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Childhood vision impairment, hearing loss and co-occurring autism spectrum disorder

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Abstract

Background—Limited population-based data on prevalence of childhood vision impairment (VI) and hearing loss (HL), and their co-occurrence with autism spectrum disorder (ASD) exists.

Objective—To examine prevalence and characteristics of VI, HL and co-occurring ASD among 8-year-olds in metropolitan Atlanta 2000–2008.

Methods—We used data from the population-based Metropolitan Atlanta Developmental Disabilities Surveillance Program. Prevalence, birth and parental characteristics, presence and severity of other co-occurring developmental disabilities, and age of earliest identification of ASD, were examined for children with VI and HL, by co-occurring ASD.

Results—VI and HL prevalences were 1.2 and 1.3 per 1000 8-year-olds, respectively. Approximately 6–7% of children with VI or HL had co-occurring ASD. Children with VI or HL with co-occurring ASD differed from those without co-occurring ASD by select birth characteristics and the presence of other co-occurring DDs. The median age of earliest known ASD diagnosis was significantly later among children with VI and ASD compared to children with ASD without VI (79 vs. 56 months). Children with HL and ASD were first evaluated by a community provider significantly earlier than those with ASD without HL (40 vs. 50 months).

Conclusions—The frequency of co-occurring ASD with VI and HL is higher than the population prevalence of ASD. The significant delays in diagnosis of ASD in children with VI and lack of earlier diagnosis of ASD among children with HL despite earlier evaluation highlight the importance of developing screening tools for early identification of ASD among children with VI and HL.

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Keywords

Autism spectrum disorder; Children; Developmental disabilities; Hearing loss; Visually impaired

Vision impairment (VI) and hearing loss (HL) are serious developmental disabilities (DDs) affecting children globally. Children with VI or HL are considered to be at risk for problems with emotional, behavioral, neurological, and physical development.[1,2] They are also faced with lifelong challenges in daily functioning, social participation, and health outcomes, which may be exacerbated by the presence of co-occurring developmental disabilities (DDs).[3–5] Autism spectrum disorder (ASD) has been described to co-occur with VI or HL due to neurological or other factors during birth or early childhood.[6–12] While population-based United States (US) data have reported the co-occurrence of DDs among children with VI or HL, particularly with cerebral palsy (CP) and intellectual disability (ID),[13,14] comparable results are limited on the co-occurrence of VI or HL, with ASD. Recent population-based prevalence estimates can provide empiric evidence to understand the resource and planning needs for children with VI or HL and co-occurring ASD as well as suggest areas for investigation of causes.

Current evidence on VI and ASD include a handful of studies outside the US, which employed different methodologies and report ranges of co-occurrence of VI and ASD from 12 to 70% (Table 1). The 2009–2010 Annual Survey of Deaf and Hard of Hearing Children and Youth (ASDHHCY), reports the co-occurrence of ASD and mild to profound HL to be approximately 2%.[17] Given the potential challenges in identifying behaviorally defined disorders among children with major sensory limitations, detailed examination of the prevalence, characteristics, and timing of identification of co-occurring ASD among children with VI or HL is necessary. Significant increases in ASD prevalence among children in various US communities further underscores the need to explore this issue.[18,19] Furthermore, early identification of ASD among children with VI and HL and appropriate intervention may improve long-term outcomes.[20] Yet, little is known about the timing of identification of ASD among children with VI and HL.

Socio-demographic characteristics, and factors such as parental age at delivery, low birth weight, and preterm birth have been reported to be independently associated with VI[21,22] as well as HL.[14,22] Similarly, a literature review found various associations between the above factors and ASD.[23] Nevertheless, these factors have not been examined related to the co-occurrence between VI and ASD, or HL and ASD, and may suggest areas for exploration regarding potential shared risk factors or etiologies.

The Metropolitan Atlanta Developmental Disabilities Surveillance Program (MADDSP), is a long-standing and unique population-based surveillance program that monitors VI, HL and other DDs among a heterogenous population of 8-year-old children living in metropolitan Atlanta using objective, systematic measures for case ascertainment and definition.[24] Data from the 2000–2008 MADDSP surveillance years were used to examine three study objectives among children with VI and HL overall, and by co-occurring ASD to: 1) estimate population period prevalence; 2) examine birth and parental characteristics, presence and

severity of other DDs, and medical conditions; and 3) assess community identification of ASD.

Methods

Data source

MADDSP uses a multiple source methodology for active population-based surveillance of five DDs including VI, HL, ASD, CP, and ID in five counties (Clayton, Cobb, DeKalb, Fulton, and Gwinnett) of metropolitan Atlanta, Georgia. Children are identified from record review at nine public school systems and selected private and public health sources that treat, diagnose, and/or serve children with DDs. Multiple records for a given child are compiled into one composite record which is then reviewed by a team of clinician reviewers to determine final case status. Additional methodological details have previously been published.[24] This project was approved by the Institutional Review Board at the Centers for Disease Control and Prevention (CDC).

