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Identification of Early Risk Factors for Developmental Delay

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Statewide birth certificate and preschool exceptionality records were integrated to identify risk factors for developmental delay (DD). Epidemiological methods were used to investigate both individual-level and population-level risk for DD associated with a number of child and maternal factors. Infants born with very low birth weight were at the greatest individual-level risk for DD, whereas prematurity (gestational age less than 37 weeks) and low maternal education posed the greatest population-level risk. For comparative purposes, individual-level risk for speech disability and other developmental disabilities was also determined. The individual-level risk associated with nearly all factors was significantly greater for DD than for speech disability or other developmental disabilities. The present study suggests that information available from birth certificate records can be used to target screening and early intervention services for children at high risk with the goal of reducing the incidence of DD and subsequent associated disabilities.

The Individuals with Disabilities Education Act and the 1991 and 1997 amendments designated developmental delay (DD) as a category of preschool eligibility. DD is a general term necessitated by the difficulties inherent in pinpointing the presence of specific disabilities in early childhood (Gallimore, Keogh, & Bernheimer, 1999). This classification characterizes children who demonstrate significant delays in one or more domains of cognitive, emotional, or physical development. The introduction of DD as an eligibility option allows children to receive needed services without being assigned a specific disability label (Bernheimer, Keogh, & Coots, 1993; McLean, Smith, McCormick, Schakel, & McEvoy, 1991). The use of this general label eliminates the potentially harmful effects of labeling young children with a specific disability and accommodates

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the lack of confidence in assessment instruments for young children (Division for Early Childhood of the Council for Exceptional Children, 2001; Holland & Merrell, 1998; Mallory & Kerns, 1988). Purportedly, labeling young children using traditional categories may result in premature categorization, miscategorization, and underidentification of children with delays who do not fit into traditional eligibility categories (Division for Early Childhood of the Council for Exceptional Children, 2001).

The specific criteria for DD vary by state but typically involve measures of delay based on standard deviation from the mean. Identification of DD in the present study was based on the administrative definition of DD adopted by the State of Florida that defines DD as performance at least 2 standard deviations below the mean in one of the following areas or at least 1.5 standard deviations below the mean in two or more of the following areas: adaptive, cognitive, communicative, social or emotional, or physical development (Florida Department of Education, 2001). Final eligibility decisions were made by an eligibility staffing committee. In Florida, DD is used in addition to traditional disability categories. Children identified with DD as a primary category do not qualify for one of the other disability categories (e.g., mild intellectual disability, specific learning disability, speech disability, language disability, emotional disability)[1] but may exhibit similar characteristics (e.g., delays in cognitive, social or emotional, or language development).

Research on DD has not typically utilized these administrative definitions, but rather has consistently relied on the results of a single assessment such as the Denver Developmental Screening Test (Najman, Bor, Morrison, Andersen, & Williams, 1992), Peabody Picture Vocabulary Test (Najman et al., 1992), Developmental Profile (Rojahn et al., 1993), or Parental Assessment Screening (Sonnander & Claesson, 1999) to identify delay. Studies of DD have also relied on parent report (Rojahn et al., 1993; Sonnander & Claesson, 1999) or less restrictive cutoff points (Rojahn et al., 1993) to obtain larger samples of children with DD. In addition, these studies have not typically attempted to identify and exclude children with other traditional disabilities.

Such inconsistencies in defining DD make the comparison of results across studies difficult and likely contribute to the inconsistent results in the literature regarding risk factors for DD. Previous researchers examined the relation among DD and a number of factors (e.g., gestational age, birth weight, Apgar score, congenital abnormalities, maternal education, maternal age, and mater-

[1]Some of the diagnostic labels presented in this article differ from those designated in the *Florida Statutes and State Board of Education Rules* (Florida Department of Education, 2001). Following are the labels presented in this article (corresponding label used in Florida in parentheses): speech disability (speech impairment), language disability (language impairment), mild intellectual disability (educable mentally handicapped), moderate intellectual disability (trainable mentally handicapped), severe–profound intellectual disability (profoundly mentally handicapped), emotional disability (emotionally handicapped), and severe emotional disability (severely emotionally disturbed).

nal medical history factors). The findings associated with these factors varied: Some studies indicated significant relations with DD, and other studies indicated nonsignificant relations. For example, several studies reported that maternal education is a significant predictor of DD (Kochanek, Kabacoff, & Lipsitt, 1987, 1990; Sonnander & Claesson, 1999). At least one study, however, did not support these findings (Rojahn et al., 1993). Another study reported that maternal education predicts child outcome at 5 years of age based on the Peabody Picture Vocabulary Test but not the Denver Developmental Screening Test (Najman et al., 1992). Analysis of other factors revealed that congenital malformation, complications during pregnancy, and the number of living children are significant risk factors for DD, whereas gestational age, Apgar scores, birth weight, maternal age, and maternal education are not (Rojahn et al., 1993).

