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Transitions between food insecurity and food security predict children's social skill development during elementary school

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Abstract

Recent findings indicate that household food insecurity affects children's social skill development in the early years of elementary school. It is important to assess the persistency of developmental consequences and investigate whether all categories of social skills are equally affected by food insecurity experiences. The present paper estimates population-averaged and subject-specific models for children's social skill scores reported by school teachers using longitudinal data on 2310 boys and 2400 girls in the USA enrolled in the 1st (aged 6–9 years), 3rd (aged 8–11 years) and 5th (aged 10–13 years) grades (1999–2003) from the Early Childhood Longitudinal Study-Kindergarten. The main findings are, first, significantly ($P<0{\cdot}05$) negative, contemporaneous and transitional relationships between food insecurity experiences and children's social skill scores are evident. Estimates based on sex-stratified samples indicate that the contemporaneous association is strongest among girls, while the association of an early transition from food insecurity in the 1st grade to food security in the 3rd grade is strongest among boys. Second, food insecurity experiences predict children's social skill scores emphasising self-control, attentiveness and task persistence, rather than interpersonal relationships or externalising behaviour. Overall, the findings underscore the multifaceted effect that household food insecurity has on children's social skills and provide the strongest empirical evidence to date that the experiences are linked with non-nutritional developmental consequences for children over a time horizon spanning several years.

Key words: Food insecurity: Child development: Social skills: Longitudinal data

Although widespread hunger and malnutrition are uncommon in the established market economies of Europe and North America, an increasing number of households often forgo or limit dietary intake because of financial hardship. The prevalence of food insecurity in the USA has now reached its highest level since regular monitoring began in 1995, and over eight million households with children (21% of the total) reported an inability to afford nutritionally adequate food in 2008[1]. While the intensity of food insecurity ranges from temporary interruptions in usual diet to chronic hunger, the experiences in developed countries can frequently involve a concurrent combination of over- and undernourishment[2]. The research investigating dietary behaviour has linked increasing financial constraints[3,4] and prevailing inverse relationships between energy cost (€/MJ) and energy density (kJ/g) of available foods[5–8] to an imbalance of macro- and micronutrient intakes. Moreover, food insecurity is negatively associated with food spending among households in the USA[1], and the substitution of low-cost, energy-dense meals for healthy meals can exacerbate the intensity of food insecurity within a household if children gain weight[9,10].

Food insecurity experiences encompass a wide range of deleterious effects associated with hunger[11,12] and are negatively associated with physical and mental health and learning outcomes for children[13–22]. However, the evidence on relationships between food insecurity and social skill development is less clear. Among children aged 6–12 years, the experience is positively associated with measures of aggression, anxiety and hyperactivity[11,13], yet not significantly related to other measures of aggression, attentiveness and shyness[13,14]. Only one earlier study has used longitudinal methods to examine relationships between food insecurity and children's social skill development[21]. While the experiences were not significantly related to composite measures of social skills overall, sex-stratified analysis revealed a positive association for boys and a negative association for girls. A limitation of the earlier study was the use of composite outcome measures that comprise several categories of social skills, and broad conclusions drawn from composite analyses may be incomplete if the effects are not equal for each component skill category. Although statistical measures of reliability, such as the Cronbach α[23], indicate the degree to which individual outcomes are inter-related, it is not certain that children's social skill development is a one-dimensional outcome with regard to food insecurity.

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Given the multifaceted threat of food insecurity, recent models of children's social skill development have emphasised the possibility of both contemporaneous and transitional relationships with the experiences[21]. Theoretical motivation for distinguishing between the two effects is grounded in the nutritional and psychological components of the household food insecurity measures in developed countries[24–26]. Food insecurity is linked with decreases in the energy sufficiency and nutrient adequacy of children's diets[22], and temporary adjustments can negatively affect children's observed social skills. For instance, metabolic stress is linked with impairment of attention and memory processes among children aged 9–11 years[27] and the voluntary exertion of effort during school among children aged 10 years[28]. However, food insecurity experiences can also negatively affect children's social adjustment in ways that persist, even if the financial circumstances of households improve. For instance, financial hardship is negatively associated with children's self-esteem[29], and recent past exposure to environmental adversity is positively associated with children's problem behaviours reported by school teachers[30]. A comprehensive, longitudinal modelling approach taking into account the potential for contemporaneous and transitional relationships is necessary to gain further insight into how food insecurity experiences affect children's social skills during elementary school.

