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Mental, Behavioral, and Developmental Disorders (MBDDs) Among U.S. Children with and Without Heart Conditions, 2016-2021

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By

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Washington and Lee University

2021

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Abstract

Mental, Behavioral, and Developmental Disorders (MBDDs) Among U.S. Children with and Without Heart Conditions, 2016-2021

By Amanda Dorsey

Background: Children with heart conditions, particularly congenital heart defects, are at greater risk than their peers for adverse neurodevelopmental and psychosocial outcomes. This research aimed to compare prevalence of mental, behavioral, and developmental disorders (MBDDs) among children with and without heart conditions and to examine sociodemographic factors associated with MBDDs in U.S. children with heart conditions.

Methods: Parent-reported National Survey of Children's Health data (2016-2021) on children aged 6-17 years without Down syndrome were analyzed. Heart condition was defined as a healthcare provider ever telling the parent that the child has a heart condition. MBDDs were defined as current diagnosis of depression, anxiety problems, attention-deficit/ hyperactivity disorder (ADHD), behavioral or conduct problems, Tourette syndrome, autism spectrum disorder, developmental delay, intellectual disability, or speech or language disorder. Logistic regression models using the predicted marginal approach were used to compare prevalence of MBDDs by heart condition status and, among children with heart conditions, assessed whether child's sex, race/ethnicity, age, adverse childhood experiences (ACEs), health insurance, family income, primary caregiver's marital status, and highest parental education were associated with MBDDs. Estimates were weighted to yield national estimates.

Results: Of children with heart conditions, 42.0% had an MBDD, compared to 22.0% of children without heart conditions (adjusted prevalence ratio [aPR]= 1.9; 95% confidence interval [CI]: 1.7, 2.0). Each MBDD was more prevalent among children with heart conditions, compared to children without, with aPRs ranging from 1.9 for depression and ADHD to 5.1 for intellectual disability. Among children with heart conditions, MBDDs were associated with an increased number of ACEs (aPR range: 2-3 ACEs: 1.7-4.0; ≥4 ACEs: 1.0-6.7). Independent associations between other factors and MBDDs varied by MBDD, and included male sex, Non-Hispanic Black race/ethnicity, older age (12-17 years), public insurance coverage, lower family income, and divorced, separated, or widowed parental marital status.

Conclusion: In a nationally representative sample of U.S. children, 2 in 5 children with heart conditions had ≥1 MBDD, almost twice that of children without heart conditions. Among children with heart conditions, varying factors associated with MBDDs suggest a need for holistic support for families of children with heart conditions to reduce MBDDs.

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CHAPTER 1: LITERATURE REVIEW

Congenital Heart Defects (CHD)

Congenital heart defects are the most prevalent type of structural birth defect in the United States, affecting almost one in every 100 births.[1,2] The cause of CHD has not been clearly identified, but potential contributing factors include pregestational diabetes,[3,4] parental smoking during pregnancy,[5,6] and maternal obesity[7]. The severity of CHD symptoms varies, with approximately 25% of babies with CHD having critical CHD, where timely surgery or medical treatment is required.[8]

Due to advances in prenatal detection and medical treatment, infant mortality due to CHD has been decreasing over time, and an increasing number of infants with CHD are surviving into and beyond childhood.[8,9] It was estimated that in 2010, one million children in the US were living with a CHD.[10] Another study using data from 2011 to 2013 estimated that one in every 157 US children had a CHD recorded in their medical records.[11]

Children with CHD have been shown to have more functional limitations and healthcare needs than their peers without CHD, including a greater need for medication, medical care, and emergency room visits.[12,13] This increased need for medical care in childhood and adolescence tends to pose significant costs to families.[14,15] Children with CHD have also been shown to have greater use of mental health services, special education, counseling, and physical, occupational, and speech therapy.[12,13]

Etiology of Mental, Behavioral and Developmental Disabilities in Children with CHD

Signs of neurological differences in children with CHD can be detected before birth and in early infancy, potentially explaining neurodevelopmental outcomes later in life. When

comparing neonates with CHD to those without CHD, brain maturation is delayed by approximately 4 weeks, particularly in cerebral development.[16] Cerebral development delay may be due to hypoxia-ischemia, cyanosis, atypical hemodynamics, and cardiopulmonary bypass in utero and in infancy[17] and may increase vulnerability for severe brain injuries.[16] One meta-analysis estimated that in neonates without genetic syndromes, 34% of those with transposition of the great arteries (TGA) and 49% of those with left-sided heart lesions exhibited brain lesions.[18] One other magnetic resonance imaging (MRI) study detected a structural abnormality rate of 28%[19] and another detected a combined structural and acquired cerebral abnormality rate of 18%[20] among fetuses with CHD without genetic syndromes. Delayed cerebral development in fetuses and infants with CHD has also been shown to alter brain metabolism, leading to more white matter injury.[16,21]

Additional abnormalities in neonates and fetuses with CHD include a lower middle cerebral artery pulsatility index,[16,20] indicating brain sparing to compensate for decreased oxygen delivery to the brain.[20] Fetuses with CHD commonly experience abnormal placental properties,[19,22] smaller prenatal head circumferences,[20] and smaller total brain weights and volumes.[16,19] Although many of these prenatal and neonatal studies exclude children with chromosomal or genetic syndromes to isolate the neurodevelopmental impact of the heart defect, these syndromes are common among babies with CHD and may also contribute to neurodevelopmental delays.[17]

Babies born with CHD often undergo corrective surgery, which could impose stress or trauma to the brain. Strokes and microhemorrhages are seen after infants undergo CHD surgery.[17] Alablani et al. (2022) also found that over half of neonates with CHD develop new abnormal findings in the brain after CHD surgery, mostly white matter injuries.[23] Though

surgery may have some influence on the neurodevelopment of individuals with CHD, many of the neurological changes that occur after CHD surgery return to baseline with a short recovery time.[21] The most recent evidence suggests that patient and perioperative risk factors and prenatal injury are more influential on the neurodevelopment of individuals with CHD.[17,21]

Brain lesions acquired in utero and infancy may remain through adolescence, and the brain's delayed maturation leaves it vulnerable to future lesions across the lifespan.[17] One systematic review and meta-analysis suggested that 13–24-year-olds with CHD are almost 16 times more likely than those without CHD to present with a brain abnormality.[24] The risk was especially high in individuals with single ventricle CHD. For children and adolescents with CHD in particular, the odds of presenting with focal and multifocal brain abnormalities were more than 40 times higher than for comparable samples without CHD. These abnormalities included infarction, iron deposits, and most commonly, brain mineralization, suggesting a history of brain hemorrhages. Total brain volume was also shown to be reduced among children and adolescents with CHD. Though research is sparse about the neurological status of individuals with CHD across the lifespan, these findings suggest that the abnormalities shown early in life persist.

The pathway through which these neurological differences in children with CHD are linked to neurodevelopmental outcomes later in life is not well understood. Studies have linked structural brain abnormalities in people with CHD to deficits in IQ and analytic thinking, and poorer executive function, academic achievement, attention, and visuospatial skills,[24] language, and dysregulated emotions and behavior.[17] Most,[16,20–24] though not all[17] research points to brain maturation, as opposed to brain injuries, as being more strongly linked to neurodevelopmental outcomes in individuals with CHD. Yet others[16] hypothesize a collective and synergistic effect of multiple neurological impairments on the neurodevelopment of individuals with CHD.

In addition to differences in neurological development, there are social and contextual factors that may influence risk of mental, behavioral, and developmental disorders among children and adolescents with CHD. From infancy, babies with CHD are exposed to stressors in the cardiac intensive care unit, including loud noises, excessive light, separation from their mother, and sleep disturbances.[25,26] For parents, receiving a CHD diagnosis for their baby causes stress,[27–30] and the medical care associated with a child's CHD treatment may impose financial hardship on families[15,28] and long hospital stays.[28] Parental stress among parents of children with CHD has been associated with parental anger, hopelessness, fear, poorer physical functioning, trauma, and psychological distress.[28,29] Parental stress may be a risk factor for mental, behavioral, and developmental disorders among children with CHD.[31] Children and adolescents with CHD who have a lower socioeconomic status, physical limitations, transportation barriers, and parents with higher stress levels and lower education levels may also have lower quality of life.[31,32] Studies on the association between quality of life and mental, behavioral, and developmental disorders among children with CHD do not yet exist; however, lower quality of life was associated with mental health disorders among pediatric populations with non-cardiac related medical conditions.[33–36]

Mental Health Conditions Among Children with CHD

One systematic review of articles published between 1996 and 2021 on the risk of anxiety and depression among patients aged 0-25 years with single ventricle heart disease showed mixed results, with only half of studies showing an increased risk of diagnoses and symptoms compared to controls and normative values.[37] However, more recent U.S.-based studies show an increased risk for depression diagnoses and treatment,[38,39] depressive symptoms,[38] anxiety diagnoses and treatment,[38–40] and anxiety symptoms[38,41] among children and adolescents with CHD.

Population-based data from Colorado show anxiety disorders to be among the most prevalent mental health concerns among adolescents with CHD.[40] One single-center study among adolescents with Tetralogy of Fallot found that only those with a comorbid genetic syndrome were at increased risk for an anxiety diagnosis.[42] However, others have found associations between CHD and increased risk of anxiety disorders among adolescents with CHD regardless of having a genetic syndrome.[38,40]

Many U.S.-based studies show that risk for symptoms or a diagnosis of an internalizing disorder, including anxiety and depression, increases with age among youth with CHD.[39,41,42] While some research supports a greater risk among youth with more severe forms of CHD, compared to less severe forms,[39,40] other research does not.[41] Comparing studies of risk factors for internalizing disorders based on symptomatology with those based on diagnoses can be problematic. For example, one study found that non-white youth and those without insurance had a lower prevalence of diagnosed anxiety and depression, compared to white individuals and those with public insurance, which is likely due to disparities in access to and quality of mental health services that could lead to diagnosis.[39] On the other hand, Cunningham et al. (2022) used standardized assessments to evaluate children with CHD at a cardiac neurodevelopment follow-up program and found private insurance, compared to public insurance and self-pay, to be protective against anxiety symptoms among 3-6 year old children, though not in 6-14 year old children. Race was not associated with anxiety symptoms in this analysis, nor were sex or income level of the family's county of residence; however, the sample was disproportionately white, male, privately insured, and all attended a cardiac neurodevelopmental follow-up program.[41]

Behavioral Disorders Among Children with CHD

Studies from the U.S. and other countries have shown an increased risk of diagnosed ADHD and ADHD symptoms among children with CHD.[13,39,40,43–47] In the only nationally representative U.S. study based on parent-reported data on children aged 2-17 years from the 1997-2011 National Health Interview Survey, hereafter referred to as the 1997-2011 NHIS study, 10.3% of children with CHD without Down syndrome had an ADHD diagnosis, a prevalence 1.6 times higher than in children without CHD.[13] Another nationally representative study using 1997-2011 data from Taiwan's Longitudinal Health Insurance Database, hereafter referred to as the 1997-2011 Taiwan LHID study, found the incidence rate of an ADHD diagnostic code in health records of youth under 18 years old with CHD to be 4.55 per 1000 person-years, a significantly higher rate than for those without CHD, after adjusting for perinatal comorbidities and early developmental disorders.[46] Additionally, these authors found that ADHD was diagnosed at younger ages in youth with CHD compared to youth without CHD. Symptoms of ADHD,[43,44,47] particularly attention, rather than hyperactivity/impulsivity,[44] ADHD diagnoses, and ADHD medication prescriptions were also higher among children and youth with CHD compared to their counterparts.

Similarly, attention, conduct, behavior and impulse control disorders were among the top mental health outcomes of adolescents with CHD residing in Colorado in 2011-2013.[40] Though no nationally representative studies exist that examine behavioral and conduct problems as an outcome, most single-center studies[38,47] and systematic reviews,[48–50] suggest increased behavior problems among children and adolescents with CHD. In one systematic review and meta-analysis, approximately 25% of individuals aged 6-18 with severe CHD experienced parent-reported behavior difficulties.[48] Interestingly, in contrast with existing ADHD literature, some

researchers argue that this difference in behavioral conduct among children and adolescents with CHD is largely driven by abnormal internalizing behavior rather than externalizing behavior.[48–50]

Some,[38,44,51] but not all,[39,45] studies have shown that children with CHD most at risk for ADHD, ADHD symptoms, and behavioral problems are those with severe CHD,[49] such as single ventricle CHD that underwent a Fontan procedure[38] or Tetralogy of Fallot,[44,51] and those with genetic syndromes.[40,42] Other risk factors for ADHD, ADHD symptoms, and behavioral impairments among children with CHD include poor maternal mental health,[47] male sex,[38,47] and older age.[39] In one study among children with CHD, socioeconomic status was not associated with ADHD; however, the authors acknowledged limited socioeconomic status variation among their participants.[47] Additionally, non-Hispanic Black, Hispanic, and Asian American children and adolescents with CHD are less likely to receive treatment or services for ADHD than white children, even when controlling for insurance.[39] Children and adolescents with CHD without health insurance, compared to those covered by public health insurance, were also less likely to receive ADHD treatment.[39]

Developmental Disorders Among Children with CHD

Autism Spectrum Disorder (AuSD)

Six studies have shown a rate of AuSD in children and adolescents with CHD significantly higher than those without CHD.[13,45,46,52–54] However, the previously described 1997-2011 NHIS study is the only U.S. nationally representative study examining AuSD in children ages 2-17 with CHD.[13] Authors found that children with CHD without Down syndrome were almost 5 times more likely to have AuSD than children without CHD, without adjusting for possible confounders. Similarly, the nationally representative 1997-2011 Taiwan LHID study found a 2 times greater risk of AuSD after controlling for perinatal comorbidities and early

developmental disorders.[46] Studies using nationwide U.S. military health administrative data,[53] retrospective chart reviews of children 3 – 19 years old at the Cardiac Neurodevelopmental Program at Children's Healthcare of Atlanta,[54] parent-reported data for 4-year old children treated at the Children's Hospital of Philadelphia,[52] and neuropsychological evaluations for patients 3-21 years old at the Cardiac Neurodevelopmental Outcome Program at Children's National Hospital[45] show a similarly elevated risk of AuSD in children with CHD. When stratifying by CHD type, Sigmon et al. (2020) saw a particularly increased risk for AuSD among children with atrial septal defects and left-sided obstructive lesions compared to controls without CHD. Existing literature has explored, but not yet identified, sociodemographic risk factors that explain this increased prevalence seen among children with CHD, including race,[45,52,54] gender,[45,54] age across childhood and adolescence,[13] and parental employment category.[52] However, each of these studies exploring the link between CHD and AuSD have limitations, including limited power, case ascertainment bias, imperfect sensitivity of AuSD and CHD diagnoses, and less recent years of data.

