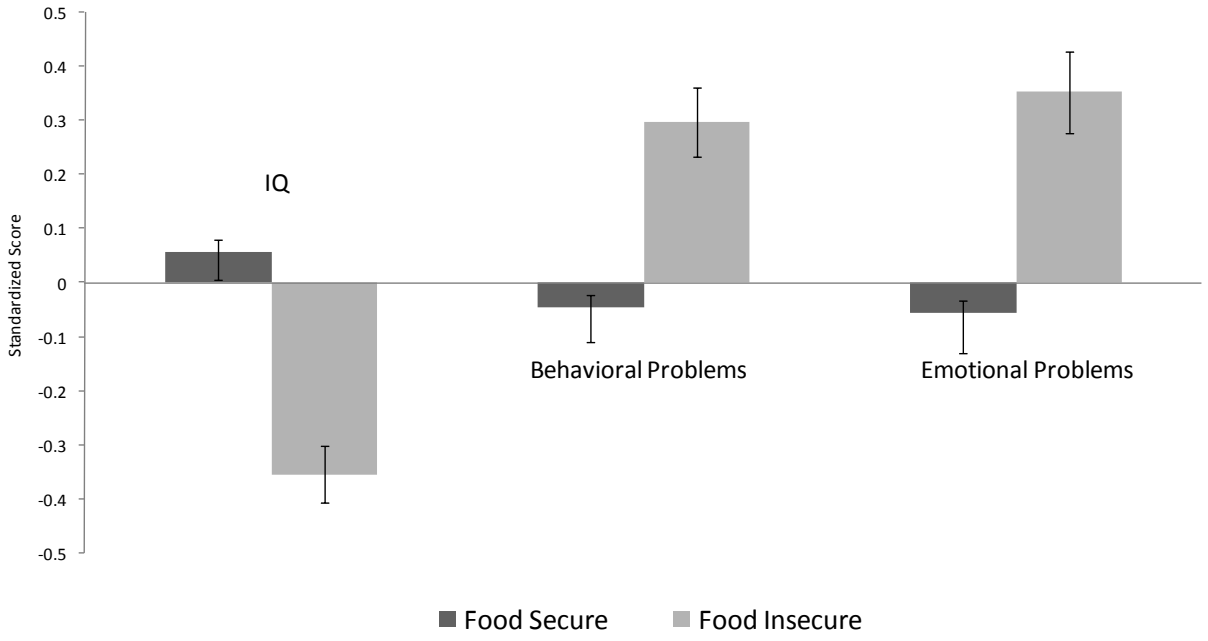
This study also has limitations. Most prominently, data come from a sample of twins and may therefore not generalize to singleton births. However, E-risk families were selected to represent the distribution of maternal age at first birth in the population[91] (i.e., by matching maternal age to the general population, older mothers whose twins resulted from assisted reproduction were under-represented) and participants are comparable to the general population of mothers and children on a variety of mental-health and cognitive markers, as well as sociodemographic characteristics.[70, 92-94] In addition, the prevalence of food insecurity in our UK sample (9.7%)[95] matches reports from other developed countries.[28, 96-99] A second limitation is that all measures were not obtained at all data collections. Consequently, designs that afford greater power for causal inference by ruling out confounding by unobserved time-invariant factors, including exposure to food insecurity prior to the baseline assessment, could not be implemented. However, the temporal ordering of measures in our study goes some way to ruling out reverse causation. Third, we lack measures of father characteristics. However, father characteristics are represented indirectly to the degree that they influence household sensitivity to children's needs and are influenced by mothers' mate preferences indexed in their personalities. In addition, mothers are the main caregivers of almost all children in the E-risk sample, and requiring measures from fathers would generate missing data for single-mother families. Finally, our study includes a coarse measure of household income, although the measure is adjusted for household

size and composition. Unfortunately, due to reliability concerns related to self-reports of actual income rather than income categories, richer data were not available.

Results from the current study have implications for how the public health field theorizes and studies food insecurity's role in the etiology of children's cognitive and mental-health problems, as well as for public health practice. At the level of theory, our findings suggest that characteristics of parents and households that affect children's development also contribute to determining whether children's households become food insecure. Currently, much research treats characteristics of mothers and parenting as outcomes of food insecurity, or mediators of food insecurity's effects on children. Theorists should consider whether these factors should also be viewed as common causes of both food insecurity and children's cognitive and mental-health problems.