Experimental methods

Study sample

The Early Childhood Longitudinal Study-Kindergarten began in the autumn of 1998 by observing nearly 20 000 children in kindergarten enrolled in over 1200 schools throughout the USA. The present study was conducted according to the guidelines laid down in the Declaration of Helsinki, and all procedures involving human subjects/patients were approved by the ethics committees of the Department of Education and Office of Management and Budget, USA. Written informed consent was obtained from all subjects/patients. Attrition due to geographical relocation resulted in approximately 11 000 children remaining in the study from kindergarten to 5th grade, and the locatable students were followed for a random 50 % of the schools[31]. Our analytic sample consists of 4710 children for whom full data were available for the 1st, 3rd and 5th grades, respectively. Demographic characteristics of our analytic sample were similar to the full sample, and the available longitudinal sampling weights are utilised in the analysis to adjust for an oversampling of Asian and Pacific Islanders and non-response across the three survey rounds.

Social skill outcome measures

Questionnaires were administered to children's teachers in the spring of the 1st, 3rd and 5th grades that asked them to report how often students exhibited certain social skills in class. The response scales and measures were adapted from an existing social skill rating system[32], and the reliability for the teacher-reported social skill observations was high[31]. The responses ranged from 1 (never) to 4 (very often), and we focus on the four most reliable social skill scores: interpersonal relationships, self-control; approaches to learning; externalising behaviour. For comparison with earlier studies, we construct composite social skill scores by taking the average of the four component scores with the scorings for externalising behaviour reversed. The Cronbach α[23] for children's composite scores was high at 0·883, 0·895 and 0·900 for the 1st, 3rd and 5th grades, respectively.

Of the four social skill outcomes, 'interpersonal relationships' measures a child's ability in forming and maintaining friendships, getting along with people who are different, comforting or helping other children, expressing feelings, ideas and opinions in positive ways, and showing sensitivity to the feelings of others. 'Self-control' measures a child's ability in respecting the property rights of others, controlling temper, accepting peer ideas for group activities and responding appropriately to pressure from peers. 'Approaches to learning' measures a child's ability to exhibit skills such as attentiveness, task persistence, eagerness to learn, learning independence, flexibility and organisation. 'Externalising behaviour' measures a child's ability to behave in ways that interfere with the learning process in the classroom such as arguing, fighting, getting angry, acting impulsively and disturbing ongoing activities; higher values indicate a worse developmental outcome.

Food insecurity measures

Food insecurity levels in children's home environments in the previous 12 months were assessed using the United States Department of Agriculture's Household Food Security Survey Module. It consists of eighteen questions that are designed to capture information about the household environment such as anxiety over insufficient food budget or supply, perceptions of inadequate food quality or quantity, and instances of reduced food intake by household members; and each question specifies that the circumstance must have occurred in the past 12 months due to financial limitations[25]. For comparison with earlier studies, we measure contemporaneous food insecurity using an indicator variable for households reporting ($\geq$1) affirmative responses on the module.

To capture transitional effects associated with the timing of food insecurity experiences, we construct indicator variables for each of the eight possible patterns. For observations in the 3rd grade, we classify households according to whether they became food secure or food insecure for the first time. For observations in the 5th grade, we classify households according to whether they became food secure or food insecure for the first time or for the second time. We classify households that do not experience a change in food security or food insecurity status from the 1st to the 5th grade as persistently food secure and persistently food insecure, respectively.