Study period

We used MADDSP data from five surveillance years: 2000, 2002, 2004, 2006, 2008, hereafter referred to as '2000–2008'.

Case definitions

A case is defined as a child aged 8 years at any time during the surveillance year of interest, whose parent or legal guardian(s) resided in the five-county metropolitan Atlanta during the respective surveillance year, and who meets criteria for one or more of five DDs.

Vision impairment

VI is defined as a measured visual acuity of 20/70 or worse in the better eye with correction. In the absence of a measured visual acuity, VI is defined based on a source record that includes a functional description, by a qualified physician or vision professional, of visual acuity of 20/70 or worse (e.g., light perception only) or a statement by a qualified physician or vision professional that the child had low vision or blindness. VI severity was defined as: a) 'low vision' with a visual acuity 20/70 to better than 20/200; b) 'legal blindness', with a visual acuity of 20/200 or worse, and c) cerebral visual impairment.

Hearing loss

HL is defined as a measured, bilateral, pure-tone hearing loss at frequencies of 500, 1,000, and 2000 Hz averaging ≥40 dB, unaided, in the better ear. Severity of HL was defined based on the measurement in the better ear: moderate (hearing loss of 40–64 dB), severe (hearing loss of 65–84 dB), and profound (hearing loss of ≥85 dB).[25]

Autism spectrum disorder

ASD is defined by the documentation of behaviors (as described on a comprehensive evaluation by a qualified professional) that are consistent with the diagnostic criteria listed in the Diagnostic and Statistical Manual-IV, Text Revision (DSM-IV-TR) for any of the

following conditions: Autistic Disorder, Pervasive Developmental Disorder-Not Otherwise Specified (PDD-NOS, including Atypical Autism), or Asperger Disorder.[19,26]

Intellectual disability

ID is defined as an intelligence quotient (IQ) of ≤70 on the most recently administered psychometric test. ID severity is defined based on the *International Classification of Diseases, Ninth Edition, Clinical Modification*[27]: mild (IQ = 50–70), moderate (IQ = 35–49), severe (IQ = 20–34), and profound (IQ <20).

Cerebral palsy

CP is defined by documentation of a CP diagnosis or description of physical findings consistent with CP noted in clinical evaluation(s) at age 2 or older by a qualified professional.[24,28] Children with CP acquired after birth (post-neonatal CP) are included. CP subtypes are categorized as spastic (monoplegia, hemiplegia, diplegia, quadriplegia, or triplegia), non-spastic (dyskinetic, ataxic, hypotonic, dyskinetic-ataxic) and mixed CP or CP NOS (spastic-ataxic, spastic-dyskinetic, spastic athetoid, mixed CP or CP NOS).

Epilepsy and Down syndrome

Information on epilepsy and Down syndrome were abstracted from MADDSP records, if documented in the record by a medical doctor, a psychologist, or an educator.

Congenital malformations

Information on congenital malformations, syndromes, and chromosomal abnormalities was obtained by linkage with the Metropolitan Atlanta Congenital Defects Program (MACDP),[29] a population-based birth defects surveillance program of children born to mothers who resided within the five-county region of metropolitan Atlanta at the time of their birth. Diagnoses of congenital malformations were confirmed and classified by MACDP clinicians. MACDP is described elsewhere.[30]

Birth, parental, and demographic characteristics

Information on birth, maternal and paternal characteristics were obtained from linkage with birth certificate data of children born in metropolitan Atlanta. Birth certificate data were not obtainable for children born outside of the 5 county metropolitan Atlanta who migrated into metropolitan Atlanta between birth and age 8 years (35%). We conducted a sub-analysis on selected characteristics of children with VI or HL by whether they were non-migrants (born and residing in metropolitan Atlanta at age 8) or in-migrants (born outside of metropolitan Atlanta and moved in by age 8) (data not shown). We found no difference between non-migrant and in-migrant children with HL by sex, severity of HL or presence of co-occurring DD. Differences were found between non-migrant and in-migrant children with VI by sex, race and ethnicity, and presence of co-occurring DDs, but not by severity of VI, which we believe may be the strongest indicator for selective migration. Child's race/ethnicity was obtained primarily from abstracted MADDSP records and supplemented with information from the child's birth certificate if not available from the abstracted data.