Intellectual Disability

The 1997-2011 NHIS study, which excluded children with Down syndrome, suggested that intellectual disability is approximately nine times more prevalent in those with CHD compared to those without CHD.[13] However, this prevalence ratio estimate was not adjusted for potential confounders.[13] Compared to children without CHD in 2009-2017 NHIS data, Loblein et al. (2022) found that 3–21-year-old patients with CHD who were referred for neuropsychological evaluation to the Cardiac Neurodevelopmental Outcome Program at Children's National Hospital had an increased prevalence of intellectual disability. Research on school-aged children in metropolitan Atlanta born between 1982 and 2004 who survived beyond age three also

showed that children with CHD were almost four times more likely than their peers without CHD to receive special education services due to an intellectual disability.[55]

Aside from increased risk of intellectual disability with a comorbid genetic condition [45] and older age throughout childhood and adolescence,[13] the CHD literature is mixed on risk factors for intellectual disability. Loblein et al. (2022) did not find race or ethnicity to be associated with risk of intellectual disability diagnosis at a neuropsychology clinic in Washington, D.C. Yet a smaller study on IQ among adolescents with CHD who required cardiac surgery in the first year of life and were referred for neuropsychological evaluation found significantly higher IQ scores among white participants compared to Black participants,[56] which the authors said was largely explained by parent education and income. Additional studies outside the U.S. support the negative association between high socioeconomic status and intellectual functioning in people with CHD, but this finding has yet to be explored in U.S. studies examining intellectual disabilities.[32,57,58] CHD severity was not associated with special education service uptake due to intellectual disability in metropolitan Atlanta, Georgia;[55] however, other studies on total IQ and intellectual functioning suggest that children and adolescents with hypoplastic left heart syndrome, univentricular CHD,[59] and other severe forms of CHD[58] may experience more impairments than children with mild or moderate CHD.

Developmental Delay

Using data from Metropolitan Atlanta, Riehle-Colarusso et al. (2015) found an increased risk of special education service uptake due to a developmental delay among children with isolated CHD compared to peers without CHD, regardless of whether the CHD was critical or non-critical.[55] Contrary to those findings, pediatric patients with CHD in the South Carolina Medicaid claims database had a decreased odds of an ICD-9 code indicating developmental

delay compared to controls matched on age at Medicaid entry and months of enrollment. Authors additionally found an increased odds of an ICD-9 code indicating developmental delay for those with a history of a cardiac or noncardiac surgical intervention or hypoxia. However, there are inherent limitations to the use of a Medicaid claims database, including a lack of accurate data for those who do not receive neuropsychological testing, lose Medicaid coverage, or do not receive accurate ICD-9 codes.[60]

Additional studies among children and adolescents with CHD have identified impairments in memory and learning,[55,61–63,63] self-care,[62] motor skills,[62,64,65] visuospatial skills[63] and executive functioning.[59,66,67]

Speech and Other Language Disorders

Literature is sparse about speech and language disorders among children and adolescents with CHD, even though this has been repeatedly shown as a concern among toddlers and children younger than 5 years old with critical CHD[68] and with cardiac surgery in infancy.[69] One study among 8-year-old children with CHD born in and around Paris, France, found that those born with CHD had significantly lower speech and language scores on a standardized assessment compared to their peers born with ventricular septal defects that spontaneously closed at less than 1 year of age; this difference was seen only in babies with overt or potential heart failure at birth.[61]

Study Rationale

Concern for the psychological and neurodevelopmental wellbeing of children and adolescents with CHD and risk factors for mental, behavioral and developmental disabilities (MBDDs) primarily stems from studies based on specific geographic areas or health centers.[38–

[40,42,45,52,55] Only a few attempts have been made to understand this issue at a U.S. national level;[13,62] however, these studies have not comprehensively examined MBDDs and both use older data. Data from the National Survey of Children's Health (NSCH) offers an opportunity to research MBDDs at a national level among children with and without heart conditions, which largely encompasses CHDs. Therefore, to help stakeholders understand the current magnitude of this issue among children with heart conditions in the United States, this analysis aims to assess the prevalence of MBDDs and their risk factors using a nationally representative sample of U.S. children with heart conditions compared to children without heart conditions.

CHAPTER II: MANUSCRIPT

Background

Children with congenital heart defects (CHD) experience differences in neurological development, which can be detected prenatally and in early infancy, and include delayed cerebral maturation, increased brain injuries and lesions, and structural abnormalities.[16–21] Corrective cardiac surgery may also induce trauma to the brains of infants with CHD, resulting in strokes, microhemorrhages, and white matter injuries.[17,23] These neurologic differences may affect outcomes later in life, including deficits in their intelligence quotient and analytic thinking;[24] poorer executive function, academic achievement, attention, visuospatial skills, and language skills;[24] and dysregulated emotions and behavior.[17]

In addition to differences in neurological development, social and contextual factors may influence risk of poor psychosocial development among children and adolescents with CHD.[15,25–29,31,32] Babies with CHD are exposed to stressors in the cardiac intensive care unit,[25,26] and into adolescence, they may experience other stressors, including lower socioeconomic status, physical limitations, and lower education levels.[31,32] Parents of children with CHD may also be exposed to financial hardship,[15,28] long hospital stays,[28] and their baby's diagnosis itself,[27,28] which may manifest as psychological distress.[28,29] Additional studies have shown parental stress, poverty, and low parental education to be risk factors for lower quality of life and poorer neurodevelopmental outcomes among children with CHD.[31,32]

Children with CHD may be at an increased risk for mental or behavioral disorders, including anxiety,[38–41] depression,[38,39] attention-deficit/hyperactivity disorder (ADHD),[13,39,40,43–47] and other behavioral concerns,[38,40,47–50] as well as developmental disorders, such as autism spectrum disorder (AuSD),[13,45,46,52–54] intellectual disability,[13,45] and developmental delay.[39]

Other developmental disorders, such as Tourette syndrome, have yet to be investigated in a CHD population. However, whether the risk is dependent on comorbid genetic conditions is less well understood.[42,70] The few US and Swiss-based studies that have investigated sociodemographic risk factors for mental, behavioral or developmental disorders (MBDDs) among children with CHD, identified disparities related to race,[39] health insurance coverage,[39,41] sex,[38,47] and age.[39]

Information on the prevalence and risk factors for MBDDs among children with CHD primarily stems from studies conducted in specific geographic areas or health centers.[38–40,42,45,52,55] Only two studies have examined this issue at a U.S. national level;[13,62] however, these studies have not comprehensively examined all MBDDs and both use data from before 2012. Data from the National Survey of Children's Health (NSCH) offers an opportunity to research MBDDs at a national level among children with and without heart conditions, which largely encompasses CHDs. Therefore, this analysis aims to assess the prevalence of MBDDs and associated demographic and contextual characteristics using a nationally representative sample of U.S. children with heart conditions compared to children without heart conditions. The receipt of early intervention or special education, medication for emotions, concentration, or behavior, and mental health professional treatment or counseling according to heart condition status among children with MBDDs were also examined.

Methods

National Survey of Children's Health

Data was analyzed from the 2016-2021 National Survey of Children's Health (NSCH), conducted by the U.S. Census Bureau. The NSCH generates a population-based cross-sectional sample of U.S. children aged 0-17 years old. Parents or guardians of children under 18 years of age were asked to complete an age-appropriate topical questionnaire about the demographic characteristics, health,

behaviors, resource access, and wellbeing of one randomly selected child living at that address. The survey purposely oversampled children with special health care needs and provided weighted estimates to generate nationally representative estimates.[71] From 2016-2021, the weighted annual completion rate for the screening questionnaires ranged from 45.4% to 53.0%, and the weighted annual completion rate of the topical surveys ranged from 30.6% to 36.9%,[71–76] capturing a total of 225,443 households over the years.

Many MBDDs do not emerge in infancy and early childhood; therefore, the sample for this analysis was restricted to children aged 6-17 years. Additionally, Down syndrome is commonly comorbid with congenital heart conditions[77] and may influence an individual's emotional and behavioral development more strongly than the heart condition itself; thus, the study population was also limited to children and adolescents without a parent-reported diagnosis of Down syndrome.

Outcome Measures

Study participants were categorized as having a heart condition if their parent or guardian responded "Yes" to the question, "Has a doctor or other health care provider EVER told you that this child has a heart condition?" The outcome of interest was whether participants were told by a healthcare provider that they currently have a mental or behavioral disorder (depression, anxiety problems, ADHD, behavioral or conduct problems, or Tourette syndrome) or a developmental disorder (AuSD, developmental delay, intellectual disability, or speech or other language disorder). Children were considered to have the outcome of interest if their parent reported that a doctor, health care provider, or educator ever told the parent that their child has this condition and that their child currently has this condition. Each of the MBDD outcomes was considered individually, in addition to whether the child had any mental or behavioral disorder, any developmental disorder, or any MBDD.

Demographic and Contextual Characteristics

The child's sex, race/ethnicity, age, adverse childhood experiences (ACE score), and health insurance coverage; family income; primary caregiver marital status; and highest level of caregiver

education were all explored as potentially being associated with MBDDs among children with heart conditions. Sex and race/ethnicity were imputed, and family income (% of the federal poverty level (FPL)) was multiply imputed by the U.S. Census Bureau to account for missing data.[71] Family income, measured by the percent of the FPL, was calculated according to the survey year. Similar to other analyses,[78–80] ACE scores were categorized as 0, 1, 2-3, or 4 or more based on the total number of responses of "yes" to questions about whether their child has experienced the following: 1) parent or guardian divorced or separated; 2) parent or guardian died; 3) parent or guardian served time in jail or prison; 4) saw or heard parents or adults slap, hit, kick, or punch one another in the home; 5) was a victim of violence or witnessed violence in their neighborhood; 6) lived with anyone who was mentally ill, suicidal, or severely depressed; 7) lived with anyone who had a problem with alcohol or drugs; 8) been treated unfairly due to their race or ethnic group; or 9) the family has found it hard to cover the basics, like food or housing, on the family's income since the child's birth.

According to the child's heart condition status, we also examined what percentage of children had: 1) a special education or early intervention plan; 2) taken any medication because of difficulties with their emotions, concentration, or behavior; and 3) received any treatment or counseling from a mental health professional.

Statistical Analysis

Descriptive statistics on the demographic characteristics of the analytic sample were calculated, stratified by whether the child or adolescent had a parent-reported heart condition. Chi square p values determined any statistical differences in demographic characteristics by heart condition status.

The prevalence of each MBDD was calculated, stratified by heart condition status. The prevalence of any MBDD, any developmental disorder, and any mental or behavioral disorder were also calculated by heart condition status. Logistic regression using the predicted marginal approach was used to calculate adjusted prevalence ratios (aPR) and 95% confidence intervals (CI) for MBDD by heart

condition status, controlling for the child's sex, race/ethnicity, family income, and the highest level of caregiver education.

Logistic regression was also used to examine associations between demographic and contextual characteristics and each MBDD outcome. Demographic and contextual characteristics examined in the model were child's sex, race/ethnicity, age, family income, primary caregiver marital status, highest level of caregiver education, health insurance coverage, and ACE score.

Sensitivity analyses were conducted, excluding children with a parent-reported genetic condition, (aside from children with Down syndrome who were already excluded). All analyses were completed in SAS-callable SUDAAN. Weights and design parameters were included throughout the analyses to account for complex sampling and to produce nationally representative population-based estimates. Ethics approval was not sought for this analysis because it uses a publicly available, de-identified dataset.

Results

Parents of 154,845 children ages 6–17 years without parent-reported Down syndrome completed the 2016-2021 NSCH. Among them, children were excluded for missing data on heart condition [n=395 (0.3%)]; an outcome of interest [n=5,886 (3.8%)]; and other demographic and contextual characteristics of interest [n=11,515 (7.4%)], leaving an analytic sample of 137,049 children (88.5%). Among children with heart conditions, those included in the analytic sample were more likely than those excluded to be female and have a caregiver with more than a high school education; race/ethnicity and family income were also differentially distributed (all p values <0.05; Supplemental Table 1). Among children without heart conditions, those included in the analytic sample were more likely than those excluded to be younger and have anxiety problems; race/ethnicity, family income, primary caregiver marital status, highest level of caregiver education, health insurance coverage, and ACE score were also differentially distributed (all p values <0.05; Supplemental Table 1).

Within our analytic sample, 3,450 (2.3%) children had a parent-reported heart condition (Table 1). In 2020 and 2021, the first two survey iterations to ask whether the heart condition was present at birth, 88.8% of these children were reported to have been born with their heart condition. Compared to children without heart conditions, those with heart conditions were more likely to have a caregiver with more than a high school education and experienced a greater number of ACE scores; race/ethnicity and health insurance coverage were also differentially distributed (all p values < 0.05; Table 1).

MBDD Prevalence

Experiencing ≥1 MBDD, which comprises both mental or behavioral disorders and developmental disorders, was 1.9 (95% CI: 1.7-2.0) times more prevalent among children with heart conditions (42.0%) compared to their peers (22.0%). The prevalence of ≥1 mental or behavioral disorder, apart from developmental disorders, was 34.8% among children with heart conditions and 18.7% among children without heart conditions (aPR: 1.8, 95% CI: 1.6-2.0) (Figure 1). Each type of mental or behavioral disorder was significantly more prevalent among children with heart conditions compared to children without heart conditions, with aPRs ranging from 1.9–3.0. The most common mental or behavioral disorders among children with heart conditions were anxiety problems (22.3%), followed by ADHD (20.5%).

Currently experiencing ≥1 developmental disorder was 2.5 (95% CI: 2.2-2.9) times more prevalent in children with heart conditions (21.4%) compared to children without heart conditions (8.3%; Figure 2). All specific developmental disorders were significantly more prevalent among children with heart conditions compared to those without, with aPRs ranging from 2.5 for AuSD to 5.1 for intellectual disability. The most common developmental disorders among children with heart conditions were developmental delay (16.1%) and speech or other language disorder (13.1%).

Resource Use Among Children with MBDDs

Among children experiencing ≥1 MBDD, 59.1% of those with heart conditions and 46.3% of those without heart conditions reported receiving early intervention or special education in their lifetime; 37.8% with and 39.1% without heart conditions took a medication in the past 12 months because of difficulties with their emotions, concentration, or behavior; and 42.9% with and 41.7% without heart conditions received any treatment or counseling from a mental health professional in the past 12 months. Almost 8% of those with and without heart conditions did not receive treatment or counseling but reported needing it.

