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Congenital Heart Defects and Receipt of Special Education Services

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Abstract

BACKGROUND—We investigated the prevalence of receipt of special education services among children with congenital heart defects (CHDs) compared with children without birth defects.

METHODS—Children born from 1982 to 2004 in metropolitan Atlanta with CHDs (n = 3744) were identified from a population-based birth defect surveillance program; children without birth defects (n = 860 715) were identified from birth certificates. Cohorts were linked to special education files for the 1992–2012 school years to identify special education services. Children with noncardiac defects or genetic syndromes were excluded; children with CHDs were classified by presence or absence of critical CHDs (ie, CHDs requiring intervention by age one year). We evaluated the prevalence of receipt of special education services and prevalence rate ratios using children without birth defects as a reference.

RESULTS—Compared with children without birth defects, children with CHDs were 50% more likely to receive special education services overall (adjusted prevalence rate ratio [aPRR] = 1.5; 95% confidence interval [CI]: 1.4–1.7). Specifically, they had higher prevalence of several special education categories including: intellectual disability (aPRR = 3.8; 95% CI: 2.8–5.1), sensory impairment (aPRR = 3.0; 95% CI: 1.8–5.0), other health impairment (aPRR = 2.8; 95% CI: 2.2–3.5), significant developmental delay (aPRR = 1.9; 95% CI: 1.3–2.8), and specific learning disability (aPRR = 1.4; 95% CI: 1.1–1.7). For most special education services, the excess prevalence did not vary by presence of critical CHDs.

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CONCLUSIONS—Children with CHDs received special education services more often than children without birth defects. These findings highlight the need for special education services and the importance of developmental screening for all children with CHDs.

Congenital heart defects (CHDs) represent one of the most prevalent birth defects, occurring in ~1% of live births annually in the United States.[1,2] As a result of medical and surgical advances, survival has greatly improved.[3,4] With more children with CHDs living into adolescence and adulthood, such children are at increased risk of developmental disabilities.[5–10] Mechanisms postulated to explain such neurodevelopmental sequelae are varied and include genetic syndromes, brain malformations,[11,12] hypoxemic-ischemic insults,[10] brain injury prenatally or after surgery,[13,14] or environmental factors at home or school.[15,16]

Several hospital-based studies have documented an increased frequency of poor neurocognitive outcomes among children with specific types of CHDs (eg, transposition of the great arteries, tetralogy of Fallot, single ventricle, and hypoplastic left heart syndrome)[17–21] and the need for developmental screening and special education services for these children. Furthermore, studies have reported that neurodevelopmental concerns are dynamic and occur at all ages.[5,16,22–26] For example, one study noted that >50% of newborns and 38% of infants with CHDs had neurobehavioral abnormalities before surgery that persisted postoperatively.[5] Other clinical studies have noted developmental delays in children with several types of CHDs in early childhood,[25] at school age,[22–24,26] and in adolescence.[16] In an effort to optimize neurodevelopmental outcomes, in 2012 the American Heart Association and the American Academy of Pediatrics issued a joint scientific statement on guidelines for systematic developmental surveillance, screening, and evaluation of children with CHDs throughout childhood.[15]

Evidence-based policies and service planning for children with CHDs would benefit from population-based data characterizing the frequency and types of special education services needed by children with CHDs. We used population-based birth defects surveillance data, vital records information, and administrative data on receipt of special education in metropolitan Atlanta to determine the prevalence of receipt of special education services among children with CHDs compared with children without major birth defects.

METHODS

Study Population

Children born to mothers residing in the 5-county metropolitan Atlanta area from 1982 to 2004 who survived to age 3 years were identified through vital records (ie, birth and death records) from the State of Georgia. To identify children with CHDs, children were deterministically linked with data from the Metropolitan Atlanta Congenital Defects Program (MACDP), an ongoing population-based birth defects surveillance system with active case ascertainment of children from birth through age 6 years born in metropolitan Atlanta. Further details about this system have been published elsewhere.[27] MACDP records of children with CHDs were previously classified by experts in pediatric cardiology, according to a standard clinical nomenclature and morphogenetic classification system.[28]

Children whose birth records did not link to the MACDP (ie, children with no birth defects) were selected as the referent cohort.