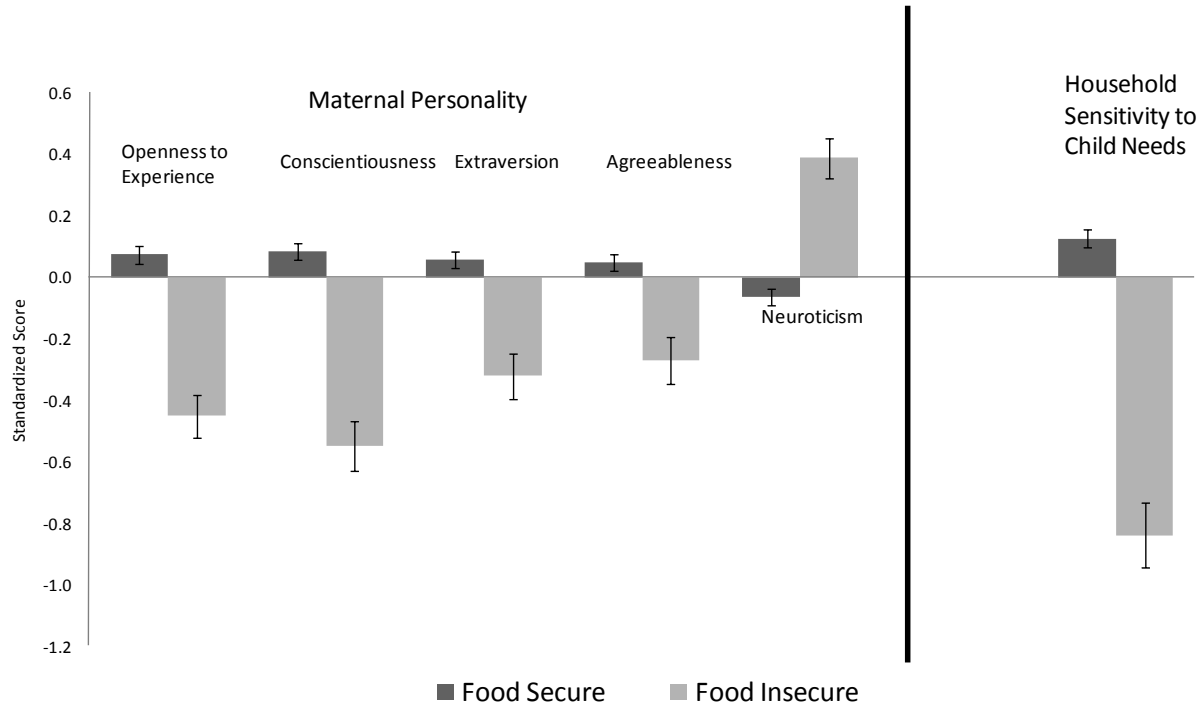
At the level of public health practice, our findings make three suggestions. 1) Programs to ameliorate children's food insecurity must be prepared to engage caregivers who struggle with poor self-control and depressive and antisocial personality tendencies, and to deliver benefits to children in the face of household environments providing little structure or nurturance. 2) Evaluations of programs seeking to ameliorate children's food insecurity should focus on emotional rather than cognitive or behavioral outcomes, as our study and two previous studies[29, 100] suggest this is the domain where food insecurity is most likely to have causal effects. 3) To improve mental health among poor children, investment in interventions shown to improve parenting and reduce child neglect, such as the Nurse Family Partnership,[101, 102] is a necessary complement to benefits that supplement household food supplies. Without such complementary intervention, stabilizing household food situations may do little to improve children's mental health.

Figure 1. Mental Health at Age 12 of Children Always Food Secure and Ever Food Insecure During Ages 7-10



Error bars indicate +/- one standard error. p<0.001 for all comparisons.

Figure 2. Maternal Personality and Household Sensitivity to Child Needs in Food Secure and Food Insecure Households



Error bars indicate +/- one standard error. p<0.001 for all comparisons.

Table 1. Interviewer Perceptions of Household Sensitivity to Child Needs at Ages 7 and 10 for Food Secure and Food Insecure Children

		Food Secure	Food Insecure
		%	
Parent monitors child appropriately	(Somewhat or Yes)	88.7%	73.7%
Parent aware of child needs	(Somewhat or Yes)	94.8%	87.4%
Parent emotionally supportive of child	(Somewhat or Yes)	94.8%	84.2%
Visible rooms of the house are clean	(Somewhat or Yes)	89.8%	71.9%
Children have a predictable daily schedule	(Somewhat or Yes)	94.4%	76.3%
Use of the TV is appropriate	(Somewhat or Yes)	73.8%	46.0%
Family encourages children to have hobbies	(Somewhat or Yes)	67.9%	37.4%
Parenting of child overly permissive, negligent	(No)	78.2%	56.1%
Child lacked attention to personal hygiene	(No)	90.7%	73.4%
Home interior is dark/ monotonous	(No)	75.1%	47.5%
Home is chaotic or overly noisy	(No)	67.5%	36.7%
Think the child is neglected?	(No)	96.9%	84.9%
N		1,845	278

$p<0.001$ for all comparisons (Fisher's Exact Test). Two children included in the analytic sample were missing data on all scale items and scale scores were imputed for regression analyses.