Statistical analysis

The prevalence for VI and HL was estimated per 1000 8-year-olds residing in the metropolitan Atlanta area during surveillance years 2000–2008. Denominator data were obtained from the CDC National Center for Health Statistics postcensal 2009 vintage population estimates for 2000–2008 surveillance years yielding a total of 230,973 8-year-olds in metropolitan Atlanta.[31] Average annual period prevalence estimates, henceforth referred to as 'prevalence', were calculated for 2000–2008 overall by summation of the numerator data divided by the summation of denominator data across all surveillance years. The 95% confidence intervals (CIs) were calculated using the Poisson approximation to the binomial distribution. Poisson regression was used to test for linear trends in the VI and HL prevalence estimates from 2000 to 2008. Chi square or Fisher exact test of significance was used to examine differences in prevalence by sex and race/ethnicity as well as selected birth and parental characteristics, severity, co-occurring DDs between children with VI or HL with and without ASD.

Children were considered to have a previously documented ASD classification if they received a diagnosis of Autistic Disorder, PDD-NOS, Asperger Disorder, or ASD that was documented in an abstracted evaluation or by an ICD-9 billing code at any time from birth through the end of the year when they reached age 8 years, or if they received special education services under an autism eligibility. Ages at earliest known ASD diagnosis and earliest evaluation were calculated by subtracting the earliest date or age of known diagnosis or evaluation from the child's date of birth. An earlier historical ASD diagnosis was taken if specified in a comprehensive evaluation. Between group differences in the median age of ASD evaluation were examined using the Mann–Whitney test. All statistical analyses were conducted using SAS (version 9.2; SAS Institute, Cary, NC).

Results

Vision impairment

The prevalence of VI during 2000–2008 was estimated as 1.2 per 1000 8-year-olds (95% CI = 1.1–1.4). Prevalence estimates across 2000–2008 were stable ($p = 0.12$) (data not shown). VI prevalence was higher among Hispanic children compared with White non-Hispanic children ($p = 0.05$), but did not differ significantly between boys and girls or between White and Black non-Hispanic children (Table 2). Sixty three percent of children with VI had at least another DD (including ASD, CP, ID, and/or HL). The frequency of ASD among children with VI was 7.2% (95% CI: 4.6–11.2); comprised of children with VI and ASD only (1.4%), and those with VI, ASD and other DDs (5.8%). These were lower than the co-occurrence of VI and ID (52.5%) and VI and CP (41.0%), but the overall frequency was slightly higher than VI and HL overall (5.8%) (Table 3). Among other conditions examined, 19.1% of children with VI had congenital malformations, Down syndrome, or a chromosomal abnormality, and 29.1% had epilepsy.

The prevalence of VI and co-occurring ASD was estimated as 0.09 per 1000 8-year-olds (95% CI = 0.06–0.13) and there was no significant linear trend in the prevalence estimates of this co-occurrence over the study period ($p = 0.44$). No significant differences were noted

in the prevalence of VI with ASD by sex and race/ethnicity (Table 2). Children with VI and ASD were significantly more likely to be low birth weight ($p = 0.01$) and/or a preterm birth ($p = 0.02$) (Table 4) and had a significantly higher frequency of co-occurring ID ($p = 0.04$), compared to children with VI without ASD (Table 3). Three out of 20 children with VI and ASD had a congenital malformation, syndrome, or chromosomal abnormality.

Approximately 70.0% of children with VI and ASD had a previously documented ASD classification compared to 81.5% of children with ASD without VI. There was no difference in the median age of earliest evaluation between children with VI and ASD compared with children with ASD without VI (Table 5). Yet, the median age of earliest known ASD diagnosis in children with VI was significantly later (79 months) compared with children with ASD without VI (56 months, $p = 0.02$).

Hearing loss

The prevalence of HL during 2000–2008 was estimated as 1.3 per 1000 8-year-olds (95% CI = 1.2–1.5). The annual HL prevalence estimates during the surveillance period did not vary significantly ($p = 0.28$) (data not shown). Overall, HL prevalence did not differ significantly by sex or race/ethnicity. Seventy seven percent of children with HL had co-occurring ASD, CP, ID or VI. The frequency of ASD among children with HL was 5.8% (95% CI = 3.7%–9.3%); including those with HL and ASD only (1.6%) and HL, ASD and other DDs (4.2%). The frequency of other co-occurring DDs among children with HL was highest for ID (23.7%) followed by CP (10.7%) and VI (5.2%). One half of children with HL had moderate loss, 23.7% were in the severe range and 26.9% had profound HL (Table 3). Among the other medical conditions examined, 12.3% of children with HL had a major congenital malformations syndrome, or chromosomal abnormality, 7.5% had epilepsy, and 2.3% had Down syndrome.