In addition to examining the relation of the previously named factors to DD, the present study highlights a number of other factors associated with risk for developmental disabilities. The majority of children identified as DD as preschoolers will continue to receive special education services in elementary school under traditional exceptionality categories such as specific learning disability, language disability, speech disability (SD), and mild intellectual disability after the DD category is no longer applicable (age 6 in Florida, through age 9 in other states; Bernheimer et al., 1993; Delgado, Vagi, & Scott, 2006; Keogh, Bernheimer, & Guthrie, 2004; Keogh, Coots, & Bernheimer, 1996). Additional factors such as multiple birth, abnormal conditions of the newborn, maternal marital status, onset of prenatal care, tobacco use, alcohol use, and complications of labor and delivery have been demonstrated to be risk factors for these disabilities (Abkarian, 1992; Andrews, Goldberg, Wellen, Pittman, & Struening, 1995; Chapman, Scott, & Mason, 2002; Delgado, Vagi, & Scott, 2005, Makin, Fried, & Watkinson, 1991; Mason, Chapman, & Scott, 1999; McMahon, Stassi, & Dodd, 1998; Stanton-Chapman, Chapman, Bainbridge, & Scott, 2002; Stanton-Chapman, Chapman, & Scott, 2001), and, as such, are important to study as potential risk factors for DD.

The present study used epidemiological methods to examine the risk for DD associated with a number of child and maternal factors. Epidemiological methods represent an effective tool in the prevention of disorders in that they result in the quantification of risk. These methods have been used in a number of studies examining childhood disabilities (Chapman et al., 2002; Hollomon, Dobbins, & Scott, 1998; Mason et al., 1999; Nonkin Avchen, Scott, & Mason, 2001; Stanton-Chapman et al., 2001). Epidemiological methods provide valuable information not obtainable from traditional analyses (Mason, Scott, Chapman, & Tu, 2000; Redden, Mulvihill, Wallander, & Hovinga, 2000; Scott, Mason, & Chapman, 1999). Most notably, although traditional statistical methods such as regression and analysis of variance provide valuable information about mean scores and variance in outcomes, they do not distinguish between level of risk to an individual versus to the population (Mason et al., 2000). This distinction is important to consider because individual-level and population-level risk are

often very different. A condition that places an individual at high risk will have little overall effect on the population if the condition is very rare. However, a condition that places an individual at a slightly elevated risk but is very common can have a large effect on the population due to the large number of cases. Evaluation of population-level risk provides a unique perspective into risk for DD that has not been previously reported. Estimates of population-level risk are necessary for the identification of the most cost-effective methods for reducing the rate of a disability. These risk estimates provide the foundation for implementing the policies and procedures necessary for early identification and treatment of children with disabilities. In addition, this information can assist service professionals in determining where their populations will come from and how service and training needs will change.

METHOD

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

Birth Certificate Records

Data contained in 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 a number of developmental disabilities (Chapman et al., 2002; Hollomon et al., 1998; Mason et al., 1999; Stanton-Chapman et al., 2002; Stanton-Chapman et al., 2001). Information for the record is obtained from the medical record and through parent report shortly after the child's birth.

CHRIS

CHRIS is a database project funded by the Florida Department of Education. CHRIS was developed in 1990 in response to the need to track children who are potentially eligible for services under Part B of the Individuals With Disabilities Education Act. The CHRIS database contains referral, screening, evaluation, and eligibility information for preschool-age children throughout Florida who have been referred to the Florida Diagnostic and Learning Resources System. In addition, service coordination information (e.g., appointments, family contacts, follow-up actions needed) may be entered into the database and is available for service providers who work with individual children to ensure the efficient use of time and resources. The data contained in CHRIS provide the Florida Department of Education with a means of documenting Child Find efforts to

locate, evaluate, and provide necessary services to preschool-age children at risk for developmental disabilities.

Database Integration

The integration of databases was accomplished using automated deterministic data linkage, whereby a child's unique record was identified in both databases and joined across data sets to establish one record. This data linkage method was based on previously established data linkage techniques (Boussy & Scott, 1993; Newcombe, 1988; Redden et al., 2000). 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. All identifying information was removed immediately following the automated data linkage process and prior to data analysis to maintain confidentiality.