Demographic and Contextual Characteristics Associated with MBDDs among Children with Heart Conditions

Among children with heart conditions, male sex, Non-Hispanic (NH) Black race, older age (12-17 years), divorced, separated, or widowed caregivers, public (versus private) health insurance coverage, and higher ACE scores were associated with having ≥1 mental or behavioral disorder (Table 2). The largest aPRs were observed with ACE scores, as 67.6% of children with 4+ ACEs had ≥1 mental or behavioral disorder compared to 20.2% of children with no ACEs (aPR= 3.4; 95% CI: 2.6–4.4). Among children with heart conditions, factors associated with having ≥1 current mental or behavioral disorder varied according to the specific type. Males were 1.8 times as likely as females to have ADHD or behavioral or conduct problems. ADHD was 1.7 times more prevalent among NH Black children than NH white children, but no other associations were found for race/ethnicity. All mental or behavioral disorders were more prevalent among older children (12-17 years old) compared to younger children (6-11 years old), except for behavioral or conduct problems. Children whose family income was less than 200% of the FPL were more likely to have depression and behavioral or conduct problems compared to children whose families earned at least 400% of the FPL. Children with caregivers who were divorced, separated, or widowed, compared to those with married or cohabiting caregivers, had 1.5-2 times the prevalence of all mental or behavioral disorders, except for anxiety problems. Highest level of caregiver education was

not significantly associated with mental or behavioral disorders, whereas public insurance coverage, compared to private insurance coverage, was significantly associated with behavioral or conduct problems. Finally, a dose-response relationship was observed with ACEs and all types of mental or behavioral disorders, where aPRs increased with an increasing number of ACEs.

Among children with heart conditions, male sex, NH Black race, lower caregiver education, public (versus private) health insurance coverage, and higher ACE scores were associated with having ≥1 developmental disorders (Table 3). The largest aPRs were observed with ACE scores, as 35.2% of children with 4 or more ACEs had ≥1 developmental disorder compared to 15.1% of children with 0 ACEs (aPR=2.2; 95% CI: 1.5-3.3). Among children with heart conditions, demographic and contextual characteristics associated with developmental disorders also varied by type of developmental disorder. Developmental disorders were 1.7-2.9 times as prevalent in males compared to females, although 95% CIs were wide and included 1.0 for intellectual disability. Intellectual disability and speech or other language disorder were 2.4 and 1.6 times, respectively, more prevalent in NH Black than NH white children with heart conditions. Children 12-17 years old were 1.8 times as likely than those 6-11 years old to have AuSD but 0.7 times as likely to have a speech or other language disorder. Children of caregivers with a high school education or less, compared to children of caregivers with at least a high school education, were over 40% more likely to have developmental delay and marginally more likely to have AuSD. Public, compared to private health insurance coverage was associated with developmental delay. Lastly, a dose-response relationship was observed with ACE scores, where children with an increasingly higher ACE score had a higher prevalence of developmental disorders.

Results did not substantially change when 6,306 children (4.6% of the analytic sample) with reported genetic conditions were excluded from the analysis (Supplemental Tables 2-4).

Discussion

In nationally representative data from 2016-2021, over two in five children with heart conditions had one or more MBDDs, twice as high as children without heart conditions. Each specific MBDD examined was approximately two to five times more prevalent among children with heart conditions compared to those without heart conditions, with the greatest adjusted prevalence ratios for intellectual disability, developmental disability, and Tourette syndrome. Among children with heart conditions, over one in three had any mental or behavioral disorder, and over one in five had any developmental disorder. Anxiety problems, ADHD, behavioral or conduct problems, and developmental delay were the most common MBDDs, affecting over one in six children with heart conditions. Demographic and contextual characteristics associated with MBDD prevalence among children with heart conditions varied according to MBDD subtype but included increased male sex, NH Black race, older age, public health insurance coverage, lower family income, and divorced, separated, or widowed primary caregiver marital status, and ACE score. ACE score was consistently and most strongly correlated with MBDDs in a dose-response fashion. Sensitivity analyses excluding children with genetic syndromes other than Down syndrome did not notably change any of these results, suggesting that genetic syndromes were not driving the observed increased prevalence of MBDDs among children with heart conditions, nor were they impacting the demographic and contextual characteristics found to be associated with MBDDs among children with heart conditions.

These results about children with heart conditions agree with previously published studies suggesting that children with CHD are at an increased risk for MBDDs.[38–40,45,55] However, this study uniquely estimates the prevalence of various MBDDs nationally rather than at specific sites or catchment areas. One other US-based nationally representative study using National Health Interview Survey data from 1997-2011 similarly showed an increased risk of AuSD, ADHD, and intellectual disability among children with CHD without Down syndrome compared to peers without CHD. The unadjusted odds ratios for AuSD and intellectual disability were 4.6 and 9.1, respectively, approximately two times greater than

the adjusted prevalence ratios found in the current results, but confidence intervals were wide, and confidence intervals overlapped with our estimate for AuSD prevalence.[13] Additionally, ours is one of the first studies to examine Tourette syndrome among children with heart conditions, finding 0.7% of children with heart conditions to have Tourette syndrome, a prevalence three times greater than among children without heart conditions. While several studies have identified speech or other language deficits among children with CHD, none have estimated the U.S. prevalence of speech or other language disorders in this population.[61,68,69]

Similar to our findings, prior studies identified associations between demographic and contextual characteristics and MBDDs among children with heart conditions, such as male sex with ADHD[38,47] and older age into adolescence and anxiety and depression.[39] However, our study identified additional associations with specific MBDDs, including family income with anxiety,[41] older age with AuSD,[13] and race/ethnicity with intellectual disability.[45] Different findings between previous studies and this one may be due to different sampling methods and MBDD classification, as our study uses parent-report data, while other studies require formal diagnoses. Using ICD-9 codes and prescribed treatment to measure anxiety and depression in children with CHD, Gonzalez et al. (2021) found that non-white children with CHD were less likely than their white counterparts to be diagnosed or treated for anxiety and depression. Meaning, differences in MBDD diagnoses by CHD status and demographic and contextual characteristics may reflect differences in access to mental healthcare and an MBDD diagnosis.[39] Additionally, ACE scores have been consistently associated with poor mental, behavioral, and developmental outcomes in children,[81–83] and our study is one of the first to confirm this association in children with heart conditions.

These results are in line with recent guidelines recommending neurodevelopmental and mental health interventions for children with CHD and their caregivers during prenatal care[84] and infancy[85] and across the lifespan.[86] To benefit the mental health of individuals with CHD, in addition to their families, some recommend that psychologists play an instrumental role in CHD care.[86,87] Additionally, pediatric cardiologists and other healthcare professionals have begun exploring the utility of screening tools to

detect stress and mental wellbeing among their patients with CHD,[88,89] and developing interventions to support affected individuals' psychological wellbeing.[90,91]

There are potential limitations to these results. This analysis examined children with congenital and acquired heart conditions, not limited to CHD. However, 2020 and 2021 NSCH data, the first two survey iterations to ask if the child was born with the heart condition, showed that 88.8% of children with parent-reported heart conditions were born with the condition. Heart condition status is parent-reported, and not validated through medical records. This study also lacked information on the child's surgical history and heart condition severity, which may influence neurodevelopment and mental health throughout childhood.[17,23,39,40] As a cross-sectional survey, we could not discern temporality between demographic and contextual characteristics, such as primary caregiver marital status and family income, and MBDD outcomes. We excluded 11.5% of children in NSCH due to missing data and MBDD prevalence and characteristics differed from between children included and excluded from the analysis. This selection bias may have led to underestimating the prevalence of MBDDs among children with heart conditions and the associations between demographic and contextual characteristics and MBDDs. Detection bias may have also affected MBDD prevalence, as 90.9% of children with heart conditions in our analytic sample saw a doctor, nurse, or other health care professional for medical care in the past 12 months, compared to 80.1% of children without heart conditions, so children with heart conditions likely have a larger number of healthcare encounters in a year, or more opportunities to have an underlying MBDD diagnosed. However, this analysis provides nationally representative information about MBDDs among children with heart conditions in the US. The NSCH consists of a large sample of 3,450 children with heart conditions included in our analytic sample, leading to precise estimates.

Conclusion

Two in five US children ages 6-17 years had one or more MBDDs, almost twice that of their peers. These data support national guidelines for screening children with CHD for MBDDs and connecting families with resources.[85,86,92] To best support the mental health and developmental wellbeing

of children with heart conditions, holistic support for a safe and secure environment may be necessary, as ACE score was the contextual characteristic most strongly associated with MBDDs, in addition to social determinants of health such as NH Black race/ethnicity, public health insurance coverage, lower family income, and divorced, separated, or widowed primary caregiver marital status. These findings draw attention to racial and socioeconomic disparities in the wellbeing and development of children with heart conditions. By addressing these larger inequities and providing holistic support for affected families, this is evidence that children with heart conditions can be set on a path for positive neurodevelopment and mental health.

CHAPTER III: PUBLIC HEALTH IMPLICATIONS

The study results showed that over two in five children with heart conditions had one or more MBDD, a prevalence almost two times greater than their peers without heart conditions. Non-Hispanic (NH) Black race/ethnicity, public health insurance coverage, lower family income, divorced, separated, or widowed primary caregiver marital status, and adverse childhood experience (ACE) scores, were associated with mental, behavioral, and developmental (MBDD) prevalence among children with heart conditions, meaning that the child's rearing environment and socioeconomic situation may influence their emotional, behavioral, and developmental trajectory. This information is important to consider when devising clinical guidelines and interventions in pediatric cardiology to support the holistic wellbeing of children with heart conditions.

To address the increased prevalence of MBDDs among children with heart conditions observed in these results, neurodevelopmental and psychosocial care for children with congenital heart defects (CHD) may be most effective if begun during prenatal care.[84] Increased use of fetal echocardiography in prenatal care has led to an increased percentage of CHD cases detected prenatally over time.[93–95] Early detection provides more opportunity for "primary prevention neuropsychology," a term defined by Cassidy and Neumann (2023) as a more integrated role of neuropsychologists in CHD care from the fetal stage.[96] This provides caregivers with empathetic support to reduce worries about their child's health, and initiates early planning on how caregivers can best support their child's development and quality of life.[84] Into infancy, the American Heart Association (AHA) released key domains of developmental care to potentially mitigate their increased risk for MBDDs among infants with CHD. These domains included the incorporation of parents in care, attending to infant cues, limiting stress and pain, and building motor capacity.[85] AHA has echoed similar messages regarding interventions for individuals with CHD across the lifespan with scientific statements on the importance of psychological interventions and neurodevelopmental interventions for children, adolescents, and adults with CHD.[85,86] The results of this research support these scientific recommendations, in addition to reviews advocating for interdisciplinary neurodevelopmental care between psychologists, medical care providers, families, and educators.[87,97]

Currently, there is great variation across pediatric cardiology centers in developmental screening protocols, whether developmental care is offered to infants and children with CHD and, if so, how the care is administered.[85,98–100] This is due, at least in part, to available funding, infrastructure, and professional expertise.[85,99] Understanding how clinics have successfully integrated psychosocial and developmental assessment and care into their pediatric cardiology centers may benefit all centers and inform evidence-based practices for optimal psychosocial and developmental care for children with CHDs.

AHA scientific statements recommend that psychosocial and developmental care should be individualized according to each infant's sociodemographic background; however, they also acknowledged that there is a significant research gap in understanding whether developmental interventions for infants with CHD vary in their effectiveness according to social determinants of health.[85,86] This current research suggests that demographic and contextual characteristics likely influence MBDD risk among children with heart conditions. However, how these characteristics affect psychosocial and developmental intervention uptake and effectiveness for children with CHD is unknown but should be a critical focus of future research.

Among the demographic and contextual characteristics explored in this research, ACE scores were most strongly associated with MBDD outcomes among children with heart conditions. Hence, when devising these evidence-based psychosocial and developmental interventions, ACEs may be a meaningful screening metric, and interventions supporting the holistic stability and safety of the child's rearing environment may be most effective. Though screening for ACEs and training healthcare professionals on trauma-informed care has been recommended in general pediatric care, this metric has yet to be explored as a useful screening tool or intervention target in a pediatric population with CHD.[101–103] There are opportunities for public health research to explore this novel approach in CHD care.

In addition to more psychosocial and developmental intervention research, future research may also address a critical limitation of this analysis: detection bias. It is unknown whether MBDDs remain

undiagnosed among both children with and without heart conditions, and to what extent this influenced the results. Among the analytic sample, it was found that rates of medical care and preventative care were higher among children with heart conditions versus those without, which could potentially influence access to MBDD evaluations and diagnoses. Future research may replicate these results with prospective MBDD assessments that decrease detection bias. Future research may also address limitations to this study by, for example, collecting more clinical indicators about children's heart conditions, collecting prospective data, and combining information from health records.

Overall, these results and prior public health literature have consistently shown that children with heart conditions are at increased risk for MBDDs, supporting numerous scientific statements about the need to support the psychosocial and developmental trajectory of children with heart conditions. This was one of the first studies to comprehensively explore sociodemographic and contextual characteristics associated with MBDDs among children with heart conditions. It may be beneficial to include ACE scores in CHD interventions to support psychosocial and neurodevelopmental interventions, as has been done in general pediatrics. Many public health questions remain, particularly implementation of interventions to mitigate the increased prevalence of MBDDs among children with heart conditions and how to consider social determinants of health in implementation research to ensure that all children with CHD and their families are equipped with the resources needed to optimize their psychosocial and developmental wellbeing.

