Association of Food Insecurity with Children's Behavioral, Emotional, and Academic Outcomes: A Systematic Review

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ABSTRACT: ***Objective:*** **Food Insecurity (FI) occurs in 21% of families with children and adolescents in the United States, but the potential developmental and behavioral implications of this prevalent social determinant of health have not been comprehensively elucidated. This systematic review aims to examine the association between FI and childhood developmental and behavioral outcomes in western industrialized countries.** ***Method:*** **This review provides a critical summary of 23 peer reviewed articles from developed countries on the associations between FI and adverse childhood developmental behavioral outcomes including early cognitive development, academic performance, inattention, externalizing behaviors, and depression in 4 groups–infants and toddlers, preschoolers, school age, and adolescents. Various approaches to measuring food insecurity are delineated. Potential confounding and mediating variables of this association are compared across studies. Alternate explanatory mechanisms of observed effects and need for further research are discussed.** ***Results:*** **This review demonstrates that household FI, even at marginal levels, is associated with children's behavioral, academic, and emotional problems from infancy to adolescence across western industrialized countries - even after controlling for confounders.** ***Conclusions:*** **While the American Academy of Pediatrics already recommends routine screening for food insecurity during health maintenance visits, the evidence summarized here should encourage developmental behavioral health providers to screen for food insecurity in their practices and intervene when possible. Conversely, children whose families are identified as food insecure in primary care settings warrant enhanced developmental behavioral assessment and possible intervention.**

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The behavioral and developmental sequelae of severe malnutrition in infancy and childhood are well researched.[1] Any sustained interruption to a child's nutrition, if not treated early, can result in persistent deficits not only in physical size, but in cognitive growth and fine and gross motor skills.[2] A lack of macronutrients and micronutrients for a sustained period of time is associated with learning and behavioral outcomes including impairments in academic performance, linguistic development, social development, and self-regulation, with increased likelihood of diagnosis of psychosocial disorders.[3]

However, the threshold for neurocognitive and developmental correlates of undernutrition in childhood is lower than previously presumed and may occur without visible anthropometric deficits. Studies have found that intermittent or modest undernutrition may have long-term implications for a child's cognitive and school performance.[4,5] Even micronutrient deficiencies during critical periods of brain development in infancy and toddlerhood are linked to persistent adverse outcomes.[6,7] For instance, infants with iron deficiency perform more poorly on assessments of attentiveness, memory, academic performance, and motor development,[8–12] with deficits persisting years after the iron deficiency has been treated.[11,12] Moreover, older iron-deficient children are fatigued, making it more difficult for them to be successful in a classroom.[13]

Two decades of research also suggests that even caregivers' reports of difficulty obtaining food of adequate quality and quantity for the household, variously termed as "hunger," "food insufficiency," or "food insecurity," without clinically obvious signs or laboratory indicators of child malnutrition, may be associated with a higher incidence of behavioral, emotional, and academic problems for children. Food insecurity (FI) fluctuates with economic trends, increasing steeply nationally from 11% to 14.6% in response to the Great Recession in 2008 and remaining at that level until 2010.[14,15] As of 2014, the food insecure 14.3% of the national population comprised a total of 49.1 million people—33.3 million adults and 15.8 million children.[17] The 21% prevalence of FI in households with children is higher than the 11.9% prevalence in households without children.[16] Given the high prevalence of FI among families with children, it is important to explore existing evidence of FI's possible impact on children's development and behavior to guide future clinical care, research, and advocacy.

The objective of our systematic review is to assess the current literature that addresses food insecurity from a developmental and behavioral perspective with a focus

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on data from relatively wealthy industrialized western countries: United States of America, United Kingdom, Canada, and Australia. We critically review and summarize the association of food insecurity and analogous measures with cognition, behavior, emotional regulation, and academic achievement, controlling for socioeconomic status and other variables, among infants, preschoolers, school-aged children, and adolescents.

Food insecurity is defined as "limited or uncertain availability of nutritionally adequate and safe foods or limited or uncertain ability to acquire food in socially acceptable ways."[16] In contrast to malnutrition, which is defined and diagnosed based on anthropometric or laboratory data, FI is assessed by structured questionnaires. Alaimo et al.[8] argued that "questionnaire-based measures of food insufficiency, FI, or hunger are more appropriate than anthropometric measures for recognizing a relationship between current resource-constrained food deprivation and negative outcomes because they capture the phenomena of interest directly rather than through an indirect indicator," such as height which may indicate past rather than current nutritional deprivation and may be influenced by genetics.

The science of assessing resource-constrained food deprivation by questionnaire evolved from the twentieth to the twenty-first century. FI was initially measured using the Community Childhood Hunger Identification Project (C-CHIP) scale in the early 1990s as part of a project to measure hunger nationwide in families with children, and also by the Cornell Radimer scale, a questionnaire developed from in-depth interviews that addressed the quantitative, qualitative, psychological, and social components of FI.[17] In 1999, the United States Department of Agriculture (USDA) developed a new measure drawing on the C-CHIP and Radimer scales while reframing the construct of "hunger" as "food insecurity," given that hunger was interpreted as a reflection of an individual's physiological perception of lack of food and not that of an entire household. In research and epidemiological studies, FI has since been measured using the validated USDA Food Security Survey Module, an 18-item questionnaire considered the gold standard in identifying household and child FI. In households with children, the module is administered to the primary caregiver and consists of 10 household-specific questions and 8 child-specific questions (Fig. 1).