Diagnostic Criteria

Developmental disability classifications were based on the diagnostic criteria specified in the *Florida Statutes and State Board of Education Rules* (Florida Department of Education, 2001). The following developmental disabilities were included in the study: DD, SD, language disability, specific learning disability, autism, mild intellectual disability, moderate intellectual disability, severe–profound intellectual disability, emotional disability, and severe emotional disability. DD was the disability of primary interest for the present study.

The State of Florida classifies preschool-age children using DD in addition to traditional disability categories. Children can be assigned a single primary exceptionality, which can be DD or another disability category. This approach was implemented to identify and provide services to preschool-age children with delays who would otherwise remain unidentified and likely be referred for special education services in the future.

DD was defined as a delay in one or more of the following areas: adaptive or self-help, cognitive, communicative, social or emotional, or physical development. Children were classified as DD in response to one of the following three criteria: (a) a score of 2 standard deviations below the mean or 25% delay on measures yielding scores in months in at least one area of development; (b) a score of 1.5 standard deviations below the mean or 20% delay on measures yielding scores in months in at least two areas of development; or (c) recommendation by the eligibility staffing committee, based on informed clinical opinion (which may have included parent interview, child observation, teacher checklists, parent checklists, and team consultation), that a DD existed and exceptional student education services were needed. All children who were considered for DD were screened for hearing and vision problems.

Final eligibility decisions were made by an eligibility staffing committee consisting of a minimum of three professionals (one of whom was the district administrator of exceptional students or a designee). During the staffing, each child's data were reviewed to determine whether the child met the criteria for DD. In addition to a primary exceptionality of DD, children may have been identified with one or more secondary exceptionalities, if appropriate.

Sample

The sample consisted of children born in Florida between January 1, 1994, and December 31, 1998 ($N = 959{,}148$). The 8,404 children with a primary exceptionality of DD were the group of primary interest for the present study. Children with DD were compared to 9,029 children with SD, 7,040 children with another developmental disability (Other group), and 934,675 children without an identified developmental disability (No Disability group). The Other group consisted of children classified as having a language disability (59%), a specific learning disability (13%), autism (9%), a mild intellectual disability (7%), a moderate/severe–profound intellectual disability (7%), or an emotional/severe emotional disability (5%). The average age at diagnosis was 3 years, 2 months, for children in the DD group and 3 years, 9 months, for children in the SD and Other groups. Children with SD were analyzed separately from those in the Other group because previous research has indicated a pattern of risk for preschool children identified with SD that is markedly different from that of children with other disabilities. Specifically, mother having 12 or more years of education, mother being older than 18 years, mother being married, and child having an Apgar score greater than 6 are associated with an increased risk for SD (Delgado et al., 2005). Due to this unique pattern of risk and the number of children with SD ($n = 9{,}029$), it was important to evaluate these children separately.

Child gender, child race, and maternal ethnicity information for each group is provided in Table 1. Maternal ethnicity is reported because child ethnicity was not provided on the birth certificate record.

Risk Factors

Risk factors are characteristics that increase the likelihood of an individual having or developing a problematic condition. The presence of risk indicates an association between the characteristic and the outcome, but it does not necessarily indicate causation. After 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).

Risk factor data were obtained from birth certificate records and reflect the status of the child or mother at the time of the child's birth. For example,

TABLE 1
Distribution of Child Gender, Child Race, and Maternal Ethnicity for the Developmental Delay (DD), Speech Disability (SD), Other Developmental Disability (Other), and No Developmental Disability (No Disability) Groups

	DD		*SD*		*Other*		*No Disability*	
Factor	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*
Child gender								
Male	5,992	71.30	6,139	67.99	5,090	72.30	474,009	50.71
Female	2,412	28.70	2,890	32.01	1,950	27.70	460,643	49.28
Unknown	0	0	0	0.00	0	0.00	23	<0.01
Child race								
White	5,679	67.57	7,701	85.29	5,079	72.14	681,806	72.95
African American	2,575	30.64	1,197	13.26	1,805	25.64	224,980	24.07
Asian/Pacific Islander	108	1.29	92	1.02	115	1.63	21,337	2.28
Other	38	0.45	37	0.41	38	0.54	5,934	0.63
Unknown	4	0.05	2	0.02	3	0.04	618	0.07
Maternal ethnicity								
Non-Hispanic/ Non-Haitian	6,835	81.33	8,127	90.01	5,024	71.36	734,252	78.56
Hispanic	1,325	15.77	854	9.46	1,836	26.08	175,881	18.82
Haitian	240	2.86	44	0.49	176	2.50	23,848	2.55
Unknown	4	0.05	4	0.04	4	0.06	694	0.07

Note. Child ethnicity was not provided on the birth certificate record. Hence, maternal ethnicity is reported here.

