The Impact of Low Birth Weight, Perinatal Conditions, and Sociodemographic Factors on Educational Outcome...

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The Impact of Low Birth Weight, Perinatal Conditions, and Sociodemographic Factors on Educational Outcome in Kindergarten

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ABSTRACT. ***Objective.*** **To assess the relative effects and the impact of perinatal and sociodemographic risk factors on long-term morbidity within a total birth population in Florida.**

Methods. **School records for 339 171 children entering kindergarten in Florida public schools in the 1992–1993, 1993–1994, or 1994–1995 academic years were matched with Florida birth records from 1985 to 1990. Effects on long-term morbidity were assessed through a multivariate analysis of an educational outcome variable, defined as placement into 9 mutually exclusive categories in kindergarten. Of those categories, 7 were special education (SE) classifications determined by statewide standardized eligibility criteria, 1 was academic problems, and the reference category was regular classroom. Generalized logistic regression was used to simultaneously estimate the odds of placement in SE and academic problems. The impact of all risk factors was assessed via estimated attributable excess/deficit numbers, based on the multivariate analysis.**

Results. **Educational outcome was significantly influenced by both perinatal and sociodemographic factors. Perinatal factors had greater adverse effects on the most severe SE types, with birth weight <1000 g having the greatest effect. Sociodemographic predictors had greater effects on the mild educational disabilities. Because of their greater prevalence, the impact attributable to each of the factors (poverty, male gender, low maternal education, or non-white race) was between 5 and 10 times greater than that of low birth weight and >10 times greater than that of very low birth weight, presence of a congenital anomaly, or prenatal care.**

Conclusions. **Results are consistent with the hypothesis that adverse perinatal conditions result in severe educational disabilities, whereas less severe outcomes are influenced by sociodemographic factors. Overall, sociodemographic factors have a greater total impact on adverse educational outcomes than perinatal factors.** ***Pediatrics*** **1999;104(6). URL: http://www.pediatrics.org/cgi/content/full/104/6/e74;** ***birth weight, child development, special education, educational status, morbidity, infant, low birth weight, risk factors, socioeconomic factors, logistic models, Florida.***

ABBREVIATIONS. LBW, low birth weight; SE, special education; DOE, Department of Education; AP, academic problems; PI, physically impaired; SI, sensory impaired; PMH, profoundly mentally handicapped; TMH, trainable mentally handicapped; EMH, educable mentally handicapped; LD, learning disabled; EH, emotionally handicapped; ELBW, extremely low birth weight; VLBW, very low birth weight.

Evaluations of the effects of perinatal risk factors on long-term developmental outcomes attract much attention because of widespread concerns that increased survival of infants at the threshold of viability leads to increased neurodevelopmental morbidity.[1–5] Tests of intelligence, physical coordination, neurological functioning, as well as teacher and parent reports and classroom assignments have all been used as educational outcome measures. It is well established that certain perinatal factors, especially low birth weight (LBW), significantly increase the risk of educational problems,[6–12] even when controlling for sociodemographic factors.[13–23] Some authors also have recognized the independent effects of sociodemographic variables, such as poverty, maternal education, race, and gender on educational outcomes[24–32] and have indicated that these effects become more pronounced as children progress through school.[4,33–35] In a few studies, it has been observed that different types of developmental problems are influenced differently by sociodemographic and perinatal risk factors.[3,8,36,37]

Still controversial is whether the absolute numbers of children with disabilities caused by perinatal factors have increased with improved survival,[1,2,5,38–42] but some evidence indicates that these children constitute a small minority of the overall number of children with disabilities requiring special education (SE) and other services.[3,43] Sociodemographic risk factors, however, are relatively more prevalent in the general school-aged population than adverse birth conditions and may have a greater impact on educational problems. Hence, it is important to assess simultaneously the contributions of perinatal and sociodemographic factors to the total number of educationally disabled children within a general population.

The effects of risk factors on educational disabilities have been studied primarily for infants at increased medical risk at birth,[31,35,36,38,44–47] and often only a few potential outcomes have been considered, for example, learning disabilities, cognitive perfor-

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mance, or retention rates.[16,32,48–49] Because of the rarity of SE outcomes and certain perinatal events, mostly case-control studies and designs with healthy newborns matched to medically fragile infants have been used with small sample sizes and in restricted geographical areas. The small study sizes allow precise measurements of the outcomes (most often with standardized tests), but selection bias is easily introduced.[48,50,51] In contrast, the availability of information on all births and all school records in a geographically defined area allows consideration of nearly all children in that region and permits utilization of school placement as an outcome.[52]

The objective of this study was to assess the relative effects and the impact of perinatal and sociodemographic factors on educational outcomes within the total birth population in Florida. We performed a similar analysis of educational disabilities for the population of premature or sick infants who were treated in Florida Regional Perinatal Intensive Care Centers between 1980 and 1987 and found that perinatal variables were associated highly with severe educational disabilities, whereas mild educational problems seemed to be influenced by sociodemographic factors.[37] In the general population considered in the current paper, we expected the effects of perinatal factors to be more pronounced because a much healthier reference group was considered than when only children at increased medical risk at birth were analyzed. By using the total birth population, we were able to estimate the impact of each predictor. That is, we were able to estimate the total number of disabled children attributable to each risk factor and compare perinatal and sociodemographic factors.