With the USDA module, families are categorized as having high, marginal, low (LFS), or very low food security (VLFS). In households with children, marginally food secure families express anxiety about sufficiency of food and answer affirmatively to 1 to 2 of the 18 questions. Families that have LFS (formerly termed food insecurity without hunger) change the quality, variety, and desirability of food with little or no changes in quantity of food, as reflected by affirmative answers to 3 to 7 questions on the USDA food security module. Finally, families with VLFS (formerly termed food insecurity with hunger) report changing their eating patterns, cutting back or skipping meals entirely, with greater than 8 or more affirmative responses to questions on the USDA food security questionnaire. Child food insecurity has

USDA category	United States Department of Agriculture Food Security Survey	Community Childhood Hunger Identification Project (C-CHIP) questionnaire
Marginal Food Security	1. "We worried whether our food would run out before we got money to buy more" What that often, sometimes, or never true for you in the last 12 months? 2. "The food that we bought just didn't last and we didn't have money to get more." What that often, sometimes, or never true for you in the last 12 months?	Does your household ever run out of money to buy food?
Low Food Security	3. We couldn't afford to eat balanced meals. Was that often, sometimes or never true for you in the last 12 months? 4. In the last 12 months, did you or other adults in the household ever cut the size of your meal or skip meals because there wasn't enough money for food? (Yes/No) 5. (If yes to Question 4) How often did this happen – almost every month, some months but not every month, or in only 1 or 2 months? 6. In the last 12 months, did you ever eat less than you felt you should because there wasn't enough money for food? (Yes/No) 7. In the last 12 months, were you ever hungry, but didn't eat, because you couldn't afford enough food? (Yes/No)	Do you ever cut the size of meals or skip because there is not enough money for food? Do you ever eat less than you should because there is not enough money for food?
Very Low Food Security	8. In the last 12 months, did you lose weight because you didn't have enough money for food? (Yes/No) 9. In the last 12 months, did you or other adults in your household ever not eat for a whole day because there wasn't enough money for food? 10. (If yes to Question 9) How often did this happen-almost every month, some months but not every month, or in only 1 or 2 months? (Questions 11 -18 are asked only If the household included children aged 0-18 years) 11. We relied on only a few kind of low-cost food to feed our children because we were running out of money to buy food." What that often, sometimes, or never true for our in the last 12 months?	Do you ever rely on a limited number of foods to feed your children because you are running out of money to buy food for a meal?
Low Food Security Among Children	12. We couldn't feed our children a balanced meal, because we couldn't afford that." Was that often, sometimes, or never true for you in the last 12 months? 13. The children were not eating enough because we just couldn't afford enough food. Was that often, sometimes or never true for you in the last 12 months? 14. In the last 12 months, did you ever cut the size of any of the children's meals because here wasn't enough money for food? (Yes/No)	Do your children ever eat less than you feel they should because there is not enough money for food?
Very Low Food Security Among Children	15. In the last 12 months, were the children ever hungry but you just couldn't afford more food? 16. In the last 12 months, did any of the children ever skip a meal because there wasn't enough money for food? (Yes/No) 17. (If yes to Question 16) How often did this happen – almost every month, some months but not every month, or in only 1 or 2 months? 18. In the last 12 months, did any of the children ever not eat for a whole day because there wasn't enough money for food? (Yes/No)	Do your children ever say they are hungry because there is not enough food in the house? Do you ever cut the size of your children's meals or do they ever skip meals because there is not enough money to buy food? Do any of your children ever go to bed hungry because there is not enough money to buy food?

Figure 1. Comparison of the United States Department of Agriculture (USDA) Food Security Survey and Community Childhood Hunger Identification Project (C-CHIP) questionnaire used to identify food insecure households and children.

been defined as 2 out of 8 affirmative answers on the child-focused questions. In our review, many of the studies grouped VLFS and LFS together and categorized them as food insecure because the number of families with children who reported VLFS is relatively small. In addition, some of the studies reviewed in this article use condensed versions of the USDA module or the C-CHIP scale or study-specific questions as a means of identifying FI. For ease of synthesis, these related but not identical measures will be referred to throughout this systematic review as FI; issues of level of exposure according to a given measure will be specified when relevant. Figure 1 compares the categories of FI identified using the USDA 18-item scale with the earlier C-CHIP measure. Figure 2 summarizes abbreviated or idiosyncratic food insecurity study-specific questionnaires and scales which have been used in a small proportion of the developmental-behavioral research summarized here.

METHODS

We searched 4 databases: PubMed, Agricola, PsycInfo, and Web of Science. We also conducted a hand search by reading through citations of articles that were found. For all of these databases, we searched using the keywords academic achievement and child mental health. Our search in PubMed also used the following keywords: food insecurity, development, behavior, child, adolescent, and mental health. Our Web of Science search included the following keywords: hunger, scholastic achievement, child behavior, and nutrition. Our PsycInfo search used the keywords food insecurity and child behavior, and our Agricola search included food security and child behavior.

We selected articles published in English from 1985 to 2016 in developed countries (United States of America, United Kingdom, Canada, and Australia) and excluded articles which addressed correlates of FI other than child development and behavior, including, but not limited to, obesity, chronic conditions such as asthma, and other health outcomes. Studies that did not use explicit metrics to measure FI were not reviewed. We also excluded studies with a sample size of less than 100 because of concern they might lack adequate statistical power to detect clinically meaningful effects.

RESULTS

As shown in Figure 3 and Tables 1–4, our systematic review assessed 23 articles. The articles were abstracted by one of the 2 authors, P.S. or R.C., whose findings were then reviewed by the senior author. Disagreements were resolved by re-review and consensus. Some studies assessed multiple age groups: 3 studies analyzed infants and toddlers,[5,29,30] 4 assessed preschoolers,[31–34] 14 looked at school-aged children,[8,31,33,35,37–43,51,52,56] and 6 assessed adolescents.[8,44–46,51,62] 8 used the entire 18-item USDA Food Security Scale,[29,30,32,39,42,43,51,61] 7 used modifications or abridged versions of the 18-item USDA Food Security Scale,[5,31,34,37,38,46,52] 2 used "food insufficiency" as the predictor,[8,44] 3 used the C-CHIP scales,[33,36,40] and 3 used idiosyncratic food insecurity measures.[35,41,45] Of note, all "n" values in tables represent the final analytic sample size. See Tables 1–4 for analysis of articles describing findings in infants and toddlers, preschoolers, school-aged children, and adolescents. The Early Childhood Longitudinal Study—Kindergarten—will be referenced as ECLS-K in Tables 1–4. In addition, as shown in Figure 4, a range of disparate instruments were used to measure childhood outcomes.

