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Early Risk Factors for Speech and Language Impairments

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Developmental epidemiological methods were used to identify risk factors for speech impairment (SI), specific language impairment (SLI), and combined speech and language impairment (CSLI) in a statewide sample of preschool-age children. Level of risk was determined by comparing the rate of occurrence of factors between 12,799 children with SI, SLI, or CSLI and a comparison group of 946,177 children. Multiple birth, presence of a newborn condition, presence of a congenital abnormality, maternal age greater than 35 years, and presence of a maternal medical history factor were associated with increased risk for SI, SLI, and CSLI. Prematurity and very low birthweight were significant risk factors for SLI and CSLI but not for SI. Prenatal exposure to alcohol was a significant risk factor for SI but not SLI and CSLI. Low maternal education and unwed marital status were associated with a decreased risk for speech and/or language impairments, indicating a potential identification bias. The study presented here demonstrates the potential for identifying children at birth who are at increased risk for speech and language impairments.

Speech and language impairments are among the most prevalent childhood disabilities. Prevalence rates vary a great deal by sample and age (see Blum-Harasty & Rosenthal, 1992; Law, Boyle, Harris, Harkness, & Nye, 2000b, for reviews) but are approximately 5 to 6% for speech impairment (SI), 7 to 8% for specific language impairment (SLI), and an additional 5 to 6% for combined speech and language impairment (CSLI; Fox, Dodd, & Howard, 2002; Law et al., 2000b; Tomblin, Records, et al., 1997; Wang & Baron, 1997). The U.S. Department of Education (2001) reported that 5,683,707 children 6 to 21 years of age and 588,300 preschool-age children with disabilities were served under the Individuals with Disabilities Education Act (IDEA) Part B in the 1999–2000 school year. Of children 6 to 21 years of age, 1,089,964 (19.2%) had speech or language impairment as a primary exceptionality. Only specific learning disabilities were more prevalent among school-age children. Although national data by disability were not available for preschool-age children, the state of Florida reported serving 20,667 preschool children with disabilities during the same time period, 8,557 (41%) of whom had speech or lan-

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guage impairment as a primary exceptionality. An additional 7,086 children (34%) had speech impairment, language impairment, or both as secondary exceptionalities (Florida Department of Education, 2001).

The high prevalence and high economic cost of speech and language disorders make the prevention of these disabilities a major public health challenge (Ruben, 2000) and a primary objective of speech–language pathologists (American Speech-Language-Hearing Association, 1991, 2002). Effective prevention includes preventing speech and language impairments from developing as well as providing early intervention services to at-risk children or children displaying early signs of disability to minimize or prevent the development of other disabilities, such as learning disabilities (Wang & Baron, 1997).

Early identification of children at risk for speech and language disabilities is crucial to providing these children with the appropriate services. The concept of risk indicates that individuals with certain characteristics are more likely to have an undiagnosed condition or to develop the condition in the future than are individuals without those characteristics (Finkelstein & Ramey, 1980). Risk measurement is useful "to recommend changes, to prevent negative events, to promote health, to inform policy, and to inform practice" (Lubker & Tomblin, 1998, p. 15). Identification of risk factors within the 1st year of life allows for the identification of those individuals likely to have speech or language disorders before language is present. Early intervention with these at-risk children is the key to limiting the negative effects of speech and language disorders (Ramey & Campbell, 1984).

Epidemiological methods have been identified as an effective tool in the prevention of disorders in that they result in the quantification of risk associated with early biological and environmental factors. The important role of epidemiology in the study of speech and language disorders has been firmly established (Antoniadis & Lubker, 1997; Longemann & Baum, 1998; Lubker, 1997; Lubker & Tomblin, 1998). Epidemiologic research provides the foundation for implementing the policies and procedures necessary for early identification and treatment of children with speech and language disorders (American Speech-Language-Hearing Association, 1991; Lubker, 1997) as well as assisting speech–language pathologists predict where their populations will come from and how service and training needs will change (Lubker, 1997; Lubker & Tomblin, 1998).

Evaluation of extant data available from birth certificate records represents a cost-effective way to identify children at risk for speech and/or language impairments. Birth certificate records are an inexpensive and widely available source of information useful in identifying children at risk for adverse medical, psychological, and educational outcomes (Finkelstein & Ramey, 1980). Due to the prevalence of speech and language impairments, the idea of screening all children for these impairments has been presented (Law, Boyle, Harris, Harkness, & Nye, 2000b). Universal screening, however, does not appear to be a cost-effective way to identify children with speech or language impairments (Law et al., 2000b). Utilization of data provided in birth certificate records provides a viable alternative to global screening. Children at high risk could be identified at very low cost, and screenings could be targeted to just those children. Such an approach would not result in the exclusive identification of children with primary speech or language difficulties, but it would be likely to identify those most in need of intervention resulting in a more efficient use of resources (Andrews, Goldberg, Wellen, Pittman, & Struening, 1995; Law et al., 2000a).