Table 2. Associations Between Household Features and Food Insecurity and Child Outcomes

		Child Outcomes		
	Household Food Insecurity (N=2,125)	IQ (N=2,112)	Behavior Problems (N=2,121)	Emotional Problems (N=2,123)
Household Features	OR/(95% CI)		Coef./(SE)	
Income				
Income <10,000 (Reference Category)	1.00	--	--	--
Income 10,000-18,000	0.57**	0.33***	-0.18*	-0.02
	(0.38,0.84)	(0.07)	(0.08)	(0.07)
Income 18,000-26,000	0.10***	0.51***	-0.31***	-0.18*
	(0.04,0.23)	(0.08)	(0.08)	(0.07)
Income >26,000	0.02***	1.06***	-0.52***	-0.30***
	(0.00,0.10)	(0.07)	(0.07)	(0.07)
Maternal Personality[a]				
Openness to Experience	0.76*	0.35***	-0.18***	-0.13***
	(0.58,0.98)	(0.03)	(0.03)	(0.03)
Conscientiousness	0.62***	0.22***	-0.26***	-0.18***
	(0.50,0.77)	(0.03)	(0.04)	(0.04)
Extraversion	0.70**	0.08**	-0.03	-0.07*
	(0.56,0.89)	(0.03)	(0.03)	(0.03)
Agreeableness	0.77*	0.09**	-0.18***	-0.12***
	(0.62,0.95)	(0.03)	(0.04)	(0.03)
Neuroticism	1.63***	-0.14***	0.13***	0.07*
	(1.31,2.03)	(0.03)	(0.04)	(0.03)
Household Sensitivity to Child Needs	0.61***	0.23***	-0.25***	-0.21***
	(0.51,0.72)	(0.03)	(0.04)	(0.03)

*p<0.05, **p<0.01, ***p<0.001. (a) Maternal personality traits were each entered in separate regression models. Associations of maternal personality traits and household sensitivity to child needs with child outcomes were adjusted for household income. Odds ratios/95% CIs are reported for logistic regression models and coefficients/SEs for ordinary least squares regression models. All models were adjusted for non-independence of outcomes among twins according to the procedure outlined by Williams (2008)[54].

Table 3. Association Between Food Insecurity and Child Outcomes: Table Presents Regression Coefficients and Standard Errors for Food Insecurity

		Child Outcomes		
		IQ (N=2,112)	Behavior Problems (N=2,121)	Emotional Problems (N=2,123)
I.	Bivariate Model	-0.41*** (0.07)	0.34*** (0.08)	0.41*** (0.09)
II.	Model adjusted for Household Income	-0.10 (0.07)	0.20* (0.09)	0.33*** (0.09)
III.	Model Adjusted for Non-Material Household Features[a]	-0.05 (0.07)	0.07 (0.08)	0.22* (0.09)
IV.	Model Adjusted for All Household Features[b]	0.02 (0.07)	0.06 (0.08)	0.22* (0.09)

*p<0.05, **p<0.01, ***p<0.001. (a) Non-material features are maternal personality and household sensitivity to child needs. (b) All household features are income, maternal personality, and household sensitivity to child needs. Coefficients are from ordinary least squares regression models with standard errors adjusted for non-independence of outcomes among twins according to the procedure outlined by Williams (2008)[54].

Appendix Table 1. Food Insecurity Instrument Items-from the United States Department of Agriculture Food Insecurity Questionnaire

In the last 12 months…
1. The food that we bought just didn't last
2. We couldn't afford to eat balanced meals
3. Did you ever eat less than you felt you should because there wasn't enough money to buy food?
4. Were you ever hungry but didn't eat because you couldn't afford enough food?
5. Did you or other adults in your house ever cut the size of your meals or skip meals because there wasn't enough money for food?
6. Did you ever cut the size of any of your children's meals or skip meals because there wasn't enough money for food?
7. If yes to any of the above, how often did this happen?