The prevalence of HL co-occurring with ASD was estimated as 0.08 per 1000 8-year-olds (95% CI = 0.05–0.12), with no significant linear trend in the prevalence over the surveillance period ($p = 0.60$). The prevalence of HL with co-occurring ASD was significantly higher among boys compared to girls; however, this was based on small samples (Table 2). Children with HL and ASD had a significantly different sex distribution compared to children with HL without ASD ($p = 0.01$) (Table 3). The majority of children with HL and ASD had moderate HL (61.1%). A greater proportion of children with HL and co-occurring ASD had co-occurring ID and co-occurring CP compared to children with HL without ASD. No significant differences were found between children with HL with and without ASD according to the other birth and parental characteristics examined (Table 4).

The proportion of children with a previously documented ASD classification was similar for children with ASD and HL and those with ASD without HL (77.8% and 81.4%, respectively). Comparison of median ages of first evaluation showed that children with ASD and HL appeared to have been evaluated significantly earlier than those with ASD without HL (40 months vs. 50 months) ($p = 0.01$) (Table 5). Nevertheless, the median age of earliest known ASD diagnosis among children with HL (57 months) was similar to the age of ASD diagnosis in children with ASD without HL (56 months).

Discussion

This is the first US population-based report detailing the frequency, presence, and timing of community identification of co-occurring ASD among children with VI or HL. Early identification of ASD is particularly important among children with sensory disabilities, as these children may require different or additional interventional approaches or both, relative to children with ASD, but without VI or HL. Furthermore, disparities in the timing of evaluation and diagnosis of children with VI or HL and co-occurring ASD compared with their peers with ASD without these sensory conditions highlight the need to develop tools specific for identification of ASD within this population and a greater awareness within the clinical community.

While the frequencies of ASD among children with VI (7.2%) and HL (5.8%) were stable from 2000 to 2008, the prevalence of ASD increased significantly (83%) from 6.5 per 1000 (95% CI = 5.8–7.3) in 2000 to 11.9 per 1000 (95% CI = 11.0–12.9) in 2008 in metropolitan Atlanta using postcensal denominator data.[18,19,32] Despite the increase in overall ASD prevalence compared with the stability of VI and HL prevalence, ASD prevalence among children with VI and HL was consistently higher than the population prevalence of ASD among 8-year-olds.

Several causal pathways have been proposed that infer a greater risk of ASD among children with VI (e.g., retrolental fibroplasia, Leber's congenital amaurosis, rubella) and a handful of case series reported co-occurrence with ASD or autism-like features in selected groups of children with VI.[8,33–37] However these data on reported co-occurrence need to be interpreted with caution as individual study case definitions and methods vary. Four studies[9,10,15,16] examined co-occurrence of VI and ASD, where ASD diagnosis was based on either DSM IVor International Classification of Diseases (ICD) 10 criteria (Table 1). One of these studies examined the frequency of autism among children and adolescents attending schools for the visually impaired defining VI through clinical examination by an ophthalmologist and found that 12% (n = 30/ 257) of children with VI also had ASD.[15] Their estimate is comparable to the upper bound of our rate of VI and ASD co-occurrence (7.2%; 95% CI = 4.6%–11.2%).

While the median age of first evaluation for children with VI and ASD was similar to those with ASD without VI, it was concerning that the age of earliest known ASD diagnosis was much later for children with VI and ASD in our study. Current diagnostic instruments used to detect ASD by assessing eye contact, joint attention, and gesture have not been validated in children with VI.[38] Also, several items in the evaluation of children for ASD rely on vision, social interaction, and intelligence testing, which likely cannot be applied to children with VI.[39] Lack of feedback on social behavior and play experiences, limited interaction with others, and potential co-occurrence with other DDs, complicate assessment of ASD among children with VI.[40] The Autism Diagnostic Interview is the only comprehensive instrument reported to identify ASD in children with VI, but further work is needed.[41]

The co-occurrence between HL and ASD was first suggested in the 1970s,[42] and it was believed that HL was a possible cause for autism,[43] pointing to social isolation, emotional

distress, psychological disorders, and language deficits in children with HL as potential pathways to a subsequent diagnosis of autism.[18,44] Conditions such as cytomegalovirus, toxoplasmosis, bacterial meningitis, rubella and measles have also been proposed as possible risk factors for co-occurrence of HL and ASD.[11] Two previous studies found varying rates of ASD among children with HL (2–5%).[11,17] Most comparable to MADDSP, the 2009–2010 ASDHHCY reported that 1 in 59 (1.7%; 95% CI = 1.8%–2.1%) children in the US with HL had ASD based on clinical ASD diagnosis or autism special education placement documented in education records.[17] This estimate is lower than our finding (5.8%; 95% CI = 3.7%–9.3%). Given that approximately 22% of children with HL and ASD in MADDSP did not have a previously documented ASD classification by a community provider, the significantly lower estimate reported by the Annual Survey may be attributable to under-identification of ASD among children with HL in the community. Of note, the ASDHHSY reported that the majority of children with ASD had profound HL while we found that the majority of children with HL and ASD functioned in the moderate range.