Researchers have examined the relation between numerous factors available from birth certificate records and speech and/or language impairments. Factors studied include gestational age, birthweight, Apgar score, plurality, newborn condition, congenital abnormalities, maternal education, maternal age, maternal marital status, prenatal exposure to alcohol, prenatal exposure to tobacco, maternal medical history factors, and complications of labor or delivery (Abkarian, 1992; American Speech-Language-Hearing Association, 1991; Campbell et al., 2003; Hammer, Tomblin, Zhang, & Weiss, 2001; McMahon, Stassi, & Dodd, 1998; Stanton-Chapman, Chapman, Bainbridge, & Scott, 2002; Tomblin, Hammer, & Zhang, 1998; Tomblin, Hardy, & Hein, 1991; Tomblin, Records, et al., 1997; Tomblin, Smith, & Zhang, 1997; Wang & Baron, 1997). The findings associated with these factors have varied, with some studies indicating significant relations with speech and/or language impairment and other studies indicating nonsignificant relations. Some factors such as maternal marital status and complications of labor or delivery have not been demonstrated to increase risk for SLI; however, the relation of these factors to SI has not been examined. The association of these factors with increased risk for other disabilities, such as specific learning disability, mental retardation, and emotional disorders (Andrews et al., 1995; Chapman, Scott, & Mason, 2002; Mason, Chapman, & Scott, 1999; Stanton-Chapman, Chapman, & Scott, 2001), as well as special education placement in general (Andrews et al., 1995; Goldberg, McLaughlin, Grossi, Tytun, & Blum, 1992), has been established and merits their further study.

Speech and language delays in children are often secondary to other conditions, each with their own etiology, making the identification of risk factors for speech and language delays complex and difficult to interpret (Lubker & Tomblin, 1998). Several researchers have examined risks associated with speech or language disorder (Campbell et al., 2003; Law et al., 2000b; Shriberg, Tomblin, & McSweeny, 1999). The largest body of research exists for SLI. SLI refers to a significant deficit in language that is not accompanied by deficits in hearing, intelligence, or motor functioning (Spitz, Tallal, Flax, & Benasich, 1997).

Several studies have indicated that factors such as low birthweight and prenatal exposure to alcohol increased a child's risk for general cognitive difficulties, which often included language difficulties, but did not increase risk for SLI specifically (Abkarian, 1992; Tomblin, Smith, & Zhang, 1997). A large population-based study by Stanton-Chapman et al. (2002), however, provided evidence that low birthweight and low maternal education were significant risk factors for SLI in 6- to 7-year-old children. The relatively small sample sizes utilized in most previous studies limits the number of cases at extreme values (e.g., very low birthweight), reducing the likelihood of finding significant associations. Population-based studies such as that conducted by Stanton-Chapman et al. (2002) and this study play a crucial role in identifying risk factors for disability because they contain sufficient subjects to examine the risk associated with extreme levels of risk factors.

Although studies of SLI are common, very few researchers have examined the risk factors associated with SI. Research on the relation between cleft palate and speech disorders are the most common (American Speech-Language-Hearing Association, 1991;

Persson, Elander, Lohmander-Agerskov, & Soderpalm, 2002; Wang & Baron, 1997), although prematurity, family history, and the presence of pre- and perinatal factors have been shown to place children at a significantly increased risk for SI (Campbell et al., 2003; Fox et al., 2002). Additional studies of SI are needed as the risks identified for SLI and CSLI may not be representative of children with speech disorders (Fox et al., 2002).

The American Speech-Language-Hearing Association (1991) and researchers in the field (Law et al., 2000b; Longemann & Baum, 1998) have stated the need for additional research on the risk factors for speech and language impairments. The purpose of our study was to address this need by examining the risk factors for SLI, SI, and CSLI in a statewide sample of preschool-age children. The use of a large, population-based sample enabled the independent examination of risk factors for SI, SLI, and CSLI. The focus on preschool-age children in our study allowed for the identification of the characteristics of children who develop these impairments at an early age, the group most in need of early intervention. A better understanding of the risks associated with speech and language impairments will facilitate the development of more effective prevention, identification, and intervention strategies.

METHOD

For the purposes of this study, we integrated data from the Florida Department of Health birth certificate records (1994–1998) with preschool exceptionality records from the Children's Registry and Information System (CHRIS).

Birth Certificate Records

The data contained in the birth certificate records are standardized by the National Center for Health Statistics, a division of the Centers for Disease Control and Prevention, and provide information on a variety of factors that have been demonstrated to increase risk for developmental disabilities (Chapman et al., 2002; Mason et al., 1999; Stanton-Chapman et al., 2002; Stanton-Chapman et al., 2001). Information for the records is obtained from the medical record and through parent report shortly after the child's birth.

CHRIS

CHRIS is a database developed in 1990 in response to the need to track children who receive services under IDEA, Part B. The CHRIS program contains referral, screening, evaluation, and eligibility information for preschool children throughout the state of Florida. In addition, service providers can enter case management information (e.g., appointments, family contacts, follow-up actions needed) into the database to ensure the efficient use of time and resources. The data contained in CHRIS provides the Florida Department of Education with a means of documenting Child Find efforts to locate, evaluate, and provide necessary services to at-risk preschool-age children.

The CHRIS database program is utilized statewide at Florida Diagnostic and Learning Resources System (FDLRS) centers. FDLRS is a network of 19 state and federally funded associate centers that provide support services to educators, families of students with exceptionalities, and community agencies throughout Florida. These centers assist local school systems in meeting the requirements of IDEA by locating preschool-age children who are potentially eligible for services under IDEA and linking those children with needed services. FDLRS staff coordinate with district diagnostic staff and other providers for completion of multidisciplinary evaluations of appropriate Child Find referrals and provide diagnostic services to those students requiring assessment. In addition, FDLRS staff provide screening services at a variety of locations including FDLRS centers, day care centers, Head Start centers, and Native American and migrant centers. The goal of FDLRS is to identify all preschool-age children in the state of Florida with or at risk for disabilities.