Control measures

Extensive data were collected in the spring of each grade using one-on-one, untimed direct child assessments and parent interviews conducted by telephone[31]. Time-invariant control variables used in the analysis are age, sex, developmental disability status and race–ethnicity. The time-varying control variables measure child-specific and ecological factors influencing social skill development. Children's heights and body weights were measured in each round using a Shorr Board (Shorr Production, Olney, MD, USA) and digital scale, respectively; duplicate measures were taken and we use the mean values. Parents reported on the overall activity level of their children relative to other children of the same age, and we constructed three categorical variables: low, high and very high overall activity level, with normal overall activity level as the reference group. Additional time-varying control variables include the average number of minutes per day a child watches television, the number of hours/week a child spends in non-parental child care, a variable indicating whether the child cares for self when not in school, a variable indicating whether the child is placed in centre-based care when not in school and a variable indicating whether the child attends a public school. At the household level, time-varying controls include the number of siblings, the overall household size, a series of indicator variables corresponding to household income categories in US $1000 (<5, 5–10, 10–15, 15–20, 20–25, 25–30, 30–35, 35–40, 40–50, 50–75, 75–100, 100–200 and >200) and a series of indicator variables corresponding to parental education levels (8th grade or below, 9th–12th grade, high school diploma/General Equivalency Diploma (GED), vocational programme, some college, bachelor's degree, graduate/professional school with no degree, master's degree, doctorate or professional degree).

Several additional variables control for potential confounding effects of the local economic and non-economic environment on household transitions between food security and food insecurity. First, information on US counties is linked to each child based on the location of the elementary school they attend. A series of county-level indicator variables are constructed to control for any time-invariant characteristics of the local environment that are correlated with the likelihood of children's households experiencing food insecurity. Second, we control for time-varying characteristics of the local county environment during the previous year when food insecurity was assessed by using measures of Food Stamp programme recipients (per capita), the unemployment rate and average household income. Third, general linear time trends by county and by the type of school are utilised to further minimise any remaining possibility of spurious associations among the variables of interest.

Models

Contemporaneous and transitional relationships between food insecurity experiences and children's social skill scores are investigated using population-averaged and subject-specific regression models. Because the teachers reporting on children's performance and the specific questions in the social skill questionnaires change across survey rounds, a static relationship between repeated observations is assumed in the empirical models, and correlation among repeated child observations is accounted for in the estimation. The first model postulated for the ith child's social skill score at time t is given in equation 1:

$$\begin{aligned}\text{Score}_{it} = {} & \beta_0 + \beta_1\,(\text{contemporaneous food insecurity})_{it} \\ & + \beta_2\,(\text{became food secure for the first time in 3rd grade})_{it} \\ & + \beta_3\,(\text{became food insecure for the first time in 3rd grade})_{it} \\ & + \beta_4\,(\text{became food secure for the first time in 5th grade})_{it} \\ & + \beta_5\,(\text{became food insecure for the first time in 5th grade})_{it} \\ & + \beta_6\,(\text{became food secure for the second time in 5th grade})_{it} \\ & + \beta_7\,(\text{became food insecure for the second time in 5th grade})_{it} \\ & + \beta_8\,(\text{persistently food insecure})_i \\ & + \beta_9\,(\text{time-invariant covariates})_i \\ & + \beta_{10}\,(\text{time-varying covariates})_{it} + E_{it}.\end{aligned} \tag{1}$$

Within-child (subject) correlation is accounted for in the computation of coefficient standard errors under the assumption that $E_{it} = c_i + e_{it}$, where c_i captures the time-invariant subject-specific correlation among repeated outcomes. This particular formulation of the model is appropriate when the aggregate response for the entire population of children is of interest, and hence provides the population-averaged marginal response[33]. The estimated β_1–β_8 coefficients indicate the difference in social skill scores for children from households that are experiencing food insecurity and transitioning between states of food insecurity and food security relative to children from households with persistent food security. Population-averaged models allow us to attribute marginal effects to time-invariant characteristics such as living in a household that is persistently food insecure; however, a practical limitation is that unbiased estimation requires that c_i is uncorrelated with the explanatory variables.