This study only included children with isolated CHDs, ie, children without syndromes, chromosomal abnormalities, or extracardiac defects. Syndromes and chromosomal abnormalities were identified through active abstraction up to age 6 years at birthing or children's hospitals and local genetics clinics. Children with isolated CHDs were divided into 2 mutually exclusive groups: (1) children with critical CHDs (ie, CHDs that usually require surgical or catheterization intervention during the first year of life; see the Appendix and Oster et al[29]) and (2) children without critical CHDs but with any other CHDs, referred to as "only noncritical CHDs." Children in either group could have >1 CHD, and children in the "critical" group could also have noncritical CHDs.

Receipt of Special Education Services

The Special Education Database of Metropolitan Atlanta (SEDMA) systematically links children identified by special education departments of 9 public school districts in the 5-county metropolitan Atlanta area longitudinally through their years of receiving special education services. SEDMA also captures the categories under which the child receive special education services: autism spectrum disorder, deaf/blind, deaf/hard of hearing, emotional or behavioral disorder, intellectual disability (mild, moderate, severe, profound), orthopedic impairment, other health impairment, significant developmental delay, specific learning disability, speech/language impairment, traumatic brain injury, and visual impairment. "Other health impairment" means that because of a health condition (eg, CHDs or attention-deficit/hyperactivity disorder) the child has a limited alertness in his/her educational environment, which affects performance and requires specialized instruction. To receive services under other health impairment (OHI) the child must not have an intellectual, visual, hearing, emotional, or motor disability.[30]

For this study, special education categories were modified as follows: moderate, severe, and profound intellectual disability were grouped as "moderate to profound intellectual disability," and deaf/blind, deaf/hard of hearing, and visual impairment were grouped as "sensory impairment." "Traumatic brain injury" was excluded because of the small number of cases. Because children may enter special education under a nonspecific category (eg, significant developmental delay), which may become more specific over time, we used the most recent reported category. Some school districts reported multiple categories for which a child was receiving services, whereas others reported only 1 category. Our analyses revealed no significant differences when various hierarchies were applied placing different categories as the primary category, if >1 was reported. The CHD and referent cohorts were deterministically linked to SEDMA to identify which children ages 3 to 10 years had received special education services at any time from 1992 through 2012.

Covariates

The study covariates were obtained from vital records and grouped as follows: birth year (1982–1987, 1988–1994, 1995–2000, 2001–2004), birth weight (<1500 g, 1500–2499 g, ≥2500 g), gender, maternal age (<19 years, 20–24 years, 25–29 years, 30–34 years, ≥35

years), maternal race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, Asian, other), and maternal level of education attained (some high school, high school graduate, college, postcollege). Gestational age was not included because gestational age, or markers used to estimate gestational age (eg, last menstrual period), was missing more often than birth weight (2.2% vs 1.5%), and birth weight was found to be correlated with, and a reasonable proxy for, gestational age. Children with missing covariate data were excluded from analysis.

Analysis

We report the number and percentage of children with no major birth defects (referent cohort), children with any type of isolated CHDs, children with critical CHDs, and children with only noncritical CHDs by maternal and infant characteristics. Pearson's χ^2 test was used to compare the distribution of characteristics of the 3 CHD groups with that of the reference group, with significance defined as $P < .05$. The prevalence of receipt of special education services overall and by special education categories among the referent group and the 3 CHD groups was estimated per 1000 3-year infant survivors. Poisson regression methods were used to estimate prevalence rate ratios, adjusted for all covariates, and 95% confidence intervals (CIs) for receipt of special education services among children with CHDs compared with the referent group. Results were reported only for cells with at least 5 observations. All analyses were performed by using SAS version 9.3 (SAS Institute, Cary, NC).

RESULTS

Study Population Characteristics

After linkages of the data sources and application of exclusion criteria, we identified 860 715 children without a birth defect and 3744 children with isolated CHDs born in metropolitan Atlanta from 1982 to 2004 (Table 1). The exclusion of deaths before age 3 years represented a greater fraction in the entire CHD cohort (9.1%) than in the referent cohort (0.8%), and among critical CHD cases (24.5%) than among noncritical CHD cases (3.4%). Additional exclusions based on missing data were comparable between the 2 cohorts (n = 123 [2.9%] of the CHD group and n = 23 905 [3.1%] of the referent group). Although the numbers were small, the excluded cases did not characteristically differ significantly from the included cases except in proportion of Hispanic and non-Hispanic black mothers (18% and 20% vs 5% and 35%, respectively; data not shown).

