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## Food Insecurity and Health Outcomes of Children with Intellectual and Developmental Disabilities

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<b>Abstract:</b>	We aimed to 1) provide nationally representative estimates of food insecurity (FI) among children with intellectual and developmental disabilities (IDDs), 2) determine the association between FI and four health outcomes (overall health, problem behavior, activities of daily living, functional limitations) in 5,657 children with IDDs compared to 1:1 propensity score matched children without IDDs. Mixed-effects ordered logistic regression models were used. Children with IDDs were more likely to experienced FI than children without IDDs (43.3% vs. 30.0%, $p < 0.001$ ). FI and IDDs were independently associated with worse scores on all four health outcomes. Having both FI and IDDs further exacerbated the adverse impacts on these health outcomes. The association was stronger among children with moderate-to-severe FI than those with mild FI.

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**Abstract**

We aimed to 1) provide nationally representative estimates of food insecurity (FI) among children with intellectual and developmental disabilities (IDDs), 2) determine the association between FI and four health outcomes (overall health, problem behavior, activities of daily living, functional limitations) in 5,657 children with IDDs compared to 1:1 propensity score matched children without IDDs. Mixed-effects ordered logistic regression models were used. Children with IDDs were more likely to experienced FI than children without IDDs (43.3% vs. 30.0%,  $p < 0.001$ ). FI and IDDs were independently associated with worse scores on all four health outcomes. Having both FI and IDDs further exacerbated the adverse impacts on these health outcomes. The association was stronger among children with moderate-to-severe FI than those with mild FI.

**Key words:** Child, Food insecurity, Special healthcare needs, Intellectual disability, Developmental disability

## **Introduction**

Food insecurity refers to the household's lack of financial resources to afford enough nutritious food for an active and healthy life (Coleman-Jensen et al., 2019). It has been a persistently concerning issue in the US over the past few decades. In 2021, 13.5 million households were food insecure at some time during the year (Coleman-Jensen et al., 2022). Food insecurity is especially prevalent in low-income families and families with children. In 2021, 26.5 percent of households with income below 185 percent of the poverty level were food insecure, compared to the national average of 10.2%; 12.5% of households with children under age 18 faced food insecurity compared to 9.4% of households without children (Coleman-Jensen et al., 2022).

Addressing the issue of food insecurity is of paramount importance due to its short and long-term consequences for young children. The direct impacts of food insecurity on child health include decreased academic and social performance, increased emergency department use, anxiety, depression, and worse overall health of children (Alaimo et al., 1998; Cook et al., 2004; Jyoti et al., 2005; Weinreb et al., 2002). Consumption of poor-quality foods over a long period can deprive children of nutrients essential for growth and development (Matrins et al., 2011). A study by Ke & Ford-Jones (2015) suggested that iron deficiencies are associated with learning impairment and loss of productivity in schoolchildren. Moreover, a reduction in the amount of food intake in children can lead to stunting and wasting, which may result in weight loss and poor health outcomes (Alaimo et al., 1998; Coleman-Jensen et al., 2019; Cook et al., 2004; Dinour et al., 2007; Jyoti et al., 2005; Roser & Ritchie, 2013). On the other hand, a meta-analysis found a positive association between food insecurity and risk of overweight or obesity in children under age 18 in developed countries, but not in developing countries (Pourmotabbed et al., 2020). In some households, parents skip meals to shield their children from experiencing food insecurity. In

such families, although children are somewhat protected from the direct effects of food insecurity, the household stress can lead to increased behavioral problems in children (Whitaker et al., 2006).

Children with intellectual and developmental disabilities (IDDs) may be more vulnerable to food insecurity's the health and developmental effects than other children (Romig, 2016). IDDs are a collection of conditions that usually become apparent before the age of 18 and hinder physical, emotional, cognitive and/or intellectual abilities (United States Department of Health and Human Services [USDHHS], 2021). Children with IDDs require more than usual care (Adams et al., 2015; Rose-Jacobs et al., 2016) and face challenges with day-to-day activities like dressing, bathing, and feeding themselves; these children also often present with behavioral problems (Cole & Levinson, 2002; Emerson, 2003). In the US, families of children with IDDs face higher levels of poverty, one of the major driving factors for food insecurity (Sriram & Tarasuk, 2016; United States Department of Agriculture [USDA], 2020). Studies have shown that parents of children with disabilities face higher financial burdens while providing care for their children due to high out-of-pocket medical costs (Goudie et al., 2010; Parish et al., 2015) and experience reduction in income due to reduced work hours, as parents might often need to stay home to provide care for the child (Sonik et al., 2016). Such financial challenges and limited resources often forces these families to make constrained choices between healthy food and medical care. Studies have found that children living in food-insecure households are more likely to forgo needed healthcare than those living in food-secure households (Thomas et al., 2019; Li et al., 2018). Since children with IDDs are already at risk of poor health and behavioral problems, these effects may be exaggerated in the presence of food insecurity.

To the best of our knowledge, no national estimate of food insecurity in children with IDDs has been reported. Moreover, existing literature has little information regarding the

association of food insecurity with health outcomes in children with IDD. Bucker & Nord (2016) assessed these relationships in young adults with IDDs, whereas Cook & Frank (2008) focused on healthy developing infants and toddlers. No studies have assessed these relationships in children with IDDs. To fill this gap, in this study, we aimed to 1) provide a national estimate of food insecurity in children with IDDs; 2) determine the association of food insecurity with health outcomes in children with IDDs, compared to children without IDDs. We hypothesized that 1) food insecurity is associated with worse health outcomes in children with IDDs and 2) the likelihood of experiencing worse health outcomes is higher in children with IDDs than children without IDDs.