As an alternative, we estimate the following subject-specific regression model given in equation 2:

$$\begin{aligned}\text{Score}_{it} = {} & \beta_0 + \beta_1\ (\text{contemporaneous food insecurity})_{it} \\ & + \beta_2\ (\text{became food secure for the first time in 3rd grade})_{it} \\ & + \beta_3\ (\text{became food insecure for the first time in 3rd grade})_{it} \\ & + \beta_4\ (\text{became food secure for the first time in 5th grade})_{it} \\ & + \beta_5\ (\text{became food insecure for the first time in 5th grade})_{it} \\ & + \beta_6\ (\text{became food secure for the second time in 5th grade})_{it} \\ & + \beta_7\ (\text{became food insecure for the second time in 5th grade})_{it} \\ & + \beta_8\ (\text{time-varying covariates})_{it} + c_i + e_{it}.\end{aligned} \quad (2)$$

In contrast to the population-averaged model in equation 1, the subject-specific model in equation 2 explains the source of the covariance among repeated observations for a child by explicitly modelling the time-invariant shared subject effects, c_i, in the conditional mean[33]. This approach provides the least biased estimates of the effects of the explanatory variables by controlling for the influence of all unobservable (and observed) time-invariant factors affecting children's social skill development.

Statistical methods

Population-averaged and subject-specific linear regression methods are utilised to estimate the contemporaneous and transitional relationships between food insecurity experiences and children's social skill scores. The Stata xtreg (version 11; StataCorp LP; College Station, TX, USA) procedure is used in the estimation, and the cluster procedure is used to allow for an arbitrary pattern of correlation among repeated child observations in subject-specific models. Early Childhood Longitudinal Study-Kindergarten longitudinal sampling weights are utilised in all models to adjust for an oversampling of Asian and Pacific Islanders and non-response. Analyses are conducted using the full sample and sex-stratified samples. Differences are considered significant at the 5% level ($P<0{\cdot}05$).

Results

Descriptive statistics for transitions between food insecurity and food security

The sample means of the variables utilised in the models are reported in Table 1. Approximately 9–11% of children were from households experiencing food insecurity in any one time period, while 81% were from persistently food secure households and 3% were from persistently food insecure households. Of the 11% of children experiencing food insecurity in the 1st grade, 7% transitioned to food security for the first time in the 3rd grade. Of the 9% of children experiencing food insecurity in the 3rd grade, 1% transitioned to food security for the first time in the 5th grade and 3% transitioned to food security for the second time in the 5th grade. In contrast, 5% of children transitioned to food insecurity for the first time in the 3rd grade, 4% of children transitioned to food insecurity for the first time in the 5th grade and 2% of children transitioned to food insecurity for the second time in the 5th grade.

Results for children's social skill development

Table 2 presents the results from the population-averaged model in equation 1 for each of the four social skill score outcomes and a composite. Contemporaneous food insecurity and persistent food insecurity are not significantly related to changes in children's social skill scores. Relative to children from households that are persistently food secure, children who experience a transition from food insecurity in the 1st grade to food security in the 3rd grade have significantly lower composite social skill scores ($\beta_2 = -0{\cdot}113$, $P<0{\cdot}019$). Stratification by sex shows that the association between this early transition and composite social skill scores is significant for boys ($\beta_2 = -0{\cdot}188$, $P<0{\cdot}005$) and close in magnitude to zero for girls ($\beta_2 = -0{\cdot}036$, $P<0{\cdot}566$). A similar pattern by sex is evident for each of the component social skill scores measuring interpersonal relationships, self-control, approaches to learning and externalising behaviour.

To assess the potential bias in the estimates of the population-averaged model, Table 3 presents the results from the subject-specific model in equation 2 for each of the four social skill score outcomes and a composite. Children's composite social skill scores are negatively associated with contemporaneous food insecurity experiences ($\beta_1 = -0{\cdot}077$, $P<0{\cdot}036$) and an early transition from food insecurity in the 1st grade to food security in the 3rd grade ($\beta_2 = -0{\cdot}132$, $P<0{\cdot}008$). Thus, children with intermittent food insecurity beginning in the 1st grade have composite social scores that are nearly 0·50 standard deviations lower overall, and 0·25 standard deviations lower relative to children with intermittent food insecurity in later grades, on average.