Mothers selected "often," "sometimes" or "never" in response to items 1-2, "Yes" or "No" for items 3-6, and "Almost every month," "Some months but not every month," or "1-2 Months" for item 7 when applicable. Items 1 and 2 were scored as affirmative if participants responded "sometimes" or "often." Item 7 was scored as affirmative if participants selected "Almost every month" or "some months but not every month."

Appendix Table 2. Full Results for Regression Models Predicting Child Outcomes: Table values are in the order of Coefficient/Standard Error/p-value. Food insecurity coefficients and standard errors from these regression models are presented in Table 3 of the manuscript.

	Child Outcomes											
	IQ (N=2,112)				Behavior Problems (N=2,121)				Emotional Problems (N=2,123)			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Food Insecurity	-0.41	-0.10	-0.05	0.02	0.34	0.20	0.07	0.06	0.41	0.33	0.22	0.22
	(0.07)	(0.07)	(0.07)	(0.07)	(0.08)	(0.09)	(0.08)	(0.08)	(0.09)	(0.09)	(0.09)	(0.09)
	0.00	0.19	0.45	0.74	0.00	0.02	0.37	0.51	0.00	0.00	0.01	0.02
Household Income												
Income 10,000-18,000		0.32		0.15		-0.16		-0.01		0.01		0.13
		(0.07)		(0.07)		(0.08)		(0.08)		(0.07)		(0.07)
		0.00		0.02		0.03		0.94		0.91		0.08
Income 18,000-26,000		0.49		0.18		-0.26		-0.02		-0.11		0.08
		(0.08)		(0.08)		(0.08)		(0.09)		(0.08)		(0.08)
		0.00		0.02		0.00		0.86		0.16		0.31
Income > 26,000		1.04		0.53		-0.47		-0.13		-0.22		0.03
		(0.08)		(0.09)		(0.07)		(0.08)		(0.07)		(0.08)
		0.00		0.00		0.00		0.09		0.00		0.73
Maternal Personality												
Openness to			0.43	0.34			-0.10	-0.07			-0.03	-0.02
Experience			(0.04)	(0.04)			(0.04)	(0.04)			(0.04)	(0.04)
			0.00	0.00			0.02	0.09			0.39	0.55
Conscientiousness			0.02	0.01			-0.08	-0.08			-0.02	-0.03
			(0.05)	(0.05)			(0.05)	(0.06)			(0.05)	(0.05)
			0.75	0.90			0.16	0.17			0.67	0.56
Extraversion			-0.10	-0.09			0.10	0.09			0.00	-0.01
			(0.04)	(0.04)			(0.04)	(0.04)			(0.04)	(0.04)
			0.00	0.01			0.01	0.01			0.91	0.83
Agreeableness			-0.13	-0.10			-0.05	-0.06			-0.03	-0.03
			(0.04)	(0.04)			(0.04)	(0.04)			(0.04)	(0.04)
			0.00	0.01			0.25	0.18			0.47	0.44
Neuroticism			-0.08	-0.08			0.04	0.04			-0.02	-0.03
			(0.04)	(0.04)			(0.04)	(0.04)			(0.03)	(0.03)
			0.02	0.02			0.31	0.31			0.50	0.46
Household Sensitivity to			0.17	0.14			-0.18	-0.17			-0.16	-0.17
Child Needs			(0.04)	(0.04)			(0.04)	(0.04)			(0.03)	(0.04)
			0.00	0.00			0.00	0.00			0.00	0.00
Intercept	0.06	-0.42	0.01	-0.21	-0.04	0.19	-0.01	0.03	-0.05	0.03	-0.03	-0.09
	(0.03)	(0.06)	(0.03)	(0.06)	(0.03)	(0.06)	(0.03)	(0.06)	(0.03)	(0.06)	(0.03)	(0.06)
	0.06	0.00	0.74	0.00	0.12	0.00	0.76	0.58	0.03	0.66	0.25	0.12