### Conceptual framework

We used the socioecological model of health as the conceptual framework, which recognizes the “interaction between, and interdependence of, factors within and across all levels of health problems.” (Cancer Institute, N. (n.d.)). Following CDC’s socioecological model framework for prevention (CDC: social-ecological model: framework for prevention), the framework considers four levels (individual, relationship, community and societal) of factors and emphasizes the causes and consequences of food insecurity on child’s health and well-being. **Figure 1** illustrates the conceptual framework. Individual-level factors included biological and personal history factors (child’s age, sex, race/ethnicity, having IDDs, having mental or physical comorbidities, health insurance, having a medical home). Relationship-level factors identified family characteristics that may increase the risk of a child experiencing food insecurity and worse health (caregiver’s education, family structure, household’s poverty level and household’s food security). Community-level factors include neighborhood characteristics (neighborhood support).

Societal-level factors include health policies that may affect children's access to sufficient and quality food (food assistance program).

## **Methods**

### **Data Source**

This cross-sectional study utilized the National Survey of Children's Health (NSCH) 2017-2018 combined data (CAHMI, 2019a). The NSCH is a rich source of children's data that collects various national and state-level child health measures such as health quality, healthcare access, healthcare utilization and quality, and family and community-related factors for children from 0 to 17 years old, including children with special healthcare needs. Starting in 2016, the NSCH integrated contents from the NSCH original survey and the National Survey of Children with Special Healthcare Needs. Households across the U.S. were randomly sampled for mail and web-based surveys each year.

Participants were parents or guardians. One child of 0-17 years old from each household was randomly selected and an age-specific questionnaire (one of the 0-5 years, 6-11 years or 12-17 years survey questionnaire) was administered. Children with special healthcare needs and those aged 0-5 years old were oversampled to ensure these groups are adequately represented in the overall data (NSCH, 2018).

### **Study Sample**

Children 3-17 years old with one or more IDD conditions were identified from the NSCH 2017-2018 combined data. This age group was selected for analysis because literature has shown that many IDD conditions become apparent after the age of 3 years old (Boat et al., 2015). Additionally, the NSCH collects information about behavioral problems in children 3 years and older. As in prior research using survey questionnaires to identify IDD conditions (Boyle et al., 1994; Brucker &

Nord, 2016), we defined IDD as currently having one or more of the following eight mutually non-exclusive conditions reported by a parent/guardian based on a diagnosis by a health care provider: cerebral palsy (CP), epilepsy or seizure, intellectual disability (ID), autism spectrum disorder (ASD), attention deficit/hyperactivity disorder (ADHD), speech disorders, learning disability (LD) and, developmental delay (DD). We excluded children who have missing information on IDD conditions, those who previously had an IDD condition without one or more currently existing IDD conditions, and those with missing data on food insecurity. For comparison, children between ages 3-17 years without a parental-reported diagnosis of any IDD conditions were also identified (“children without IDs”). To minimize confounding by variables that predispose these children to worse health outcomes, we used propensity scores (PS) to match children with and without IDs (Austin, 2011).

## **Study Measures**

### ***Food Insecurity***

Food insecurity was ascertained using a survey question that asked, “*which of these statements best describes the food situation in your household in the past 12 months?*” The response categories were: 1) always able to afford nutritious food to eat, 2) always able to afford enough food but not always nutritious food, 3) sometimes not able to afford enough food to eat and, 4) often not able to afford enough food to eat. This question measures household food insufficiency, a more severe form of food hardship (Balistreri, 2019; Coleman-Jensen et al., 2017). Food insufficiency measured by this item is closely related to food insecurity measured using the 18-item Core Food Security Module developed by the United States Department of Agriculture. (Balistreri, 2019; Coleman-Jensen et al., 2017; Nord & Hopwood. 2007).

Following previous studies (Jackson et al., 2019), we distinguished households that could not afford enough food from those with enough food but not the quality of food required for an active, healthy life. The response categories were classified into three groups: no food insecurity (response 1), mild food insecurity (response 2: enough but not always nutritious food) and moderate-to-severe food insecurity (responses 3 or 4: not enough food sometimes or often).

## **Outcome Measures**

### ***Overall Health***

Overall health was assessed through a single survey item that asked the primary caregiver to describe the child's health in general, using one of the 5 response options that were combined into 3 response categories by the NSCH: 1 (Excellent or very good), 2 (Good), or 3 (Fair or poor).

### ***Problem Behavior***

Problem behavior was measured through a single survey item, which asked, "*Compared to other children his or her age, how much difficulty does this child have making or keeping friends?*" (Howie et al., 2010; CAHMI, 2019b). More difficulty making or keeping friends was interpreted as having more problem in behavior. The responses were: 0 (no difficulty), 1 (a little difficulty) or 2 (a lot of difficulty).

### ***Activities of Daily Living (ADL)***

ADL was a composite measure created by the NSCH, based on two questions that asked about how often and to what extent the child's daily activities were affected by the child's condition in the past year. The responses were: 0 (do not have any conditions), 1 (condition never affected ADL), 2 (condition moderately affected ADL some of the time), or 3 (condition consistently affected ADL and often to a great extent).