Database Integration

We integrated the birth certificate record and CHRIS databases using an automated deterministic data linkage method based on previously established techniques (Boussy & Scott, 1993; Redden, Mulvihill, Wallander, & Hovinga, 2000). A computer program identified each child's unique record in both databases and joined them to establish one record. Records were linked based on an exact match of child's last name, first name, and date of birth. If any of the matching variables differed, the pair was considered a nonmatch and was not included in the linked sample. To maintain confidentiality, the database administrator removed all identifying information from the linked data set immediately following the automated data linkage process and prior to data analysis.

Diagnostic Criteria

The Florida Statutes and State Board of Education Rules (Florida Department of Education, 2002) specified the diagnostic criteria used to determine speech and language impairments in this study.

SI was defined as an impairment in articulation (substitutions, distortions, or omissions of speech sounds that are nonmaturational in nature), fluency (abnormal flow of speech that impairs rate and rhythm and may be accompanied by struggle behavior), or voice (absence or abnormal production of voice quality, pitch, loudness, resonance, or duration). An articulation disorder was present when at least one of the following criteria was met: (a) Based on normative data, the frequency of incorrect sound production and the delay of correct sound production were significant; (b) the error pattern was characteristic of disordered rather than delayed acquisition; or (c) articulation was rated as moderately or severely impaired on an articulation severity rating scale. A fluency disorder was present when fluency was rated as mildly, moderately, or severely impaired on a fluency severity rating scale and when there were supportive data presented by a primary caregiver, a teacher/educator, or the student when appropriate, in addition to a certified speech–language pathologist that a disorder existed. A voice disorder was present when voice was rated as moderately or severely impaired on a voice severity rating scale and there were supportive data presented by a primary caregiver, a teacher/educator, or the student when appropriate, in addition to a certified speech–language pathologist that a disorder existed.

Language impairment was defined as abnormal processing or production of form including phonology, syntax, and morphology, content including semantics, or function including pragmatics. A language disorder was present when there was a significant language delay and either (a) a significant difference between language performance and other developmental behaviors or (b) a significant difference between receptive and expressive language abilities.

Certified speech–language pathologists were responsible for implementing and conducting diagnostic assessments. Administration of at least one standardized assessment to identify speech and/or language delays was required for eligibility determination. All children considered for speech or language programs were screened for hearing and vision problems. Children who had speech and/or language difficulties solely because English was not their native or primary language were not classified with speech or language impairments. As required by state and federal laws, final eligibility decisions were based on the recommendation of an eligibility staffing committee consisting of a minimum of three professional personnel including a certified speech–language pathologist. During the staffing, professionals reviewed each child's data to determine whether the child met the criteria for speech and/or language impairment. All eligible children were identified with one primary exceptionality. Children may have also been identified with one or more secondary exceptionalities, if appropriate.

The specific disability definitions used for our study were as follows:

- SI: A primary exceptionality of speech impairment and no secondary exceptionalities.
- SLI: A primary exceptionality of language impairment and no secondary exceptionalities.
- CSLI: A primary exceptionality of speech impairment with a secondary exceptionality of language impairment or a primary exceptionality of language impairment with a secondary exceptionality of speech impairment.
- Comparison group: Either no primary exceptionality, or a primary exceptionality other than speech or language impairment.

Sample

The sample consisted of children born in Florida between January 1, 1994 and December 31, 1998 (N = 959,148). Children with primary exceptionalities of speech or language impairment were the group of interest for this study. The CHRIS database included 6,835 children with SI, 2,357 with SLI, and 3,607 with CSLI. The 946,177 children who were born in Florida but were not classified as SI, SLI, or CSLI served as the comparison group. An additional 172 children who had a primary exceptionality of speech or language impairment and a secondary exceptionality other than speech or language impairment (e.g., developmental delay, specific learning disability, autism, visual impairment) were excluded from the study as they did not meet the criteria for the SI, SLI, CSLI, or comparison groups. Each of these other disabilities is associated with its own unique risk profile. Inclusion of these children would impair the ability to report on the risk factors unique to speech and/or language impairments.

The average age of children at diagnosis was 3 years 10 months. Table 1 provides information on gender, race, and ethnicity for the SI, SLI, CSLI, and comparison groups. The rate of speech and language impairments was greater for boys across all disability groups. This finding is consistent with previous research (Campbell et al., 2003; Law et al., 2000b; Shriberg et al., 1999; Stanton-Chapman et al., 2002; Tomblin, Records, et al., 1997; Weindrich, Jennen-Steinmetz, Laucht, Esser, & Schmidt, 2000). The breakdown of children by race was similar for SLI and the comparison group. The SI and CSLI groups, however, had more Caucasian children and fewer African American and Asian/Pacific Islander children relative to the comparison group. The birth certificate record does not include the child's ethnicity. It does, however, include the ethnicities of the child's mother and father. We examined data for maternal ethnicity only because paternal information was missing from the birth certificate much more frequently than maternal information. The SI and CSLI groups had a greater proportion of children with non-Hispanic mothers (and consequently a smaller proportion of children with Hispanic mothers) than the comparison group. The SLI group, however, had a smaller proportion of children with non-Hispanic mothers (and consequently a greater proportion of children with Hispanic mothers) than the comparison group.