Stratification by sex further reveals significant differences in the relationship between food insecurity and social skills; the contemporaneous association is strongest for girls ($\beta_1 = -0{\cdot}119$, $P<0{\cdot}016$), while the association of an early transition from food insecurity in the 1st grade to food security in the 3rd grade is strongest for boys ($\beta_2 = -0{\cdot}172$, $P<0{\cdot}012$). Furthermore, in contrast to results from the population-averaged model, the early transition is not a significant predictor of boys' social skill scores for interpersonal relationships ($\beta_2 = -0{\cdot}167$, $P<0{\cdot}066$) and externalising behaviour ($\beta_2 = 0{\cdot}180$, $P<0{\cdot}070$), and contemporaneous food insecurity is a significant predictor of girls' social skill scores for self-control ($\beta_1 = -0{\cdot}124$, $P<0{\cdot}050$) and approaches to learning

Table 1. Selected variables for children in the Early Childhood Longitudinal Study-Kindergarten observed at 2-year intervals in the period 1999–2003* (Mean values and standard deviations for 4710 subjects)

	1st grade		3rd grade		5th grade	
Variables	Mean	SD	Mean	SD	Mean	SD
Social skill composite score (*n*)	2·01	0·52	1·99	0·52	1·99	0·52
Interpersonal relationship score (1–4)	3·19	0·61	3·17	0·62	3·14	0·62
Self-control score (1–4)	3·26	0·57	3·26	0·58	3·28	0·58
Approaches to learning score (1–4)	3·18	0·64	3·16	0·64	3·16	0·65
Externalising problem behaviour score (1–4)	1·57	0·58	1·63	0·56	1·60	0·54
Contemporaneous food insecurity (%)	11		9		11	
Persistently food secure (%)	81		–		–	
Persistently food insecure (%)	3		–		–	
Became food secure for the first time in 3rd grade (%)	–		7		–	
Became food insecure for the first time in 3rd grade (%)	–		5		–	
Became food secure for the first time in 5th grade (%)	–		–		1	
Became food insecure for the first time in 5th grade (%)	–		–		4	
Became food secure for the second time in 5th grade (%)	–		–		3	
Became food insecure for the second time in 5th grade (%)	–		–		2	
Black household (%)	7		–		–	
Hispanic (of all races) household (%)	12		–		–	
Siblings (*n*)	1·46	1·04	1·49	1·05	1·48	1·04
Household size (*n*)	4·50	1·22	4·49	1·22	4·47	1·23
Parental education level (1–9)	5·26	1·84	5·42	1·83	5·48	1·83
Household income category (1–13)	8·88	2·80	9·14	2·72	9·26	2·76
Age (months)	87·19	4·28	–		–	
Boys (%)	49		–		–	
Developmental disability (%)	14		–		–	
Height (m)	1·23	0·06	1·35	0·07	1·47	0·08
Weight (kg)	25·79	5·71	34·11	8·92	44·08	12·42
Low overall activity level (%)	3		6		8	
High overall activity level (%)	31		29		28	
Very high overall activity level (%)	14		15		16	
Television watching (min/d)	112·57	67·26	114·11	68·83	121·21	71·24
Non-parental care (h/week)	4·80	7·95	3·68	6·73	3·18	6·65
Cares for self when not in school (%)	2		4		13	
Centre-based care when not in school (%)	15		13		10	
Parental care when not in school (%)	55		60		57	
Attends public school (%)	74		75		75	
County-level characteristics†						
Unemployment rate (%)	4	2	5	2	6	2
Food stamp recipients (per capita)	6	5	6	5	8	5
Income ($ per capita)	28 404·28	8110·78	30 407·75	8850·84	31 515·11	8480·99

* Food insecurity is defined as ≥1 affirmative response on the United States Department of Agriculture's Household Food Security Survey Module.
† County-level unemployment rate data are from the US Bureau of Labor Statistics. Food stamp recipient data are from the County Level Food Stamp Recipient File, US Bureau of the Census. County-level per capita income data are from the Regional Economic Information System, US Department of Commerce, Bureau of Economic Analysis, Regional Economic Measurement Division.

($\beta_1 = -0{\cdot}190$, $P<0{\cdot}003$). Overall, the change in magnitude and precision of the estimated effects between the two models indicates that unobservable time-invariant characteristics of children and their households are correlated with both food insecurity experiences and observed social skills in elementary school.