METHODS

Study Participants

The study sample consisted of children born in the state of Florida between 1985 and 1990 (just before the introduction of surfactant) who entered kindergarten in Florida public schools in the academic years 1992–1993, 1993–1994, or 1994–1995. Children entered kindergarten if they were ≥5 years of age on or before August 31 of the school year. School records were obtained from the Florida Department of Education (DOE) database and were linked to the Florida Vital Statistics datasets for the birth years considered. Of the student records from kindergarten 1992–1993, 1993–1994, and 1994–1995, 67%, 68%, and 69%, respectively, were matched successfully with records for births in the State of Florida. The percentages unmatched consisted of children who were not born in Florida and of children born in Florida whose DOE records could not be matched to birth records (name changes, incorrectly entered identifiers, duplicate matches).

A total of 339 171 records (65% of all available DOE records) were available for analysis after deleting records with missing values for any of the variables studied. A comparison of the 3 groups (matched with no missing values, matched with missing values, and unmatched) with respect to the outcome variable is presented in Table 1.

The representativeness of our population with respect to the predictor variables was ascertained by comparing the raw percentages from our matched dataset to the raw percentages from the birth vital statistics dataset for 1987, 1988, and 1989, the 3 years that contributed most of the children in our population (~90%). In the birth vital statistics dataset, we excluded infants who died during their first year of life. The comparison is presented in Table 2.

Variables

Outcome Variables

The outcome variable was educational placement at kindergarten into 7 mutually exclusive SE categories designed to serve children with an educational disability, an academic problems (AP) category for children with milder educational problems, and a reference category consisting of children who attended regular classroom or gifted classes only. Assignment to SE was determined by the child's primary exceptionality, which identified the disability requiring the greatest allocation of personnel resources (in cases in which more than 1 disability was diagnosed). SE categories included: 1) physically impaired (PI), severe skeletal or neuromuscular conditions adversely affecting educational performance; 2) sensory impaired (SI), deaf, blind, hard of hearing, or partially sighted; 3) profoundly mentally handicapped (PMH), IQ <25; 4) trainable mentally handicapped (TMH), IQ between 25 and 54; 5) educable mentally handicapped (EMH), IQ between 55 and 69; 6) learning disabled (LD), psychological processing disorders marked by difficulties in the acquisition and use of language, reading, writing, or math; and 7) emotionally handicapped (EH), condition resulting in persistent and maladaptive behaviors.

Procedures for eligibility determination and classification criteria of primary exceptionality are standardized throughout the state's 67 school districts. Placement criteria are dictated by Florida Board of Education Rules in accordance with Federal guidelines and monitored by the Florida Bureau of Student Services and Exceptional Education.[53,54] These definitions and eligibility criteria that classify children into SE types are comprehensive and require extensive multidisciplinary evaluation procedures by qualified professionals using widely accepted assessment tools and methods.

The AP category comprised milder educational intervention or remedial programs and practices used in Florida, which could not be analyzed separately without bias because of the variations of local districts in assigning students to these programs. Speech and language impairment was a type of assignment for remedial services for disorders of language, articulation, fluency, or voice. Federal Chapter 1/Title 1 Basic Program provided educational services to low-achieving students. Nonpromotion to first grade was defined as a child found again in kindergarten the following year.

Children with both a SE primary exceptionality and an AP were placed in the SE category.

Predictor Variables

The risk factors considered are given in Table 3. Poverty was obtained from the DOE dataset, whereas the rest of the factors

TABLE 1. Number and Percent Distribution of Three Groups Into Outcome Variable Categories

Groups	PI		SI		PMH		TMH		EMH		LD		EH		AP		RC		Total
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*
Matched, complete data	972	.3	486	.1	338	.1	688	.2	1846	.5	1530	.5	1845	.5	96 860	28.6	234 606	69.2	339 171
Matched, incomplete data	43	.3	18	.1	22	.2	23	.2	84	.6	41	.3	45	.3	3515	25.8	9846	72.2	13 637
Not matched	453	.3	245	.1	153	.1	325	.2	740	.4	593	.4	818	.5	39 452	23.6	124 550	74.4	167 330

RC indicates regular classroom.