Risk Factors

Risk factors are characteristics that increase the likelihood of an individual having or developing a condition. The presence of risk indicates an association between the charac-

TABLE 1
Gender, Race, and Ethnicity Information for Preschool-Age Children in the SI, SLI, CSLI, and Comparison Groups

	SI		*SLI*		*CSLI*		*Comparison*	
	n	%	*n*	%	*n*	%	*n*	%
Gender								
Male	4,622	67.6	1,671	70.9	2,535	70.3	482,279	51.0
Female	2,213	32.4	686	29.1	1,072	29.7	463,875	49.0
Unknown	0	0.0	0	0.0	0	0.0	23	< 0.1
Child's race								
Caucasian	5,897	86.3	1,722	73.1	2,827	78.4	689,691	72.9
African American	830	12.1	580	24.6	731	20.3	228,375	24.1
Asian/Pacific Islander	73	1.0	43	1.8	36	1.0	21,498	2.3
Other	33	0.5	11	0.5	13	0.4	5,989	0.6
Unknown	2	< 0.1	1	< 0.1	0	0.0	624	0.1
Maternal ethnicity								
Non-Hispanic	6,225	91.1	1,636	69.4	3,031	84.0	743,215	78.5
Hispanic	586	8.6	647	27.5	530	14.7	178,096	18.8
Haitian	21	0.3	73	3.1	44	1.2	24,166	2.6
Unknown	3	< 0.1	1	< 0.1	2	< 0.1	700	0.1

Note. SI = speech impairment; SLI = specific language impairment; CSLI = combined speech and language impairments.

teristic and the outcome; it does not necessarily indicate causation. Once risk factors are identified, additional research is necessary to determine the basis of the relation and to determine if the relation is causal (Tomblin, 1996).

We obtained risk factor data from the birth certificate records. These data reflect the status of the child or mother at the time of the child's birth. For example, mother's education represents the level of educational attainment the mother reported at the time of the child's birth. Any additional education obtained since the birth is not reflected in the data. We examined 13 risk factors. The 6 child risk factors of interest were gestational age less than 37 weeks (prematurity), birthweight less than 2,500 g, 5-min Apgar score less than 7, multiple birth, presence of newborn conditions (e.g., anemia, fetal alcohol syndrome, assisted ventilation), and presence of congenital abnormalities (e.g., cleft lip/palate, chromosomal abnormalities, abnormalities of the circulatory/respiratory system, abnormalities of the central nervous system). The 7 maternal risk factors of interest were 12 or fewer years of education, age younger than 18 years or older than 35 years, unwed marital status, tobacco use during pregnancy, alcohol use during pregnancy, presence of maternal medical history factors (e.g., anemia, cardiac disease, lung disease, diabetes, genital herpes), and presence of complications of labor or delivery (e.g., premature rupture of membranes, placenta previa, cord prolapse, fetal distress).

Developmental Epidemiology

We utilized developmental epidemiological methodology to analyze the significance of the child and maternal factors obtained from birth certificate records. Numerous researchers have employed epidemiological methods to examine childhood disabilities (Chapman et al., 2002; Mason et al., 1999; Stanton-Chapman et al., 2002; Stanton-Chapman et al., 2001). The use of such methodology provides valuable information not obtainable from traditional analyses (Mason, Scott, Chapman, & Tu, 2000; Redden et al., 2000; Scott, Mason, & Chapman, 1999). When examining uncommon outcomes such as disabilities it may be mathematically impossible to obtain a large correlation or account for a large proportion of variance. This is particularly true when dealing with common risk factors such as low maternal education. In addition, the focus on rates, ratios, and proportions is more in line with the interests of service providers and policymakers and is more readily understood by people outside the field who have not had any statistical training (Scott et al., 1999).

The influence of risk factors such as low maternal education, low birthweight, substance exposure, and poverty has traditionally been evaluated using regression or analysis of variance models. These statistical methods provide valuable information about mean scores and variance in outcomes but do not address the level of risk to an individual (Mason et al., 2000). We utilized risk ratios (RRs) to determine the increased risk to an individual when a risk factor is present compared to when it is absent (Mason et al., 2000; Redden et al., 2000). The risk ratios reported represent the ratio of risk of disability outcome among those exposed to a risk factor over the risk among those unexposed (see Table 2). A value of 1.0 indicates equal levels of risk for an outcome (e.g., SLI) between the groups being compared (e.g., being born premature vs. full term). A value of less than 1.0

TABLE 2
Example Computation of the RR for Premature Birth as a Risk Factor for SLI

	Disability Present (SLI)	*Disability Absent (Comparison Group)*
Risk factor present (gestational age < 37 weeks)	298	90,701
Risk factor absent (gestational age ≥ 37 weeks)	2,054	853,720

$$RR = \frac{\text{Probability of being classified as SLI for children born at} < 37 \text{ weeks}}{\text{Probability of being classified as SLI for children born at} \geq 37 \text{ weeks}}$$

$$RR = \frac{(298 \div 90{,}701)}{(2{,}054 \div 853{,}720)}$$

$$RR = 1.36$$

The obtained RR indicates that the probability of a child born prematurely later being classified as SLI is 1.36 times (or 36% greater than) that of a child born full term.

Note. RR = risk ratio; SLI = specific language impairment.

represents a decreased risk, and a value of greater than 1.0 represents an increased risk for an outcome.