Discussion

The comprehensive, longitudinal modelling approach of the study emphasised the multifaceted threat of household food insecurity to children's social skill development through both contemporaneous and transitional relationships. Several insights into how food insecurity experiences affect the social skills of children aged 6–13 years in the USA are evident from the empirical results. In particular, we find that children have below-average social skill scores during the same time period in which their households report food insecurity. A negative contemporaneous effect of food insecurity experiences on children's social skills is consistent with a concurrent combination of unhealthy changes in dietary intake and psychological stress; and estimates based on sex-stratified samples indicate that the association is strongest among girls. Previous analyses of 24 h recall data indicate that food insecurity is linked with a reduced consumption of fruit and vegetables and a higher prevalence of nutrient inadequacy for protein among girls aged 9–13 years in Canada[22]; however, a comparable sex-stratified analysis does not exist for the USA. To the extent that food insecurity acts as a psychological stressor, earlier studies have shown that girls are more likely to experience emotional distress such as anxiety and depression in response to household financial hardship and stress[34,35]. Moreover, parental depression resulting from financial hardship is negatively associated with adolescent girls' social adjustment[36].

Table 2. Estimates from population-averaged models of the contemporaneous and transitional effects of household food insecurity experiences on children's social skill scores in elementary school*†‡

(β-Coefficients and *P* values)

		Contemporaneous food insecurity		Became food secure for the first time in 3rd grade		Became food insecure for the first time in 3rd grade		Became food secure for the first time in 5th grade		Became food insecure for the first time in 5th grade		Became food secure for the second time in 5th grade		Became food insecure for the second time in 5th grade		Persistently food insecure	
Outcome	*n*	β	*P*	β	*P*	β	*P*	β	*P*	β	*P*	β	*P*	β	*P*	β	*P*
Social skill composite score																	
All	4710	−0·055	0·074	−0·113	0·019	0·003	0·948	−0·038	0·668	0·054	0·366	0·021	0·809	0·117	0·100	−0·016	0·776
Boys	2310	−0·051	0·190	−0·188	0·005	−0·003	0·962	0·048	0·686	0·065	0·351	0·058	0·489	0·118	0·280	−0·125	0·106
Girls	2400	−0·047	0·267	−0·036	0·566	−0·012	0·821	−0·066	0·561	0·058	0·491	0·001	0·993	0·097	0·147	0·100	0·164
Interpersonal relationship score																	
All	4710	−0·073	0·061	−0·106	0·052	0·030	0·604	−0·054	0·621	0·032	0·651	0·027	0·785	0·184	0·100	−0·001	0·993
Boys	2310	−0·052	0·309	−0·190	0·019	0·023	0·800	0·098	0·460	0·019	0·830	0·035	0·751	0·150	0·371	−0·108	0·190
Girls	2400	−0·072	0·188	−0·014	0·837	0·002	0·975	−0·116	0·443	0·037	0·701	0·018	0·890	0·230	0·074	0·118	0·151
Self-control score																	
All	4710	−0·048	0·215	−0·120	0·030	0·013	0·799	−0·033	0·748	−0·005	0·950	0·038	0·686	0·118	0·140	−0·023	0·708
Boys	2310	−0·045	0·361	−0·217	0·002	0·054	0·427	0·068	0·636	−0·004	0·967	0·111	0·201	0·137	0·185	−0·159	0·056
Girls	2400	−0·049	0·343	−0·022	0·761	−0·032	0·659	−0·092	0·478	0·020	0·846	−0·015	0·903	0·081	0·342	0·129	0·100
Approaches to learning score																	
All	4710	−0·046	0·194	−0·125	0·068	−0·005	0·923	0·049	0·617	0·056	0·406	0·053	0·537	0·134	0·074	−0·017	0·803
Boys	2310	−0·020	0·674	−0·156	0·009	−0·063	0·437	0·208	0·159	0·042	0·611	0·060	0·596	0·138	0·192	−0·109	0·227
Girls	2400	−0·061	0·235	−0·080	0·476	0·030	0·656	−0·049	0·690	0·069	0·485	0·057	0·607	0·111	0·204	0·088	0·320
Externalising behaviour score																	
All	4710	0·039	0·265	0·096	0·076	0·032	0·440	0·083	0·246	−0·105	0·087	0·040	0·632	−0·012	0·880	0·029	0·648
Boys	2310	0·075	0·141	0·189	0·048	0·026	0·685	0·148	0·156	−0·162	0·094	0·001	0·991	−0·017	0·884	0·136	0·167
Girls	2400	−0·017	0·645	0·007	0·855	0·063	0·207	−0·031	0·717	−0·085	0·219	0·055	0·588	0·040	0·613	−0·061	0·384