Previous studies have shown that communication limitations delay the timing of ASD diagnosis in children with HL.[11,45] Interestingly, in the current study, the median age at first evaluation for children with HL and ASD was earlier than for children with ASD and no HL, yet the median age of earliest known ASD diagnosis was the same regardless of the presence of co-occurring HL. Diagnostic overshadowing indicated by the masking of a diagnosis of ASD in children with HL and ID, discussed by Szymanski et al (2012), may be occurring in our study for HL as well as VI.[17] The earlier age of evaluation among children with HL is encouraging and indicates an opportunity for earlier identification of ASD, but underscores the need for improved diagnostic tools and education for potentially confirming a possible co-occurring diagnosis of ASD with the goal of facilitating earlier receipt of appropriate services.

With respect to birth characteristics as shared risk factors, low birth weight and preterm birth are suggested to expose the developing visual systems in the fetus to high levels of oxygen and early light stimulus, resulting in sub-optimal vision development.[21,22,46,47] Disruption in typical neuronal development has been suggested as a common pathway for VI, HL, and ASD among children born preterm.[9] Schendel and Bhasin (2008), using data from MADDSP, showed an increased prevalence of VI and HL, as well as ASD, among children born preterm compared to term.[22] Sex, plurality, maternal age, race/ethnicity, and parental education have all been considered to play a role in the etiology and association between low birth weight, gestational age, and VI, HL, and ASD as individual conditions,[22] but there have been no population-based data on the influence of these factors on the co-occurrence of VI or HL and ASD. HL and VI are low prevalence conditions and as a result the sample sizes for children with VI or HL and co-occurring ASD are somewhat limited when stratified by various socio-demographic and birth characteristics. Nevertheless, MADDSP data are uniquely capable of examining these issues. Interestingly, the only differences we found in the presence of co-occurring ASD was for children with VI by birth weight and gestational age. As MADDSP continues to accumulate additional surveillance data, we plan to revisit these findings.

Our study also contributes recent overall, sex, and racial/ethnic specific prevalence estimates of childhood VI and HL. The 2000–2008 MADDSP prevalence estimates for VI and HL were comparable to those reported for previous surveillance years using the MADDSP methods.[4,48,49] While our VI prevalence (1.2 per 1000) was comparable to the reported prevalence of "blindness/ unable to see at all" based on parental report from the 1997–2008 National Health Interview Survey (1.3 per 1000 children aged 3–17 years), the reported prevalence of "moderate to profound hearing loss" based on parental report (4.5 per 1000) was much higher than that found in MADDSP (1.3 per 1000).[4,32] The discordance between HL prevalence estimates may be attributable to a more liberal definition of HL being interpreted upon parental report compared to the objective, audiologic test scores and established cut-offs used to define moderate to profound HL in MADDSP.

The strengths of MADDSP include systematic and consistent methodology, a comprehensive approach to case ascertainment, and rigorous quality assurance. MADDSP uses objective test data to determine case status for VI and HL rather than a more subjective measure such as parental report. In addition, MADDSP does not rely solely on a clinical diagnosis of autism or special education autism classification, but rather on documented behaviors consistent with ASD. Therefore, MADDSP identifies children who were not previously identified with ASD by a community professional, a group likely not identified as having ASD by other studies.

Our results are subject to a few limitations. Retrospective review of administrative records for case ascertainment relies on the availability and quality of information documented in the source records. If limited, this may result in under-identification of behaviors and diagnoses of ASD among children with VI and HL. Given functional limitations related to the child's VI or HL, evaluation and diagnosis of ASD in children with VI and HL may be challenging and result in an underestimation of the number of children with VI and ASD or HL and ASD. We speculate that the proportion of children with VI or HL with a co-occurring congenital malformations, syndromes, or abnormalities other than Down syndrome may also be an underestimate as MADDSP does not actively collect this information on children with DDs.

Conclusions

In summary, our findings demonstrate that the frequency of co-occurring ASD among children with VI or HL has been stable over time, but consistently higher than ASD prevalence among 8-yr-olds in metropolitan Atlanta for 2000–2008. The delay found in the age of diagnosis for children with VI, and lack of earlier ASD diagnosis despite earlier evaluation among children with HL, underscore the need for development of valid and reliable diagnostic tools coupled with greater awareness of behaviors consistent with ASD among clinicians serving children with VI and HL. Improved tools and greater awareness are needed to provide more complete and timely identification of ASD among children with VI or HL and greater subsequent planning of educational, interventional, and preventative services for affected children. Our findings also suggest potential venues for future investigation of shared risk factors for the co-occurrence of VI or HL with ASD. As such,

focused efforts are needed to better understand preventable risk factors and causes of ASD in children with VI or HL, to ultimately improve the quality of life of those affected.