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 these data. A total of 14 risk factors (6 child factors and 8 maternal factors) were examined. The six child risk factors of interest were gestational age less than 37 weeks, birth weight less than 2,500 g, 5-min Apgar score less than 7, multiple birth, presence of a newborn condition (e.g., anemia, fetal alcohol syndrome, assisted ventilation), and presence of a congenital abnormality (e.g., chromosomal abnormalities, abnormalities of the circulatory or respiratory systems, abnormalities of the central nervous system). The eight maternal risk factors of interest were 12 or fewer years of education, age of fewer than 18 years or more than 35 years, unwed marital status, prenatal care beginning after the third month of pregnancy, tobacco use during pregnancy, alcohol use during pregnancy, presence of a medical history factor (e.g., anemia, cardiac disease, lung disease, diabetes, genital herpes), and presence of a complication of labor and/or delivery (e.g., premature rupture of membranes, placenta previa, cord prolapse, fetal distress).

Data Analysis

The present study utilized risk ratios and population attributable fraction percentages (PAF%) to evaluate the level of risk for an individual and the population, respectively.

Risk Ratios

Risk ratios were used to evaluate the influence of child and maternal risk factors on DD, SD, and other developmental disabilities. A risk ratio represents 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. The level of risk associated with each factor was determined for each group by comparing the rate of occurrence of the factor within each group against the No Disability group. More detailed information on the calculation of risk ratios can be found in Delgado and colleagues (2005). A value of 1.0 indicates equal levels of risk for an outcome (e.g., DD) between the groups being compared (e.g., being born at low birth weight versus at normal birth weight). A value of less than 1.0 represents a decreased risk for an outcome, and a value of greater than 1.0 represents an increased risk. Risk ratios greater than 2.0 (i.e., double or greater risk) are considered of substantial importance in health research, and risk ratios of 5.0 or greater are considered very large.

We calculated 95% confidence intervals for each risk ratio. These intervals indicate the lower and upper limit of the risk ratio that contains the true parameter 95% of the time over unlimited repetitions of the study, assuming there is no bias. Thus, risk ratios for which either confidence limit was equal to or crossed 1.0 are not considered meaningful because they do not reach the conventional 5% level of significance. In these cases, one cannot be confident that the rate of disability is truly different from the rate found in the comparison (No Disability) group.

PAF%

The risk ratio reflects the degree of risk to an individual, but it is also possible to examine the effect of a risk factor on a population as a whole. The PAF% weighs the risk ratio against the proportion of the population that has experienced the risk factor and results in an estimate of the percentage of cases of the disorder in the population that are related to the presence of the risk factor (Mason et al., 2000). The PAF% can be used to estimate the percentage of cases of a disorder that would be reduced in the population if the rate associated with a risk factor (e.g., low birth weight) were reduced to that of the referent group (e.g., normal birth weight). A PAF% of 5% is considered important, 10% is considered large,

and 20% is considered very large (Scott, 2003). PAF% identifies the group that has the largest impact on the number of cases in the population. Groups with the largest impact on the population can then be targeted for services or programs aimed at reducing the rate of the disorder. PAF%s were computed to identify the population-level risk associated with risk factors for DD.

RESULTS

The distributions of risk factors examined for preschool children in the DD, SD, Other, and No Disability groups are presented in Table 2. The number of children for which risk factor information was unknown was consistently 0.41% or less. Slightly higher levels of missing information occurred for onset of prenatal care (1.21%, 0.81%, and 0.93% for the DD, SD, and No Disability groups, respectively).

TABLE 2
Distribution of Factors for Children in the Developmental Delay (DD), Speech Disability (SD), Other Developmental Disability (Other), and No Developmental Disability (No Disability) Groups