Of children with isolated CHDs who survived to age 3 years, 843 (22.5%) had critical CHDs and 2901 (77.4%) had only noncritical CHDs, most of whom (n = 2664; 91.8%) had a single noncritical CHD (data not shown). There was a wide variety of CHD phenotypes represented (Table 2), the most common being ventricular septal defects (47% among any isolated CHDs and 60% among only noncritical CHDs) (Table 2). Among children with critical CHDs, the most common phenotypes were tetralogy of Fallot (24%) and coarctation (24%) (Table 2).

Compared with children without major birth defects, a slightly greater proportion of children with CHDs were born to mothers who were ≥35 years of age, non-Hispanic white, and with a postcollege education (Table 3). Also, compared with children without major birth defects, children with CHDs were more likely to have lower birth weight and be born in the most recent birth year group. Table 3 also shows that the prevalence of CHDs increased across birth year groups, a finding consistent with previous published work from the same data.[31]

Receipt of Special Education Services

Of children with any isolated CHDs, 15% (558 of 3744) receive special education compared with 9% (79 141 of 860 715) of children with no major birth defects (Table 4). Children with any isolated CHDs were 50% more likely than those without birth defects to receive special education services (aPRR = 1.5; 95% CI: 1.4–1.7). Compared with children without major birth defects, the prevalence of several special education categories was significantly higher among children with any CHDs: intellectual disability (aPRR = 3.8; 95% CI: 2.8–5.1), sensory impairment (aPRR = 3.0; 95% CI: 1.8–5.0), other health impairment (aPRR = 2.8; 95% CI: 2.2–3.5), significant developmental delay (aPRR = 1.9; 95% CI: 1.3–2.8), and specific learning disability (aPRR = 1.4; 95% CI: 1.1–1.7) (Table 4). Children in the 3 CHD cohorts (any isolated CHDs, critical CHDs, or only noncritical CHDs) did not have an increased prevalence of the categories of autism, emotional/behavioral disorders, orthopedic impairment, or speech/language impairment compared with children without birth defects. The most common category among all children in special education, including those in the 3 CHD cohorts, was speech/language impairment. A sensitivity analysis including children with missing covariates revealed no statistically significant changes in any of the aPRRs for the CHD cohorts (data not shown).

The statistically higher prevalence of several special education categories occurred in both the critical and only noncritical CHD groups of children. For most categories showing an association with any CHDs, there was no significant variation in the magnitude of the excess prevalence by presence or absence of critical CHDs. The “other health impairment” category was the only category that showed a significantly higher prevalence among children with critical CHDs (aPRR= 5.4; 95% CI: 3.8–7.7) compared with children with only noncritical CHDs (aPRR = 2.0; 95% CI: 1.5–2.8) (Table 4).

DISCUSSION

Compared with children born without major birth defects in metropolitan Atlanta between 1982 and 2004, children born with isolated CHDs were 50% more likely to receive special education services in Atlanta during 1992–2012. Furthermore, the increased likelihood of receiving special education services for children with CHDs was not influenced appreciably by the presence of critical CHDs. Special education categories that were more prevalent among children with CHDs than among children without major birth defects included intellectual disability, other health impairment, sensory impairment, specific learning disability, and significant developmental delay.

Our finding that 15% of children with CHDs received special education services is similar to observations from other studies in children with CHDs who underwent newborn or early

childhood surgery.[16,26] Our findings of a higher prevalence of receipt of special education services among children with CHDs compared with children without birth defects are consistent with previous reports of a higher prevalence of cognitive and other types of developmental impairment for children with specific types of CHD reported from hospital-based studies.[7,8] Furthermore, our findings are also consistent with reports that children with complex CHDs who underwent neonatal or infant surgery have a range of neurodevelopmental outcomes.[16,22,24–26,32]