As the tables summarize, these articles demonstrated a number of associations between household FI and children's cognitive, emotional, and behavioral outcomes. The studies differ not only in the measure of food insecurity used, but in sample size and selection, the statistical methods used, the outcome measures, and the range of potential covariates evaluated. (List of covariates for each article can be obtained from the authors by request.) Each table is alphabetized by first author within age group, with a parallel construction of columns for

Alaimo et al. (2001, 2002)

- Food insufficiency: "if family respondent reported that his or her family sometimes or often did not get enough food to eat"

McIntyre et al. (2012)

- Single question on severe food insecurity: "Has the child/have you ever experienced being hungry because the family has run out of food or money to buy food?"

Slopen et al. (2010)

- Single question: "In the past 6 months has there been a time when there was not enough money at home to buy food?"

Melchior et al. (2012)

- Four question food insecurity measure:
  a) Whether the family members had eaten less than they should have because they had run out of food or money to buy food
  b) Whether family members had eaten the same food several times because they did not have anything else and could not afford to buy other foods
  c) Whether the family could not afford to offer nutritious meals to the children as they should have because they had run out of food or money to buy food
  d) How often family members did not eat as much as they should have because they had run out of food or money to buy food

Figure 2. Summary of abbreviated or idiosyncratic food insecurity study specific questionnaires and scales in developmental-behavioral research.

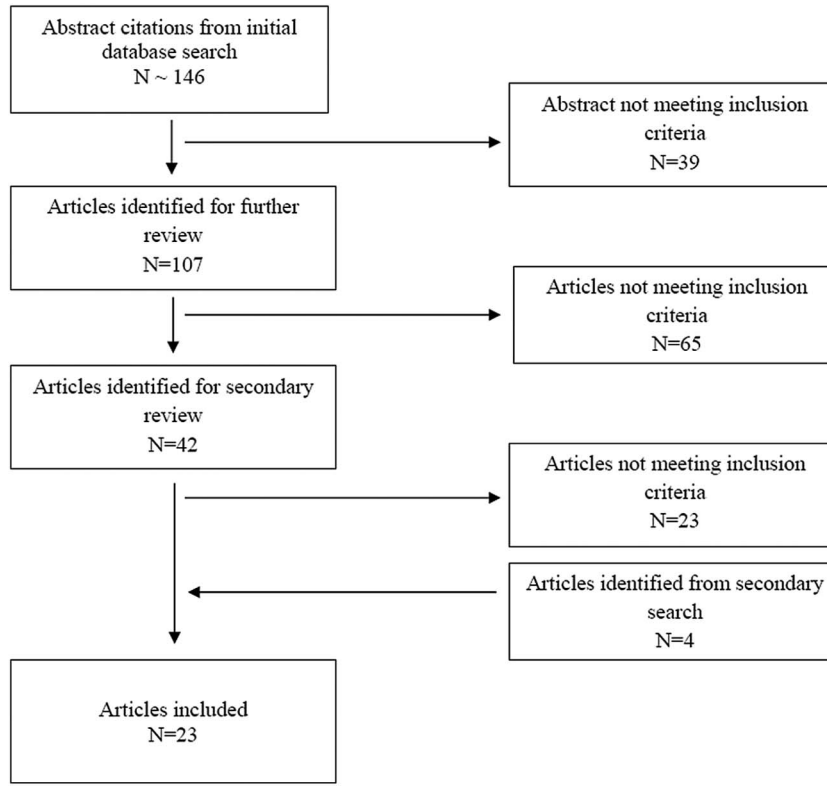

Figure 3. Flow chart for identifying eligible articles for systematic review.

these domains to facilitate readers' rapid comparative assessment of the findings.

Infants and Toddlers

Table 1 shows that the impact of FI can be identified in infants and toddlers. Rose-Jacobs et al. found that caretakers of 4 to 36 months old children from food insecure households reported a 3-fold increase in children's developmental risk as identified using the Parents' Evaluation of Developmental Status screening instrument.[18] In this study, when families with very low food security (VLFS) ("hunger") and children who were underweight were excluded, LFS was still associated with increased developmental risk for young children.

Zaslow et al. assessed children at ages 9 to 24 months using the Bayley Short Form Research Edition (BSF-R) mental and motor subscale assessment and parent-toddler Attachment Sort (TAS)-45.[19] The authors found that increasing levels of FI at 9 months of age were associated with insecure child attachment and lower mental proficiency at 24 months of age, an association mediated entirely through maternal depression and other confounders.[20] Hernandez and Jacknowitz[5] found that 24-month-old toddlers with food insecure mothers scored 1.5

Childhood Outcomes Measurement Tools
Parents' Evaluation of Developmental Status (PEDS)[18]
Bayley Short Form-Research Edition (BSF-R)[19]
Parent-Toddler Attachment Sort (TAS)[30]
Child Behavior Check List[20]
Weschler Intelligence Scale for Children –Revised (WISC)[21]
Wide Range Achievement Test –Revised (WRAT-R)[22]
Multidimensional Anxiety Scale for Children and Children's Depression Inventory[23]
Pediatric Symptom Checklist[24]
Preschool Behavior Questionnaire[25]
Ontario Child Health Study Scales
Children's Global Assessment Scale (CGAS)[26]
Strengths and Difficulties Questionnaire (SDQ)[27]
Diagnostic Interview Scale[61]
Center for Epidemiologic Studies Depression Rating Scale (CES-D)[45]
Composite International Diagnostic Interview[60]
Weschler Individual Achievement Test Screener (WIAT)[61]
Social Skills Rating System Parent Form[28]
Teachers' reports of behavior
Examination scores

Figure 4. Instruments used to measure childhood and adolescent outcomes.