### ***Functional Limitations***



Function limitation was a composite measure in the NSCH, based on a set of 12 questions that asked whether the child had chronic difficulty during the past year with age-appropriate bodily functions like breathing, swallowing, digestion, pain, vision, hearing, using hands (age 0-5 years), coordination/moving around (age 0-5 years), concentrating/remembering/making decisions (age 6-17 years), walking/climbing stairs (age 6-17 years), dressing/bathing (age 6-17 years), doing errands alone (age 12-17 years). The responses were categorized as: 0 (not having any difficulty), 1 (one functional difficulty), or 2 (two or more difficulties).

### **Covariates**

The NSCH provides a rich set of variables about the children and their families that enabled us to select several covariates to be included in the PS matching described below. We selected a list of covariates based on previous literature that indicated associations with food insecurity and one or more health outcome measures (Balistreri, 2019; Thomas et al., 2019; “USDA ERS - Key Statistics & Graphics,” n.d.). These included, child’s age, sex, race/ethnicity, presence of three mental comorbidities (depression, anxiety problems, or behavioral or conduct problems), presence of 11 physical comorbidities (allergies, arthritis, asthma, blood disorder, brain injury/concussion/head injury, cystic fibrosis, diabetes, heart condition, frequent and severe headache, Tourette Syndrome, genetic/inherited conditions), child's insurance type, child's access to a medical home, family structure, highest education of primary caregiver(s) in the household, household’s poverty level, living in a supportive neighborhood, and household receiving food or cash assistance program.

The NSCH computes the poverty level based on the household’s annual income and the number household members. We constructed summary scores for mental (0 to 2) and physical comorbidities (0, 1, 2-11) based on parent-reported current diagnosis of mental and physical

comorbidities. Supportive neighborhood ratings were derived from responses to three statements: 1) People in this neighborhood help each other out; 2) We watch out for each other's children in this neighborhood; and 3) When we encounter difficulties, we know where to go for help in our community. Respondents were asked whether they definitely agree, somewhat agree, somewhat disagree, or definitely disagree with each statement. Children were considered to live in a supportive neighborhoods if their parents/guardians reported “definitely agree” to at least one of the items above and “somewhat agree” or “definitely agree” to other two items.

Household receipt of food or cash assistance was a composite measure in the NSCH based on responses to the four survey items that ask about whether someone in the child's family received: (a) cash assistance from government welfare program; (b) Food Stamps or Supplemental Nutrition Assistance Program (SNAP) benefits; (c) free or reduced-cost breakfasts or lunches at school during the past 12 months; or (d) benefits from the Woman, Infants, and Children (WIC) Program at any time during the past 12 months, even for one month. Children were classified as living in families that received assistance if someone in the child's family received at least one type of the afore-mentioned assistance at any time during the past 12 months, even for one month. We used the variable created by the NSCH, which counts the types of food or cash assistance received by a child's family: 1) none, 2) 1-2 types; or 3) 3-4 types. Family structure was categorized as: 1) two parents (both biological or adoptive, or one not biological or adoptive), currently married; 2) two parents (both biological or adoptive, or one not biological or adoptive), not currently married; 3) single parent (mother or father); grandparent household; other family type.

### **Statistical Analysis**

We generated nationally representative estimates of food insecurity in children aged 3-17 years with IDD using survey weights in the NSCH. These estimates were compared to children

without IDD. We also compared the characteristics of children with and without IDDs. Comparisons were tested using a design-based F-test. All estimates accounted for complex sampling design of the NSCH.

A 1:1 greedy PS matching without replacement was performed based on logit of PS using a caliper of 0.2 pooled standard deviation, which can eliminate 99% of bias due to measured confounders and minimize the mean square errors (Rosenbaum & Rubin, 1985; Austin, 2011). We further required an exact match on sex and age groups (3-5 years, 6-11 years, 12-17 years) to improve matching. We assessed the balance of covariates by examining their standardized mean differences (<0.10) before proceeding to our main analysis (Austin & Stuart, 2015).

Using the matched cohort, we employed mixed-effects ordered logistic regression models to determine the associations of food insecurity with health outcomes of children with IDDs compared to children without IDDs. We used ordered logistic regression because all health outcomes were measured on an ordinal scale. Mixed effect models were used to account for the clustering effect of the matched pairs (Stata, 2021). For each model, we included indicators for food security and IDDs, and a 2-way interaction between food insecurity and IDDs to determine 1) the independent association of food insecurity and IDDs with the health outcomes and 2) whether this association is different between children with and without IDDs. Following recommendations of Lenis et al. (2019), survey weights of children with IDDs were applied to their matched children without IDDs for generation of nationally representative estimates using the matched cohort.

In all models, post-hoc pairwise comparisons were used to assess the interaction effects (Stata Press, n.d.). *P*-values <0.05 for two-sided tests indicated a statistical significance. Data preparation and PS matching were performed using SAS version 9.4 (SAS Institute Inc., Cary,

NC, USA.), and all the statistical models were conducted using STATA/SE 17.0 (StataCorp, College Station, TX, USA).