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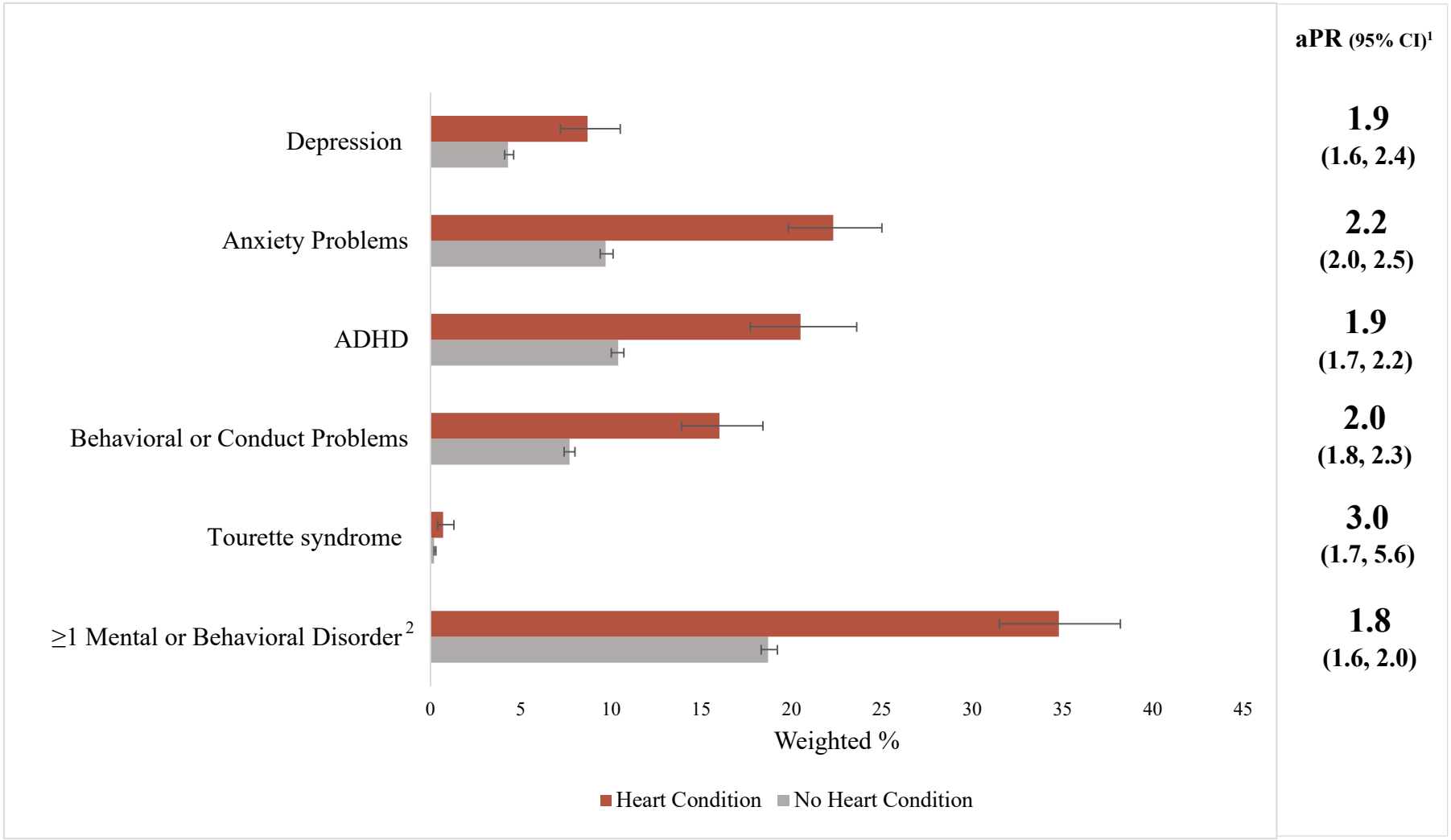
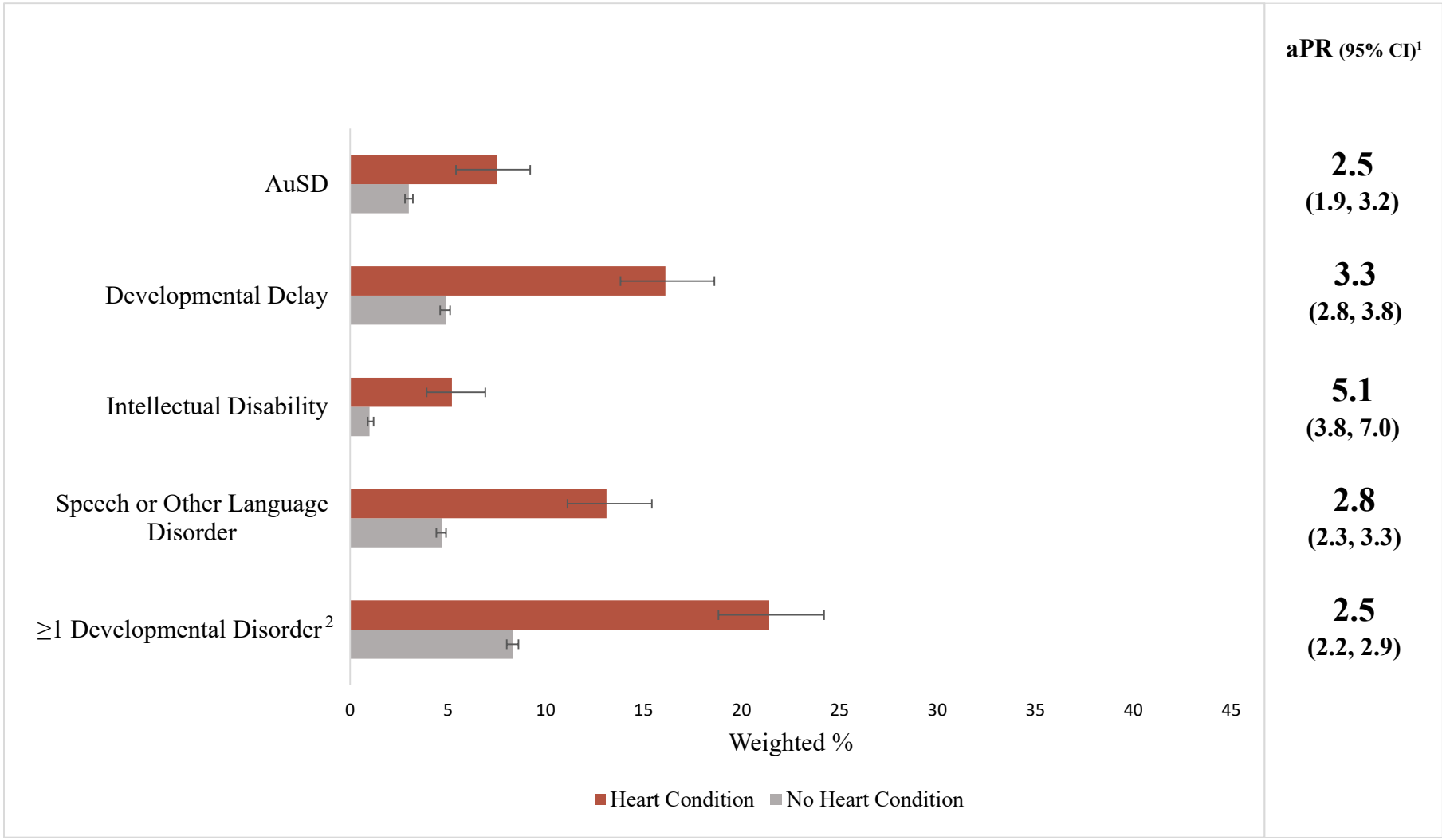
Figure 1. Prevalence of Mental or Behavioral Disorders Among Children 6-17 Years Old with and Without Heart Conditions, National Survey of Children's Health, United States, 2016-2021



aPR: adjusted prevalence ratio; CI: confidence interval; ADHD: attention-deficit/hyperactivity disorder

[1]Prevalence ratio adjusted for the child's sex, race/ethnicity, family income, and highest level of caregiver education
[2]Any current depression, anxiety problems, ADHD, behavioral or conduct problems, or Tourette syndrome

Figure 2. Prevalence of Developmental Disorders Among Children 6-17 Years Old with and Without Heart Conditions, National Survey of Children's Health, United States, 2016-2021



aPR: adjusted prevalence ratio; CI: confidence interval; AuSD: autism spectrum disorder

[1]Prevalence ratio adjusted for the child's sex, race/ethnicity, income, and the highest level of caregiver education

[2]Any current AuSD, developmental delay, intellectual disability, and/or speech or other language disorder

Table 1. Characteristics of Children 6-17 Years Old by Heart Condition Status, National Survey of Children's Health, United States, 2016-2021

		Heart Condition				
		Yes		No		
Characteristic		N	Weighted Percent (95% CI[1])	N	Weighted Percent (95% CI[1])	Chi-square p-value
Total	Total	3450	2.3 (2.1, 2.5)	133599	97.7 (97.5, 97.9)	
Sex	Male	1899	51.3 (47.6, 55.0)	68963	51.2 (50.5, 51.8)	0.94
	Female	1551	48.7 (45.0, 52.4)	64636	48.8 (48.2, 49.5)	
Race/ ethnicity	NH White	2487	58.0 (54.2, 61.8)	92375	51.7 (51.1, 52.3)	0.002
	NH Black	216	12.5 (10.3, 15.1)	8212	12.9 (12.5, 13.4)	
	Hispanic	370	21.2 (17.7, 25.3)	15990	25.0 (24.3, 25.6)	
	Other	377	8.2 (6.7, 10.0)	17022	10.4 (10.1, 10.7)	
Age (years)	6-11 years	1450	49.8 (46.1, 53.4)	58142	50.0 (49.4, 50.6)	0.90
	12-17 years	2000	50.2 (46.6, 53.9)	75457	50.0 (49.4, 50.6)	
Family Income (% FPL)	<100%	434	19.7 (15.8, 24.3)	14490	18.1 (17.5, 18.6)	0.19
	100-199%	592	20.2 (16.5, 24.5)	21064	21.4 (20.8, 22.0)	
	200-399%	1106	30.9 (27.5,34.6)	41005	28.5 (27.9, 29.1)	

	>400%	1318	29.1 (26.1, 32.4)	57040	32.1 (31.5, 32.6)	
Primary Caregiver Marital Status	Married or living with a partner	2723	73.3 (69.3, 76.9)	107851	77.8 (77.3, 78.3)	0.08
	Never married	193	8.3 (6.3, 10.9)	6391	7.2 (6.9, 7.6)	
	Divorced, separated, or widowed	534	18.4 (15.1, 22.2)	19357	15.0 (14.6, 15.5)	
Highest Level of Caregiver Education	High school or less than high school	509	24.8 (21.2, 28.9)	20546	28.7 (28.1, 29.4)	0.05
	>High school	2941	75.2 (71.1, 78.8)	113053	71.3 (70.6, 71.9)	
Health Insurance Coverage	Any private insurance	2502	60.6 (56.7, 64.4)	102064	64.5 (63.8, 65.1)	0.02
	Public insurance only	827	34.2 (30.5, 38.1)	25653	28.8 (28.1, 29.4)	
	None	121	5.2 (3.5, 7.6)	5882	6.8 (6.4, 7.2)	
ACE Score	0	1609	40.5 (37.1, 44.0)	74919	53.2 (52.6, 53.8)	<0.001
	1	819	25.2 (22.1, 28.7)	30043	23.9 (23.4, 24.4)	
	2-3	690	23.1 (19.9, 26.6)	20141	16.0 (15.6, 16.5)	
	4 or more	332	11.1 (9.1, 13.6)	8496	6.9 (6.6, 7.2)	
Survey Year	2016	718	17.4 (14.8, 20.4)	30392	16.3 (15.9, 16.7)	0.67
	2017	334	16.9 (13.7, 20.5)	13414	16.8 (16.3, 17.4)	
	2018	491	15.7 (13.5, 18.1)	19083	16.8 (16.3, 17.3)	

	2019	494	15.6 (13.4, 18.0)	18454	17.0 (16.5, 17.5)	
	2020	701	16.7 (14.2, 19.6)	26606	16.6 (16.2, 17.1)	
	2021	712	17.7 (15.2, 20.6)	25650	16.4 (16.0, 16.8)	

CI: confidence interval; NH: Non-Hispanic; FPL: Federal Poverty Line; ACE: adverse childhood experiences
[1]Confidence interval calculated using Taylor Series

Table 2. Demographic and Contextual Characteristics Associated with Mental or Behavioral Disorders Among Children 6-17 Years Old with Heart Conditions, National Survey of Children's Health , United States, 2016-2021

		Depression		Anxiety Problems		ADHD		Behavioral or Conduct Problems		≥ 1 Mental or Behavioral Disorder[1]	
Characteristic		Weighted Percent (95% CI[2])	aPR (95% CI)	Weighted Percent (95% CI[2])	aPR (95% CI)	Weighted Percent (95% CI[2])	aPR (95% CI)	Weighted Percent (95% CI[2])	aPR (95% CI)	Weighted Percent (95% CI[2])	aPR (95% CI)
Sex[3]	Male	9.7 (7.5, 12.5)	1.25 (0.87, 1.82)	23.8 (20.4, 27.6)	1.15 (0.91, 1.46)	25.9 (22.5, 29.8)	1.75 (1.24, 2.47)	20.5 (17.4, 23.9)	1.80 (1.32, 2.47)	39.2 (35.3, 43.4)	1.31 (1.07, 1.60)
	Female	7.7 (5.9, 10.0)	ref	20.7 (17.2, 24.7)	ref	14.8 (10.7, 20.1)	ref	11.3 (8.6, 14.8)	ref	30.1 (25.1, 35.5)	ref
Race/ethnicity[3]	NH White	8.9 (7.1, 11.2)	ref	23.4 (20.4, 26.6)	ref	19.6 (16.9, 22.7)	ref	15.8 (13.5, 18.5)	ref	35.4 (31.9, 39.1)	ref
	NH Black	7.3 (4.0, 13.1)	0.82 (0.44, 1.55)	26.8 (18.5, 37.2)	1.15 (0.79, 1.67)	33.7 (24.3, 44.6)	1.72 (1.22, 2.41)	23.5 (15.3, 34.3)	1.48 (0.96, 2.29)	44.9 (35.0, 55.2)	1.27 (0.99, 1.63)
	Hispanic	6.9 (3.8, 12.3)	0.78 (0.41, 1.46)	16.6 (11.2, 23.9)	0.71 (0.47, 1.06)	15.9 (8.8, 27.1)	0.81 (0.45, 1.46)	11.2 (7.1, 17.3)	0.71 (0.44, 1.14)	28.2 (19.6, 38.7)	0.80 (0.56, 1.14)
	Other	14.2 (9.1, 21.5)	1.59 (0.98, 2.60)	22.5 (16.1, 30.7)	0.96 (0.68, 1.37)	18.6 (12.8, 26.4)	0.95 (0.64, 1.41)	18.6 (12.5, 26.6)	1.17 (0.78, 1.77)	31.8 (24.0, 40.9)	0.90 (0.67, 1.20)
Age (years)[3]	6-11 years	3.5 (2.3, 5.4)	ref	17.5 (14.1, 21.4)	ref	16.4 (13.2, 20.2)	ref	16.3 (13.3, 19.9)	ref	27.8 (23.7, 32.4)	ref

		Depression		Anxiety Problems		ADHD		Behavioral or Conduct Problems		≥ 1 Mental or Behavioral Disorder[1]	
Characteristic		**Weighted Percent (95% CI[2])**	**aPR (95% CI)**	**Weighted Percent (95% CI[2])**	**aPR (95% CI)**	**Weighted Percent (95% CI[2])**	**aPR (95% CI)**	**Weighted Percent (95% CI[2])**	**aPR (95% CI)**	**Weighted Percent (95% CI[2])**	**aPR (95% CI)**
	12-17 years	13.9 (11.3, 17.0)	3.97 (2.47, 6.38)	27.1 (23.5, 31.0)	1.55 (1.21, 1.99)	24.6 (20.3, 29.5)	1.50 (1.13, 1.99)	15.7 (12.8, 19.2)	0.97 (0.73, 1.29)	41.6 (37.0, 46.3)	1.49 (1.23, 1.81)
Family Income (FPL)[4]	<100%	12.3 (7.8, 19.0)	2.52 (1.45, 4.38)	23.2 (16.6, 31.5)	1.23 (0.79, 1.89)	24.7 (17.2, 34.2)	1.40 (0.92, 2.14)	19.5 (13.3, 27.7)	1.58 (0.96, 2.61)	35.7 (26.4, 46.1)	1.18 (0.85, 1.65)
	100-199%	13.0 (8.7, 19.1)	2.65 (1.61, 4.37)	25.7 (19.9, 32.6)	1.41 (1.00, 1.98)	20.1 (15.1, 26.4)	1.21 (0.83, 1.76)	21.8 (16.4, 28.4)	1.89 (1.24, 2.88)	37.8 (30.7, 45.4)	1.29 (1.01, 1.66)
	200-399%	6.5 (4.5, 9.2)	1.20 (0.74, 1.95)	22.3 (17.6, 27.8)	1.20 (0.87, 1.64)	21.3 (15.4, 28.8)	1.25 (0.86, 1.83)	14.0 (10.4, 18.6)	1.21 (0.83, 1.77)	35.9 (29.3, 43.0)	1.19 (0.92, 1.53)
	>400%	5.8 (4.2, 7.9)	ref	19.3 (15.7, 23.6)	ref	17.2 (13.7, 21.2)	ref	11.8 (9.0, 15.3)	ref	31.0 (26.4, 35.9)	ref
Primary Caregiver Marital Status[4]	Married or living with a partner	7.3 (5.8, 9.1)	ref	21.2 (18.5, 24.2)	ref	17.4 (14.9, 20.2)	ref	13.9 (11.7, 16.4)	ref	30.9 (27.8, 34.2)	ref
	Never married	8.8 (5.0, 15.1)	1.18 (0.58, 2.40)	22.4 (13.5, 34.8)	0.99 (0.60, 1.65)	25.4 (14.8, 40.1)	1.28 (0.78, 2.11)	22.4 (13.0, 35.9)	1.38 (0.81, 2.35)	41.8 (29.0, 55.9)	1.32 (0.95, 1.84)