Table 1. Infants and Toddlers

Author	Longitudinal/ Cross-sectional	N =	Study Population, Age	Informants	Outcome	Results	Limitations
Hernandez et al.[5]	Longitudinal	7900	Early Childhood Longitudinal Survey-Birth Cohort (ECLS-B)	FI: parents	Cognitive Ability: Bayley Short Form Research (BSF-R) Edition mental and motor subscales[19]	Toddlers living with temporarily food insecure adult experienced small but immediate negative effects on development. Toddlers scored 1.5 points ↓ on cognitive assessments at 24 mo if living with food insecure adults.	Oversampling of Asian and Native American children, twins, low and very low birth weight children; substantial loss to follow-up; Variables do not indicate timing, intensity, and duration of FI; informant unclear
Rose-Jacobs et al.[29]	Cross-sectional	2010	Low-income households, children 4–36 mo	FI: parents	Child Developmental Risk PEDS screening instrument[18]	Underweight children 3x more likely to have developmental risk; food insecure children more likely to be at developmental risk even when underweight and children with VLFS removed from analysis.	English, Spanish, Somali only; multisite, not national; shared-method variance
Zaslow et al.[30]	Longitudinal	10,688 parents and 10,211 children at 9 mo; 9835 parents and 9218 children at 24 mo	ECLS-B	FI: parents	Cognitive ability: BSF-R Edition mental subscales[19] Child Attachment: Toddler Attachment Sort (TAS-45)	Greater FI at 9 mo predicted insecure child attachment and less advanced mental proficiency at 24 mo.	Single method rather than multiple measures for each domain of child development; child attachment measure not gold standard; concurrent FI and parental characteristics not measured at 24 mo; shared-method variance for FI and attachment

points lower on cognitive assessments. In addition, this study showed that 24 month olds residing with temporarily food insecure adults, compared with never food insecure adults, experienced small but immediate negative effects on their cognitive development and health status.

Preschoolers

In the preschool years, several studies identify a relationship between FI and adverse behavioral outcomes and mental health symptoms (Table 2). Slack et al. used parents' responses to the Social Skills Rating System Parent Form[28] and found that "food hardship" was associated with both externalizing and internalizing problems among children aged 3 to 5 years.[31] Kimbro et al. found that there were consistently adverse impacts of transitions to FI on teachers' reports of children's externalizing behaviors, self-control, and interpersonal skills.[21] In contrast to Zaslow's findings, 2 other studies identified adverse behavioral/emotional correlates of FI among children during the preschool years, even after control for sociodemographic variables and mothers' mental health. Weinreb et al. reported severe "hunger" was associated with higher levels of children's internalizing behavior problems.[22] Whitaker et al. found that preschoolers from food insecure households had increased risk of aggressive behavior, anxious/depressed mood, and attention-deficit/hyperactivity.[23]

School Age

An association was also seen between FI and behavioral/emotional symptoms among school-aged children (Table 3).[24,25,34] Children aged 6 to 13 years in food insecure households were more likely to miss school and activities and display atypical or borderline emotional symptoms, even if the exposure to FI was intermittent.[26] Belsky et al. also showed an association between FI and childhood anxiety and depression.[27] FI also affected other noncognitive skill development, including interpersonal relations, self-control, and approaches to learning.[39] Kleinman et al. found that problems such as aggression and anxiety were more prevalent among children with "hunger."[40] Importantly, Kleinman et al.[40] also found a dose-response relationship using C-CHIP scales in which "hungry" children younger than 12 years old were more likely to report previous mental health counseling, compared with those "at risk for hunger." In a study based in Quebec, Canada, Melchior et al.[35] also found that food insecure children had higher rates of hyperactivity and inattention. This finding was corroborated in the United States by Murphy et al., who found higher rates of hyperactivity, absenteeism, and tardiness among "hungry" children than children reported as "not hungry" and "at-risk of hunger", and that even intermittent experiences of household food insufficiency and child "hunger" were associated with less optimal behavioral and academic functioning in low-income children.[56]

Other studies suggested that FI was correlated with a number of mental health-related outcomes and symptoms. For instance, Alaimo et al.[8] found that 6 to 11 years old children from food insufficient households had a 2-fold increase in likelihood of having seen a psychologist. In addition, in a longitudinal study covering children between 4 and 14 years old at recruitment and at 5 and 16 years old at follow-up, Slopen et al.[41] found that persistently food insecure school-aged children were 1.5 times more likely than those in never food insecure households to show internalizing behavior and twice as likely to show externalizing behavior. Children in this study transitioning from food secure to food insecure were also 1.8 times more likely to have externalizing problems at follow-up. Slack and Yoo[31] similarly found that "food hardship" is positively associated with internalizing behavior problems at 6 to 12 years of age. However, once controls for parental characteristics were added to the analysis, the effect of food hardship disappeared, suggesting only an indirect association between food hardship and behavior problems.[31] Of note, in contrast to Slopen et al., Slack and Yoo[31] did not find a statistically significant association between food insecurity and externalizing behaviors among school-aged children.