TABLE 2. Comparison of the Merged and the Total Vital Statistics Datasets

Variables	Merged Dataset (%)	Vital Statistics 1987–1989 %
Birth weight		
450–749 g	.1	.1
750–999 g	.2	.2
1000–1499 g	.6	.6
1500–2499 g	6.4	6.2
2500–2999 g	17.2	16.6
4750–6049 g	.6	.6
3000–4749 g	74.9	75.6
Congenital anomaly		
Yes	2.4	2.4
No	97.6	97.6
Complications of labor		
Yes	32.9	33.3
No	67.1	66.7
Race/ethnicity		
Black	27.7	23.3
Other	12.8	15.9
White	59.6	60.8
Gender		
Male	51.5	51.2
Female	48.5	48.8
Maternal age		
11–17 y	6.4	5.5
18–19 y	8.9	8.1
36 y or older	4.9	5.5
20–35 y	79.8	80.8
Maternal marital status		
Not married	31.4	28.5
Married	68.6	71.5
Maternal education		
Less than high school	27.6	24.6
High school	42.5	40
More than high school	30	35.4
Prenatal care		
No	3.2	3.3
Yes	96.8	96.7
Previous pregnancy experience		
Previous failed pregnancy	27.6	27.8
No previous pregnancy	31.3	32.9
One or more previous successful pregnancies	41.1	39.3

were available in the vital statistics dataset. Poverty was defined according to whether the child received free or reduced price lunch in kindergarten. Eligibility for free or reduced price lunch was based on family size and family income.

Birth weight was classified into the following 7 categories: 450 to 749 g, 750 to 999 g, 1000 to 1499 g, 1500 to 2499 g, 2500 to 2999 g, 4750 to 6049 g, and 3000 to 4749 g. The first 2 categories (<1000 g) consisted of extremely low birth weight (ELBW) children, the first 3 categories (<1500 g) comprised very low birth weight (VLBW) children, and the first 4 categories (<2500 g) corresponded to LBW children. Congenital anomaly, complications of labor, and maternal marital status were yes or no variables obtained from the vital statistics on the birth certificate. Maternal education was categorized as less than high school, high school, or greater than high school education based on the number of years of schooling completed by the mother. Four categories of maternal age at birth were considered: a young teenage group (11–17 years), a late teenage group (18 to 19), women of 20 to 35 years of age, and women ≥36 years of age. Race/ethnicity had 3 categories: white, black, and other, with the other category being predominantly Hispanic (93%) and most Hispanics being white. Prenatal care was a yes or no variable with yes assigned if the mother received any type of prenatal care. Previous pregnancy experience had 3 categories: previous failed pregnancy (including any pregnancy terminations and child deaths occurring after birth), no previous pregnancy experience, and 1 or more previous successful pregnancies.

The risk factors considered were limited to only those variables that were available in vital statistics for all the years in the period 1985–1990. Hence, we were not able to study the effects of ventilation and of certain medical conditions such as intraventricular hemorrhage and seizures.

Statistical Methods

The CATMOD procedure in SAS (SAS Institute, Cary, NC)[55] was used to fit a generalized logistic regression model to assess simultaneously the effects of the perinatal and sociodemographic predictors on educational outcomes. Generalized odds ratios, with regular classroom as the reference category, were used to measure the effect on each educational disability of levels of each predictor in relation to a reference level perceived a priori to be the lowest risk category for the predictor. All generalized odds ratios reported herein were adjusted for the other risk factors in the model. Odds ratios >1 indicated that the level of the risk factor under consideration was associated with higher odds of the outcome than the reference level. Confidence intervals were constructed to test the significance of the odds ratios. All tests were performed at .05 significance level. The available sample was large enough to allow assessment of the effects of rare risk factors (for example, birth weight <750 g) on rare outcomes (for example, PMH) via a main effects model but was not sufficient to study interactions.

The impact of each of the risk factors was assessed via excess/deficit numbers, calculated from the formula in the Appendix. Positive (excess) numbers are interpreted as the number of children in a specific group who would have been prevented from being placed in the educational disability category under consideration if the risk in that group could have been reduced to the risk of the reference group. Negative (deficit) numbers are interpreted as the number of additional children in a specific group who would have been placed in the educational disability category had the risk in that group been the same as in the reference group.

It should be noted that causation could not be inferred from the associations found from model fitting. Like the generalized odds ratios, the excess/deficit numbers were adjusted for the other factors in the model.