Our study expands on previous studies by documenting the variation in the prevalence of receipt of special education services by severity of CHD with the use of population-based data. Although developmental impairments in children with critical CHDs (eg, transposition of the great arteries, tetralogy of Fallot, single ventricle, and hypoplastic left heart syndrome) have been documented,[17–21] little is known about the special education service needs among children with noncritical CHDs. A particularly interesting finding in our study is that even after excluding chromosomal abnormalities, syndromes, and extracardiac defects, children with only noncritical CHDs were noted to have a higher prevalence of receiving special education services relative to children without major birth defects. A variety of perioperative risk factors, especially among those with cyanotic or complex CHDs (ie, critical CHDs), have been considered major contributors to impaired brain function later in life.[10,33–36] However, neurodevelopmental outcomes may result from a complex combination of factors, in addition to perioperative risks. In fact, there is evidence to suggest that perioperative factors may be less significant as the child ages.[16,37] In contrast, there may be embryopathologic insults from yet to be identified genetic and/or environmental factors affecting both the brain and cardiac development.[6] MRI studies have shown evidence of impaired brain function preoperatively, which supports the hypothesis that some neurodevelopmental impairment may be related to intrauterine factors.[37] Furthermore, recent literature notes that numerous medical and nonmedical risk factors occurring prenatally, perioperatively, and later in the school-age period may contribute to neurodevelopmental delays in children with many CHD phenotypes.[16,25,32] Nonmedical contributors to developmental milestones in these children may include environmental or sociodemographic factors, parental expectations, or access to early intervention services. These evolving hypotheses may partially explain the finding in our current study that children with both critical and noncritical CHDs have a higher prevalence of receipt of special education services. Developmental delays in children with CHDs have been noted to be common and to vary with the age of the child[25] and therefore may require a variety of special education services.

Current recommendations are for periodic neurodevelopmental surveillance, screening, evaluation, and management of children with CHDs.[15] A management algorithm was created to stratify children with CHDs on the basis of several risk factors, with children at high risk receiving regular formal developmental evaluation.[15] Early intervention may help with school performance and enhance long-term outcomes.[15,24] However, our results suggest that using risk stratification criteria as the indicator for conducting a developmental evaluation may miss children with mild or noncritical CHDs who may be in need of special services.

Strengths

This study has several strengths. First, children with CHDs were identified from a population-based, active-ascertainment birth defects surveillance program with detailed case review and CHD classification. Second, vital records were linked to the MACDP to identify a contemporary cohort of children without major birth defects for comparison and to exclude all deaths under age 3 years from the study. Third, linkage to SEDMA allowed for longitudinal following of children through their receipt of special education services, so that the most recent and specific special education category was used in analysis. Finally, this study spans 20 years of population-based data, providing a substantial sample size to examine groups of CHD phenotypes and specific special education categories.

Limitations

First, we did not have individual clinical information to distinguish the severity or surgical interventions within a CHD phenotype. Some phenotypes, such as ventricular septal defects, which were considered noncritical, may consist of children with a range of severity, treatment, and neurodevelopmental outcomes. Thus, the noncritical CHD group of children is a heterogeneous mix of severity, treatment, and other risk factors. However, our grouping of children with critical CHDs distinguishes CHDs that are likely to be cyanotic or have more severe functional limitations relative to other CHDs. Because of the small sample size we were unable to examine specific CHD phenotypes with special education eligibility categories.

Another limitation is that we lack migration data for the 5 central counties of metropolitan Atlanta that serve as the catchment area for the MACDP. We do not know how many children in the MACDP and vital records databases migrated out of the 5 central Atlanta counties and were not available for linkage to the special education data. Also, in-migrants are necessarily excluded because only children born in the catchment area were eligible for the study. Because most of the major pediatric cardiology referral centers in Georgia are located within the MACDP region, stable residence within the MACDP counties may have been more likely than for other children. Further work is warranted to evaluate the extent to which differential migration could affect our findings on receipt of special education services.

Finally, it is important to note that these data reflect the receipt of special education services as reported by 1 of the 9 public school special education departments serving the 5 central metropolitan Atlanta counties and do not include children attending and receiving services at private schools or through homeschooling. These data reflect the category through which the child primarily received his or her special education services as reported by the school system. Active review of children’s records was not conducted as a part of SEDMA. Therefore, these data do not include assessment of specific types of developmental disability (eg, IQ measurements, behavioral characteristics, or physical findings). Furthermore, the category of “other health impairment,” by definition, is heterogeneous and therefore results in this category are challenging to interpret. It is also important to note that additional factors may affect the receipt of special education services that we were unable to study,

such as access to early intervention services, developmental screening, or other environmental factors influencing development.