Concurrent and previous FI has also been found to be correlated at school age with less optimal academic outcomes. Among children aged 6 to 11 years from food insufficient households, Alaimo et al. found lower reading and arithmetic scores on the Wide Range Achievement Test-Revised (WRAT-R)[22] and a higher likelihood of repeating a grade.[8] Kleinman et al.[40] noted that caregivers of "hungry" school-aged children reported that their children had elevated rates of grade repetition and use of special education services compared with their "at-risk-for hunger" and "non-hungry" peers. Jyoti et al.[42] found that even marginal FI predicted lower test scores in both reading and math among children between kindergarten to third grade. In addition, children whose households transitioned from food secure to food insecure exhibited worse reading performance, especially among girls, and the persistence of food insecure through third grade was correlated with a delay in reading relative to the effect of FI in kindergarten alone.[42] Moreover, the associated decrease in reading scores with kindergarten FI was reversed if a household was no longer FI by third grade. A cross-sectional study by Winicki et al. found a trend toward a dose-response relationship between household FI and academic performance, with lower math scores obtained with increasing levels of FI[43]; the threshold for a statistically significant effect was marginal food insecurity. In addition, the gain in math scores from fall to spring was less for children from food insecure households compared with food secure households.

Adolescents

As Table 4 summarizes, among adolescents, the major correlates of household FI were psychosocial. FI was associated with mental health symptoms and diagnoses

Table 2. Preschoolers

Author	Longitudinal/ Cross-sectional	N =	Study Population, Age	Informants	Outcome	Results	Limitations
Kimbro et al.[32]	Longitudinal	6300	Early Childhood Longitudinal Survey-Kindergarten (ECLS-K) and first grade	FI: parents	Academic performance: math, reading, and science achievement scores; child behavior: teachers' rating through Social Skills Rating System (SSRS)	Negative impacts of transitions to FI on teachers' report of children's externalizing behaviors, self-control, and interpersonal skills. Persistent FI associated with internalizing behaviors.	Data only on children in kindergarten and 1st grade; limited set of covariates
Slack and Yoo[31] (see Table 3 for School-Aged)	Longitudinal	458	Illinois Families Study (IFS), 3–5 yr, families transitioning from welfare to work	FI: parents	Child behavior: parents assessed children through SSRS,[28] Parenting Stress Index (PSI)[59]	"Food hardship" ↑internalizing and externalizing behavior problems for children 3–5 yr. Parental stress, depression, and warmth mediate FI effects on externalizing behaviors; only parental stress affects internalizing behaviors.	Incomplete data on alternative food sources; single-site study; USDA FI scale focuses on household; no discussion of families experiencing VLFS
Weinreb et al.[33] (see Table 3 for School-Aged)	Cross-sectional	180	Homeless and low-income mothers and their children; 180 children 2.5–6 yr	FI: mothers	Internalizing behavior/anxiety: mothers assessed children through the Child Behavior Checklist (CBCL)[20]	"Hunger" associated with↑ levels of internalizing behavior problems.	Small sample; cross-sectional; I educational outcomes only among older children
Whitaker et al.[34]	Cross-sectional	2870	The Fragile Families and Child Wellbeing Study, 3 yr	FI: mothers	Child behavior: mothers assessed through CBCL[20] subscales aggressive, anxious/depressed, inattentive/hyperactive	↑ behavior problems in children with ↑ FI even after adjustment for maternal mental health.	Nonmarital births oversampled; English- or Spanish-speaking mothers only, mothers <18 yr excluded

Table 3. School-aged children

Author	Longitudinal/ Cross-sectional	N =	Study Population, Age	Informants	Outcome	Results	Limitations
Alaimo et al.[8] (see Table 4 for Adolescents)	Cross-sectional	3286	NHANES III, children 6–11 yr	Food insufficiency: parents	Cognitive Function: WIS[21] and WRAT-R[22]; social skills: school records	Food insufficiency ↓ reading and arithmetic scores, ↑ likelihood to have repeated a grade and to have seen a psychologist.	Food insufficiency rather than FI scale used; Mexican and African-Americans oversampled; homeless children excluded
Belsky et al.[38]	Longitudinal	1116	Environmental Risk Longitudinal Twin Study (ERLTS), children 5–12 yr	FI: parents	Cognitive function: WISC[21]; anxiety and depression: Multidimensional Anxiety Scale for children, Children's Depression Inventory[23]; emotional problems: Teacher Report Form (TRF)	FI ↑emotional problems, but not cognitive or behavior problems after controlling for home environments.	Only twins; not all measures at every data collection; lacked measures of fathers' characteristics
Casey et al.[51] (see Table 4 for Adolescents)	Cross-sectional	216	Children 3–11 yr	FI: parents	Child Health Related Quality of Life (HRQOL): parents responded for children 3–8 yr; 9–11 yr responded with parent assistance	Children in FI households have poorer HRQOL, ↓physical functioning and borderline ↓psychosocial functioning.	Unmeasured covariates; both measures self/proxy reported; exclusion of highest need group by reliance on telephone survey collection; small "n" in some categories
Howard et al.[39]	Longitudinal	4710	Early Childhood Longitudinal Survey-Kindergarten (ECLS-K), children 6–13 yr	FI: parents	Child behavior/skill outcomes: teachers asked to report how often student exhibited noncognitive skills	FI ↓ noncognitive skill development; dose-response relationship between FI severity, self-control, and externalizing behaviors; children transitioning from FI in 1st grade to food secure in 3rd grade have large skill impairments persisting through 5th grade.	No control for age, race/ ethnicity
Jyoti et al.[42]	Longitudinal	21,260	ECLS-K	FI: parents	Academic performance: children; social skills: teachers	FI ↑ impaired academic performance in reading and math for girls and boys; persistent FI through 3rd grade ↑↑↑ delay in reading.	None noted

(*Table continues*)