We computed 95% confidence intervals for each risk ratio using the Stat Calc procedure in Epi Info 2002 (2002). These intervals indicate the lower and upper limit of the risk ratio which contains the true parameter 95% of the time over unlimited repetitions of the study, assuming there was no bias. Thus, risk ratios for which either confidence limit was equal to or crossed 1.0 were not considered meaningful because they did not reach the conventional 5% level of significance. In these cases, one cannot be confident that the rate of disability was truly different from the rate found in the referent group. In addition to providing information regarding statistical significance, the width of the confidence interval provides an indication of the precision of the risk ratio estimate. Confidence intervals with large ranges between the lower and upper bounds represent less precise estimates and are usually indicative of a small sample size in the disability group, comparison group, or both.

RESULTS

Table 3 displays the distribution of risk factors examined for children in the SI, SLI, CSLI and comparison groups. The number of subjects for which risk factor information was unknown was consistently 0.3% or less. The only exception to this was maternal education where information was unknown for 0.4 and 0.6% of children for the comparison and the SLI groups, respectively.

Table 4 includes the risk ratios for all factors examined. Results indicated that the following factors were associated with a significantly increased risk for SI: (a) presence of a congenital abnormality ($RR = 1.69$), (b) multiple birth ($RR = 1.65$), (c) maternal alcohol use during pregnancy ($RR = 1.30$), (d) maternal age older than 35 years ($RR = 1.28$), (e) presence of a newborn condition ($RR = 1.17$), and (f) presence of a maternal medical his-

TABLE 3
Distribution of Risk Characteristics Among Preschool-Age Children in the SI, SLI, CSLI, and Comparison Groups

	SI		*SLI*		*CSLI*		*Comparison*	
	n	%	*n*	%	*n*	%	*n*	%
Gestational age								
< 37 weeks	674	9.9	298	12.6	434	12.0	70,701	9.6
≥ 37 weeks	6,142	89.9	2,054	87.1	3,168	87.8	853,720	90.2
Unknown	19	0.3	5	0.2	5	0.1	1,756	0.2
Birthweight								
VLBW (< 1,500 g)	87	1.3	64	2.7	73	2.0	14,501	1.5
LBW (1,500–2,499 g)	449	6.6	189	8.0	257	7.1	60,218	6.4
NBW (≥ 2,500 g)	6,298	92.1	2,103	89.2	3,276	90.8	871,205	92.1
Unknown	1	0.0	1	0.0	1	0.0	253	0.0
5-min Apgar								
< 7	58	0.8	30	1.3	38	1.1	11,545	1.2
≥ 7	6,764	99.0	2,324	98.6	3,563	98.8	932,365	98.5
Unknown	13	0.2	3	0.1	6	0.2	2,267	0.2
Multiple birth								
Yes	294	4.3	141	6.0	134	3.7	24,949	2.6
No	6,540	95.7	2,216	94.0	3,473	96.3	921,203	97.4
Unknown	1	0.0	0	0.0	0	0.0	25	0.0
Newborn conditions								
Yes	527	7.7	208	8.8	328	9.1	62,808	6.6
No	6,301	92.2	2,148	91.1	3,279	90.9	882,800	93.3
Unknown	7	0.1	1	0.0	0	0.0	569	0.1
Congenital abnormalities								
Yes	108	1.6	36	1.5	74	2.1	8,864	0.9
No	6,720	98.3	2,320	98.4	3,533	97.9	936,739	99.0
Unknown	7	0.1	1	0.0	0	0.0	574	0.1
Maternal education								
< 12 years	835	12.2	524	22.2	704	19.5	206,833	21.9
12 years	2,213	32.4	793	33.6	1,267	35.1	334,004	35.3
> 12 years	3,769	55.1	1,026	43.5	1,626	45.1	401,542	42.4
Unknown	18	0.3	14	0.6	10	0.3	3,798	0.4
Maternal age								
< 18 years	191	2.8	128	5.4	143	4.0	50,426	5.3
18–35 years	5,810	85.0	1,950	82.7	3,068	85.1	805,152	85.1
> 35 years	834	12.2	278	11.8	395	11.0	90,426	9.6
Unknown	0	0.0	1	0.0	1	0.0	173	0.0
Mother married								
Yes	5,417	79.3	1,654	70.2	2,499	69.3	610,239	64.5
No	1,415	20.7	703	29.8	1,107	30.7	335,726	35.5
Unknown	3	0.0	0	0.0	1	0.0	212	0.0
Tobacco use								
Yes	888	13.0	219	9.3	487	13.5	116,328	12.3
No	5,944	87.0	2,132	90.5	3,118	86.4	828,910	87.6
Unknown	3	0.0	6	0.3	2	0.1	939	0.1

(continued)

TABLE 3 *(Continued)*

	SI		*SLI*		*CSLI*		*Comparison*	
	n	%	*n*	%	*n*	%	*n*	%
Alcohol use								
Yes	81	1.2	19	0.8	27	0.7	8,633	0.9
No	6,751	98.8	2,332	98.9	3,578	99.2	936,584	99.0
Unknown	3	0.0	6	0.3	2	0.1	960	0.1
Maternal medical history factors								
Yes	1,746	25.5	607	25.8	967	26.8	223,604	23.6
No	5,082	74.4	1,749	74.2	2,640	73.2	721,957	76.3
Unknown	7	0.1	1	0.0	0	0.0	616	0.1
Labor or delivery complications								
Yes	2,124	31.1	779	33.1	1,180	32.7	293,746	31.0
No	4,702	68.8	1,577	66.9	2,427	67.3	651,893	68.9
Unknown	9	0.1	1	0.0	0	0.0	538	0.1