Conclusions

Children in metropolitan Atlanta with critical and/or noncritical CHDs received special education services more often than children without major birth defects. These findings highlight the need for special education services and the importance of developmental screening for children with both critical and noncritical CHDs. As survival continues to improve for all persons with CHDs, and with the increase in CHD prevalence over the study period, one public health implication of our study is that there will be a corresponding increased need for special education services for this growing population of children with CHDs, which may be magnified without early and appropriate intervention. Further corroboration of our findings is warranted to better understand the scope of long-term neurodevelopmental outcomes of all children with CHDs.

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APPENDIX: Classification of CHDs

Critical	Noncritical
Coarctation of the aorta	Aortopulmonary window
dextro-Transposition of the great arteries	Aortic stenosis
Double-outlet right ventricle	Atrial septal defects
Ebstein anomaly	Atrioventricular septal defect
Hypoplastic left heart syndrome	Bicuspid aortic valve
Interrupted aortic arch	Congenitally corrected transposition of the great arteries
Pulmonary atresia	Cor triatriatum
Single ventricle	Double-chambered right ventricle
Tetralogy of Fallot	Partial anomalous pulmonary venous return
Total anomalous pulmonary venous return	Patent ductus arteriosus
Tricuspid atresia	Pulmonic stenosis
Truncus arteriosus	Vascular ring
	Ventricular septal defect

ABBREVIATIONS

aPRR	adjusted prevalence rate ratio
CHD	congenital heart defect
CI	confidence interval
MACDP	Metropolitan Atlanta Congenital Defects Program
SEDMA	Special Education Database of Metropolitan Atlanta

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WHAT'S KNOWN ON THIS SUBJECT

Poor neurocognitive outcomes are associated with some types of congenital heart defects (CHDs). Guidelines for developmental screening for children with CHDs have been published. Population-based information on special education services needed among children with CHDs is limited.

WHAT THIS STUDY ADDS

Children in metropolitan Atlanta with congenital heart defects (CHDs) received special education services more often than children without birth defects. These findings highlight the need for special education services and the importance of developmental screening for all children with CHDs.

TABLE 1

Steps in the Selection of a Cohort of Children Without Birth Defects and a Cohort of Children With Isolated CHDs Born Between 1982 and 2004 in Metropolitan Atlanta

Processing Step	No Birth Defect, *n* (%)	Isolated CHDs, *n* (%)		
		Any CHDs	Critical CHDs[a]	Only Noncritical CHDs[b]
Born between 1982 and 2004 in metropolitan Atlanta	891 647	4254	1144	3110
Remaining after removal of deaths before age 3 years	884 620 (99.2)	3867 (90.9)	864 (75.5)	3003 (96.6)
Remaining after exclusion of children with missing covariate information[c]	860 715 (96.5)	3744 (88.0)	843 (73.7)	2901 (93.3)

Isolated CHDs exclude children with syndromes, chromosomal abnormalities, and extracardiac defects.

[a] CHDs that usually require surgical or catheterization intervention during the first year of life.

[b] Absence of critical CHDs but with ≥1 other CHDs.

[c] Missing information on gender, birth weight, maternal age at delivery, maternal education, or maternal race/ethnicity.

TABLE 2

Frequency of Select CHDs Among Children With Isolated CHDs Born Between 1982 and 2004 in Metropolitan Atlanta