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Table 1

Published studies on co-occurrence of vision impairment and hearing loss with autism spectrum disorder

Author (Year)	Study year	Age group	Study design	Children with VI N	Children with VI and ASD percentage, (95% CI)	Type of VI	ASD subtype and diagnostic criteria
Ek (1998)[9]	1980–1990 Birth years	0–19 year-olds	Case series	27 27	55.6%, (33.5–92.2) 70.4%, (44.9–110.3)	Retinopathy of prematurity Retinopathy of prematurity	Autistic disorder: DSM-IV and Childhood Autism Rating Scale Autistic Disorder + Autism like conditions
Ek (2005)[10]	1988–1998 Birth years	5–15 year-olds	Case series	13 13	46.2%, (20.7–102.7) 69.2%, (36.0–133.1)	Optic nerve hypoplasia Optic nerve hypoplasia	Autism: DSM-IV Autism + Autism like conditions
Mukkades (2007)[15]	NS	7–18 year-olds	Case series	257	11.7%, (8.2–16.7)	Total blindness, near blindness, profound VI, severe VI	Autistic disorder: autism behavior checklist; developmental history form; school records, Childhood Autism Rating Scale, DSM IV criteria for autistic disorder
Parr (2010)[16]	2007–2009	10 months–6 years 10 months	Retrospective case-note study	83	33.7%, (23.3–48.9)	Severe/profound VI	Autism spectrum disorder: ICD-10
				Children with HL N	Children with HL and ASD percentage, (95% CI)	Type of HL	
Jure (1991)[11]	1966–1988	Children	Case series	1150	4.0%, (3.0–5.3)	Mild-profound	Autism: DSM–III–R
Szymanski (2012)[17]	2009–2010	8 year-olds	Cross-sectional	32,334	1.9%, (1.8–2.1)	Mild-profound	Autism spectrum disorder: Clinical diagnosis (DSM-IV) and/or IDEA classification code from education records

AD = autistic disorder; ASD = autism spectrum disorder; CI = confidence interval; DSM = Diagnostic and Statistical Manual; HL = hearing loss; ICD = International Classification of Diseases; IDEA = Individuals with Disabilities Education Act; NS = not stated; VI = vision impairment.

Table 2

Prevalence and Characteristics of Children with Vision Impairment and Hearing Loss, and Co-occurring Autism Spectrum Disorder, Metropolitan Atlanta Developmental Disabilities Surveillance Program, 2000–2008[a]

Characteristics	All VI	Prevalence of VI (95% CI)	VI with ASD (N)	Proportion with VI and ASD	Prevalence of VI and ASD (95% CI)	All HL	Prevalence of HL (95% CI)	HL with ASD (N)	Proportion with HL and ASD	Prevalence of HL and ASD (95% CI)
Surveillance Years										
2000–2008	278	1.20 (1.07, 1.35)	20	7.2	0.09 (0.06, 0.13)	308	1.33 (1.19, 1.49)	18	5.8	0.08 (0.05, 0.12)
Sex										
Male	148	1.26 (1.07, 1.48)	13	65.0	0.11 (0.06, 0.19)	167	1.42 (1.22, 1.65)	15	83.3	0.13 (0.08, 0.21)[b]
Female	130	1.15 (0.97, 1.36)	7	35.0	0.06 (0.03, 0.13)	141	1.24 (1.06, 1.47)	3	16.7	0.03 (0.01, 0.08)
Race/Ethnicity[c]										
NH White	87	0.95 (0.77, 1.17)	5	25.0	0.05 (0.02, 0.13)	116	1.27 (1.06, 1.52)	7	38.9	0.08 (0.04, 0.16)
NH Black	128	1.28 (1.08, 1.52)	10	50.0	0.10 (0.05, 0.19)	125	1.25 (1.05, 1.49)	8	44.4	0.08 (0.04, 0.16)
Hispanic	39	1.46 (1.06, 1.99)	3	15.0	0.11 (0.04, 0.35)	43	1.61 (1.19, 2.16)	1	5.6	0.04 (0.01, 0.27)
Other	21	–	1	5.0	–	17	–	2	11.1	–

ASD=Autism Spectrum Disorders; CI = Confidence Interval; HL = Hearing Loss; NH = Non-Hispanic; VI = Vision Impairment.

[a] Per 1,000 8-year-olds residing in the five-county region of metropolitan Atlanta.

[b] Prevalence odds ratio significantly different (p <0.05).