		Depression		Anxiety Problems		ADHD		Behavioral or Conduct Problems		≥ 1 Mental or Behavioral Disorder[1]	
Characteristic		**Weighted Percent (95% CI[2])**	**aPR (95% CI)**	**Weighted Percent (95% CI[2])**	**aPR (95% CI)**	**Weighted Percent (95% CI[2])**	**aPR (95% CI)**	**Weighted Percent (95% CI[2])**	**aPR (95% CI)**	**Weighted Percent (95% CI[2])**	**aPR (95% CI)**
	Divorced, separated, or widowed	14.6 (9.7, 21.3)	1.99 (1.29, 3.05)	26.5 (19.7, 34.8)	1.22 (0.90, 1.66)	30.8 (21.5, 42.0)	1.73 (1.18, 2.55)	21.6 (15.5, 29.3)	1.47 (1.02, 2.11)	47.0 (36.2, 58.1)	1.52 (1.17, 1.98)
Highest Level of Caregiver Education[5]	High school or less than high school	10.2 (6.4, 15.7)	1.26 (0.77, 2.05)	23.6 (17.7, 30.7)	1.10 (0.81, 1.50)	20.3 (14.7, 27.4)	0.99 (0.69, 1.40)	19.4 (13.9, 26.5)	1.32 (0.94, 1.87)	34.2 (26.8, 42.6)	0.99 (0.77, 1.27)
	>High school	8.3 (6.8, 10.0)	ref	21.9 (19.2, 24.8)	ref	20.6 (17.5, 24.1)	ref	14.9 (12.8, 17.3)	ref	34.9 (31.5, 38.6)	ref
Health Insurance Coverage[6]	Any private insurance	6.9 (5.5, 8.8)	Ref	20.5 (17.7, 23.6)	ref	18.6 (15.0, 22.8)	ref	12.2 (9.9, 14.9)	ref	32.5 (28.7, 36.6)	ref
	Public insurance only	12.2 (8.9, 16.5)	1.20 (0.76, 1.91)	26.0 20.9, 31.8)	1.22 (0.86, 1.74)	24.8 (19.8, 30.4)	1.28 (0.84, 1.96)	23.4 (18.7, 28.9)	1.75 (1.06, 2.87)	40.1 (33.6, 46.9)	1.24 (0.94, 1.62)
	None	7.1 (3.4, 14.5)	0.77 (0.32, 1.85)	18.9 (10.2, 32.3)	0.90 (0.47, 1.72)	15.2 (7.4, 28.6)	0.79 (0.37, 1.68)	11.5 (5.4, 22.9)	0.88 (0.37, 2.07)	26.2 (14.9, 41.8)	0.81 (0.47, 1.40)
ACE Score[7]	0	3.0 (2.1, 4.3)	ref	12.2 (9.9, 15.0)	ref	9.6 (7.6, 11.9)	ref	7.9 (6.1, 10.3)	Ref	20.2 (17.1, 23.6)	ref

		Depression		Anxiety Problems		ADHD		Behavioral or Conduct Problems		≥ 1 Mental or Behavioral Disorder[1]	
Characteristic		**Weighted Percent (95% CI[2])**	**aPR (95% CI)**	**Weighted Percent (95% CI[2])**	**aPR (95% CI)**	**Weighted Percent (95% CI[2])**	**aPR (95% CI)**	**Weighted Percent (95% CI[2])**	**aPR (95% CI)**	**Weighted Percent (95% CI[2])**	**aPR (95% CI)**
	1	7.0 (5.0, 9.8)	2.31 (1.36, 3.91)	22.4 (17.3, 28.4)	2.03 (1.47, 2.82)	22.2 (15.5, 30.8)	2.31 (1.62, 3.28)	12.6 (9.3, 16.8)	1.58 (1.07, 2.35)	36.5 (29.2, 44.4)	1.85 (1.45, 2.36)
	2-3	13.2 (9.0, 18.8)	4.02 (2.29, 7.07)	29.4 (23.1, 36.6)	2.73 (1.97, 3.78)	26.1 (20.3, 32.8)	2.60 (1.77, 3.82)	20.9 (15.8, 27.1)	2.44 (1.58, 3.77)	42.7 (35.0, 50.8)	2.14 (1.65, 2.77)
	4 or more	24.3 (17.0, 33.3)	6.76 (3.93, 11.61)	44.0 (34.0, 54.4)	4.13 (2.95, 5.79)	45.2 (34.8, 56.0)	4.65 (3.21, 6.71)	43.0 (32.9, 53.7)	5.20 (3.49, 7.77)	67.6 (56.6, 77.0)	3.40 (2.64, 4.37)

ADHD: attention-deficit/hyperactivity disorder; aPR: adjusted prevalence ratio; CI: Confidence Interval; NH: non-Hispanic; FPL: Federal Poverty Level; ACE: adverse childhood experiences;

[1]Any current depression, anxiety problems, ADHD, behavioral or conduct problem, and/or Tourette syndrome

[2]Confidence interval calculated using Taylor Series

[3]Not adjusted for confounders

[4]Adjusted for race/ethnicity and highest level of caregiver education

[5]Adjusted for race/ethnicity

[6]Adjusted for family income

[7]Adjusted for race/ethnicity, age, family income, primary caregiver marital status, highest level of caregiver education, health insurance coverage

Table 3. Demographic and Contextual Characteristics Associated with Developmental Disorders Among Children 6-17 Years Old with Heart Conditions, National Survey of Children's Health, United States, 2016-2021

		AuSD		Developmental Delay		Intellectual Disability		Speech or Other Language Disorder		≥1 Developmental Disorder[1]	
Characteristic		**Weighted Percent (95% CI[2])**	**aPR (95% CI)**	**Weighted Percent (95% CI[2])**	**aPR (95% CI)**	**Weighted Percent (95% CI[2])**	**aPR (95% CI)**	**Weighted Percent (95% CI[2])**	**aPR (95% CI)**	**Weighted Percent (95% CI[2])**	**aPR (95% CI)**
Sex[3]	Male	11.0 (8.4, 14.2)	2.87 (1.49, 5.52)	20.2 (16.9, 23.8)	1.71 (1.26, 2.34)	6.5 (4.5, 9.3)	1.70 (0.96, 3.02)	16.6 (13.6, 20.1)	1.77 (1.27, 2.46)	26.9 (23.3, 30.8)	1.73 (1.32, 2.27)
	Female	3.8 (2.1, 6.9)	ref	11.8 (9.0, 15.2)	ref	3.8 (2.4, 5.9)	ref	9.4 (7.2, 12.2)	ref	15.6 (12.2, 19.6)	ref
Race/ ethnicity[3]	NH White	6.7 (5.0, 9.0)	ref	15.4 (12.8, 18.5)	ref	3.9 (2.8, 5.4)	ref	11.9 (9.7, 14.4)	ref	20.2 (17.3, 23.5)	ref
	NH Black	11.3 (5.5, 22.1)	1.69 (0.79, 3.63)	20.8 (14.1, 29.7)	1.35 (0.89, 2.05)	9.1 (4.7, 17.0)	2.35 (1.13, 4.87)	18.7 (12.0, 27.8)	1.57 (0.99, 2.50)	31.6 (22.7, 42.1)	1.56 (1.11, 2.21)
	Hispanic	8.1 (4.4, 14.6)	1.21 (0.62, 2.38)	14.1 (9.2, 21.0)	0.92 (0.58, 1.44)	6.5 (3.2, 12.9)	1.68 (0.77, 3.66)	12.6 (8.0, 19.2)	1.06 (0.65, 1.71)	18.1 (12.5, 25.4)	0.89 (0.61, 1.32)
	Other	5.7 (2.7, 11.5)	0.85 (0.39, 1.86)	18.4 (12.3, 26.5)	1.19 (0.78, 1.83)	5.0 (2.5, 9.8)	1.30 (0.61, 2.78)	14.6 (9.2, 22.3)	1.22 (0.75, 1.99)	22.7 (15.9, 31.3)	1.12 (0.77, 1.63)
Age (years)[3]	6-11 years	5.3 (3.8, 7.5)	ref	16.9 (13.8, 20.5)	ref	4.0 (2.5, 6.1)	ref	15.5 (12.5, 19.1)	ref	22.4 (18.8, 26.5)	ref

Characteristic		AuSD		Developmental Delay		Intellectual Disability		Speech or Other Language Disorder		≥1 Developmental Disorder[1]	
		Weighted Percent (95% CI[2])	aPR (95% CI)	Weighted Percent (95% CI[2])	aPR (95% CI)	Weighted Percent (95% CI[2])	aPR (95% CI)	Weighted Percent (95% CI[2])	aPR (95% CI)	Weighted Percent (95% CI[2])	aPR (95% CI)
	12-17 years	9.6 (6.9, 13.4)	1.80 (1.12, 2.91)	15.2 (12.2, 18.9)	0.90 (0.67, 1.21)	6.4 (4.4, 9.2)	1.62 (0.91, 2.87)	10.7 (8.2, 13.8)	0.69 (0.49, 0.96)	20.3 (16.8, 24.4)	0.91 (0.70, 1.17)
Family Income (% FPL)[4]	<100%	11.0 (6.1, 19.2)	1.82 (0.86, 3.85)	21.3 (14.6, 29.9)	1.47 (0.89, 2.43)	6.1 (3.3, 10.9)	1.29 (0.52, 3.18)	10.8 (7.0, 16.2)	0.82 (0.44, 1.52)	26.8 (18.9, 36.4)	1.28 (0.82, 2.00)
	100-199%	10.0 (6.3, 15.6)	1.71 (0.83, 3.49)	21.9 (16.3, 28.8)	1.58 (1.02, 2.46)	8.3 (4.7, 14.4)	1.87 (0.78, 4.46)	18.6 (13.4, 25.3)	1.51 (0.88, 2.60)	26.9 (20.9, 33.9)	1.37 (0.95, 1.99)
	200-399%	6.0 (3.4, 10.3)	1.16 (0.56, 2.37)	11.8 (8.6, 16.0)	0.89 (0.60, 1.34)	3.9 (2.0, 7.6)	0.96 (0.43, 2.13)	12.6 (9.1, 17.2)	1.07 (0.68, 1.68)	18.0 (13.9, 22.9)	0.99 (0.71, 1.39)
	>400%	4.9 (3.2, 7.6)	ref	13.0 (9.9, 16.9)	ref	3.8 (2.2, 6.3)	ref	11.4 (8.3, 15.4)	ref	17.5 (13.9, 21.9)	ref
Primary Caregiver Marital Status[4]	Married or living with a partner	6.4 (4.8, 8.5)	ref	15.4 (13.0, 18.1)	ref	5.2 (3.6, 7.2)	ref	13.8 (11.5,16.5)	ref	20.5 (17.8, 23.4)	ref
	Never married	11.1 (4.2, 26.6)	1.39 (0.59, 3.32)	18.9 (10.6, 31.6)	1.01 (0.52, 1.96)	3.5 (1.3, 9.1)	0.47 (0.14, 1.57)	11.3 (5.8, 20.7)	0.64 (0.31, 1.33)	28.5 (17.0, 43.6)	1.11 (0.67, 1.85)

Characteristic		AuSD		Developmental Delay		Intellectual Disability		Speech or Other Language Disorder		≥1 Developmental Disorder[1]	
		Weighted Percent (95% CI[2])	aPR (95% CI)	Weighted Percent (95% CI[2])	aPR (95% CI)	Weighted Percent (95% CI[2])	aPR (95% CI)	Weighted Percent (95% CI[2])	aPR (95% CI)	Weighted Percent (95% CI[2])	aPR (95% CI)
	Divorced, separated, or widowed	10.1 (5.8, 16.9)	1.42 (0.79, 2.56)	17.5 (11.9, 25.0)	1.05 (0.70, 1.56)	6.1 (3.4, 10.6)	1.06 (0.58, 1.96)	11.2 (7.4, 16.5)	0.75 (0.49, 1.16)	21.7 (15.4, 29.6)	0.97 (0.68, 1.37)
Highest Parental Education[5]	High school or less than high school	11.0 (6.6, 18.0)	1.70 (0.95, 3.07)	21.4 (15.6, 28.6)	1.49 (1.04, 2.14)	6.7 (3.9, 11.2)	1.33 (0.69, 2.57)	14.9 (10.5, 20.8)	1.17 (0.79, 1.74)	28.2 (21.2, 36.3)	1.47 (1.09, 1.99)
	>High school	6.3 (4.8, 8.3)	ref	14.3 (12.1, 16.8)	ref	4.7 (3.4, 6.5)	ref	12.5 (10.4, 15.0)	ref	19.1 (16.6, 21.9)	ref
Insurance Coverage[6]	Any private insurance	6.4 (4.4, 9.2)	ref	12.2 (9.9, 14.9)	ref	4.5 (3.0, 6.8)	ref	11.8 (9.5, 14.6)	ref	17.9 (15.0, 21.1)	ref
	Public insurance only	10.2 (7.1, 14.3)	1.06 (0.45, 2.48)	23.4 (18.5, 29.1)	1.65 (1.09, 2.50)	7.0 (4.6, 10.3)	1.08 (0.44, 2.65)	16.6 (12.8, 21.3)	1.41 (0.86, 2.33)	28.6 (23.2, 34.7)	1.39 (0.95, 2.04)
	None	3.0 (1.1, 7.6)	0.33 (0.10, 1.14)	13.0 (5.9, 26.2)	0.95 (0.41, 2.22)	1.0 (0.2, 5.4)	0.17 (0.03, 1.15)	5.2 (2.0, 12.8)	0.45 (0.16, 1.26)	14.7 (7.0, 28.0)	0.73 (0.33, 1.61)
ACE Scores[7]	0	3.2 (2.1, 4.6)	ref	10.7 (8.3, 13.6)	ref	2.9 (1.9, 4.3)	ref	10.9 (8.4, 13.9)	ref	15.1 (12.3, 18.5)	ref