* Food insecurity is defined as ≥1 affirmative response on the United States Department of Agriculture's Household Food Security Survey Module.

† *P* values are adjusted for within-child correlation among repeated observations, and the use of longitudinal Early Childhood Longitudinal Study-Kindergarten sampling weights adjusted for oversampling and non-response across the three survey rounds.

‡ Controlling for child's age, age-squared, sex, race–ethnicity, disability status, overall activity level, ln(height), ln(weight), television watching, non-parental child care hours and arrangements, type of school, number of siblings, household size, a series of household income category indicator variables, a series of parental education-level indicator variables, a general linear time trend, a linear time trend for children attending a public-type school, time-varying county-level characteristics, and a series of county-level indicator variables and linear time trends.

Table 3. Estimates from subject-specific models of the contemporaneous and transitional effects of household food insecurity experiences on children's social skill scores in elementary school*†‡ (β-Coefficients and *P* values)

		Contemporaneous food insecurity		Became food secure for the first time in 3rd grade		Became food insecure for the first time in 3rd grade		Became food secure for the first time in 5th grade		Became food insecure for the first time in 5th grade		Became food secure for the second time in 5th grade		Became food insecure for the second time in 5th grade	
Outcome	*n*	β	*P*	β	*P*	β	*P*	β	*P*	β	*P*	β	*P*	β	*P*
Social skill composite score															
All	4710	−0·077	0·036	−0·132	0·008	0·011	0·786	−0·099	0·278	0·089	0·179	0·025	0·776	0·111	0·195
Boys	2310	−0·037	0·389	−0·172	0·012	−0·020	0·714	0·022	0·854	0·066	0·415	0·075	0·437	0·123	0·355
Girls	2400	−0·119	0·016	−0·104	0·078	0·039	0·497	−0·161	0·193	0·135	0·139	0·002	0·986	0·078	0·276
Interpersonal relationship score															
All	4710	−0·074	0·139	−0·118	0·059	0·016	0·794	−0·083	0·500	0·065	0·435	0·052	0·618	0·222	0·089
Boys	2310	−0·016	0·793	−0·167	0·066	−0·035	0·692	0·113	0·444	0·070	0·495	0·080	0·540	0·227	0·249
Girls	2400	−0·133	0·061	−0·083	0·268	0·058	0·466	−0·207	0·241	0·063	0·580	0·047	0·732	0·204	0·144
Self-control score															
All	4710	−0·057	0·225	−0·124	0·041	0·021	0·715	−0·093	0·409	0·030	0·736	0·073	0·438	0·103	0·230
Boys	2310	−0·015	0·793	−0·194	0·011	0·045	0·540	0·055	0·728	−0·022	0·841	0·193	0·080	0·107	0·389
Girls	2400	−0·124	0·050	−0·078	0·282	0·013	0·874	−0·195	0·168	0·119	0·312	−0·015	0·898	0·095	0·285
Approaches to learning score															
All	4710	−0·118	0·015	−0·182	0·011	0·028	0·668	−0·073	0·485	0·131	0·111	0·033	0·699	0·145	0·099
Boys	2310	−0·034	0·575	−0·148	0·017	−0·101	0·250	0·129	0·430	0·084	0·435	0·017	0·893	0·223	0·063
Girls	2400	−0·190	0·003	−0·200	0·056	0·151	0·051	−0·195	0·138	0·173	0·116	0·085	0·439	0·060	0·541
Externalising behaviour score															
All	4710	0·059	0·127	0·103	0·064	0·019	0·654	0·148	0·062	−0·132	0·062	0·060	0·516	0·028	0·763
Boys	2310	0·085	0·112	0·180	0·070	−0·009	0·900	0·209	0·063	−0·130	0·241	−0·008	0·929	0·066	0·651
Girls	2400	0·030	0·467	0·055	0·200	0·067	0·167	0·046	0·656	−0·184	0·022	0·110	0·304	0·046	0·586

* Food insecurity is defined as ≥1 affirmative response on the United States Department of Agriculture's Household Food Security Survey Module.