## **Results**

### *Food insecurity in children with IDD's compared to children without IDD's*

After applying inclusion and exclusion criteria, there were 7,679 children aged 3-17 years with IDD's and 33,989 children in the same age range who were never diagnosed with IDD's in the 2017-2018 NSCH data, representing 9,958,522 and 46,661,951 children in the US respectively (**Figure 2**). Compared to children without IDD's, children with IDD's were more likely to experience food insecurity at home ( $p < 0.001$ ). Nearly half (43.3%) of the children with IDD's were estimated to have had some food insecurity at home in the past year; 32.9% were living in households that could not always afford nutritious food (mild); and 10.4% were living in households that were unable to afford enough food sometimes or often (moderate-to severe). On the other hand, only 30% of children without IDD's experienced some food insecurity in the past year, with 25.2% having limited access to nutritious food and 4.8% unable to afford enough food sometimes or often. (**Table 1**)

### *Difference in baseline characteristics between children with IDD's and children without IDD's*

Children with IDD's differ significantly from children without IDD's (**Table 2**). Compared to children without IDD's, children with IDD's were older (13.6% vs. 20.9% under 6), more likely to be males (66.0% vs. 47.4%), having more mental (45.9% vs. 5.4%) and physical (39.6% vs. 24.1%) comorbidities, and have only public insurance (38.4% vs. 28.2%) (all  $p < 0.0001$ ). Children with IDD's were also less likely to have access to a medical home (58.6% vs. 50.5%) and more likely to live in a household with caregivers having high school or less education (33.1% vs. 28.6%), having a single or no parent (34.0% vs. 24.4%), with income  $< 200\%$  FPL (48.5% vs.

30.6%), having no neighborhood support (49.2% vs. 40.7%), and receiving less food assistance in the past year (all  $p < 0.0001$ ). After PS matching, 5,657 pairs of children with and without IDD were identified, resulting in a match cohort of 11,314 children (**Figure 1**). All covariates had standardized differences  $< 0.10$  indicating that the groups were well-balanced on all the covariates (**Supplemental Table 1**).

#### *Effect of IDDs and food Insecurity on health outcomes*

**Table 3** reports the effects of IDDs and food Insecurity on health outcomes from the mixed-effects ordered logistic regression. Compared to children without IDDs and food insecurity, having IDDs alone was associated with worse reported scores on all four health outcomes (ORs range from 2.97 to 6.93, all  $p < 0.001$ ). Having food insecurity alone was also associated with worse reported health outcomes on all four health outcomes, with the adverse impact increased from having mild (ORs range from 1.54 to 3.36 for the four measures, all  $p < 0.001$ ) to moderate-to-severe (ORs range from 2.09 to 4.63 for the four measures, all  $p < 0.001$ ) food insecurity. However, having both food insecurity and IDDs further increased the risk of reporting worse health outcomes in all four measures compared to children with neither (i.e. no IDDs and no food insecurity), with the adverse impact increasing from having mild food insecurity and IDDs (ORs range from 5.81 to 8.83 for the four measures, all  $p < 0.001$ ) to moderate-to-severe food insecurity and IDDs (ORs range from 8.09 to 13.05 for the four measures, all  $p < 0.001$ ). Coefficients from the mixed-effects ordered logistic regressions are reported in **Supplemental Table 2**.

## **Discussion**

In the US, child food insecurity rates have remained unchanged over the past two decades despite repeatedly proven pervasive health consequences (Alaimo et al., 1998; Cook et al., 2004; Jyoti et al., 2005; Weinreb et al., 2002). Children with IDDs, in addition to facing health-related

consequences owing to their condition, are also at an increased risk of food insecurity (Sannicandro et al., 2017). Utilizing a nationally representative database, this study showed that having either food insecurity or IDD are associated with worsening of four key health outcomes for children aged 3-17 years. Additionally, a combination of food insecurity and IDDs further exacerbates the negative impacts, leading to a stronger association with worse health outcomes than the presence of either factor alone. Moreover, the adverse impact increases with the level of food insecurity, with moderate-to-severe food insecurity showing a larger relative impact than mild food insecurity. This provides useful information to support policy decision-makers in taking steps to address food insecurity in this population.

Our study findings provide evidence of the negative effects of food insecurity on children's health that aligns with previous literature. Poor health outcomes were found among children who lived in a household with food insecurity, regardless of IDD condition, which is consistent with the literature (Gundersen & Kreider, 2009; Stanish et al., 2016). We found that food-insecure children without IDDs, when compared to food-secure children without IDDs, face increased behavior problem and worse overall health (Gundersen & Kreider, 2009; Huang et al., 2010; John T. Cook et al., 2001). Also, children with IDDs and food insecurity had significantly increased likelihood of facing problems with ADL and functional limitations. These findings were similar to previous work that suggested limited activity in children with IDDs and increased functional limitations among children with food insecurity (Stanish et al., 2016; Thomas et al., 2019). The combination of food insecurity and IDDs was associated with stronger effects than the either condition independently, indicating a pressing need to focus on this vulnerable population for preventing and addressing food insecurity. This is especially urgent among children with

moderate-to-severe food insecurity where the negative impact was even larger than children with mild or no food insecurity.

We found that children with IDD are more likely to experience food insecurity in the last year, which could be attributed to multitude of demographic and socioeconomic factors. Using the socioecological model of health framework, we considered four levels (individual, relationship, community and societal) of factors that could affect children experiencing food insecurity and health outcomes based on previous published literature. Compared to children without IDDs, children with IDDs were disadvantaged in many of these factors that could lead to experiencing more food insecurity. Using PS matching, we identified children with and without IDDs that are effectively balanced on these differences. As a result, proportions of children experiencing food insecurity between the groups were similar. Nonetheless, even after matching on these factors, children with IDDs was still three times as likely to report worse key health outcomes than children without IDDs and food insecurity; having IDDs with food insecurity, especially moderate-to-severe food insecurity, further increased the negative impact on health outcomes, suggesting that food insecurity is associated with worse reported health outcomes independent of these known socioeconomic, community, and societal factors.