		AuSD		Developmental Delay		Intellectual Disability		Speech or Other Language Disorder		≥1 Developmental Disorder[1]	
Characteristic		**Weighted Percent (95% CI[2])**	**aPR (95% CI)**	**Weighted Percent (95% CI[2])**	**aPR (95% CI)**	**Weighted Percent (95% CI[2])**	**aPR (95% CI)**	**Weighted Percent (95% CI[2])**	**aPR (95% CI)**	**Weighted Percent (95% CI[2])**	**aPR (95% CI)**
	1	7.7 (4.7, 12.5)	2.25 (1.21, 4.20)	16.2 (12.0, 21.5)	1.50 (1.01, 2.22)	6.3 (3.5, 11.0)	1.92 (0.91, 4.09)	12.6 (8.8, 17.5)	1.11 (0.71, 1.74)	20.2 (15.5, 25.9)	1.32 (0.95, 1.84)
	2-3	9.8 (6.2, 15.1)	2.80 (1.40, 5.62)	19.7 (14.7, 26.0)	1.66 (1.09, 2.54)	7.9 (4.6, 13.3)	2.40 (1.16, 4.98)	19.3 (14.1, 25.9)	1.75 (1.14, 2.67)	27.0 (20.9, 34.0)	1.64 (1.16, 2.32)
	4 or more	18.1 (10.3, 29.8)	5.10 (2.74, 9.50)	27.9 (19.3, 38.6)	2.37 (1.50, 3.73)	5.6 (3.2, 9.6)	1.81 (0.78, 4.19)	9.5 (5.9, 15.0)	0.95 (0.52, 1.73)	35.2 (25.3, 46.5)	2.20 (1.50, 3.25)

AuSD: autism spectrum disorder; aPR: adjusted prevalence ratio; CI: Confidence Interval; NH: non-Hispanic; FPL: Federal Poverty Level, ACE: adverse childhood experiences;

[1]Any current AuSD, developmental delay, intellectual disability, and/or speech or other language disorder

[2]Confidence interval calculated using Taylor Series

[3]Not adjusted for confounders

[4]Adjusted for race/ethnicity and highest level of caregiver education

[5]Adjusted for race/ethnicity

[6]Adjusted for family income

[7]Adjusted for race/ethnicity, age, family income, primary caregiver marital status, highest level of caregiver education, health insurance coverage

Supplemental Table 1. Characteristics of Children 6-17 Years Old by Heart Condition Status and Inclusion in the Analytic Sample, National Survey of Children's Health, United States, 2016-2021

		Heart Condition					No Heart Condition				
		Included		Excluded			Included		Excluded		
Characteristic		N	Weighted Percent (95% CI[1])	N	Weighted Percent (95% CI[1])	Chi-square p-value	N	Weighted Percent (95% CI[1])	N	Weighted Percent (95% CI[1])	Chi-square p-value
Sex	Male	1899	51.3 (47.6, 55.0)	216	63.6 (53.3, 72.8)	0.03	68963	51.2 (50.5, 51.8)	8784	50.2 (48.4, 52.0)	0.30
	Female	1551	48.7 (45.0, 52.4)	135	36.4 (27.2, 46.7)		64636	48.8 (48.2, 49.5)	8266	49.8 (48.0, 51.6)	
Race/ethnicity	NH White	2487	58.0 (54.2, 61.8)	217	42.1 (32.8, 52.1)	0.02	92375	51.7 (51.1, 52.3)	10275	39.3 (37.7, 40.8)	<0.001
	NH Black	216	12.5 (10.3, 15.1)	41	24.2 (16.6, 33.8)		8212	12.9 (12.5, 13.4)	1803	19.4 (18.1, 20.8)	
	Hispanic	370	21.2 (17.7, 25.3)	47	22.6 (13.0, 36.2)		15990	25.0 (24.3, 25.6)	2577	31.3 (29.3, 33.3)	
	Other	377	8.2 (6.7, 10.0)	46	11.1 (5.3, 21.7)		17022	10.4 (10.1, 10.7)	2395	10.0 (9.3, 10.9)	
Age (years)	6-11 years	1450	49.8 (46.1, 53.4)	144	51.9 (41.4, 62.2)	0.72	58142	50.0 (49.4, 50.6)	7035	46.9 (45.1, 48.7)	0.002
	12-17 years	2000	50.2 (46.6, 53.9)	207	48.1 (37.8, 58.6)		75457	50.0 (49.4, 50.6)	10015	53.1 (51.3, 54.9)	
Family Income (% FPL)	<100%	434	19.7 (15.8, 24.3)	68	32.0 (21.2, 45.2)	0.02	14490	18.1 (17.5, 18.6)	3143	28.6 (26.5, 30.7)	<0.001
	100-199%	592	20.2 (16.5, 24.5)	74	30.4 (20.5, 42.5)		21064	21.4 (20.8, 22.0)	3433	24.7 (22.9, 26.6)	

		Heart Condition					No Heart Condition				
		Included		Excluded			Included		Excluded		
Characteristic		**N**	**Weighted Percent (95% CI[1])**	**N**	**Weighted Percent (95% CI[1])**	**Chi-square p-value**	**N**	**Weighted Percent (95% CI[1])**	**N**	**Weighted Percent (95% CI[1])**	**Chi-square p-value**
	200-399%	1106	30.9 (27.5, 34.6)	112	19.8 (13.3, 28.3)		41005	28.5 (27.9, 29.1)	4672	23.5 (21.9,25.2)	
	>400%	1318	29.1 (26.1, 32.4)	97	17.8 (12.0, 25.6)		57040	32.1 (31.5, 32.6)	5802	23.2 (21.9,24.6)	
Primary Caregiver Marital Status	Missing			73		0.32			4279		0.002
	Married or living with a partner	2723	73.3 (69.3, 76.9)	201	66.3 (55.1, 75.9)		107851	77.8 (77.3, 78.3)	9709	74.5 (72.8,76.2)	
	Never married	193	8.3 (6.3, 10.9)	26	13.5 (7.8, 22.3)		6391	7.2 (6.9, 7.6)	843	8.3 (7.3,9.4)	
	Divorced, separated, or widowed	534	18.4 (15.1, 22.2)	51	20.2 (13.0, 30.0)		19357	15.0 (14.6, 15.5)	2219	17.2 (15.8,18.7)	
Highest Level of Caregiver Education	Missing			16		<0.001			857		<0.001
	High school or less than high school	509	24.8 (21.2, 28.9)	90	51.6 (40.9, 62.1)		20546	28.7 (28.1, 29.4)	4013	42.4 (40.4, 44.3)	
	>High school	2941	75.2 (71.1, 78.8)	245	48.4 (37.9, 59.1)		113053	71.3 (70.6, 71.9)	12180	57.6 (55.7, 59.6)	

		Heart Condition					No Heart Condition				
		Included		Excluded			Included		Excluded		
Characteristic		**N**	**Weighted Percent (95% CI[1])**	**N**	**Weighted Percent (95% CI[1])**	**Chi-square p-value**	**N**	**Weighted Percent (95% CI[1])**	**N**	**Weighted Percent (95% CI[1])**	**Chi-square p-value**
Health Insurance Coverage	Missing			47		0.09			2491		<0.001
	Any private insurance	2502	60.6 (56.7, 64.4)	195	45.6 (34.7, 57.0)		102064	64.5 (63.8, 65.1)	9687	51.9 (49.9, 53.8)	
	Public insurance only	827	34.2 (30.5, 38.1)	88	41.3 (29.5, 54.2)		25653	28.8 (28.1, 29.4)	3846	37.5 (35.5, 39.5)	
	None	121	5.2 (3.5, 7.6)	21	13.1 (5.9, 26.3)		5882	6.8 (6.4, 7.2)	1026	10.7 (9.3, 12.1)	
ACE Score	Missing			190		0.34			9133		<0.001
	0	1609	40.5 (37.1, 44.0)	69	45.9 (29.7, 63.0)		74919	53.2 (52.6, 53.8)	3790	46.7 (44.1, 49.4)	
	1	819	25.2 (22.1, 28.7)	38	26.0 (14.3, 42.6)		30043	23.9 (23.4, 24.4)	1939	24.5 (22.4, 26.8)	
	2-3	690	23.1 (19.9, 26.6)	36	14.4 (8.5, 23.4)		20141	16.0 (15.6, 16.5)	1435	17.9 (16.0, 19.9)	
	4 or more	332	11.1 (9.1, 13.6)	18	13.7 (6.4, 26.9)		8496	6.9 (6.6, 7.2)	753	10.8 (9.2, 12.8)	
Survey Year	2016	718	17.4 (14.8, 20.4)	92	26.1 (16.8, 38.2)	0.52	30392	16.3 (15.9, 16.7)	4311	18.5 (17.4, 19.7)	<0.001
	2017	334	16.9 (13.7, 20.5)	25	10.5 (5.3, 19.8)		13414	16.8 (16.3, 17.4)	1590	15.7 (14.2, 17.4)	

		Heart Condition					No Heart Condition				
		Included		Excluded			Included		Excluded		
Characteristic		**N**	**Weighted Percent (95% CI[1])**	**N**	**Weighted Percent (95% CI[1])**	**Chi-square p-value**	**N**	**Weighted Percent (95% CI[1])**	**N**	**Weighted Percent (95% CI[1])**	**Chi-square p-value**
	2018	491	15.7 (13.5, 18.1)	45	16.4 (9.5, 26.6)		19083	16.8 (16.3, 17.3)	2219	16.5 (15.1, 17.9)	
	2019	494	15.6 (13.4, 18.0)	46	14.5 (8.5, 23.6)		18454	17.0 (16.5, 17.5)	2164	15.0 (13.8, 16.3)	
	2020	701	16.7 (14.2, 19.6)	71	14.0 (9.6, 20.2)		26606	16.6 (16.2, 17.1)	3141	16.7 (15.4, 18.0)	
	2021	712	17.7 (15.2, 20.6)	72	18.5 (12.7, 26.2)		25650	16.4 (16.0, 16.8)	3625	17.6 (16.4, 18.9)	
Ever had a Special Education or Early Intervention Plan	Missing	7		5		0.99	331		326		0.23
	Yes	1101	30.9 (27.8, 34.2)	124	30.9 (22.5, 40.6)		22314	15.5 (15.1, 16.0)	3044	16.4 (15.1, 17.8)	
	No	2342	69.1 (65.8, 72.2)	222	69.1 (59.4, 77.5)		110954	84.5 (84.0, 84.9)	13680	83.6 (82.2, 84.9)	
Took Medication in the Past Year for Emotions, Concentration, or Behavior	Missing	35		10		0.58	1417		554		0.002
	Yes	625	16.6 (14.4, 19.1)	74	18.7 (12.7, 26.6)		15157	9.1 (8.8, 9.4)	2215	10.5 (9.7, 11.5)	

		Heart Condition					No Heart Condition				
		Included		Excluded			Included		Excluded		
Characteristic		**N**	**Weighted Percent (95% CI[1])**	**N**	**Weighted Percent (95% CI[1])**	**Chi-square p-value**	**N**	**Weighted Percent (95% CI[1])**	**N**	**Weighted Percent (95% CI[1])**	**Chi-square p-value**
	No	2790	83.4 (80.9, 85.6)	267	81.3 (73.4, 87.3)		117025	90.9 (90.6, 91.2)	14281	89.5 (88.5, 90.3)	
Received Treatment or Counseling from a Mental Health Professional	Missing	8		7		0.71	403		333		0.002
	Yes	769	20.6 (18.1, 23.4)	93	20.7 (14.5, 28.7)		19280	12.1 (11.7, 12.4)	2614	11.9 (11.0, 12.9)	
	No, but needed	142	4.2 (3.1, 5.5)	15	7.5 (2.5, 20.3)		3255	2.5 (2.3, 2.7)	549	4.0 (3.3, 4.9)	
	No, but not needed	2531	75.2 (72.3, 78.0)	236	71.8 (61.4, 80.3)		110661	85.4 (85.0, 85.8)	13554	84.1 (82.8, 85.2)	
Genetic or Inherited Condition	Missing	11		3		0.41	385		217		0.78
	Yes	526	13.6 (11.6, 15.8)	66	17.0 (10.5, 26.5)		5780	3.9 (3.7, 4.1)	716	3.8 (3.2, 4.4)	
	No	2913	86.4 (84.2, 88.4)	282	83.0 (73.5, 89.5)		127434	96.1 (95.9, 96.3)	16117	96.2 (95.6, 96.8)	
Depression	Missing			16		0.51			668		0.34
	Yes	384	8.7 (7.2, 10.5)	39	11.6 (5.5, 22.8)		7412	4.3 (4.1, 4.6)	926	4.7 (4.0, 5.5)	

		Heart Condition					No Heart Condition				
		Included		Excluded			Included		Excluded		
Characteristic		**N**	**Weighted Percent (95% CI[1])**	**N**	**Weighted Percent (95% CI[1])**	**Chi-square p-value**	**N**	**Weighted Percent (95% CI[1])**	**N**	**Weighted Percent (95% CI[1])**	**Chi-square p-value**
	No	3066	91.3 (89.5 ,92.8)	296	88.4 (77.2, 94.5)		126187	95.7 (95.4, 95.9)	15456	95.3 (94.5, 96.0)	
Anxiety Problems	Missing			29		0.92			1095		<0.001
	Yes	863	22.3 (19.8, 25.0)	88	21.8 (14.0, 32.3)		16725	9.7 (9.4, 10.1)	1692	7.9 (7.1, 8.7)	
	No	2587	77.7 (75.0, 80.2)	234	78.2 (67.7, 86.0)		116874	90.3 (89.9, 90.6)	14263	92.1 (91.3, 92.9)	
ADHD	Missing			28		0.69			1460		0.21
	Yes	713	20.5 (17.7, 23.6)	78	22.2 (15.4, 30.8)		16062	10.4 (10.0, 10.7)	2047	11.0 (10.1, 12.0)	
	No	2737	79.5 (76.4, 82.3)	245	77.8 (69.2, 84.6)		117537	89.6 (89.3, 90.0)	13543	89.0 (88.0, 89.9)	
Behavioral or Conduct Problems	Missing			20		0.18			740		0.84
	Yes	583	16.0 (13.9, 18.4)	69	21.7 (14.7, 30.9)		10793	7.7 (7.4, 8.0)	1375	7.8 (7.0, 8.7)	
	No	2867	84.0 (81.6, 86.1)	262	78.3 (69.1, 85.3)		122806	92.3 (92.0, 92.6)	14935	92.2 (91.3, 93.0)	
Tourette Syndrome	Missing			8		0.001			483		0.63
	Yes	26	0.8 (0.4, 1.3)	0	0.0 (.,.)		391	0.2 (0.2, 0.3)	46	0.3 (0.1, 0.9)	