[c] Prevalence was not estimated for Other race/ethnicities including Asian/Pacific Islander, American Indian/Alaska Native, and multi-racial. Children categorized as 'Missing' race/ethnicities are excluded. There were 3 VI cases with missing data one of which had co-occurring ASD. There were 7 HL cases with missing race/ethnicity data none of which had co-occurring ASD.

Table 3

Severity and co-occurring conditions among children with vision impairment and hearing loss, and co-occurring autism spectrum disorder, Metropolitan Atlanta Developmental Disabilities Surveillance Program, 2000–2008

	All VI (*N* = 278)		VI with ASD (*N* = 20)		VI without ASD (*N* = 258)		All HL (*N* = 308)		HL with ASD (*N* = 18)		HL without ASD (*N* = 290)	
Characteristics	***n***	**%**	***n***	**%**	***n***	**%**	***n***	**%**	***n***	**%**	***n***	**%**
Severity of VI	-	-	-	-	-	-	**16**	**5.2**	**2**	**11.1**	**14**	**4.8**
Low vision	83	29.9	5	25.0	78	30.2	5	31.2	1	50.0	4	28.6
Legal blindness	189	68.0	15	75.0	174	67.4	10	62.5	1	50.0	9	64.3
Cerebral VI	4	1.4	0	-	4	1.6	1	6.3	0	0	1	7.1
Missing/unknown	2	0.7	0	-	2	0.8	0	-	0	-	0	-
Severity of HL	**16**	**5.8**	**2**	**10.0**	**14**	**5.4**	-	-	-	-	-	-
Moderate HL	10	62.5	2	100.0	8	57.1	154	50.0	11	61.1	143	49.3
Severe HL	4	25.0	0	0	4	28.6	71	23.1	5	27.8	66	22.8
Profound HL	2	12.5	0	0	2	14.3	83	26.9	2	11.1	81	27.9
Co-occurring ID	**146**	**52.5**	**15**	**75.0**	**131**	**50.8**[a]	**73**	**23.7**	**11**	**61.1**	**62**	**21.4**[a]
Mild	32	21.9	3	20.0	29	22.1	26	35.6	3	27.3	23	37.1
Mod-profound	96	65.8	11	73.3	85	64.9	38	52.1	8	72.7	30	48.4
ID-NOS	18	12.3	1	6.7	17	13.0	9	12.3	0	-	9	14.5
Co-occurring CP	**114**	**41.0**	**10**	**50.0**	**104**	**40.3**	**33**	**10.7**	**7**	**38.9**	**26**	**9.0**[a]
Spastic CP	92	80.7	10	100.0	82	78.8	18	54.6	4	57.1	14	53.8
Non spastic CP	8	7.0	0	-	8	7.7	4	12.1	0	-	4	15.4
Mixed CP or CP-NOS	14	12.3	0	-	14	13.5	11	33.3	3	42.9	8	30.8
Other medical conditions												
Congenital malformations	53	19.1	3	15.0	50	19.4	38	12.3	3	16.7	35	12.1
Epilepsy	81	29.1	3	15.0	78	30.2	23	7.5	0	0	23	7.9
Down syndrome	6	2.1	0	0	6	2.3	7	2.3	0	0	7	2.4

Bold indicates subjects and percent of all cases, within the selected category (sub-strata).

ASD = autism spectrum disorder; CP = cerebral palsy; DD = developmental disabilities; HL = hearing loss; ID = intellectual disability; NH = non-Hispanic; VI = vision impairment; wks = weeks; yrs = years.

All VI = VI with and without co-occurring ASD; All HL = HL with and without co-occurring ASD.

Severity of ID: Mild = IQ 50–70; Moderate to profound = IQ <50.

Severity of HI: Moderate = 40–64 dB; Severe = 64–84 dB; Profound = 85–121 dB.

Severity of VI (US Definition): Low vision = better than 20/200; Legal blindness = 20–200 or worse.

Spastic CP = spastic monoplegia, spastic hemiplegia, spastic diplegia, spastic quadriplegia, and spastic triplegia, Non-spastic CP = dyskinetic, ataxic, hypotonic, and dyskinetic-ataxic, Mixed CP, CP NOS = spastic-ataxic, spastic-dyskinetic, spastic athetoid, mixed CP and cerebral palsy not otherwise specified.

[a] *p* value significant at <0.05 (comparison between VI with ASD and VI without ASD; and between HL with ASD and HL without ASD).