The NSCH surveyed participating households about their receipt of four types of food assistance programs: (a) cash assistance from government welfare programs; (b) Food Stamps or SNAP benefits; (c) free or reduced-cost breakfasts or lunches at school during the past 12 months; or (d) benefits from the WIC Program. Despite their higher risk of experiencing food insecurity and worse socioeconomic status, we found children with IDDs were more likely to live in households that have received less food assistance and fewer types of assistance in the last year, suggesting that interventions to increase access to these food assistance programs among children

with IDD's may potentially lead to some immediate health benefits given that food insecurity was independently associated with reporting worse health outcomes. However, the recent updates to SNAP policies such as elimination of "categorical eligibility" is projected to drastically reduce SNAP benefits for children in general, increasing the rates of food insecurity (Mason, 2020). This may especially aggravate food insecurity in children with IDD's who are already at increased risk for food insecurity, resulting in worse health outcomes. Future studies are needed to assess these changes on food insecurity and the effectiveness of various food assistance programs in children with IDD's.

This study has several limitations. First, given the study's cross-sectional nature, we could not establish causality between food insecurity and child's health outcomes. Second, PS matching cannot control for confounding due to unobserved factors. Third, measure of problem behavior was based on a single survey item. Several other problem behavior items were dropped by the NSCH due to changes in response categories when the 2017 and 2018 datasets were combined. Since a construct is better measured through multiple related questions covering different aspects of the construct (Morrison, 2019), future studies that include more items to capture problem behavior could address this limitation. Fourth, the IDD population encompasses heterogeneous groups. Due to limited sample size, we could not investigate the effect attributed to each IDD condition separately. Future studies utilizing longitudinal data with larger sample sizes could help address these limitations. Nevertheless, given the large nationally representative database, theoretically informed approach, and robust statistical method to balance observed confounders between children with and without IDD's, our study offers a robust analysis to estimate the associations of food insecurity and health outcomes in children with IDD's compared to children without IDD's.



## **Conclusion**

We reported the nationally representative estimates of food insecurity in children with IDD and compared these estimates to children without IDD. Using PS matching method, our study revealed the direct adverse impacts of food insecurity on the key health components of both children with IDD and children without IDD as well as those resulting from a combination of food insecurity and IDD. This provides useful information to encourage policy makers to re-evaluate and expand the assistance programs' eligibility criteria for the high-risk children with IDD. Additionally, implications for healthcare providers include engaging in routine patient screenings for food insecurity as well as partnering with community organizations to offer resources that increase access to quality foods and raise awareness about food insecurity. Schools and early care and education settings can play an important role in addressing food insecurity by considering systems-level programs such as food pantries for children.

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Table 1. Nationally Representative Estimates of Food Insecurity: Children with IDD vs. Children without IDD

	No IDDs				IDDs				IDDs vs. No IDDs
	n	Weighted n	Weighted %	95% CI	n	Weighted n	Weighted %	95% CI	p-value
<b>Total</b>	33,989	46,661,951			7,679	9,958,522			
<b>Food Insecurity</b>									<0.001
No	25,605	32,674,758	70.0	[68.9, 71.1]	4,888	5,652,352	56.8	[54.2, 59.3]	
Mild	7,277	11,767,026	25.2	[24.2, 26.3]	2,242	3,271,850	32.9	[30.5, 35.3]	
Moderate-to-severe	1,107	2,220,167	4.8	[4.2, 5.4]	549	1,034,320	10.4	[8.7, 12.4]	

IDDs: Intelligent and developmental disorders

Table 2. Child's and Household's Characteristics by IDD Status

	All		No IDDs	IDDs	p	
	n	Weighted n	Weighted %	Weighted %		
<b>Age group</b>						
3-5 years	7,353	11,098,957	19.6	20.9	13.6	<0.0001
6-11 years	14,683	22,823,869	40.3	39.5	44.0	
12-17 years	19,632	22,697,647	40.1	39.6	42.4	
<b>Sex</b>						
Male	21,371	28,697,770	50.7	47.4	66.0	<0.0001
Female	20,297	27,922,703	49.3	52.6	34.0	
<b>Race/ethnicity</b>						
Hispanic	4,869	14,362,141	25.4	25.7	24.0	0.0033
White, Non-Hispanic	28,828	28,668,727	50.6	50.3	52.4	
Black, Non-Hispanic	2,675	7,681,258	13.6	13.2	15.4	
Other, Non-Hispanic	5,296	5,908,347	10.4	10.9	8.2	
<b>Number of mental comorbidities (anxiety, depression, behavioral problem)</b>						
0	35,404	49,501,726	87.4	94.5	54.1	<0.0001
1	3,924	4,621,757	8.2	4.0	27.5	
2	1,784	1,911,763	3.4	1.3	13.3	
3	550	581,877	1.0	0.2	5.1	
Missing	6	3,350	0.006	0.0007	0.03	
<b>Number of physical comorbidities (11 conditions)</b>						
No	28,925	41,418,795	73.2	75.9	60.4	<0.0001
1	9,474	11,269,530	19.9	18.4	26.8	
>=2	3,269	3,932,147	6.9	5.7	12.8	
<b>Insurance type at time of survey</b>						
Public only	8,222	16,980,758	30.0	28.2	38.4	<0.0001
Private only	29,584	32,481,543	57.4	59.6	46.9	
Public and private	1,570	2,493,261	4.4	3.7	7.8	
Currently uninsured	1,774	3,678,245	6.5	6.8	5.1	
Missing	518	986,665	1.7	1.7	1.9	
<b>Medical home</b>						
Yes	22,389	27,223,738	48.1	49.5	41.3	<0.0001
No	19,271	29,374,228	51.9	50.5	58.6	
Missing	8	22,507	0.04	0.03	0.1	
<b>Primary caregivers' highest education</b>						
Less than high school	1,021	5,485,081	9.7	9.8	9.4	0.0005
High school degree/GED	5,505	11,124,915	19.7	18.8	23.7	
Some college/technical school	9,986	12,569,591	22.2	21.9	23.7	
College degree or higher	25,156	27,440,885	48.5	49.6	43.2	
<b>Family structure</b>						
						<0.0001