References

1. Poulton R, Caspi A, Milne BJ, et al. Association between children's experience of socioeconomic disadvantage and adult health: a life-course study. *Lancet* 2002;360(9346):1640-1645.
2. Galobardes B, Lynch JW, Smith GD. Childhood socioeconomic circumstances and cause-specific mortality in adulthood: Systematic review and interpretation. *Epidemiologic Reviews* 2004;26:7-21.
3. Galobardes B, Smith GD, Lynch JW. Systematic review of the influence of childhood socioeconomic circumstances on risk for cardiovascular disease in adulthood. *Annals of Epidemiology* 2006;16(2):91-104.
4. Gilman SE, Kawachi I, Fitzmaurice GM, Buka SL. Socioeconomic status in childhood and the lifetime risk of major depression. *International Journal of Epidemiology* 2002;31(2):359-367.
5. Langenberg C, Kuh D, Wadsworth MEJ, Brunner E, Hardy R. Social circumstances and education: Life course origins of social inequalities in metabolic risk in a prospective national birth cohort. *American Journal of Public Health* 2006;96(12):2216-2221.
6. Melchior M, Moffitt TE, Milne BJ, Poulton R, Caspi A. Why do children from socioeconomically disadvantaged families suffer from poor health when they reach adulthood? A life-course study. *American Journal of Epidemiology* 2007;166(8):966-974.
7. Vermeiren R. Psychopathology and delinquency in adolescents: a descriptive and developmental perspective. *Clinical Psychology Review* 2003;23(2):277-318.
8. Gottfredson LS. Intelligence: Is it the epidemiologists' elusive "Fundamental cause" of social class inequalities in health? *Journal of Personality and Social Psychology* 2004;86(1):174-199.
9. Odgers CL, Caspi A, Broadbent JM, et al. Prediction of differential adult health burden by conduct problem subtypes in males. *Archives of General Psychiatry* 2007;64(4):476-484.
10. Rutter M, Kim-Cohen J, Maughan B. Continuities and discontinuities in psychopathology between childhood and adult life. *Journal of Child Psychology and Psychiatry* 2006;47(3-4):276-295.
11. Aber JL, Bennett NG, Conley DC, Li JL. The effects of poverty on child health and development. *Annual Review of Public Health* 1997;18:463-483.
12. Bradley RH, Corwyn RF. Socioeconomic status and child development. *Annual Review of Psychology* 2002;53:371-399.
13. Aughinbaugh A, Gittleman M. Does money matter? A comparison of the effect of income on child development in the United States and Great Britain. *Journal of Human Resources* 2003;38(2):416-440.
14. Blau DM. The effect of income on child development. *Review of Economics and Statistics* 1999;81(2):261-276.
15. Dooley M, Stewart J. Family income, parenting styles and child behavioural-emotional outcomes. *Health Economics* 2007;16(2):145-162.
16. Yoo JP, Slack KS, Holl JL. Material Hardship and the Physical Health of School-Aged Children in Low-Income Households. *American Journal of Public Health* 2009;99(5):829-836.
17. Cook JT, Frank DA, Casey PH, et al. A brief indicator of household energy security: Associations with food security, child health, and child development in US infants and toddlers. *Pediatrics* 2008;122(4):E867-E875.
18. Oulette T, Burstein N, Long D, Beecroft E. Measures of Material Hardship. In. Washington, DC: U.S. Department of Health and Human Services, Office of the Secretary, Office of the Assistant Secretary for Planning and Evaluation; 2004.
19. Cook JT, Frank DA. Food security, poverty, and human development in the United States. In: *Reducing the Impact of Poverty on Health and Human Development: Scientific Approaches*; 2008:193-209.