Note. SI = speech impairment; SLI = specific language impairment; CSLI = combined speech and language impairments; VLBW = very low birthweight; LBW = low birthweight; NBW = normal birthweight.

tory factor (*RR* = 1.11). Presence of a congenital abnormality and multiple birth were the factors associated with the largest increased risk for SI. Prematurity (gestational age younger than 37 weeks), birthweight less than 2,500 g, maternal tobacco use during pregnancy, and presence of a labor or delivery complication were not significant risk factors for SI. Of interest, several results were opposite to those expected indicating a decrease in risk for SI: low 5-min Apgar score (*RR* = 0.69), maternal education less than 12 years (*RR* = 0.43), maternal education equal to 12 years (*RR* = 0.71), maternal age younger than 18 years (*RR* = 0.53), and unwed maternal marital status (*RR* = 0.48). Therefore, a significantly smaller proportion of children with a low Apgar score (less than 7), a mother with 12 or fewer years of education, a mother younger than 18 years of age, or a mother who was unmarried were classified as SI than would be expected given the distribution of these characteristics in the general population.

The following factors were associated with an increased risk for SLI: (a) multiple birth (*RR* = 2.34), (b) very low birthweight (<1500g, *RR* = 1.82), (c) presence of a congenital abnormality (*RR* = 1.64), (d) prematurity (gestational age younger than 37 weeks, *RR* = 1.36), (e) presence of a newborn condition (*RR* = 1.36), (f) low birthweight (1,500–2,499 g; *RR* = 1.30), (g) maternal age older than or equal to 35 years (*RR* = 1.27), (h) presence of a maternal medical history factor (*RR* = 1.12), and (i) presence of a labor or delivery complication (*RR* = 1.10). Multiple birth and very low birthweight were the factors associated with the largest increased risk for SLI. Five-min Apgar score of less than 7, maternal educational attainment of 12 years or less, maternal age younger than 18, and maternal alcohol use during pregnancy were not significant risk factors for SLI. Results for unwed maternal marital status (*RR* = 0.77) and maternal tobacco use during pregnancy (*RR* = 0.73) were in the opposite direction to that expected indicating a decrease in risk for SLI associated with these factors. Therefore, a significantly smaller proportion of children who were exposed to tobacco prenatally or with mothers who

TABLE 4
Risk Ratios Associated With Factors Present at Birth on Rates of SI, SLI, and CSLI in Preschool-Age Children

	SI		*SLI*		*CSLI*	
	RR	*95% CI*	*RR*	*95% CI*	*RR*	*95% CI*
Gestational age						
< 37 weeks	1.03	0.95–1.12	1.36	1.21–1.54	1.29	1.17–1.42
≥ 37 weeks	1.00		1.00		1.00	
Birthweight						
VLBW (< 1,500 g)	0.83	0.67–1.03	1.82	1.42–2.34	1.34	1.06–1.69
LBW (1,500–2,499 g)	1.03	0.94–1.13	1.30	1.12–1.51	1.13	1.00–1.29
NBW (≥ 2,500 g)	1.00		1.00		1.00	
5-min Apgar						
<7	0.69	0.54–0.90	1.04	0.73–1.49	0.86	0.63–1.19
≥ 7	1.00		1.00		1.00	
Multiple birth						
Yes	1.65	1.47–1.86	2.34	1.98–2.78	1.42	1.20–1.69
No	1.00		1.00		1.00	
Newborn conditions						
Yes	1.17	1.07–1.28	1.36	1.18–1.57	1.40	1.25–1.57
No	1.00		1.00		1.00	
Congenital abnormalities						
Yes	1.69	1.40–2.04	1.64	1.18–2.27	2.20	1.75–2.77
No	1.00		1.00		1.00	
Maternal education						
<12 years	0.43	0.40–0.47	0.99	0.89–1.10	0.84	0.77–0.92
12 years	0.71	0.67–0.75	0.93	0.85–1.02	0.94	0.87–1.01
> 12 years	1.00		1.00		1.00	
Maternal age						
< 18 years	0.53	0.46–0.61	1.05	0.88–1.25	0.74	0.63–0.88
18–35 years	1.00		1.00		1.00	
> 35 years	1.28	1.19–1.37	1.27	1.12–1.44	1.15	1.03–1.37
Mother married						
Yes	1.00		1.00		1.00	
No	0.48	0.45–0.51	0.77	0.71–0.84	0.81	0.75–0.86
Tobacco use						
Yes	1.06	0.99–1.14	0.73	0.64–0.84	1.11	1.01–1.22
No	1.00		1.00		1.00	
Alcohol use						
Yes	1.30	1.04–1.62	0.88	0.56–1.39	0.82	0.56–1.20
No	1.00		1.00		1.00	
Maternal medical history factors						
Yes	1.11	1.05–1.17	1.12	1.02–1.23	1.18	1.10–1.27
No	1.00		1.00		1.00	
Labor or delivery complications						
Yes	1.00	0.95–1.05	1.10	1.01–1.19	1.08	1.01–1.16
No	1.00		1.00		1.00	

Note. SI = speech impairment; SLI = specific language impairment; CSLI = combined speech and language impairments; RR = risk ratio; CI = confidence interval; VLBW = very low birthweight; LBW = low birthweight; NBW = normal birthweight were unmarried were classified as SLI than would be expected given the distribution of these characteristics in the general population.