Two parents currently married	29,342	36,637,239	64.7	66.7	55.5	
Two parents, not currently married	2,622	4,616,543	8.2	7.9	9.5	
Single parent (mother or father)	7,652	11,506,062	20.3	19.2	25.7	
Grandparent household	1,375	2,364,078	4.2	3.7	6.4	
Other family type, no parent reported	425	894,667	1.6	1.5	1.9	
Missing	252	601,885	1.1	1.1	1.0	
<b>Household income as % of federal poverty level (FPL)</b>						<0.0001
0-99% FPL	5,018	11,312,001	20.0	19.1	24.0	
100-199% FPL	6,568	12,446,079	22.0	21.5	24.5	
200-399% FPL	12,713	15,310,330	27.0	27.6	24.5	
>=400% FPL	17,369	17,552,064	31.0	31.8	27.1	
<b>Neighborhood support</b>						<0.0001
Yes	25,319	31,793,521	56.2	57.6	49.6	
No	15,823	23,904,915	42.2	40.7	49.2	
Missing	526	922,037	1.6	1.7	1.2	
<b>Food assistance received last year</b>						<0.0001
None	1,143	3,671,226	6.5	5.5	10.9	
1-2 types	9,425	19,002,827	33.6	32.4	38.8	
3-4 types	31,076	33,901,593	59.9	62.0	50.0	
Missing	24	44,826	0.1	0.04	0.3	

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IDDs: Intelligent and developmental disorders

Table 3. Odds Ratios for the Associations of Food Insecurity and IDD with Health Outcomes

Health Outcomes	Food Insecurity Only vs. Neither									Food Insecurity and IDD vs. Neither					
	IDDs Only vs. Neither			Mild Food Insecurity			Moderate-to-Severe Food Insecurity			Mild Food Insecurity and IDDs			Moderate-to-Severe Food Insecurity and IDDs		
	OR	95% CI	p-value	OR	95% CI	p-value	OR	95% CI	p-value	OR	95% CI	p-value	OR	95% CI	p-value
Overall															
Health Problem	2.97	[2.23, 3.96]	<0.001	<b>3.36</b>	[2.13, 5.32]	<0.001	<b>4.63</b>	[2.56, 8.36]	<0.001	<b>8.83</b>	[5.42, 14.38]	<0.001	<b>13.05</b>	[7.11, 23.96]	<0.001
Behavior	3.88	[3.11-4.85]	<0.001	<b>1.54</b>	[1.14, 2.10]	<0.001	<b>2.09</b>	[1.32, 3.30]	<0.001	<b>5.81</b>	[4.34, 7.78]	<0.001	<b>8.90</b>	[5.05-15.69]	<0.001
Activities of Daily Living	6.93	[5.65-8.50]	<0.001	<b>1.69</b>	[1.25, 2.29]	<0.001	<b>2.31</b>	[1.33, 4.01]	<0.001	<b>8.31</b>	[6.33, 10.89]	<0.001	<b>10.72</b>	[6.39, 17.98]	<0.001
Functional Limitations	3.72	[3.02, 4.58]	<0.001	<b>2.02</b>	[1.49, 2.74]	<0.001	<b>4.59</b>	[2.80, 7.55]	<0.001	<b>5.83</b>	[5.01-6.68]	<0.001	<b>8.09</b>	[4.79, 13,65]	<0.001