20. Kursmark M, Weitzman M. Recent findings concerning childhood food insecurity. *Current Opinion in Clinical Nutrition and Metabolic Care* 2009;12(3):310-316.
21. Service USDoAER. Food Security in the United States; http://www.ers.usda.gov/briefing/Foodsecurity/. Accessed December 2, 2009 2009.
22. Fanjiang G, Kleinman RE. Nutrition and performance in children. *Current Opinion in Clinical Nutrition and Metabolic Care* 2007;10(3):342-347.
23. Liu JH, Raine A, Venables PH, Mednick SA. Malnutrition at age 3 years and externalizing behavior problems at ages 8, 11, and 17 years. *American Journal of Psychiatry* 2004;161(11):2005-2013.
24. Ashiabi GS, O'Neal KK. A Framework for Understanding the Association Between Food Insecurity and Children's Developmental Outcomes. *Child Development Perspectives* 2008;2(2):71-77.
25. Bhattacharya J, Currie J, Haider S. Poverty, food insecurity, and nutritional outcomes in children and adults. *Journal of Health Economics* 2004;23(4):839-862.
26. Alaimo K, Olson CM, Frongillo EA. Food insufficiency and American school-aged children's cognitive, academic, and psychosocial development. *Pediatrics* 2001;108(1):44-53.
27. Casey PH, Szeto KL, Robbins JM, et al. Child health-related quality of life and household food security. *Archives of Pediatrics & Adolescent Medicine* 2005;159(1):51-56.
28. Jyoti DF, Frongillo EA, Jones SJ. Food insecurity affects school children's academic performance, weight gain, and social skills. *Journal of Nutrition* 2005;135:2831-2839.
29. Weinreb L, Wehler C, Perloff J, et al. Hunger: Its impact on children's health and mental health. *Pediatrics* 2002;110(4).
30. Kleinman RE, Murphy JM, Little M, et al. Hunger in children in the United States: Potential behavioral and emotional correlates. *Pediatrics* 1998;101(1):art. no.-e3.
31. Murphy JM, Wehler CA, Pagano ME, Little M, Kleinman RE, Jellinek MS. Relationship between hunger and psychosocial functioning in low-income American children. *Journal of the American Academy of Child and Adolescent Psychiatry* 1998;37(2):163-170.
32. Connell CL, Lofton KL, Yadrick K, Rehner TA. Children's experiences of food insecurity can assist in understanding its effect on their well-being. *Journal of Nutrition* 2005;135(7):1683-1690.
33. Bellisle F, Blundell JE, Dye L, et al. Functional food science and behaviour and psychological functions. *British Journal of Nutrition* 1998;80:S173-S193.
34. Benton D. The influence of children's diet on their cognition and behavior. *European Journal of Nutrition* 2008;47:25-37.
35. Ells LJ, Hillier FC, Shucksmith J, et al. A systematic review of the effect of dietary exposure that could be achieved through normal dietary intake on learning and performance of school-aged children of relevance to UK schools. *British Journal of Nutrition* 2008;100(5):927-936.
36. Evans GW, Kantrowitz E. Socioeconomic status and health: The potential role of environmental risk exposure. *Annual Review of Public Health* 2002;23:303-331.
37. Linver MR, Brooks-Gunn J, Kohen DE. Family processes as pathways from income to young children's development. *Developmental Psychology* 2002;38(5):719-734.
38. Alaimo K, Briefel RR, Frongillo EA, Olson CM. Food insufficiency exists in the United States: Results from the third National Health and Nutrition Examination Survey (NHANES III). *American Journal of Public Health* 1998;88(3):419-426.
39. Cutler-Triggs C, Fryer GE, Miyoshi TJ, Weitzman M. Increased Rates and Severity of Child and Adult Food Insecurity in Households With Adult Smokers. *Archives of Pediatrics & Adolescent Medicine* 2008;162(11):1056-1062.
40. Roberts BW, DelVecchio WF. The rank-order consistency of personality traits from childhood to old age: A quantitative review of longitudinal studies. *Psychological Bulletin* 2000;126(1):3-25.
41. Costa PT, McCrae RR. 4 ways 5 factors are basic. *Personality and Individual Differences* 1992;13(6):653-665.

42. Caspi A, Roberts BW, Shiner RL. Personality development: Stability and change. *Annual Review of Psychology* 2005;56:453-484.
43. Farkas G. Cognitive skills and noncognitive traits and behaviors in stratification processes. *Annual Review of Sociology* 2003;29:541-562.
44. Chapman BP, Fiscella K, Kawachi I, Duberstein PR. Personality, Socioeconomic Status, and All-Cause Mortality in the United States. *American Journal of Epidemiology* 2010;171(1):83-92.
45. Moffitt TE, Caspi A, Harrington H, et al. Generalized anxiety disorder and depression: childhood risk factors in a birth cohort followed to age 32. *Psychological Medicine* 2007;37(3):441-452.
46. Schwartz JE, Friedman HS, Tucker JS, Tomlinsonkeasey C, Wingard DL, Criqui MH. Sociodemographic and psychosocial factors in childhood as predictors of adult mortality. *American Journal of Public Health* 1995;85(9):1237-1245.
47. John O, Srivastava S. The Big Five Trait taxonomy: History, measurement and theoretical perspectives. In: Pervin LAaJ, O. P., ed. *Handbook of Personality*. 2 ed. New York, NY: The Guilford Press; 1999:102-138.
48. Verplanken B, Herabadi A. Individual differences in impulse buying tendency: Feeling and no thinking. *European Journal of Personality* 2001;15:S71-S83.
49. McCrae RR, Costa PT. Personality, coping, and coping effectiveness in an adult sample. *Journal of Personality* 1986;54(2):385-405.
50. Daly M, Harmon CP, Delaney L. Psychological and biological foundations of time preference. *Journal of the European Economic Association* 2009;7(2-3):659-669.
51. Asendorpf JB, Wilpers S. Personality effects on social relationships. *Journal of Personality and Social Psychology* 1998;74(6):1531-1544.
52. Bolger N, Zuckerman A. A framework for studying personality in the stress process. *Journal of Personality and Social Psychology* 1995;69(5):890-902.
53. Harknett K. The relationship between private safety nets and economic outcomes among single mothers. *Journal of Marriage and the Family* 2006;68(1):172-191.
54. Sullivan JX, Turner L, Danziger S. The relationship between income and material hardship. *Journal of Policy Analysis and Management* 2008;27(1):63-81.
55. Wilde P, Nord M. The effect of food stamps on food security: A panel data approach. *Review of Agricultural Economics* 2005;27(3):425-432.
56. Henly JR, Danziger SK, Offer S. The contribution of social support to the material well-being of low-income families. *Journal of Marriage and the Family* 2005;67(1):122-140.
57. Ryan RM, Kalil A, Leininger L. Low-Income Mothers' Private Safety Nets and Children's Socioemotional Well-Being. *Journal of Marriage and the Family* 2009;71(2):278-297.
58. Jensen-Campbell LA, Knack JM, Waldrip AM, Campbell SD. Do Big Five personality traits associated with self-control influence the regulation of anger and aggression? *Journal of Research in Personality* 2007;41(2):403-424.
59. Prinzie P, Stams G, Dekovic M, Reijntjes AHA, Belsky J. The Relations Between Parents' Big Five Personality Factors and Parenting: A Meta-Analytic Review. *Journal of Personality and Social Psychology* 2009;97(2):351-362.
60. Oliver PH, Guerin DW, Coffman JK. Big five parental personality traits, parenting behaviors, and adolescent behavior problems: A mediation model. *Personality and Individual Differences* 2009;47(6):631-636.
61. Serbin LA, Karp J. The intergenerational transfer of psychosocial risk: Mediators of vulnerability and resilience. *Annual Review of Psychology* 2004;55:333-363.
62. Dunn MG, Tarter RE, Mezzich AC, Vanyukov M, Kirisci L, Kirillova G. Origins and consequences of child neglect in substance abuse families. *Clinical Psychology Review* 2002;22(7):1063-1090.