		Heart Condition					No Heart Condition				
		Included		Excluded			Included		Excluded		
Characteristic		**N**	**Weighted Percent (95% CI[1])**	**N**	**Weighted Percent (95% CI[1])**	**Chi-square p-value**	**N**	**Weighted Percent (95% CI[1])**	**N**	**Weighted Percent (95% CI[1])**	**Chi-square p-value**
	No	3424	99.3 (98.7, 99.6)	343	100.0 (.,.)		133208	99.8 (99.7, 99.8)	16521	99.7 (99.2, 99.9)	
≥1 Mental or Behavioral Disorder[2]	Missing			51		0.31			2753		<0.001
	Yes	1293	34.8 (31.5, 38.2)	141	40.9 (30.1, 52.6)		29396	18.7 (18.3, 19.2)	3671	22.1 (20.7, 23.6)	
	No	2157	65.2 (61.8, 68.5)	159	59.1 (47.4, 69.9)		104203	81.3 (80.8, 81.7)	10626	77.9 (76.4, 79.3)	
AuSD	Missing			15		0.59			735		0.36
	Yes	250	7.5 (5.8, 9.6)	29	9.1 (4.9, 16.3)		4121	3.0 (2.8, 3.2)	534	2.7 (2.2, 3.3)	
	No	3200	92.5 (90.4, 94.2)	307	90.9 (83.7, 95.1)		129478	97.0 (96.8, 97.2)	15781	97.3 (96.7, 97.8)	
Developmental Delay	Missing			21		0.94			697		0.42
	Yes	538	16.1 (13.8, 18.6)	64	16.3 (10.7, 24.0)		6620	4.9 (4.6, 5.1)	879	5.2 (4.5, 6.2)	
	No	2912	83.9 (81.4, 86.2)	266	83.7 (76.0, 89.3)		126979	95.1 (94.9, 95.4)	15474	94.8 (93.8, 95.5)	
Intellectual Disability	Missing			12		0.33			558		0.08

		Heart Condition					No Heart Condition				
		Included		Excluded			Included		Excluded		
Characteristic		**N**	**Weighted Percent (95% CI[1])**	**N**	**Weighted Percent (95% CI[1])**	**Chi-square p-value**	**N**	**Weighted Percent (95% CI[1])**	**N**	**Weighted Percent (95% CI[1])**	**Chi-square p-value**
	Yes	163	5.2 (3.9, 6.9)	20	3.7 (1.8, 7.4)		1310	1.0 (0.9, 1.2)	212	1.5 (1.1, 2.0)	
	No	3287	94.8 (93.1, 96.1)	319	96.3 (92.6, 98.2)		132289	99.0 (98.8, 99.1)	16280	98.5 (98.0, 98.9)	
Speech or Other Language Disorder	Missing			17		0.48			617		0.57
	Yes	417	13.1 (11.1, 15.4)	52	15.9 (9.7, 25.0)		5835	4.7 (4.4, 4.9)	748	4.9 (4.1, 5.9)	
	No	3033	86.9 (84.6, 88.9)	282	84.1 (75.0, 90.3)		127764	95.3 (95.1, 95.6)	15685	95.1 (94.1, 95.9)	
≥1 Developmental Disorder[3]	Missing			41		0.15			2036		0.03
	Yes	711	21.4 (18.8, 24.2)	85	28.7 (20.2, 39.0)		10925	8.3 (8.0, 8.6)	1481	9.6 (8.5, 10.8)	
	No	2739	78.6 (75.8, 81.2)	225	71.3 (61.0, 79.8)		122674	91.7 (91.4, 92.0)	13533	90.4 (89.2, 91.5)	
≥1 MBDD[4]	Yes	1512	42.0 (38.5, 45.5)	168	45.2 (34.9, 55.9)	0.58	33308	22.0 (21.5, 22.5)	4185	21.6 (20.3, 23.0)	0.62
	No	1938	58.0 (54.5, 61.5)	183	54.8 (44.1, 65.1)		100291	78.0 (77.5, 78.5)	12865	78.4 (77.0, 79.7)	

aPR: adjusted prevalence ratio; CI: Confidence Interval; NH: non-Hispanic; FPL: Federal Poverty Level; ACE: adverse childhood experiences; ADHD: attention-deficit/hyperactivity disorder; AuSD: autism spectrum disorder; MBDD: Mental, behavioral or developmental disorder

[1]Confidence interval calculated using Taylor Series
[2]Any current depression, anxiety problems, ADHD, behavioral or conduct problems, or Tourette syndrome
[3]Any current AuSD, developmental delay, intellectual disability, and/or speech or other language disorder
[4]Any current depression, anxiety problems, ADHD, behavioral or conduct problems, Tourette syndrome, AuSD, developmental delay, intellectual disability, and/or speech or other language disorder

Supplemental Table 2. Prevalence of MBDDs Among Children 6-17 Years Old with and Without Heart Conditions, National Survey of Children's Health, United States, 2016-2021 (Sensitivity Analysis Excluding children with Any Genetic Condition in Addition to Down Syndrome)

	Heart Condition		No Heart Condition		
Characteristic	**N**	**Weighted Percent (95% CI[2])**	**N**	**Weighted Percent (95% CI[2])**	**aPR (Heart Condition v. No Heart Condition)[1] (95% CI)**
≥1 MBDD[3]	1120	36.1 (32.5, 39.8)	29639	20.3 (19.9, 20.8)	1.73 (1.56, 1.93)
Depression	273	6.8 (5.4, 8.6)	6567	4.0 (3.7, 4.2)	1.67 (1.31, 2.13)
Anxiety Problems	628	18.6 (16.1, 21.4)	14795	8.9 (8.6, 9.2)	2.02 (1.74, 2.34)
ADHD	534	17.7 (14.9, 21.0)	13965	9.3 (9.0, 9.7)	1.85 (1.54, 2.21)
Behavioral or Conduct Problems	395	12.3 (10.4, 14.5)	9045	6.8 (6.5, 7.1)	1.77 (1.49, 2.09)
Tourette syndrome	14	0.5 (0.2, 1.1)	337	0.2 (0.2, 0.3)	2.24 (0.96, 5.23)

	Heart Condition		No Heart Condition		
Characteristic	**N**	**Weighted Percent (95% CI[2])**	**N**	**Weighted Percent (95% CI[2])**	**aPR (Heart Condition v. No Heart Condition)[1] (95% CI)**
≥1 Mental or Behavioral Disorder[4]	965	29.7 (26.3, 33.2)	26191	17.4 (16.9, 17.8)	1.66 (1.47, 1.88)
AuSD	148	5.5 (4.0, 7.5)	3193	2.4 (2.2, 2.7)	2.24 (1.63, 3.09)
Developmental Delay	301	11.6 (9.5, 14.2)	5129	4.0 (3.8, 4.3)	2.87 (2.34, 3.53)
Intellectual Disability	63	2.7 (1.6, 4.4)	846	0.7 (0.6, 0.9)	3.92 (2.36, 6.52)
Speech or Other Language Disorder	247	10.2 (8.3, 12.6)	4756	4.0 (3.8, 4.3)	2.50 (2.01, 3.10)
≥1 Developmental Disorder[5]	448	16.6 (14.1, 19.5)	8927	7.2 (6.9, 7.5)	2.28 (1.94, 2.68)

aPR: adjusted prevalence ratio; CI: confidence interval; MBDD: mental, behavioral or developmental disorder; ADHD: attention-deficit/hyperactivity disorder; AuSD: autism spectrum disorder

[1]Adjusted for child's sex, race/ethnicity, income, and the highest level of education in the household

[2]Confidence interval calculated using Taylor Series

[3]Any current depression, anxiety problems, ADHD, behavioral or conduct problems, Tourette syndrome, AuSD, developmental delay, intellectual disability, and/or speech or other language disorder

[4]Any current depression, anxiety problems, ADHD, behavioral or conduct problems, and/or Tourette syndrome

[5]Any current AuSD, developmental delay, intellectual disability, and/or speech or other language disorder

Supplemental Table 3. Demographic and Contextual Characteristics Associated with Mental or Behavioral Disorders Among Children 6-17 Years Old with Heart Conditions, National Survey of Children's Health, United States, 2016-2021 (Sensitivity Analysis Excluding children with Any Genetic Condition in Addition to Down Syndrome)

		Depression		Anxiety Problems		ADHD		Behavioral or Conduct Problems		≥ 1 Mental or Behavioral Disorder[1]	
Characteristic		Weighted Percent (95% CI[2])	aPR (95% CI)	Weighted Percent (95% CI[2])	aPR (95% CI)	Weighted Percent (95% CI[2])	aPR (95% CI)	Weighted Percent (95% CI[2])	aPR (95% CI)	Weighted Percent (95% CI[2])	aPR (95% CI)
Sex[3]	Male	8.4 (6.0, 11.4)	1.59 (1.02, 2.46)	20.4 (16.9, 24.4)	1.22 (0.91, 1.62)	22.8 (19.2 ,26.8)	1.83 (1.20, 2.81)	16.7 (13.8, 20.2)	2.20 (1.54, 3.14)	34.4 (30.2, 38.8)	1.39 (1.08, 1.79)
	Female	5.3 (3.9, 7.1)	ref	16.7 (13.4, 20.7)	ref	12.4 (8.3, 18.2)	ref	7.6 (5.6, 10.2)	ref	24.7 (19.7, 30.5)	ref
Race/ ethnicity[3]	NH White	7.5 (5.7, 9.9)	ref	20.6 (17.6, 24.0)	ref	17.5 (14.6, 20.8)	ref	12.6 (10.3, 15.2)	ref	30.9 (27.2, 34.9)	ref
	NH Black	6.3 (3.1, 12.4)	0.84 (0.40, 1.78)	24.0 (16.0, 34.5)	1.17 (0.77, 1.77)	27.6 (19.1, 37.9)	1.58 (1.07, 2.32)	17.7 (11.5, 26.2)	1.41 (0.89, 2.22)	37.4 (27.9, 47.9)	1.21 (0.90, 1.63)
	Hispanic	4.1 (1.7, 9.3)	0.54 (0.22, 1.32)	11.0 (6.4, 18.2)	0.53 (0.31, 0.92)	13.5 (6.2, 26.7)	0.77 (0.36, 1.64)	7.5 (4.0, 13.4)	0.59 (0.32, 1.12)	23.7 (14.8, 35.5)	0.76 (0.48, 1.21)
	Other	10.2 (5.9, 17.0)	1.36 (0.75, 2.46)	16.2 (10.6, 24.1)	0.79 (0.51, 1.22)	16.2 (10.1, 24.8)	0.92 (0.57, 1.50)	14.8 (9.1, 23.2)	1.18 (0.71, 1.96)	25.1 (17.6, 34.3)	0.81 (0.57, 1.16)

		Depression		Anxiety Problems		ADHD		Behavioral or Conduct Problems		≥ 1 Mental or Behavioral Disorder[1]	
Characteristic		**Weighted Percent (95% CI[2])**	**aPR (95% CI)**	**Weighted Percent (95% CI[2])**	**aPR (95% CI)**	**Weighted Percent (95% CI[2])**	**aPR (95% CI)**	**Weighted Percent (95% CI[2])**	**aPR (95% CI)**	**Weighted Percent (95% CI[2])**	**aPR (95% CI)**
Age (years)[3]	6-11 years	2.4 (1.4, 4.1)	ref	13.6 (10.5, 17.3)	ref	14.6 (11.5, 18.4)	ref	13.8 (10.9, 17.3)	ref	23.6 (19.5, 28.1)	ref
	12-17 years	11.5 (8.9, 14.7)	4.85 (2.63, 8.95)	23.8 (20.1, 28.1)	1.76 (1.30, 2.37)	21.0 (16.5, 26.4)	1.44 (1.03, 2.02)	10.7 (8.4, 13.6)	0.78 (0.56, 1.09)	36.0 (31.1, 41.3)	1.53 (1.21, 1.92)
Family Income (% FPL)[4]	<100%	8.5 (4.5, 15.6)	1.97 (0.99, 3.91)	18.6 (12.1, 27.5)	1.09 (0.63, 1.88)	20.8 (13.6, 30.5)	1.36 (0.80, 2.30)	15.3 (10.0, 22.8)	1.77 (0.91, 3.43)	29.0 (20.2, 39.7)	1.11 (0.73, 1.69)
	100-199%	10.3 (6.3, 16.2)	2.51 (1.42, 4.43)	21.0 (15.2, 28.3)	1.32 (0.86, 2.02)	17.3 (12.3, 23.9)	1.19 (0.76, 1.86)	17.7 (12.4, 24.6)	2.20 (1.26, 3.85)	32.0 (24.9, 40.1)	1.25 (0.92, 1.71)
	200-399%	5.8 (3.7, 8.9)	1.34 (0.76, 2.37)	19.0 (14.4, 24.7)	1.20 (0.83, 1.75)	18.4 (12.1, 26.9)	1.24 (0.78, 1.97)	10.4 (7.5, 14.3)	1.28 (0.79, 2.06)	31.0 (24.0, 39.0)	1.19 (0.87, 1.62)
	>400%	4.6 (3.2, 6.4)	ref	16.5 (12.9, 20.9)	ref	15.3 (11.8, 19.7)	ref	8.5 (5.9, 12.2)	ref	27.2 (22.5, 32.4)	ref
Primary Caregiver Marital Status[4]	Married or living with a partner	5.4 (4.1, 7.2)	ref	17.3 (14.6, 20.2)	ref	15.3 (12.8, 18.1)	ref	11.2 (9.1, 13.5)	ref	26.3 (23.2, 29.7)	ref

		Depression		Anxiety Problems		ADHD		Behavioral or Conduct Problems		≥ 1 Mental or Behavioral Disorder[1]	
Characteristic		**Weighted Percent (95% CI[2])**	**aPR (95% CI)**	**Weighted Percent (95% CI[2])**	**aPR (95% CI)**	**Weighted Percent (95% CI[2])**	**aPR (95% CI)**	**Weighted Percent (95% CI[2])**	**aPR (95% CI)**	**Weighted Percent (95% CI[2])**	**aPR (95% CI)**
	Never married	5.8 (3.0, 10.9)	0.98 (0.43, 2.23)	20.3 (11.0, 34.5)	1.10 (0.61, 1.97)	17.8 (9.2, 31.5)	1.03 (0.55, 1.95)	15.8 (9.2, 25.6)	1.17 (0.63, 2.19)	34.3 (22.2, 48.9)	1.30 (0.87, 1.94)
	Divorced, separated, or widowed	13.3 (8.2, 20.9)	2.23 (1.40, 3.93)	23.4 (16.3, 32.4)	1.30 (0.90, 1.89)	28.0 (17.7, 41.2)	1.81 (1.11, 2.94)	15.4 (10.1, 22.8)	1.28 (0.80, 2.04)	41.5 (29.7, 54.2)	1.58 (1.13, 2.21)
Highest Level of Caregiver Education[5]	High school or less than high school	8.9 (5.1, 15.0)	1.52 (0.85, 2.72)	21.0 (15.0, 28.7)	1.25 (0.87, 1.79)	17.3 (12.0, 24.2)	0.98 (0.64, 1.50)	15.4 (10.5, 22.1)	1.43 (0.95, 2.14)	28.7 (21.5, 37.1)	0.98 (0.72, 1.33)
	>High school	6.2 (4.9, 7.7)	ref	17.8 (15.2, 20.7)	ref	17.9 (14.6, 21.7)	ref	11.2 (9.4, 13.4)	ref	30.0 (26.4, 33.9)	ref
Health Insurance Coverage[6]	Any private insurance	5.5 (4.2, 7.2)	Ref	17.6 (14.8, 20.8)	ref	16.0 (12.4, 20.5)	ref	8.2 (6.6, 10.2)	ref	27.6 (23.6, 31.9)	ref
	Public insurance only	9.8 (6.6, 14.5)	1.34 (0.81, 2.23)	20.9 (16.0, 27.0)	1.17 (0.75, 1.83)	21.6 (16.6, 27.6)	1.38 (0.85, 2.22)	20.4 (15.6, 26.2)	2.47 (1.49, 4.10)	34.6 (27.9, 41.9)	1.35 (0.97, 1.87)
	None	3.3 (1.4, 7.7)	0.48 (0.18, 1.24)	15.7 (7.8, 28.9)	0.88 (0.41, 1.87)	13.1 (5.8, 27.2)	0.82 (0.35, 1.96)	7.7 (2.9, 18.9)	0.94 (0.33, 2.70)	22.7 (12.2, 38.5)	0.88 (0.48, 1.62)