The following factors were associated with increased risk for CSLI: (a) presence of a congenital abnormality (*RR* = 2.20), (b) prematurity (gestational age younger than 37 weeks, *RR* = 1.29), (c) multiple birth (*RR* = 1.42), (d) presence of a newborn condition (*RR* = 1.40), (e) very low birthweight (< 1,500 g; *RR* = 1.34), (f) presence of a maternal medical history factor (*RR* = 1.18), (g) maternal age older than 35 years (*RR* = 1.15), (h) maternal tobacco use during pregnancy (*RR* = 1.11), and (i) presence of a labor or delivery complication (*RR* = 1.08). Presence of a congenital abnormality was the factor associated with the largest increased risk for CSLI. Low birthweight (1,500–2,499 g), 5-min Apgar score of less than 7, maternal education equal to 12 years, and maternal alcohol use during pregnancy were not significant risk factors for CSLI. Results for maternal education less than 12 years (*RR* = 0.84), maternal age younger than 18 years (*RR* = 0.74), and unwed maternal marital status (*RR* = 0.81) were in the opposite direction to that expected indicating a decrease in risk for CSLI associated with these factors. Therefore, a significantly smaller proportion of children with a mother that did not complete high school, a mother younger than 18, or an unmarried mother were classified as CSLI than would be expected given the distribution of these characteristics in the general population.

DISCUSSION

Children with speech or language delays often demonstrate continued communication, education, social, and employment difficulties (Beitchman et al., 2001; Law et al., 2000b; Ruben, 2000). Early identification of speech and language impairments is essential to lessening the potential negative effects of these disorders (Scherer, 2001). Speech–language pathologists should closely monitor the progress of children identified as at risk and initiate early intervention services as soon as a delay is suspected (American Speech-Language-Hearing Association, 1991). Tomblin et al. (1991) estimated that early monitoring of children at risk could lead to the identification of most children with speech and/or language impairments by 24 to 30 months of age.

The results of the study presented here indicated that multiple birth, presence of a newborn condition, presence of a congenital abnormality, maternal age older than 35 years, and presence of a maternal medical history factor were associated with increased risk for speech and language impairments, as isolated disabilities or in combination.

The most notable differences between disability groups were found for prematurity and low birthweight. Children born before 37 weeks gestation or weighing less than 2,500 g were at increased risk for SLI but not for SI. Very low birthweight (< 1,500 g) was one of the most salient risk factors for SLI in this study. This finding is consistent with previous research (Stanton-Chapman et al., 2002). Although few researchers have examined the relation between gestational age, birthweight, and SI, this study indicated that gestational age and birthweight were not associated with SI in preschool-age children.

Maternal alcohol use during pregnancy was identified as a significant risk factor for SI but not for SLI or CSLI. Although studies have indicated a link between maternal alcohol consumption during pregnancy and speech and language disorders (Abkarian, 1992; American Speech-Language-Hearing Association, 1991), these disorders may be related to underlying cognitive impairments, especially for children diagnosed with fetal alcohol syndrome or fetal alcohol effects. Studies of the relation between prenatal alcohol exposure and SLI have indicated nonsignificant findings (Tomblin, Smith, & Zhang, 1997) or even outcomes opposite to those expected in that prenatal alcohol exposure was associated with decreased risk for SLI (Tomblin, 1996). The findings of our study indicate that in the absence of diagnosed cognitive impairments, prenatal exposure to alcohol increased risk for SI only. Interpretations need to be made with caution, however, because although the number of subjects in this study was quite large, the number of mothers reporting alcohol use during pregnancy with SLI or CSLI children was relatively small (19 and 27, respectively).

Several results of this study were opposite to those expected, most notably low maternal education, unwed marital status, low Apgar score, and maternal tobacco use during pregnancy. A detailed discussion of each of these findings follows.

Numerous studies have indicated that low maternal education is a risk factor for speech and language impairments (Campbell et al., 2003; Hammer et al., 2001; Stanton-Chapman et al., 2002; Tomblin, Smith, & Zhang, 1997). At least two studies, however, report no increase in risk for SLI associated with low levels of maternal education (Tomblin, 1996; Tomblin et al., 1991). Our results did not indicate an increased risk for speech and/or language impairment among children whose mothers had a high school education or less at the time of the child's birth.

Of interest, though, the likelihood of a child being classified as SI increased with higher educational attainment. Although higher levels of education do not likely pose an increased biological or environmental risk to the child, these findings may indicate a bias toward the identification of SI in more educated families with higher socioeconomic status (SES). The additional findings that the likelihood of SI increased for children of mothers who were married and/or older than 18 are consistent with this interpretation. Although factors such as maternal education, age, and marital status may not have a direct relation to the development of speech problems, they are indicators of family income and overall SES (Hernandez, 1997).

Maternal education, in particular, is often used as a measure of SES and is preferred over other potential measure of SES such as occupation and family income because it is more accurately reported and more stable than these other factors (Bornstein, Hahn, Suwalsky, & Haynes, 2003; Grossman, 2000). This is particularly true at the time of a child's birth when maternal occupation and family income are particularly unstable.