63. Belsky J. Etiology of child maltreatment: A developmental ecological analysis. *Psychological Bulletin* 1993;114(3):413-434.
64. Wehler C, Weinreb LF, Huntington N, et al. Risk and protective factors for adult and child hunger among low-income housed and homeless female-headed families. *American Journal of Public Health* 2004;94(1):109-115.
65. Cicchetti D, Toth SL. Developmental psychopathology perspective on child-abuse and neglect. *Journal of the American Academy of Child and Adolescent Psychiatry* 1995;34(5):541-565.
66. Coldwell J, Pike A, Dunn J. Household chaos - links with parenting and child behaviour. *Journal of Child Psychology and Psychiatry* 2006;47(11):1116-1122.
67. Evans GW. Child development and the physical environment. *Annual Review of Psychology* 2006;57:423-451.
68. Hildyard KL, Wolfe DA. Child neglect: developmental issues and outcomes. *Child Abuse & Neglect* 2002;26(6-7):679-695.
69. Trouton A, Spinath FM, Plomin R. Twins Early Development Study (TEDS): A multivariate, longitudinal genetic investigation of language, cognition and behavior problems in childhood. *Twin Research* 2002;5(5):444-448.
70. Moffitt TE, Team ERS. Teen-aged mothers in contemporary Britain. *Journal of Child Psychology and Psychiatry* 2002;43(6):727-742.
71. D W. Wechsler Intelligence Scale for Children. 4 (UK Version) ed. San Antonio, TX: Harcourt Assessment; 2003.
72. M SJ. Assessment of Children: WIOSC-III and WPPSI-R Supplement. Dan Diego, CA; 1992.
73. Thomas A. Manual for Teacher's Report Form and 1991 Profile. Burlington, VT: University of Vermont Department of Psychology; 1991.
74. Association AP. Diagnostic and Statistical Manual of Mental Disorders. 4 ed. Washington, DC: American Psychiatric Association; 1994.
75. Arseneault L, Moffitt TE, Caspi A, et al. Strong genetic effects on cross-situational antisocial behaviour among 5-year-old children according to mothers, teachers, examiner-observers, and twins' self-reports. *Journal of Child Psychology and Psychiatry* 2003;44(6):832-848.
76. March JS, Parker JDA, Sullivan K, Stallings P, Conners CK. The multidimensional anxiety scale for children (MASC): Factor structure, reliability, and validity. *Journal of the American Academy of Child and Adolescent Psychiatry* 1997;36(4):554-565.
77. Kovacs M. The Children's Depression Inventory (CDI). *Psychopharmacology Bulletin* 1985;21(4):995-998.
78. Gary B, Mark N, Cristofer P, William H, John C. Guide to Measuring Household Food Security, Revised. In: *Measuring Food Security in the United States: Reports of the Federal Interagency Food Security Measurement Project*. Alexandria, VA: United States Department of Agriculture, Food, and Nutrition Service; 2000.
79. Cutler DM, Katz LF. Rising inequality: Changes in the distribution of income and consumption in the 1980s. *American Economic Review* 1992;82(2):546-551.
80. Benet-Martinez V, John OP. Los Cinco Grandes across cultures and ethnic groups: Multitrait multimethod analyses of the Big Five in Spanish and English. *Journal of Personality and Social Psychology* 1998;75(3):729-750.
81. B C, R B, Staff. Home Observation for Measurement of the Environment. Revised ed. Homewood, IL: Dorsey; 1984.
82. Bradley RH, Caldwell BM. Home observation for measurement of the environment: Validation-study of screening efficiency. *American Journal of Mental Deficiency* 1977;81(5):417-420.
83. Webster-Stratton C. Preventing conduct problems in head start children: Strengthening parenting competencies. *Journal of Consulting and Clinical Psychology* 1998;66(5):715-730.