IDDs: Intelligent and developmental disorders

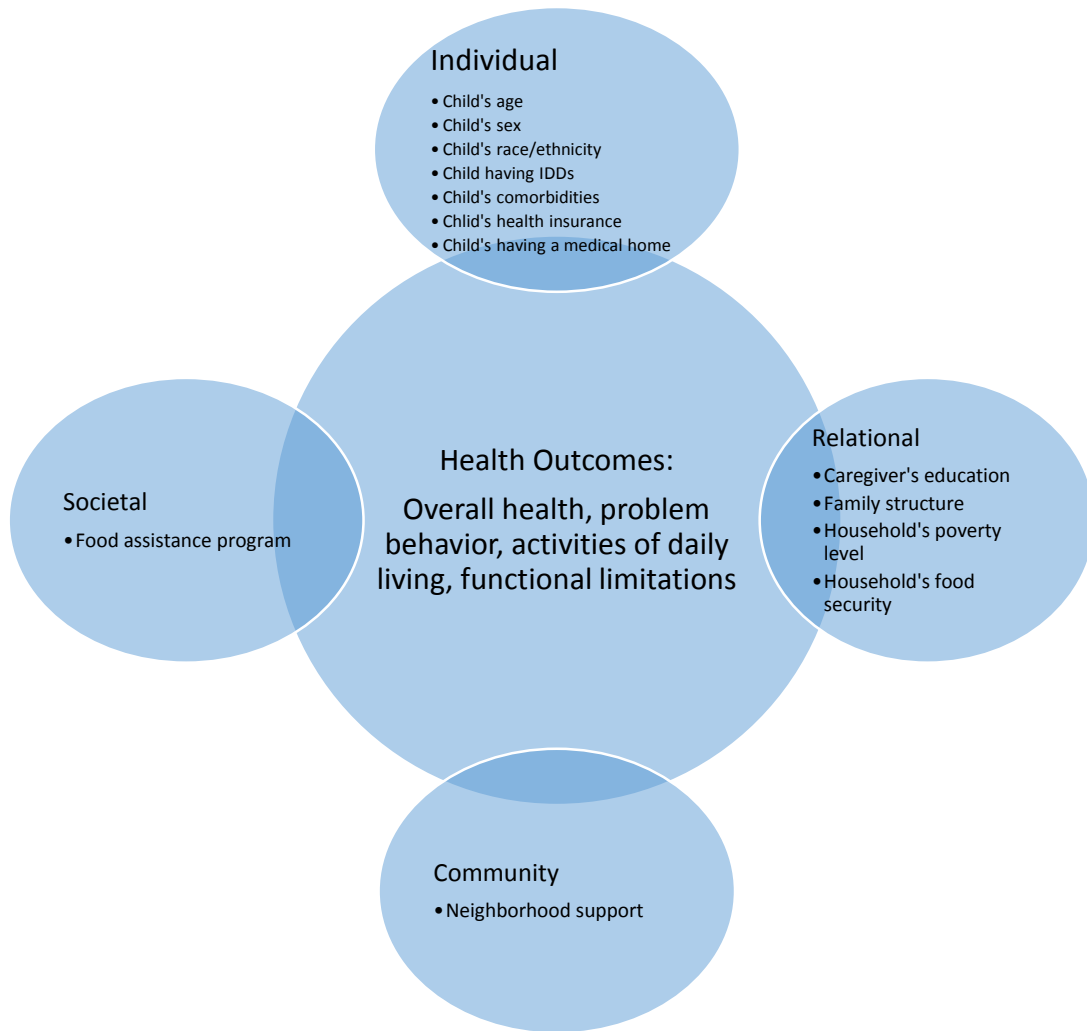
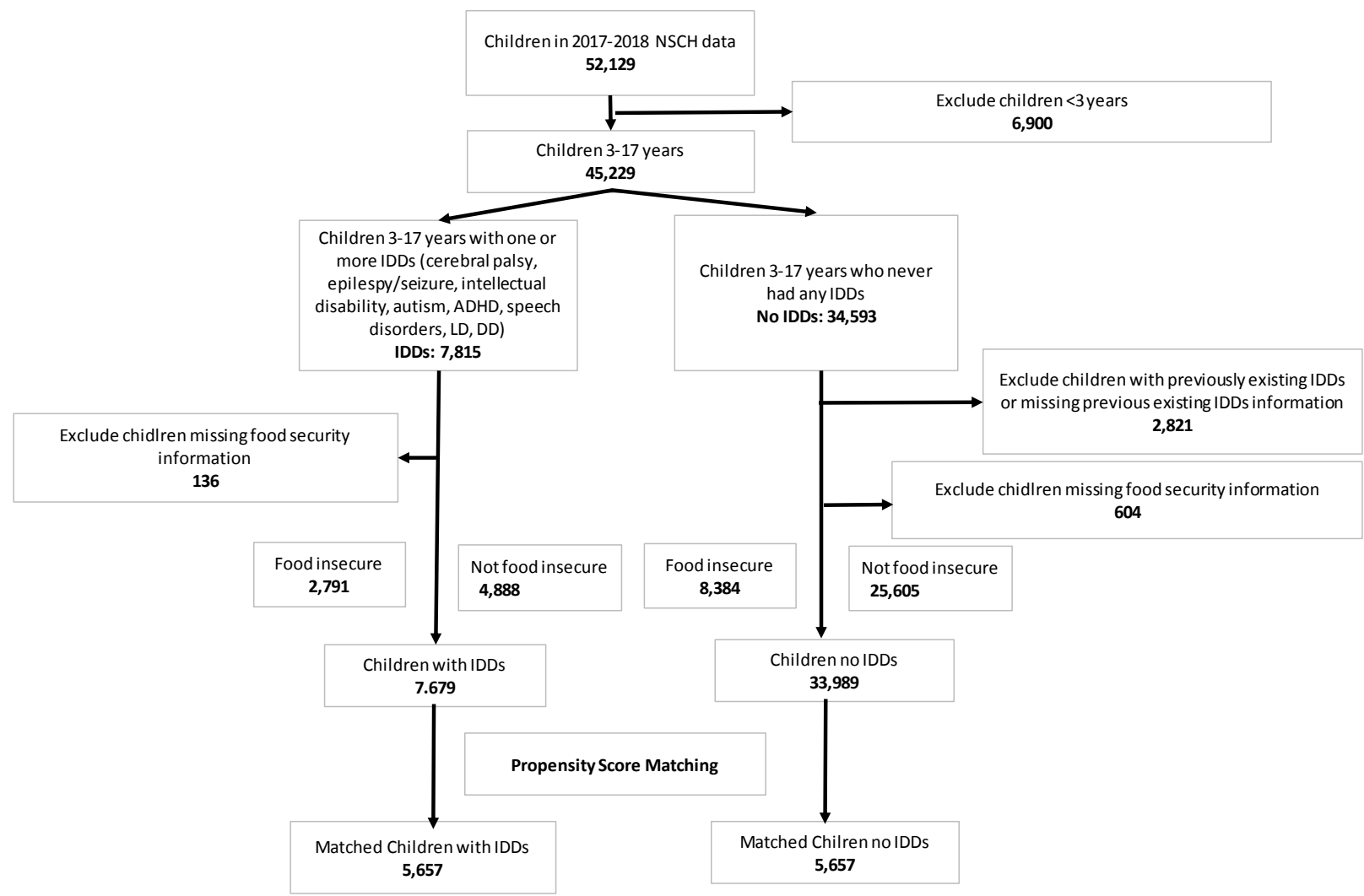