Maternal education is associated with the environment and experiences of children, including the availability of books and toys in the home that create a stimulating environment as well as nutrition and health care (Entwisle & Astone, 1994). Maternal education is also associated with knowledge of child development, parenting practices, and quality of the language environment (Benasich & Brooks-Gunn, 1996; Hart & Risley, 1995). Less educated mothers may not recognize the early signs of SI or may view speech problems as something the child will naturally outgrow. In addition to being more able to identify aberrant speech or language, mothers with higher levels of education may be more aware of the services provided in their communities and recognize the importance of early intervention for improving outcomes (Leventhal, Brooks-Gunn, McCormick, & McCarton, 2000). Further longitudinal research on the relation between educational attainment and the identification of speech and language impairments is needed.

Low Apgar score was not found to be a significant risk factor for SLI or CSLI in our study. The results of previous research have been inconsistent with regard to the relation of Apgar scores to speech and language impairments. Although Stanton-Chapman et al. (2002) reported Apgar score to be one of the most salient predictors of SLI, several other studies have not indicated a significant relation (Bishop, 1997; Blackman, 1988). In addition, low Apgar score was associated with a decreased likelihood of SI. This may be a reflection of the tendency for children with low Apgar scores to be classified with other disabilities such as mental retardation, emotional disorders, and learning disabilities (Scott, Mason, & Gonzalez, 2000; Stanton-Chapman et al., 2001).

Maternal tobacco use during pregnancy was found to significantly increase risk for CSLI and to actually decrease risk for SLI but was not related to SI. Previous research has indicated an association between prenatal exposure to tobacco and SLI, however, when parental education was controlled for, these significant associations no longer existed indicating that prenatal exposure to tobacco was not independently associated with SLI (Tomblin, 1996; Tomblin et al., 1998; Tomblin, Smith, & Zhang, 1997). The findings in our study indicating decreased risk for SLI associated with prenatal exposure to tobacco are difficult to interpret and merit further study.

Additional research is also needed to determine the unique contributions of individual factors and to determine the specific combinations of factors that lead to the greatest risk for speech and/or language impairments, particularly for children with established biological risks who are being raised in less than optimal environments. Identification of unique risk profiles for speech versus language impairments would likely be associated with risk ratios much larger in magnitude than those identified in this study and would represent the most accurate way to identify those children at the greatest risk for these disabilities. As universal screening has been demonstrated to not be cost effective (Law et al., 2000a), mass screening based on at-risk status would likely result in a more efficient use of resources. Future studies implementing such a high-risk screening are needed to evaluate the effectiveness of this practice.

Although the large scope of this study provides a unique look into the contributions of the factors studied that has not previously been possible, we need to acknowledge the presence of several limitations.

First, the use of extant birth certificate record data enables the examination of a number of important factors on extremely large samples of children. It does not allow, however, for the examination of risk associated with other factors related to speech and/or language impairments such as positive family history (Campbell et al., 2003; Fox et al., 2002; Tallal, Ross, & Curtiss, 1989), otitis media (Paden, 1994; Roberts, Burchinal, & Davis, 1991), and lead exposure (Needleman, 1983).

Second, the inclusion of children in the comparison group for whom outcome status is unknown represents an additional limitation to the study. Although having outcome data on all preschool children in the state of Florida would be ideal, this information was not available. A reasonably large percentage of the population of preschool-age children (2.9%) were referred to FDLRS for further evaluation. Even within such a comprehensive system, however, there remain children with speech and language impairments that do not have records in the CHRIS database. These children will represent a very small percentage of the overall comparison group, and their misclassification should serve to weaken the magnitude of the effects reported. Given the size of the comparison group, the error introduced by the relatively small number of unidentified cases of speech and language impairments should have only a negligible effect on the results of the study.

Finally, although the use of large extant data sets provides the opportunity to efficiently and inexpensively assess the relation of factors to disabilities on extremely large, population-based samples, the quality of the data contained within such data sets is largely unknown. Both the birth certificate record data set and the CHRIS data set, however, represent official government sources of information that are utilized for a variety of research and policy-making purposes. Inaccuracies present in the data would likely serve to weaken the magnitude of the effects reported (Rothman, 2002). Hence, any significant effects reported are likely to be larger in reality than those indicated by the data. In addition, errors within the birth certificate record data are likely much less frequent than those associated with the recall bias inherent to acquiring this type of information via parent report years after a child's birth.

In conclusion, this study contributes to the existing body of research on SLI and is one of the very few studies of risk factors for SI. Results indicated that factors such as multiple birth, presence of a newborn condition, presence of a congenital abnormality, maternal age older than 35 years, and presence of a maternal medical history factor were consistently associated with an increased risk for speech and/or language impairments in preschool-age children. Separate evaluation of SI and SLI allowed for the identification of differences in the factors that increased a child's likelihood of having only one of these disorders. The differences in risk factors associated with these disabilities suggest separate etiologies and support the development of separate risk profiles for each disorder. As such, tactics used for early identification should be customized for speech and language impairments.

Awareness of the factors that place a child at increased risk for speech and/or language impairments is essential to the early identification and prevention of these impairments. Clinicians and health care professionals can utilize the risk factors identified in this study to better identify those children whose development should be closely monitored for signs of potential delay or impairment. In addition, these professionals can provide the parents of at-risk children with information on ways to foster a child's speech and language development. Such early efforts have the potential to ameliorate the effects of these disabilities and possibly eliminate them altogether.

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