Table 3. Continued

Author	Longitudinal/ Cross-sectional	N =	Study Population, Age	Informants	Outcome	Results	Limitations
Kleinman et al.[40]	Cross-sectional	328	Families with at least 1 child <12 yrs	FI: parents	Child behavior: parents through Pediatric Symptom Checklist (PSC)[24]	Dose-response relationship between "hunger" and special education services, mental health counseling, repeating a grade; "hungry" children ↑ clinical levels of psychosocial dysfunction, especially aggression and anxiety.	No control variables
Melchior et al.[52]	Longitudinal	1116	ERLTS, children ≥5 yr	FI: mothers	Child behavior: teachers through TRF; mothers through CBCL[20]	FI ↑ rates of clinically significant behavioral problems after controlling for maternal mental health.	All twins; does not analyze sex or twin discordance
Melchior et al.[35]	Longitudinal	1682	Children born in 1997–98 and evaluated at 1½, 4½, and 8 yr	FI: mothers	Mental health symptoms: parental reports through adapted Preschool Behavior Questionnaire, CBCL,[20] and Ontario Child Health Study Scales	FI children ↑ hyperactivity/ inattention but not aggression.	Excludes twins and persons with major diseases or handicaps; no control for race/ethnicity; 4 part questionnaire for FI rather than USDA scale
Murphy et al.[36]	Cross-sectional	204	Collaborative study of free breakfast program in Philadelphia and Baltimore, children grades 3–8	FI: children and parents	Psychosocial problems: parents used CBCL,[20] PSC; teachers used Conners Teacher Rating Scale-39; investigators used CGAS[26]; academic functioning: school records of attendance and tardiness	"Hungry" and at risk for "hunger" children 2x more likely to have impaired functioning; ↑ hyperactivity, absenteeism, tardiness; intermittent food insufficiency and "hunger" associated with poor behavioral and academic functioning.	Sampling bias; "hunger"-related feeding intervention between 1st and 2nd rounds of survey may have influenced parents' rating of children's "hunger"
Ramsey et al.[37]	Cross-sectional	185	Families in ↓ socioeconomic status (SES) suburbs, children 3–17 yr	FI: parents	Child behavior: parents Strength and Difficulties Questionnaire[27]	Children in food insecure households more likely to miss school/activities, have borderline or atypical emotional symptoms.	Only sampled from lower 5% of SES of Australians; mailed survey biased against non-English speaking/poor literacy

(*Table continues*)

Table 3. Continued

Author	Longitudinal/ Cross-sectional	N =	Study Population, Age	Informants	Outcome	Results	Limitations
Slack and Yoo[31] (see Table 2 for Preschoolers)	Longitudinal	754	Illinois Families Study (IFS), children 6–12 yr, families transitioning from welfare to work	FI: parents	Child behavior: parents through SSRS,[28] Parenting Stress Index (PSI)[59]	Food hardship ↑ internalizing behavior problems for children 6–12 yr; parental stress, depression, and warmth mediate FI effects on externalizing behaviors, only parental stress affects internalizing behaviors.	(see Table 2)
Slopen et al.[41]	Longitudinal	2810	Project on Human Development in Chicago neighborhoods, children 4–14 yr at baseline and 5–16 yr at follow-up	FI: primary caregiver	Child behavior: primary caregivers through the CBCL[20]	Persistent FI ↑internalizing and externalizing problems; children moving from food secure to insecure had ↑ externalizing problems at follow-up; caregiver depression significant predictor of internalizing and externalizing problems	Not validated measure of FI; relatively short observation period with infrequent assessments; incomplete data and loss to follow-up
Weinreb et al.[33] (see Table 2 for Preschoolers)	Cross-sectional	228	Children 6–17 yr	FI: mothers	Internalizing behavior/anxiety: mothers through the CBCL[20]; academic performance: Weschler Individual Achievement Test (WIAT)[60] screener	Children with severe hunger" had 2x ↑anxiety and depression scores; no relationship between "hunger" and academic achievement; severe "hunger" associated with↑ levels of internalizing behavior problems; mothers of children with severe "hunger" ↑ lifetime diagnosis of PTSD, anxiety, or substance abuse.	(see Table 2)
Winicki et al.[43]	Longitudinal	21,260	ECLS-K	FI: parents	Academic performance: compared fall school-administered math test scores to spring scores	Math scores ↓ with ↑levels of FI; average gain in math scores from fall to spring ≥ for children in food secure households.	No control for race/ethnicity

Table 4. Adolescents

Author	Longitudinal/ Cross-sectional	N =	Study Population, Age	Informants	Outcome	Results	Limitations
Alaimo et al.[8]	(see Table 3)	2063	National Health and Nutrition Examination Survey (NHANES), 12–16 yr	(see Table 3)	(see Table 3)	Children divided into low-risk and high-risk groups. Food insecure adolescents did not have ↓WRAT-R[22] or WISC[21] scores in either the low- or high-risk FI groups; lower risk food insecure teens ↑ likelihood to have worse psychosocial outcomes (difficulty getting along with others, having fewer friends); both risk groups more likely to have been suspended from school.	(see Table 3)
Alaimo et al.[44]	Cross-sectional	754	NHANES III, 15–16 yr	Food insufficiency: respondent to family questionnaire	Mental health: Diagnostic Interview scale (DIS)[61]	Adolescents from food insecure households: 4x more likely: dysthymia; 2x more likely: thoughts of death; 3.4x more likely: desire to die; 5x more likely: attempted suicide; Food insecure children more likely to report losing and gaining weight without trying; 21% of suicide attempts attributable to FI.	Oversampling of Mexican-American and African-American children; sample limited to children 15–16 yrs
Casey et al.[51]	(see Table 3)	183	Children 12–17 yr	(see Table 3)	Child Health Related Quality of Life (HRQOL): children 12–17 yrs responded on their own	Adolescents 12–17 yr reported↓ psychosocial function.	(see Table 3)
McIntyre et al.[45]	Longitudinal	22,831	Canadian National Longitudinal Survey of children and youth, 0–11 yr, 14–25 yr	FI: person most knowledgeable	Mental health: Center for Epidemiologic Studies Depression Rating Scale (CES-D), General Self Image, Emotional Quotient scale[45]	Child hunger was robust, independent predictor of depression and suicidal ideation in late adolescence and young adulthood; females had ↑ odds of depression/suicidal ideation in late adolescence/young adulthood.	Single question used to assess child hunger
McLaughlin et al.[46]	Cross-sectional	6483	National Comorbidity Survey Replication Adolescent Supplement, 13–17 yr	FI: child and parents	Mental health: Composite International Diagnostic Interview (CIDI) and parental reports[60]	Higher or more severe FI is significantly associated with↑ odds of any mental disorder in the last year and ↑ odds of DSM-IV mood, anxiety, behavior, and substance disorders.	Dramatic ↑in child poverty since survey conduction (2001–2004); underrepresentation of homeless teens; non-English speaking participants; unable to determine if FI is risk or risk marker