	DD		*SD*		*Other*		*No Disability*	
Factor	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*
Gestational age								
< 37 weeks	1,701	20.24	929	10.29	978	13.89	88,527	9.47
≥ 37 weeks	6,683	79.52	8,079	89.48	6,045	85.87	844,421	90.34
Unknown	20	0.24	21	0.23	17	0.24	1,727	0.18
Birth weight								
Very low (< 1,500 g)	645	7.67	128	1.42	255	3.62	13,704	1.47
Low (1,500–2,499 g)	978	11.64	590	6.53	627	8.91	58,932	6.31
Normal (≥ 2,500 g)	6,778	80.65	8,310	92.04	6,155	87.43	861,790	92.20
Unknown	3	0.04	1	0.01	3	0.04	249	0.03
5-min Apgar score								
< 4	47	0.56	14	0.16	27	0.38	3,750	0.40
4–6	196	2.33	70	0.78	105	1.49	7,469	0.80
> 6	8,130	96.74	8,931	98.91	6,884	97.78	921,236	98.56
Unknown	31	0.37	14	0.16	24	0.34	2,220	0.24
Multiple birth								
Yes	569	6.77	393	4.35	339	4.82	24,226	2.59
No	7,835	93.23	8,635	95.64	6,701	95.18	910,424	97.41
Unknown	0	0.00	1	0.01	0	0.00	25	< 0.01
Newborn conditions								
Yes	1,176	13.99	727	8.05	683	9.70	61,304	6.56
No	7,222	85.94	8,295	91.87	6,352	90.23	872,812	93.38
Unknown	6	0.07	7	0.08	5	0.07	559	0.06
Congenital abnormalities								
Yes	246	2.93	161	1.78	184	2.61	8,495	0.91
No	8,151	96.99	8,861	98.14	6,851	97.32	925,617	99.03
Unknown	7	0.08	7	0.08	5	0.07	563	0.06

(*continued*)

TABLE 2
(*Continued*)

	DD		*SD*		*Other*		*No Disability*	
Factor	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*
Maternal education								
< 12 years	2,361	28.09	1,248	13.82	1,611	22.88	203,708	21.79
12 years	3,104	36.93	2,984	33.05	2,478	35.20	329,771	35.28
> 12 years	2,908	34.60	4,772	52.85	2,922	41.51	397,441	42.52
Unknown	31	0.37	25	0.28	29	0.41	3,755	0.40
Maternal age								
< 18 years	494	5.88	271	3.00	354	5.03	49,780	5.33
18–35 years	7,040	83.77	7,702	85.30	5,840	82.95	795,536	85.11
> 35 years	869	10.34	1,055	11.68	843	11.97	89,189	9.54
Unknown	1	0.01	1	0.01	3	0.04	170	0.02
Mother married								
Yes	4,908	58.40	7,024	77.79	4,576	65.00	603,417	64.56
No	3,496	41.60	2,001	22.16	2,464	35.00	331,046	35.42
Unknown	0	0.00	4	0.04	0	0.00	212	0.02
Onset of prenatal care								
First trimester	6,755	80.38	7,946	88.01	5,873	83.42	767,758	82.14
Second trimester	1,218	14.49	845	9.36	876	12.44	126,580	13.54
Third trimester/none	329	3.91	165	1.83	229	3.25	31,616	3.38
Unknown	102	1.21	73	0.81	62	0.88	8,721	0.93
Tobacco use during pregnancy								
Yes	1,306	15.54	1,192	13.20	812	11.53	114,630	12.26
No	7,087	84.33	7,833	86.75	6,214	88.27	819,124	87.64
Unknown	11	0.13	4	0.04	14	0.20	921	0.10
Alcohol use during pregnancy								
Yes	121	1.44	95	1.05	64	0.91	8,480	0.91
No	8,271	98.42	8,930	98.90	6,963	98.91	925,253	98.99
Unknown	12	0.14	4	0.04	13	0.18	942	0.10
Medical history factors								
Yes	2,617	31.14	2,327	25.77	1,764	25.06	220,260	23.57
No	5,779	68.76	6,695	74.15	5,271	74.87	713,811	76.37
Unknown	8	0.10	7	0.08	5	0.07	604	0.06
Labor complications								
Yes	3,099	36.88	2,857	31.64	2,341	33.25	289,595	30.98
No	5,299	63.05	6,163	68.26	4,694	66.68	644,552	68.96
Unknown	6	0.07	9	0.10	5	0.07	528	0.06

Individual-Level Risk

Individual-level risk was estimated using risk ratios. The results of these analyses are provided in Table 3. All of the risk factors examined were associated with a significantly increased risk for DD. There were noticeable differences, however, between the child factors and the maternal factors. All of the perinatal child factors (i.e., gestational age, birth weight, Apgar score, multiple birth, newborn condition, congenital abnormality), with the exception of 5-min Apgar score of less than 4, resulted in risk ratio values greater than 2.0, whereas all of the risk ratio values for the maternal factors (i.e., maternal education, maternal age,