† *P* values are adjusted for within-child correlation among repeated observations, and the use of longitudinal Early Childhood Longitudinal Study-Kindergarten sampling weights adjusted for oversampling and non-response across the three survey rounds.

‡ Controlling for child's overall activity level, ln(height), ln(weight), television watching, non-parental child care hours and arrangements, type of school, number of siblings, household size, a series of household income category indicator variables, a series of parental education-level indicator variables, a general linear time trend, a linear time trend for children attending a public-type school, time-varying county-level characteristics, and a series of county-level indicator variables and linear time trends.

In addition to contemporaneous relationships, we find that children have below-average social skill scores following an early transition from food insecurity in the 1st grade to food security in the 3rd grade. A negative transitional effect of food insecurity experiences on children's social skills is consistent with persistent psychological stress associated with the timing of intermittent food insecurity experiences; and estimates based on sex-stratified samples indicate that the association is strongest among boys. Previous analyses indicate that past financial hardship reduces the extent to which boys aged 14–17 years feel in control of events in their life[34], and teachers report more learning and social adjustment problems for boys aged 10–14 years who experienced stressful life events within the past year[37]. Although 3rd-grade boys in our analytic sample are relatively younger at the age of 8–11 years, the negative transitional effect we find is probably due to persistent stress associated with household financial hardship occurring in the 1st grade. After adjusting for increases in the price level, a one-tailed mean comparison test indicates significantly ($P<0{\cdot}046$) higher household incomes during the 3rd grade relative to the 1st grade for boys experiencing this particular transition. While a number of factors are related to household income, parental education levels also significantly ($P<0{\cdot}041$) increased over the same period of time.

Furthermore, Jyoti *et al.*[21] analysed children's development from kindergarten to 3rd grade and found that boys who transition to food security in the 3rd grade have composite social skill scores that change by $-0{\cdot}080$ ($P<0{\cdot}038$). We find that this negative effect on boys' social skills persists through the 5th grade and is larger in size at $-0{\cdot}172$ ($P<0{\cdot}012$). In contrast, they find that girls benefit from the same transition with a change in composite social skill scores of 0·123 ($P<0{\cdot}001$). While our estimate of $-0{\cdot}104$ ($P<0{\cdot}078$) indicates no significant effect of this particular transition through the 5th grade, we do find corroborating evidence that girls benefit from not experiencing food insecurity; girls with no food insecurity experiences during elementary school have composite social skill scores that are 0·119 ($P<0{\cdot}016$) higher, on average. The difference in our conclusions for the persistency of the benefits from the early transition for girls is most likely due to the extended time horizon of our analysis, and the use of subject-specific models that allow for both contemporaneous and transitional relationships.

Finally, determining that children's self-control, attentiveness and task persistence are differentially affected by food insecurity, relative to interpersonal skills or the propensity to engage in aggressive or disruptive classroom behaviour, has important implications because hindered social skill development can undermine the effectiveness of classroom-based learning[38] and persist into adulthood[39,40]. Moreover, the social skill outcomes negatively affected by food insecurity experiences are those most likely to be influenced by metabolic stress in controlled experiments[27,28]. Public policy responses to ameliorate household food insecurity in developed countries include a wide range of programmes designed to increase access to available food[41]. However, the effectiveness of existing programmes in eradicating food insecurity experiences is questionable. Recent analyses have found that food insecurity remains strongly related to low consumption of healthy foods, even for those currently receiving food aid[42], and that below-average nutrition education among households participating in food aid programmes results in unhealthy dietary choices[43]. Providing comprehensive assistance that includes both food aid and nutrition education to families reporting food insecurity can help prevent unfavourable nutritional and non-nutritional consequences for young children.

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