(*Table continues*)

Table 4. Continued

Author	Longitudinal/ Cross-sectional	N =	Study Population, Age	Informants	Outcome	Results	Limitations
Poole-Di Salvo et al.[62]	Cross-Sectional	8600	Early Childhood Longitudinal Survey-Kindergarten (ECLS-K), children in 8th grade	FI: parents	Child Behavior: parents assessed children through Strength and Difficulties Questionnaire[27]	FI adolescents had ↑rates of mental health, emotional, and conduct problems. ↑ peer problems, hyperactivity.	Only 8th grade children; internalizing problems reported by parents

including anxiety, depression, dysthymia, seeing a counselor, and having suicidal ideation. Alaimo et al.[8] observed that 12 to 16 years olds, even those with a lower background demographic risk whose households experienced food insufficiency, were more likely to have seen a psychologist, been suspended, had difficulty getting along with others, and had fewer friends. Another study by Alaimo et al.[44] found a 4-fold increase in food insufficient households in dysthymia as well as an increase in the adolescent's reported desire to die, history of attempted suicide, and unintentional weight loss or weight gain. In a Canadian longitudinal study by McIntyre et al.,[45] child/youth "hunger" at ages 0 to 11 and 14 to 18 was a predictor of depression and suicidal ideation in late adolescence and young adulthood up to age 25 with a greater impact among females. Using a sample from the United States, McLaughlin et al.[46] similarly described how higher FI in the last 12 months was associated with increased odds of any mental disorder and with diagnoses of mood, anxiety, behavior, and substance use disorders over the same period. Finally, in another study from the United States by Poole-Di Salvo et al.,[62] adolescents from food insecure households had higher rates of overall mental health problems, emotional problems, conduct problems, hyperactivity, and peer problems.

SUMMARY

In summary, across developed countries, household FI, even at marginal levels, identified by a variety of measures, is associated with children's behavioral, academic, and emotional problems beginning as early as infancy. Correlates of FI differ by developmental stage. Articles that examine infants and toddlers suggest that FI poses a developmental risk, impairs child attachment, mental proficiency, and cognitive assessment scores.[5,29,30] Studies also demonstrate the impact of temporary FI on subsequent child outcomes. In preschool years, studies have found an association between FI, externalizing and internalizing behaviors and mental health symptoms,[31–33] and less optimal self-control and interpersonal skills.[32] In school-aged children, an association is found between FI and impaired academic performance, increased hyperactivity, inattention,[34–36] aggressive behavior,[34] missing school,[36] borderline emotional problems,[37] less adaptive interpersonal relations, self-control and approaches to learning,[39] more internalizing and externalizing behaviors,[31,41] and greater likelihood of having seen a psychologist.[8] In addition, some of the studies demonstrate a dose-response relationship between length of time experiencing FI or level of FI and developmental-behavioral domains in areas such as academic performance, utilization of mental health services, grade repetition, and use of special education services.[40,43] Finally, studies involving adolescents indicate associations between FI and anxiety,[46] depression and suicidal ideation,[45] attempted suicide,[8] dysthymia,[8] seeing a counselor,[8] suspension from

school,[8] difficulty getting along with others,[8] and substance use disorders.[46]

DISCUSSION

Despite a clear and consistent bivariate association between FI and adverse childhood behavioral, emotional, and cognitive function, the exact pathways by which FI may have an impact remains unclear.

Many studies have found that maternal depression is associated with the household's experience of FI and may partially or fully mediate negative cognitive, behavior, and mental health–related consequences.[30] Particularly, maternal distress, whether a predictor or an outcome of FI, may be associated with childhood developmental and behavioral problems through parental anxiety and parenting behavior, i.e. "the stresses that accumulate on parents can affect how well they are able to care for their children."[47] In parallel, as noted by Radimer, parents from food insecure families attempt to buffer their children and may deprive themselves of food to allow their children to eat; parental nutritional deprivation and the constant effort to buffer children may induce parental anxiety and irritability which may in turn affect children.[50] This point is further examined in the article by Hernandez and Jacknowitz,[5] which found that while temporary FI was associated with a negative impact on toddler development, toddlers seem to be buffered in families that are persistently food insecure, perhaps because of parents evolving coping strategies to assure children receive an adequate diet.

Alaimo et al.[8] suggests that FI may be an independent physiologic predictor of behavioral, emotional, or academic consequences given that going even briefly without food causes irritability, distractibility, and emotional changes, which in turn affect children's achievement scores or psychosocial behaviors. However, the author also describes another possibility that food insufficiency can perhaps be likened to experiences such as homelessness, such that the absence of basic family necessities like food or housing could cause anxiety and other emotional problems in children, even if the mechanism does not result from disrupted physiologic processes.[8,47]