TABLE 3
Risk Ratios and 95% Confidence Intervals for Factors Present at Birth on Rates of Developmental Delay (DD), Speech Disability (SD), and Other Developmental Disabilities (Other)

Factor	*DD*	*SD*	*Other*
Gestational age			
< 37 weeks	2.40 (2.28–2.53)	1.10 (1.02–1.17)	1.54 (1.44–1.64)
≥ 37 weeks	1.00	1.00	1.00
Birth weight			
Very low (<1,500 g)	5.76 (5.32–6.23)	0.97 (0.81–1.15)	2.58 (2.28–2.92)
Low (1,500–2,499 g)	2.09 (1.96–2.24)	1.04 (0.96–1.13)	1.48 (1.37–1.61)
Normal (≥ 2,500 g)	1.00	1.00	1.00
5-min Apgar score			
< 4	1.41 (1.06–1.88)	0.39 (0.23–0.65)	0.96 (0.66–1.40)
4–6	2.92 (2.54–3.36)	0.97 (0.77–1.22)	1.87 (1.54–2.26)
> 6	1.00	1.00	1.00
Multiple birth			
Yes	2.69 (2.47–2.93)	1.70 (1.54–1.88)	1.89 (1.69–2.10)
No	1.00	1.00	1.00
Newborn conditions			
Yes	2.29 (2.16–2.44)	1.24 (1.15–1.34)	1.53 (1.41–1.65)
No	1.00	1.00	1.00
Congenital abnormalities			
Yes	3.22 (2.85–3.65)	1.96 (1.68–2.29)	2.89 (2.50–3.34)
No	1.00	1.00	1.00
Maternal education			
< 12 years	1.58 (1.49–1.66)	0.51 (0.48–0.55)	1.08 (1.01–1.14)
12 years	1.28 (1.22–1.35)	0.76 (0.72–0.79)	1.02 (0.97–1.08)
> 12 years	1.00	1.00	1.00
Maternal age			
< 18 years	1.12 (1.02–1.23)	0.56 (0.50–0.64)	0.97 (0.87–1.08)
18–35 years	1.00	1.00	1.00
> 35 years	1.10 (1.03–1.18)	1.22 (1.14–1.30)	1.28 (1.20–1.38)
Mother married			
Yes	1.00	1.00	1.00
No	1.30 (1.24–1.35)	0.52 (0.50–0.55)	0.98 (0.93–1.03)
Onset of prenatal care			
First trimester	1.00	1.00	1.00
Second trimester	1.09 (1.03–1.16)	0.65 (0.60–0.69)	0.91 (0.84–0.97)
Third trimester	1.18 (1.06–1.32)	0.51 (0.43–0.59)	0.95 (0.83–1.08)
Tobacco use during pregnancy			
Yes	1.31 (1.24–1.39)	1.09 (1.02–1.15)	0.93 (0.87–1.00)
No	1.00	1.00	1.00
Alcohol use during pregnancy			
Yes	1.59 (1.33–1.90)	1.16 (0.95–1.42)	1.00 (0.78–1.28)
No	1.00	1.00	1.00
Medical history factors			
Yes	1.46 (1.40–1.53)	1.13 (1.07–1.18)	1.08 (1.03–1.14)
No	1.00	1.00	1.00
Labor complications			
Yes	1.30 (1.24–1.36)	1.03 (0.99–1.08)	1.11 (1.06–1.17)
No	1.00	1.00	1.00

Note. Data are risk ratios (95% confidence intervals).

marital status, onset of prenatal care, tobacco use, alcohol use, maternal medical history factor, labor complications) were less than 2.0.

The factor associated with the highest risk ratio was very low birth weight, indicating that children born weighing less than 1,500 g were at nearly 6 times the risk of being diagnosed with DD in preschool than children born at normal birth weight (2,500 g or more). Previous research has indicated that children born with very low birth weight are at increased risk for cognitive delays, possibly due to neurological impairment (Nonkin Avchen et al., 2001; Smith, Ulvund, & Lindemann, 1994). Such delays may be nonspecific in nature, leading to a classification of DD in young children.

Compared to the SD and Other groups, the risk ratios associated with the factors studied were consistently larger for the DD group. Most of these differences were statistically significant. Statistical significance was determined by comparing the confidence intervals of the risk ratios. Risk ratios with confidence intervals that did not overlap were considered statistically significantly different. For example, the risk ratio for prematurity (gestational age less than 37 weeks) for the DD group was 2.40, with a confidence interval of 2.28 to 2.53. The risk ratios for the SD and Other groups were both less than 2.40 (1.10 and 1.54, respectively) and had confidence intervals that did not overlap that for the DD group (1.02 to 1.17 and 1.44 to 1.64, respectively). Therefore, the risk ratio for the DD group was significantly greater than the risk ratios for the SD and Other groups (and the risk ratios for the SD and Other groups were significantly different from each other as well).