	Any CHDs, *n* (%)	Critical CHDs,[a] *n* (%)	Only Noncritical CHDs,[b] *n* (%)
Total number of children	3744	843	2901
Total number of defects	4178 (100)	1019 (100)	3159 (100)
Anomalous pulmonary venous return	46 (1.1)	42 (4.1)	4 (0.1)
Aortic stenosis	75 (1.8)	—	75 (2.4)
Atrial septal defect	463 (11.1)	29 (2.8)	434 (13.7)
Atrioventricular septal defect	61 (1.5)	3 (0.3)	58 (1.8)
Coarctation	241 (5.8)	241 (23.7)	—
dextro-Transposition of the great arteries	142 (3.4)	142 (13.9)	—
Ebstein anomaly	38 (1.0)	38 (3.7)	—
Hypoplastic left heart syndrome	47 (1.1)	47 (4.6)	—
Patent ductus arteriosus	214 (5.1)	6 (0.6)	208 (6.6)
Pulmonary or tricuspid atresia	56 (1.3)	56 (5.5)	—
Pulmonary stenosis	308 (7.4)	1 (0.1)	307 (9.7)
Single ventricle	34 (1.0)	34 (3.3)	—
Tetralogy of Fallot	242 (5.8)	242 (23.8)	—
Vascular ring[c]	80 (1.9)	7 (0.7)	73 (2.3)
Ventricular septal defect	1981 (47.4)	96 (9.4)	1885 (60.0)
Other[d]	150 (3.6)	35 (3.4)	115 (3.6)

Select CHDs represent ≥1% of the total number of defects among children with any CHDs. Isolated CHDs exclude children with syndromes, chromosomal abnormalities, and extracardiac defects. —, defects with no occurrences among the group.

[a] CHDs that usually require surgical or catheterization intervention during the first year of life.

[b] Absence of critical CHDs but with ≥1 other CHDs.

[c] Includes vascular rings, slings, and aberrant subclavian arteries.

[d] "Other" is a collective group of CHDs that individually are <1% of the total number of defects among children with any CHDs.

TABLE 3

Maternal and Infant Characteristics of Children Without Birth Defects and Children With Isolated CHDs Born Between 1982 and 2004 in Metropolitan Atlanta

	No Birth Defect, *n* (%)	Any CHDs, *n* (%)	Critical CHDs,[a] *n* (%)	Only Noncritical CHDs,[b] *n* (%)
Total	860 715	3744	843	2901
Maternal age at delivery				
<19 years	98 095 (11.4)	326 (8.7)*	78 (9.3)*	248 (8.5)*
20–24 years	200 895 (23.3)	760 (20.3)*	180 (21.4)*	580 (30.0)*
25–29 years	243 299 (28.3)	1048 (28.0)*	231 (27.4)*	817 (28.2)*
30–34 years	212 974 (24.7)	1013 (27.1)*	221 (26.2)*	792 (27.3)*
≥35 years	105 452 (12.3)	597 (16.0)*	133 (15.7)*	464 (16.0)*
Maternal race/ethnicity				
Non-Hispanic white	441 875 (51.3)	2071 (55.3)*	479 (56.8)*	1592 (54.9)*
Non-Hispanic black	339 326 (39.4)	1323 (35.3)*	285 (33.8)*	1038 (35.7)*
Hispanic	43 887 (5.1)	202 (5.4)*	35 (4.2)*	167 (5.8)*
Asian	27 078 (3.2)	124 (3.3)*	37 (4.4)*	87 (3.0)*
Other	8549 (1.0)	24 (0.6)*	7 (0.8)*	17 (0.6)*
Maternal education				
Some high school	157 279 (18.3)	646 (17.2)*	138 (16.4)	508 (17.5)*
High school graduate	254 566 (29.6)	1027 (27.4)*	252 (29.9)	775 (26.7)*
College	189 295 (22.0)	832 (22.2)*	189 (22.4)	643 (22.2)*
Postcollege	259 575 (30.1)	1239 (33.1)*	264 (31.3)	975 (33.6)*
Infant gender				
Female	426 754 (49.6)	1903 (50.8)	341 (40.4)*	1562 (53.8)*
Male	433 961 (50.4)	1841 (49.2)	502 (59.6)*	1339 (46.2)*
Infant birth weight				
<1500 g	9451 (1.1)	254 (6.8)*	21 (2.5)*	233 (8.0)*
1500–2499 g	56 544 (6.6)	496 (13.2)*	89 (10.6)*	407 (14.0)*
≥2500 g	794 720 (92.3)	2994 (80.0)*	733 (86.9)*	2261 (78.0)*
Infant birth year				
1982–1987	171 549 (19.9)	538 (14.4)*	163 (19.3)	375 (12.9)*
1988–1994	253 735 (29.5)	903 (24.1)*	228 (27.1)	675 (23.3)*
1995–2000	246 508 (28.6)	1178 (31.5)*	260 (30.8)	918 (31.6)*
2001–2004	188 923 (22.0)	1125 (30.0)*	192 (22.8)	933 (32.2)*

Isolated CHDs exclude children with syndromes, chromosomal abnormalities, and extracardiac defects.