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Table 4

Birth, maternal and paternal characteristics of children with vision impairment and hearing loss, and co-occurring autism spectrum disorder, Metropolitan Atlanta Developmental Disabilities Surveillance Program, 2000–2008

	All VI (*N* = 278)		VI with ASD (*N* = 20)		VI without ASD (*N* = 258)		All HL (*N* = 308)		HL with ASD (*N* = 18)		HL without ASD (*N* = 290)	
Birth certificate Characteristics	***n***	**%**	***n***	**%**	***n***	**%**	***n***	**%**	***n***	**%**	***n***	**%**
Birth												
Birth weight (gms)	*n* = 184	%	*n* = 15	%	*n* = 169	%	*n* = 201	%	*n* = 13	%	*n* = 188	%
<2500	76	41.3	11	73.3	65	38.5[a]	46	22.9	5	38.5	41	21.8
≥2500	108	58.7	4	26.7	104	61.5	155	77.1	8	61.5	147	78.2
Gestational age (wks)	*n* = 182	%	*n* = 15	%	*n* = 167	%	*n* = 197	%	*n* = 13	%	*n* = 184	%
<37	71	39.0	10	66.7	61	36.5[a]	45	22.8	4	30.8	41	22.3
≥37	111	61.0	5	33.3	106	63.5	152	77.2	9	69.2	143	77.7
Plurality	*n* = 184	%	*n* = 15	%	*n* = 169	%	*n* = 201	%	*n* = 13	%	*n* = 188	%
Singleton	171	92.9	14	93.3	157	92.9	194	96.5	11	84.6	183	97.3
Multiple	13	7.1	1	7.7	12	7.1	7	3.5	2	15.4	5	2.7
Maternal												
Age at delivery (yrs)	*n* = 184	%	*n* = 15	%	*n* = 169	%	*n* = 201	%	*n* = 13	%	*n* = 188	%
<25	67	36.4	6	40.0	61	36.1	87	43.3	7	53.8	80	42.5
25–34	81	44.0	6	40.0	75	44.4	82	40.8	5	38.5	77	41.0
≥35	36	19.6	3	20.0	33	19.5	32	15.9	1	7.7	31	16.5
Education (yrs)	*n* = 179	%	*n* = 13	%	*n* = 166	%	*n* = 195	%	*n* = 12	%	*n* = 183	%
<12	34	19.0	4	30.8	30	18.1	48	24.6	4	33.3	44	24.0
≥12	145	81.0	9	69.2	136	81.9	147	75.4	8	66.7	139	76.0
Paternal												
Age at delivery (yrs)	*n* = 136	%	*n* = 11	%	*n* = 125	%	*n* = 153	%	*n* = 7	%	*n* = 146	%
<25	35	23.5	5	45.5	27	21.6	22	14.4	1	14.3	21	14.4
25–34	67	49.3	5	45.5	62	49.6	89	58.2	4	57.1	85	58.2
≥35	37	27.2	1	9.1	36	28.8	42	27.4	2	28.6	40	27.4
Education (yrs)	*n* = 135		*n* =% 10	%	*n* = 125	%	*n* = 149	%	*n* = 6	%	*n* = 143	%
<12	22	16.3	3	30.0	19	15.2	20	13.4	1	16.7	19	13.3
≥12	113	83.7	7	70.0	106	84.8	129	86.6	5	83.3	124	86.7

Totals differ based on available data from birth certificates. Frequency and percent may not equal total because of missing data.

ASD = autism spectrum disorder; CP = cerebral palsy; DD = developmental disabilities; gms = grams; HL = hearing loss; ID = Intellectual disability; NH = non-Hispanic; VI = vision impairment; wks = weeks; yrs = years.

All VI = VI with and without co-occurring ASD; All HL = HL with and without co-occurring ASD.

[a] *p* value significant at <0.05 (comparison between VI with ASD and VI without ASD; and between HL with ASD and HL without ASD).

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Table 5

Median age at first evaluation and/or diagnosis of autism spectrum disorder by co-occurring vision impairment or hearing loss, Metropolitan Atlanta Developmental Disabilities Surveillance Program, 2000–2008

Median age at earliest evaluation		
	N	**Median (months)**
ASD with VI	20	46
ASD without VI	2078	50
TOTAL ASD	2098	Median difference p value = 0.37
ASD with HL	18	40
ASD without HL	2080	50
TOTAL ASD	2098	Median difference p value = 0.02[a]
Median age at earliest known ASD diagnosis		
	N	Median (months)
ASD with VI	12	79
ASD without VI	1233	56
TOTAL ASD	1245	Median difference p value = 0.02[a]
ASD with HL	11	57
ASD without HL	1234	56
TOTAL ASD	1245	Median difference p value = 0.83

ASD = autism spectrum disorder; HL = hearing loss; MADDSP = Metropolitan Atlanta Developmental Disabilities Surveillance Program; SD = standard deviation; VI = vision impairment.

[a] p value significant at <0.05.