LIMITATIONS

Of note, the articles in this systematic review have a number of important limitations. Eleven of these studies use cross-sectional[8,29,33,34,36,37,40,44,46,51,62] and twelve use longitudinal designs.[5,31,32,35,38,39,41–43,45,52,54] Longitudinal studies provide stronger, but not conclusive, evidence that FI is on a causal pathway to negative developmental and behavioral outcomes. Other limitations include that several of these studies used older,[33,36,40] idiosyncratic,[8,35,41,44,45] or nonstandard versions of the USDA 18-item Food Security scale.[5,31,34,37,38,46] Some studies on FI are not nationally representative and may not be generalizable to a larger population or to other contexts. In addition, many of the older articles with relatively small samples describe only bivariate associations, without statistical control for potential confounders.[8,36,40] Also, although the parents are asked in the USDA Food Security Survey about the frequency of providing children a balanced meal, the food security measures do not characterize the nutritional quality of the food, nor the frequency with which children receive meals in schools and day care center, or the homes of other relatives or friends. Except for Howard et al., Alaimo et al., Jyoti, et al., Winicki et al., Murphy et al., and Casey et al., all of the articles are limited by shared-method variance, as caregivers report not only FI but all outcomes.[39,42–44,51,56] In McIntyre et al.,[45] there was some degree of shared-method variance, particularly in the older age group where the youth reported both "hunger" and their symptoms. In addition, as in much infant research, the infant studies, such as Hernandez et al., are constrained by the fact that standardized assessments used under a year may be insufficiently sensitive to distinguish early developmental differences.[53]

CONCLUSION

The available peer-reviewed literature consistently identifies a bivariate relationship in the United States, Canada, United Kingdom, and Australia between FI and concurrent and future negative developmental and behavioral outcomes. In general, multivariate analyses show that this relationship persists but is attenuated after controlling for background characteristics including parental distress, although at least 2 studies find that the relationship is no longer significant after controlling for maternal mental health symptoms.[30,31]

Clinically obvious malnutrition has visible effects on brain size and structure, but the impact of food insecurity without severe anthropometric or biochemical deficits on the developing brain is less well understood. According to Cook et al., recent research has suggested that the "toxic stress" of FI has adverse consequences for brain architecture,[47–49] but no research has yet been performed to confirm or disconfirm this hypothesis.

Whether the mechanisms of effect are direct, indirect, or both, food insecurity in households with children constitutes a preventable and remediable threat to the behavioral and emotional health of children in all stages of childhood, from infancy to adolescence, with additional negative associations with cognitive and academic development identified through school age but not in adolescence.

The Council on Community Pediatrics and the Committee on Nutrition of the American Academy of Pediatrics have recommended routine screening for food insecurity at pediatric health maintenance visits.[57] From a clinical perspective, findings summarized here also suggest that families presenting to specialty clinics with children for evaluation of developmental and behavioral diagnoses should be screened for FI and conversely that

children from families identified by any method as food insecure should be evaluated for developmental and behavioral risk, as well as need for intervention for caregivers' psychological symptoms.

In the United States, clinicians should be aware of and ensure families are connected with available food assistance programs which supplement the diets of parents and children in their homes like Supplemental Nutrition Assistance Program (SNAP, formerly known as food stamps) the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC), and community providers such as food pantries. In addition, families should be assisted in accessing public child nutrition programs designed to feed children in congregate settings, including the National School Breakfast and Lunch Programs, Child and Adult Care Food Program (CACFP), and Summer Food Service Program (SFSP). Developmental, behavioral, and psychiatric professionals also have a role in addressing parental distress, particularly maternal depression, and FI given the potential link of both with adverse childhood outcomes.

Although this systematic review begins to explore the relationships cited in the current literature between FI and developmental and behavioral outcomes, there is a need for formal meta-analysis, which will provide a greater understanding of the "strength and consistency of the effects of FI on child outcomes in the social and cognitive domains."[54] Although randomly assigning families to experience FI is clearly neither ethical nor feasible, randomized studies could be performed to decrease FI by sustained macronutrient or micronutrient supplementation in at-risk families similar to those that have already been performed in the developing world.[55] These studies may be useful in evaluating to what extent enhancing a family's food security may lead to improved behavioral or cognitive outcomes in children. There are also several suggestive observational but not randomized studies that describe measurable, although not always large, improvements in academic and behavioral outcomes among low-income children who gain access to public nutrition programs. Notably, there is one study that identifies deterioration among children whose families cease receiving benefits.[56]

There are many other potential areas for multigenerational research and intervention to address the impact of FI on childhood outcomes. Family-focused multigenerational studies that use longitudinal design and explore the dose-response between degree and duration as well as the developmental timing of FI and childhood behavioral, emotional, and academic outcomes can provide an evidence base for program implementation. Zaslow et al.[30] suggests that we may further extend research by examining the impact of fathers in food insecure households on the development and behavioral outcomes of their children given the potential that FI may affect "depression and parenting in both parents." In addition, only 3 of the articles analyzed in this systematic review assessed the effects of FI during the sensitive period of brain development of infants, reflecting the need to increase the number of studies undertaken in this population and to extend research to early behavioral problems. The long-term sequelae of experiencing FI in childhood may persist over a lifetime and into the next generation as young adults, who have experienced and may still experience food insecurity, themselves become parents.[63] However, multigenerational relationships are not well understood; longitudinal studies into young adulthood or old age have not yet been undertaken.

At a policy level, also suggested in a statement by the Council on Community Pediatrics and the Committee on Nutrition of the American Academy of Pediatrics, developmental and behavioral professionals can educate policymakers that preventing and remediating FI in families with children has the potential to decrease costly adverse developmental and behavioral outcomes in America's children.[57] Although FI is certainly not the sole mechanism by which poverty impacts child development and behavior, it seems to have incremental effects on childhood outcomes after controlling for poverty. FI is also the most rapidly remediable social determinant of child health simply by enhancing public resources for and increasing families' access to already available public nutrition programs including WIC, SNAP, CACFP, and school and summer meals.[54] Further research could also assess whether the effectiveness on developmental and behavioral outcomes of these programs would be enhanced by raising benefits levels to the levels recommended by the National Academy of Sciences (2013), which are more consistent with the current nutritional science.[58]

Ultimately, in America and other developed nations, the reality that food insecurity remains a pervasive and persistent threat to families and to the developmental and psychosocial health of children does not reflect a lack of informative research, but a failure of political will.

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