The one exception to the increased risk associated with the factors for DD was high maternal age. Children born to mothers older than 35 years were at greater risk for SD and other developmental disabilities than they were for DD, although the risk was only significantly greater for children with other developmental disabilities.

Population-Level Risk

Population-level risk for DD was estimated using PAF%. The results of these analyses are provided in Table 4. Prematurity and low maternal education posed the highest level of risk to the population. Nearly 12% of the cases of DD were associated with prematurity. In other words, the number of children classified as DD could be reduced by 12% if the risk associated with prematurity were brought to the level of risk associated with being born at full term. Whereas low maternal education was associated with a high population-level risk (PAF% values of 9.20 for 12 years and 11.31 for fewer than 12 years of education), the level of individual risk associated with low maternal education was relatively low (risk ratio values of 1.28 for 12 years and 1.58 for fewer than 12 years of education). Other factors that were associated with relatively high population-level risk were unwed marital status and the presence of medical history factors or labor complications.

TABLE 4
Population Attributable Fraction Percentages (PAF%) for Risk Factors Present at Birth on Rates of Developmental Delay (DD)

Factor	*PAF%*
Gestational age < 37 weeks	11.78
Very low birth weight (< 1,500 g)	6.74
Low birth weight (1,500–2,499 g)	6.46
5-min Apgar score < 4	0.17
5-min Apgar score 4–6	1.53
Multiple birth	4.22
Newborn condition	7.86
Congenital abnormality	2.00
Maternal education < 12 years	11.31
Maternal education = 12 years	9.20
Maternal age < 18 years	0.66
Maternal age > 35 years	0.91
Unmarried mother	9.66
Prenatal care onset second trimester	1.30
Prenatal care onset third trimester/none	0.63
Maternal tobacco use	3.70
Maternal alcohol use	0.53
Maternal medical history factor	9.81
Labor complications	8.45

DISCUSSION

Approximately 33% of preschool-age children with disabilities in Florida were classified as DD, making it the second most common exceptionality category for preschool-age children in the state. The frequency with which this exceptionality category is used underscores the importance of identifying factors that place children at risk.

The results of the present study demonstrate that children born with any of a variety of perinatal risk factors, particularly very low birth weight, are at increased risk for being classified as DD and that the risk associated with these factors is greater for DD than for other developmental disabilities. These results are consistent with previous research indicating that prematurity, low birth weight, low Apgar score, and presence of a congenital abnormality are associated with poor developmental outcomes (Breitmeyer & Ramey, 1986; Escobar, Littenberg, & Petitti, 1991; Nonkin Avchen et al., 2001; Rojahn et al., 1993; Smith et al., 1994; Stanton-Chapman et al., 2001; Walther, den Ouden, & Verloove-Vanhorick, 2000). The magnitude of the risk associated with the child risk factors studied indicates that these factors are important to consider and can be useful in identifying at-risk children. The interpretations by other researchers that child factors are not useful predictors of developmental outcome (King, Logsdon, & Schroeder, 1992; Kochanek et al., 1987) were based

on studies with much smaller sample sizes, reducing the ability to identify the true level of risk associated with such factors. With small sample sizes, extreme cases are not adequately represented in the data, which weakens the statistical power of the analyses. The present study overcame this limitation inherent to previous research by using population data.

Maternal factors such as age, education, alcohol and tobacco use, and onset of prenatal care did not place the child at as great a risk for DD as did child factors. In particular, low maternal educational attainment (fewer than 12 years) only increased the child's risk of DD by 1.58 times. These findings demonstrate that the impact of low maternal education is similar to that reported for learning disabilities but lower than for mental retardation and emotional handicaps (risk ratio values of approximately 11 and 5, respectively) in school-age children (Chapman et al., 2002; Mason et al., 1999; Scott, Mason, & Gonzalez, 2000; Stanton-Chapman et al., 2001).

The differences in the risk associated with low maternal education across disabilities may be a function of underlying deficits. The federal government allows the use of DD as a category of exceptionality through age 9; however, DD is only used through age 5 in Florida (Florida Department of Education, 2001). Therefore, children identified with DD must be reclassified into another disability category if continued special education services are necessary. Previous research indicates that most children with DD continue to demonstrate delays and receive special education services in elementary school (Bernheimer et al., 1993; Delgado et al., 2006; Keogh et al., 2004; Keogh et al., 1996). Examination of the outcome exceptionalities of these children deserves attention and should be the focus of further study.