*Significant difference in distribution of characteristics for CHD group compared with referent group of children without major birth defects, $P < .05$.

[a]CHDs that usually require surgical or catheterization intervention during the first year of life.

[b] Absence of critical CHDs but with ≥1 other CHDs.

TABLE 4

Prevalence and aPRRs of the Most Recent Special Education Categories Among Children Without Birth Defects and Children With Isolated CHDs in Metropolitan Atlanta, 1992–2012

Special Education Category	No Birth Defect (*n* = 860 715)	Any CHDs (*n* = 3744)		Critical CHDs[a] (*n* = 843)		Noncritical CHDs[b] (*n* = 2901)	
	Prev, *n* (/1000)	Prev, *n* (/1000)	aPRR[c] (95% CI)	Prev, *n* (/1000)	aPRR[c] (95% CI)	Prev, *n* (/1000)	aPRR[c] (95% CI)
Any special education services	79 141 (91.9)	558 (149.0)	1.5 (1.4–1.7)*	141 (167.3)	1.7 (1.4–2.1)*	417 (127.5)	1.5 (1.3–1.7)*
Autism spectrum disorder	2826 (3.3)	21 (5.6)	1.3 (0.8–2.1)	7 (8.3)	2.0 (0.8–4.7)	14 (4.8)	1.1 (0.6–2.1)
Emotional or behavioral disorder	7333 (8.5)	25 (6.7)	0.9 (0.6–1.5)	7 (8.3)	1.0 (0.4–2.5)	18 (6.2)	0.9 (0.5–1.6)
Any intellectual disability	4343 (5.0)	86 (23.0)	3.8 (2.8–5.1)*	14 (16.6)	3.4 (1.7–6.8)*	72 (24.8)	3.9 (2.9–5.4)*
Mild intellectual disability	3195 (3.7)	53 (14.2)	3.5 (2.4–5.2)*	10 (11.9)	3.4 (1.5–7.8)*	43 (14.8)	3.6 (2.4–5.4)*
Moderate to profound intellectual disability	1148 (1.3)	33 (8.8)	4.3 (2.8–6.5)*	—	—	29 (10.0)	4.4 (2.8–7.1)*
Orthopedic impairment	358 (0.4)	7 (1.9)	1.9 (1.0–3.5)	—	—	5 (1.7)	1.6 (0.8–3.2)
Other health impairment	6517 (7.6)	94 (25.1)	2.8 (2.2–3.5)*	40 (47.4)	5.4 (3.8–7.7)[d]*	54 (18.6)	2.0 (1.5–2.8)[d]*
Specific learning disability	19 129 (22.2)	117 (31.3)	1.4 (1.1–1.7)*	26 (30.8)	1.3 (0.9–1.9)	91 (31.4)	1.4 (1.1–1.7)*
Sensory impairment	754 (0.9)	13 (3.5)	3.0 (1.8–5.0)*	—	—	10 (3.4)	2.9 (1.6–5.1)*
Significant developmental delay	2308 (2.7)	33 (8.8)	1.9 (1.3–2.8)*	5 (5.9)	1.8 (0.6–5.0)	28 (9.7)	1.9 (1.2–3.0)*
Speech/language impairment	33 354 (38.8)	155 (41.4)	1.1 (0.9–1.3)	34 (40.3)	1.0 (0.7–1.4)	121 (41.7)	1.1 (0.9–1.3)

Isolated CHDs exclude children with syndromes, chromosomal abnormalities, and extracardiac defects.

*Statistically significant aPRR. Estimates with <5 cases are not reported. Prev, prevalence.

[a]CHDs that usually require surgical or catheterization intervention during the first year of life.

[b]Absence of critical CHDs but with ≥1 other CHDs.

[c]Adjusted for maternal age at delivery, race/ethnicity, and education and infant gender, birth weight, and birth year group; referent group is children with no birth defect.

[d]Significant difference in aPRR between critical and noncritical CHDs, $P < .05$.