84. Williams RL. A note on robust variance estimation for cluster-correlated data. *Biometrics* 2000;56(2):645-646.
85. LP S. Stata/SE for Windows. In. 10.1 ed. College Station, TX: Stata Corp LP; 2009.
86. Patrick R. Multiple Imputation of Missing Values: Update of ICE. *The Stata Journal* 2005;5(4):527-536.
87. Rosenbaum PR, Rubin DB. The central role of the propensity score in observational studies for causal effects. *Biometrika* 1983;70(1):41-55.
88. Leuven E, Sianesi B. PSMATCH2: Stata module to perform full Mahalanobis and propensity score matching, common support graphing, and covariate imbalance testing. In. 2009 ed: http://ideas.repec.org/c/boc/bocode/s432001.html; 2003.
89. Thomas A. The Achenbach System of Empirically Based Assessment (ASEBA): Development, Findings, Theory, and Applications. Burlington, VT: The Research Center for Children, Youth, and Families; 2009.
90. Murray CJL, Lopez AD. Alternative projections of mortality and disability by cause 1990-2020: Global burden of disease study. *Lancet* 1997;349(9064):1498-1504.
91. Bennett N, Jarvis L, Rowlands O, Singleton N, Haselden L. Living in Britain: Results from the 1994 General Household Survey. In. London: Her Majesty's Stationary Office; 1996.
92. Kendler KS, Martin NG, Heath AC, Eaves LJ. Self-report psychiatric symptoms in twins and their nontwin relatives: Are twins different? *American Journal of Medical Genetics* 1995;60(6):588-591.
93. Gjone H, Novik TS. Parental ratings of behavior problems: A twin and general-population comparison. *Journal of Child Psychology and Psychiatry and Allied Disciplines* 1995;36(7):1213-1224.
94. Levy F, Hay D, McLaughlin M, Wood C, Waldman I. Twin-sibling differences in parental reports of ADHD, speech, reading and behaviour problems. *Journal of Child Psychology and Psychiatry and Allied Disciplines* 1996;37(5):569-578.
95. Melchior M, Caspi A, Howard LM, et al. Mental Health Context of Food Insecurity: a Representative Cohort of Families With Young Children. *Pediatrics* 2009;124:e564-e572.
96. J C, J C. Food insecurity in Canadian households. *Health Rep* 2001;12:11-22.
97. Evenson KR, Laraia BA, Welch VLL, Perry AL. Statewide prevalences of concern about enough food, 1996-1999. *Public Health Reports* 2002;117(4):358-365.
98. Rose D, Bodor JN. Household food insecurity and overweight status in young school children: Results from the Early Childhood Longitudinal Study. *Pediatrics* 2006;117(2):464-473.
99. Whitaker RC, Phillips SM, Orzol SM. Food insecurity and the risks of depression and anxiety in mothers and behavior problems in their preschool-aged children. *Pediatrics* 2006;118(3):E859-E868.
100. Slack KS, Yoo J. Food hardship and child behavior problems among low-income children. *Social Service Review* 2005;79(3):511-536.
101. Olds DL, Eckenrode J, Henderson CR, et al. Long-term effects of home visitation on maternal life course and child abuse and neglect - Fifteen-year follow-up of a randomized trial. *Jama-Journal of the American Medical Association* 1997;278(8):637-643.
102. Olds DL. The nurse-family partnership: An evidence-based preventive intervention. *Infant Mental Health Journal* 2006;27(1):5-25.