In this study, the population-level risk for DD associated with maternal educational attainment was quite high, even though the risk to the individual was relatively low. Such disparities between individual-level and population-level risk occur because, although the PAF% calculation includes the risk ratio, it also includes the prevalence of the factor. Because the prevalence associated with each risk factor varies, the population-level risk (PAF%) is unique from the individual-level risk (risk ratio). Therefore, although the individual-level risk associated with having a mother with fewer than 12 years of education is only 1.58 times that of having a mother with more than 12 years of education, low maternal education is associated with a relatively large risk to the population studied. If the risk associated with low maternal education (fewer than 12 years) could be reduced to that associated with higher levels of education (more than 12 years), the number of cases of DD would be reduced by more 11%. Other factors with a large population risk were prematurity (gestational age less than 37 weeks), mother's unwed marital status, presence of medical history factors, and presence of labor complications.

Because it is likely that both biological and environmental factors contribute to the development of DD, optimal identification of children at risk for DD requires the assessment of the child's environment in addition to the perinatal

information available from birth records (Benn, 1993; Gallimore et al., 1999; Molfese & DiLalla, 1995; Rojahn et al., 1993; Siegel, 1982; Werner, 1989). Environmental factors such as maternal intelligence, socioeconomic status, availability of stimulating materials in the home, stressful life events, family social support, and the quality of mother–child interactions are all important to a child's development and have been shown to be related to developmental outcome (Benn, 1993; King et al., 1992; Molfese & DiLalla, 1995; Ramey & MacPhee, 1986; Siegel, 1982; Werner, 1986). Obtaining this type of information, however, is labor intensive and expensive. Although such environmental influences are important to consider for optimal identification of children at risk for DD, the use of information already collected by public agencies may be a cost-effective initial filter for identifying these children. Information obtained from birth certificate records has been demonstrated in a number of studies to be a cost-effective way to evaluate risk and predict adverse outcomes in children (Chapman et al., 2002; Nonkin Avchen et al., 2001; Ramey, Steadman, Borders-Patterson, & Mengel, 1978; Sonnander & Claesson, 1999; Stanton-Chapman et al., 2001). Children deemed at risk based on factors present at birth should then receive more extensive evaluations, including those that assess the child's family and home environment (Meisels, 1992).

The use of epidemiological methodology in the present study allowed for the differentiation between individual-level and population-level risk for DD not previously reported. Individual-level risk information is particularly important for professionals who serve children on an individual basis. Clinicians and health care professionals can utilize the data from this study to better identify those children whose development should be closely monitored for signs of potential delay or impairment. Knowing about population-level risk, however, is particularly useful for policymakers whose goal is to allocate resources in such a way as to have the largest positive impact on a population. Targeting programs and services based on the risk factors associated with the largest population-level risks will, if effective, have the greatest impact on the reduction of the rate of DD and represent the most efficient use of resources.

Although the large scope of the present study provides a unique look into the contributions of these factors, the presence of several limitations must be acknowledged.

The inclusion of children in the No Disability group for whom outcome status was unknown represents one limitation to the study. Although having outcome data on all preschool children in Florida would have been ideal, this information was not available. A reasonably large percentage of the population of preschool-age children (3%) were referred to the Florida Diagnostic and Learning Resources System; however, even within such a comprehensive system there remain children with developmental disabilities who do not have records in the CHRIS database. These children represent a very small percentage of the No Disability group, and their misclassification would weaken the magnitude of the effects reported. Yet given the size of the No Disability group, the error

introduced by the relatively small number of unidentified cases of developmental disabilities has only a negligible effect on the results of the study.

Also, although large extant data sets provide the opportunity to efficiently and inexpensively assess the relation of factors to disabilities in extremely large, population-based samples, the quality of the data contained within extant 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 weaken the magnitude of the effects reported (Rothman, 2002). Hence, any significant effects reported are likely larger than those indicated by the results. In addition, errors within the birth certificate record data are likely much rarer 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, states face the difficult task of identifying individuals in need of disability services and providing those services in a cost-effective manner. Identification of relatively mild disabilities such as DD is more difficult than identification of more severe disabilities, particularly in young children. Utilization of extant data sets provides a powerful tool in the identification of potential risk factors for disabilities. Additional follow-up research is necessary to identify the nature of the relations between identified risk factors and disability outcome as well as to identify and develop effective prevention and intervention practices.

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