Figure 1. Conceptual Framework. IDD's: intellectual and developmental disabilities

Figure 2. Sample Cohort Selection





NSCH: National Survey of Children's Health; IDD: intellectual and developmental disabilities; ADHD: attention deficit/hyperactivity disorder; LD: learning disability; DD: developmental delay



Grandparent household			<b>-0.11</b>	1.74	0.00	0.19	<b>-0.01</b>	88.85	1.06
Other family type, no parent reported			<b>-0.09</b>	2.31	0.00	0.12	<b>0.00</b>	98.43	0.99
Single parent (mother or father)	-0.06	0.40	<b>-0.14</b>	1.24	0.00	0.41	<b>0.00</b>	99.69	1.00
Two parents currently married	0.10	0.46	<b>0.21</b>	1.18	0.01	0.47	<b>0.02</b>	92.58	1.01
Two parents, not currently married	-0.01	0.25	<b>-0.03</b>	1.10	-0.01	0.25	<b>-0.02</b>	22.53	1.08
<b>Household income as % of federal poverty level (FPL)</b>									
0-99% FPL	-0.04	0.34	<b>-0.13</b>	1.32	-0.01	0.34	<b>-0.02</b>	84.33	1.04
100-199% FPL	-0.04	0.37	<b>-0.10</b>	1.20	0.00	0.37	<b>-0.01</b>	87.19	1.02
200-399% FPL	0.01	0.46	<b>0.02</b>	0.98	0.01	0.46	<b>0.03</b>	0	0.98
>=400% FPL	0.07	0.49	<b>0.15</b>	0.94	0.00	0.49	<b>0.00</b>	98.77	1.00
<b>Neighborhood support</b>									
Yes	0.09	0.49	<b>0.18</b>	1.07	0.00	0.49	<b>0.00</b>	97.8	1.00
No	-0.09	0.49	<b>-0.18</b>	1.07	0.00	0.49	<b>0.00</b>	97.8	1.00
<b>Food assistance received in the last year</b>									
None	0.12	0.45	<b>0.28</b>	1.29	0.01	0.46	<b>0.03</b>	88.83	1.03
1-2 types	-0.10	0.43	<b>-0.24</b>	1.31	-0.01	0.44	<b>-0.03</b>	86.52	1.03
3-4 types	-0.02	0.18	<b>-0.12</b>	1.87	0.00	0.19	<b>0.00</b>	100	1.00

IDDs: Intelligent and developmental disorders; Diff.: Difference; Std. Diff.: Standardized difference  
Mean differences were calculated as difference in means (children without IDDs -children with IDD).

Supplemental Table 2. Coefficients from the mixed-effects ordinal logistic regression for association of food security and IDD with health outcomes using matched cohort

Variables	Overall Health			Problem Behavior			Activities of Daily Living			Functional Limitations		
	Coeff.	Robust St. Err.	p-value	Coeff.	Robust St. Err.	p-value	Coeff.	Robust St. Err.	p-value	Coeff.	Robust St. Err.	p-value
<b>Food insecurity (Ref=No)</b>												
Mild (enough but not nutritious food)	<b>1.21</b>	0.23	<0.001	<b>0.43</b>	0.16	0.005	<b>0.53</b>	0.15	0.001	<b>0.70</b>	0.16	<0.001
Moderate to Severe (not enough food)	<b>1.53</b>	0.30	<0.001	<b>0.73</b>	0.23	0.002	<b>0.84</b>	0.28	0.003	<b>1.52</b>	0.25	<0.001
<b>IDDs</b>												
Yes vs. No	<b>1.09</b>	0.15	<0.001	<b>1.36</b>	0.11	<0.001	<b>1.94</b>	0.10	<0.001	<b>1.31</b>	0.11	<0.001
<b>Food Insecurity and IDDs interaction</b>												
Mild x IDDs	<b>-0.12</b>	0.28	0.659	<b>-0.03</b>	0.21	0.884	<b>-0.35</b>	0.19	0.075	<b>-0.001</b>	0.23	0.997
Moderate- to-severe x IDDs	<b>-0.05</b>	0.43	0.904	<b>0.09</b>	0.35	0.785	<b>-0.40</b>	0.39	0.301	<b>-0.75</b>	0.37	0.041

IDDs: Intelligent and developmental disorders; Coeff.: coefficients