		Depression		Anxiety Problems		ADHD		Behavioral or Conduct Problems		≥ 1 Mental or Behavioral Disorder[1]	
Characteristic		**Weighted Percent (95% CI[2])**	**aPR (95% CI)**	**Weighted Percent (95% CI[2])**	**aPR (95% CI)**	**Weighted Percent (95% CI[2])**	**aPR (95% CI)**	**Weighted Percent (95% CI[2])**	**aPR (95% CI)**	**Weighted Percent (95% CI[2])**	**aPR (95% CI)**
ACE Scores[7]	0	2.6 (1.7, 3.8)	ref	9.9 (7.7, 12.6)	ref	8.6 (6.7, 11.1)	ref	6.5 (4.7, 9.0)	Ref	17.4 (14.4, 20.9)	ref
	1	5.0 (3.3, 7.5)	1.66 (0.89, 3.09)	18.5 (13.4, 25.0)	2.04 (1.36, 3.07)	19.6 (12.4, 29.7)	2.28 (1.49, 3.49)	9.4 (6.5, 13.4)	1.43 (0.89, 2.31)	31.4 (23.5, 40.5)	1.84 (1.37, 2.48)
	2-3	10.1 (6.4, 15.7)	3.04 (1.57, 5.86)	25.9 (19.5, 33.5)	2.86 (1.96, 4.18)	23.4 (17.5, 30.5)	2.61 (1.67, 4.06)	18.2 (13.1, 24.8)	2.40 (1.45, 3.99)	38.0 (30.0, 46.7)	2.18 (1.61, 2.96)
	4 or more	23.1 (14.8, 34.1)	6.85 (3.86, 12.16)	40.2 (29.6, 51.9)	4.70 (3.21, 6.89)	39.8 (29.0, 51.7)	4.83 (3.16, 7.39)	31.4 (22.5, 42.1)	4.23 (2.59, 6.90)	59.9 (47.3, 71.4)	3.55 (2.62, 4.81)

ADHD: attention-deficit/hyperactivity disorder; aPR: adjusted prevalence ratio; CI: Confidence Interval; NH: non-Hispanic; FPL: Federal Poverty Level; ACE: adverse childhood experiences;

[1]Any current depression, anxiety problems, ADHD, behavioral or conduct problem and/or Tourette syndrome

[2]Confidence interval calculated using Taylor Series

[3]Not adjusted for confounders

[4]Adjusted for race/ethnicity and highest level of caregiver education

[5]Adjusted for race/ethnicity

[6]Adjusted for family income

[7]Adjusted for race/ethnicity, age, family income, primary caregiver marital status, highest level of caregiver education, health insurance coverage

Supplemental Table 4. Demographic and Contextual Characteristics Associated with Developmental Disorders Among Children 6-17 Years Old with Heart Conditions, National Survey of Children's Health, United States, 2016-2021 (Sensitivity Analysis Excluding children with Any Genetic Condition in Addition to Down Syndrome)

		AuSD		Developmental Delay		Intellectual Disability		Speech or Other Language Disorder		≥1 Developmental Disorder[1]	
Characteristic		**Weighted Percent (95% CI[2])**	**aPR (95% CI)**	**Weighted Percent (95% CI[2])**	**aPR (95% CI)**	**Weighted Percent (95% CI[2])**	**aPR (95% CI)**	**Weighted Percent (95% CI[2])**	**aPR (95% CI)**	**Weighted Percent (95% CI[2])**	**aPR (95% CI)**
Sex[3]	Male	9.8 (7.0, 13.5)	10.41 (3.87, 27.98)	16.3 (12.9, 20.3)	2.42 (1.52, 3.84)	4.1 (2.3, 7.3)	3.43 (1.21, 9.75)	14.4 (11.2, 18.3)	2.43 (1.57, 3.77)	23.5 (19.7, 27.9)	2.52 (1.75, 3.62)
	Female	0.9 (0.4, 2.4)	ref	6.7 (4.5, 10.0)	ref	1.2 (0.5, 2.9)	ref	5.9 (4.1, 8.5)	ref	9.4 (6.8, 12.8)	ref
Race/ ethnicity[3]	NH White	5.1 (3.3, 7.7)	ref	10.6 (8.0, 13.8)	ref	1.5 (0.7, 3.0)	ref	8.6 (6.5, 11.2)	ref	15.4 (12.4, 18.9)	ref
	NH Black	8.8 (4.5, 16.5)	1.73 (0.80, 3.74)	20.5 (13.3, 30.3)	1.94 (1.18, 3.18)	7.7 (3.3, 16.8)	5.13 (1.75, 14.99)	19.8 (12.5, 30.1)	2.32 (1.38, 3.89)	28.9 (20.4, 39.2)	1.88 (1.27, 2.78)
	Hispanic	4.8 (1.8, 11.8)	0.94 (0.34, 2.62)	8.5 (4.5, 15.3)	0.80 (0.41, 1.57)	2.7 (0.6, 10.9)	1.83 (0.37, 8.98)	8.4 (4.5, 15.1)	0.98 (0.50, 1.91)	12.1 (7.3, 19.3)	0.79 (0.46, 1.33)
	Other	5.2 (2.1, 12.4)	1.03 (0.38, 2.76)	14.3 (8.4, 23.1)	1.35 (0.76, 2.40)	3.8 (1.5, 9.7)	2.57 (0.79, 8.34)	13.0 (7.4, 22.0)	1.52 (0.83, 2.81)	19.4 (12.4, 28.9)	1.26 (0.79, 2.03)

		AuSD		Developmental Delay		Intellectual Disability		Speech or Other Language Disorder		≥1 Developmental Disorder[1]	
Characteristic		**Weighted Percent (95% CI[2])**	**aPR (95% CI)**	**Weighted Percent (95% CI[2])**	**aPR (95% CI)**	**Weighted Percent (95% CI[2])**	**aPR (95% CI)**	**Weighted Percent (95% CI[2])**	**aPR (95% CI)**	**Weighted Percent (95% CI[2])**	**aPR (95% CI)**
Age (years)[3]	6-11 years	4.0 (2.5, 6.2)	ref	12.6 (9.6, 16.2)	ref	2.0 (0.9, 4.3)	ref	12.7 (9.7, 16.4)	ref	18.2 (14.7, 22.4)	ref
	12-17 years	7.1 (4.6, 10.8)	1.79 (0.96, 3.35)	10.7 (7.7, 14.7)	0.85 (0.56, 1.29)	3.4 (1.8, 6.4)	1.72 (0.63, 4.69)	7.7 (5.3, 11.0)	0.61 (0.39, 0.95)	15.0 (11.6, 19.1)	0.82 (0.59, 1.14)
Family Income (% FPL)[4]	<100%	7.5 (3.6, 14.7)	1.88 (0.63, 5.61)	14.7 (8.4, 24.6)	1.37 (0.63, 2.99)	2.9 (1.0, 8.0)	2.10 (0.31, 14.12)	7.0 (3.7, 12.7)	0.62 (0.24, 1.56)	17.3 (10.9, 26.2)	1.12 (0.58, 2.17)
	100-199%	6.6 (3.4, 12.4)	1.76 (0.64, 4.84)	17.0 (11.6, 24.2)	1.75 (0.94, 3.29)	4.7 (1.9, 11.1)	3.91 (0.64, 23.83)	14.9 (9.9, 21.8)	1.49 (0.70, 3.17)	18.4 (11.4, 28.4)	1.48 (0.90, 2.43)
	200-399%	5.5 (2.8, 10.7)	1.62 (0.62, 4.20)	9.7 (6.4, 14.3)	1.15 (0.66, 2.02)	2.8 (1.1, 7.4)	2.78 (0.54, 14.42)	11.3 (7.6, 16.5)	1.32 (0.72, 2.41)	21.8 (15.9, 29.2)	1.22 (0.78, 1.90)
	>400%	3.4 (1.8, 6.6)	ref	8.0 (5.3, 12.0)	ref	1.1 (0.2, 5.2)	ref	8.1 (5.1, 12.6)	ref	16.0 (11.7, 21.5)	ref
Primary Caregiver Marital Status[4]	Married or living with a partner	4.9 (3.4, 7.2)	ref	10.8 (8.6, 13.5)	ref	2.8 (1.5, 5.0)	ref	11.0 (8.7, 13.9)	ref	16.0 (13.4, 19.1)	ref

		AuSD		Developmental Delay		Intellectual Disability		Speech or Other Language Disorder		≥1 Developmental Disorder[1]	
Characteristic		**Weighted Percent (95% CI[2])**	**aPR (95% CI)**	**Weighted Percent (95% CI[2])**	**aPR (95% CI)**	**Weighted Percent (95% CI[2])**	**aPR (95% CI)**	**Weighted Percent (95% CI[2])**	**aPR (95% CI)**	**Weighted Percent (95% CI[2])**	**aPR (95% CI)**
	Never married	3.3 (1.3, 8.2)	0.50 (0.17, 1.50)	14.8 (6.6, 30.1)	0.94 (0.37, 2.40)	1.2 (0.2, 6.4)	0.22 (0.03, 1.53)	7.6 (3.0, 17.9)	0.44 (0.17, 1.11)	19.8 (10.1, 35.1)	0.88 (0.42, 1.85)
	Divorced, separated, or widowed	8.8 (4.3, 17.0)	1.61 (0.76, 3.41)	13.6 (8.1, 22.2)	1.09 (0.63, 1.88)	3.1 (1.2, 7.8)	0.92 (0.34, 2.50)	8.2 (4.7, 13.8)	0.65 (0.37, 1.15)	17.7 (11.4, 26.5)	0.98 (0.62, 1.54)
Highest Level of Caregiver Education[5]	High school or less than high school	7.5 (3.8, 14.1)	1.55 (0.70, 3.45)	17.6 (11.7, 25.6)	1.84 (1.14, 2.97)	3.7 (1.5, 8.8)	1.45 (0.47, 4.50)	12.7 (8.2, 19.1)	1.32 (0.81, 2.16)	22.5 (15.9, 30.9)	1.55 (1.05, 2.28)
	>High school	4.8 (3.4, 6.8)	ref	9.6 (7.7, 12.1)	ref	2.4 (1.3, 4.3)	ref	9.4 (7.4, 12.0)	ref	14.6 (12.2, 17.4)	ref
Health Insurance Coverage[6]	Any private insurance	4.4 (2.8, 6.9)	ref	8.2 (6.2, 10.8)	ref	2.1 (1.0, 4.5)	ref	9.0 (6.7, 11.8)	ref	13.3 (10.7, 16.3)	ref
	Public insurance only	8.3 (5.1, 13.1)	1.59 (0.63, 4.02)	18.3 (13.3, 24.5)	2.00 (1.13, 3.55)	4.2 (2.2, 8.0)	1.51 (0.32, 7.10)	14.0 (10.0, 19.2)	1.78 (0.93, 3.40)	23.7 (18.1, 30.4)	1.77 (1.12, 2.81)
	None	0.4 (0.1, 1.7)	0.08 (0.02, 0.40)	9.1 (3.2, 23.0)	1.02 (0.34, 3.11)	0.0 (0.0, 0.3)	0.01 (0.00, 0.16)	1.7 (0.3, 8.3)	0.22 (0.04, 1.17)	10.8 (4.3, 24.6)	0.82 (0.32, 2.11)
ACE Scores[7]	0	2.0 (1.1, 3.5)	ref	6.8 (4.8, 9.6)	ref	1.0 (0.5, 2.2)	ref	8.4 (6.1, 11.5)	ref	11.3 (8.7, 14.6)	ref

		AuSD		Developmental Delay		Intellectual Disability		Speech or Other Language Disorder		≥1 Developmental Disorder[1]	
Characteristic		**Weighted Percent (95% CI[2])**	**aPR (95% CI)**	**Weighted Percent (95% CI[2])**	**aPR (95% CI)**	**Weighted Percent (95% CI[2])**	**aPR (95% CI)**	**Weighted Percent (95% CI[2])**	**aPR (95% CI)**	**Weighted Percent (95% CI[2])**	**aPR (95% CI)**
	1	6.9 (3.7, 12.4)	3.11 (1.36, 7.11)	12.6 (8.4, 18.4)	1.64 (0.97, 2.75)	4.2 (1.7, 10.1)	2.93 (0.92, 9.37)	10.0 (6.3, 15.6)	1.07 (0.60, 1.92)	16.1 (11.5, 22.2)	1.33 (0.87, 2.03)
	2-3	7.6 (4.3, 13.2)	3.14 (1.22, 8.06)	13.6 (9.2, 19.8)	1.44 (0.81, 2.57)	3.9 (1.5, 9.6)	2.50 (0.71, 8.83)	15.9 (10.7, 23.0)	1.67 (0.99, 2.82)	21.6 (15.7, 29.0)	1.59 (1.02, 2.47)
	4 or more	12.5 (5.9, 24.5)	5.50 (2.40, 12.60)	25.8 (15.7, 39.3)	2.98 (1.68, 5.28)	3.3 (1.6, 6.7)	2.57 (0.77, 8.55)	5.5 (2.7, 10.6)	0.69 (0.31, 1.52)	29.7 (19.3, 42.7)	2.40 (1.49, 3.87)

AuSD: autism spectrum disorder; aPR: adjusted prevalence ratio; CI: Confidence Interval; NH: non-Hispanic; FPL: Federal Poverty Level; ACE: adverse childhood experiences;

[1]Any current AuSD, developmental delay, intellectual disability, and/or speech or other language disorder

[2]Confidence interval calculated using Taylor Series

[3]Not adjusted for confounders

[4]Adjusted for race/ethnicity and highest level of caregiver education

[5]Adjusted for race/ethnicity

[6]Adjusted for family income

[7]Adjusted for race/ethnicity, age, family income, primary caregiver marital status, highest level of caregiver education, health insurance coverage