RESULTS

Sample Counts and Percentages

A description of the study sample is provided in Table 3. Of the children, 7705 (2.3%) required SE and 96 860 (28.6%) were placed in the AP category. The total percentages of children requiring SE by type were .3% PI, .1% SI, .1% PMH, .2% TMH, .5% EMH, .5% LD, and .5% EH. These are similar to the percentages for the unmatched records (Table 1), suggesting that the sample available for analysis was representative of the entire population of kindergarten students with respect to SE placement. The percentage of children with AP among those unmatched was slightly lower than among those matched (23.6%, compared with 28.56%). Note that nearly all children receiving SE services in the state of Florida are in public schools; therefore, nearly all severely and moderately disabled children in kindergarten were included in the analysis.

Our sample was also representative of the total birth population of children who survived past their first year of life with respect to the predictor variables (Table 2). Only small differences were observed on few variables (maternal education, race, and marital status). These differences probably are explained by the sociodemographic characteristics of children who attend private schools.

Main Effects Analysis

The main effects analysis indicated that all considered variables had significant effects on educational placement. Adjusted generalized odds ratios that de-

TABLE 3. Description of the Study Sample: Perinatal and Sociodemographic Variables by Educational Outcomes

Variables	Total		PI		SI		PMH		TMH		EMH		LD		EH		SE Total		AP		RC	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
Overall	339 171	100	972	.3	486	.1	338	.1	688	.2	1846	.5	1530	.5	1845	.5	7705	2.3	96 860	28.6	234 606	69.2
Perinatal factors																						
Birth weight																						
450–749 g	335	.1	19	5.7	14	4.2	9	2.7	18	5.4	18	5.4	9	2.7	2	.6	89	26.6	126	37.6	120	35.8
750–999 g	662	.2	39	5.9	18	2.7	11	1.7	10	1.5	36	5.4	14	2.1	9	1.4	137	20.7	236	35.7	289	43.7
1000–1499 g	2163	.6	85	3.9	18	.8	22	1	18	.8	62	2.9	32	1.5	17	.8	254	11.7	776	35.9	1133	52.4
1500–2499 g	21 663	6.4	172	.8	57	.3	68	.3	103	.5	270	1.3	145	.7	163	.8	978	4.5	7409	34.2	13 276	61.3
2500–2999 g	58 460	17.2	180	.3	97	.2	76	.1	172	.3	406	.7	276	.5	359	.6	1566	2.7	18 246	31.2	38 648	66.1
4750–6049 g	1871	.6	6	.3	2	.1	4	.2	2	.1	8	.4	8	.4	15	.8	45	2.4	490	26.2	1336	71.4
3000–4749 g	254 017	74.9	471	.2	280	.1	148	.1	365	.1	1046	.4	1046	.4	1280	.5	4636	1.8	69 577	27.4	179 804	70.8
Congenital anomaly																						
Yes	8061	2.4	163	2	30	.4	47	.6	72	.9	119	1.5	55	.7	55	.7	541	6.7	2790	34.6	4730	58.7
No	331 110	97.6	809	.2	456	.1	291	.1	616	.2	1727	.5	1475	.5	1790	.5	7164	2.2	94 070	28.4	229 876	69.4
Complications of labor																						
Yes	111 596	32.9	496	.4	173	.2	170	.2	282	.3	711	.6	538	.5	651	.6	3021	2.7	29 552	26.5	79 023	70.8
No	227 575	67.1	476	.2	313	.1	168	.1	406	.2	1135	.5	992	.4	1194	.5	4684	2.1	67 308	29.6	155 583	68.4
Sociodemographic factors																						
Race/ethnicity																						
Black	93 819	27.7	212	.2	122	.1	138	.2	271	.3	850	.9	426	.5	754	.8	2773	3	36 127	38.5	54 919	58.5
Other	43 341	12.8	92	.2	56	.1	41	.1	86	.2	152	.4	214	.5	161	.4	802	1.9	18 096	41.8	24 443	56.4
White	202 011	59.6	668	.3	308	.2	159	.1	331	.2	844	.4	890	.4	930	.5	4130	2	42 637	21.1	155 244	76.9
Gender																						
Male	174 558	51.5	573	.3	291	.2	182	.1	427	.2	1162	.7	1104	.6	1469	.8	5208	3	55 160	31.6	114 190	65.4
Female	164 613	48.5	399	.2	195	.1	156	.1	261	.2	684	.4	426	.3	376	.2	2497	1.5	41 700	25.3	120 416	73.2
Maternal age																						
11–17 y	21 786	6.4	64	.3	29	.1	34	.2	44	.2	193	.9	106	.5	176	.8	646	3	7612	34.9	13 528	62.1
18–19 y	30 098	8.9	87	.3	59	.2	40	.1	58	.2	224	.7	110	.4	244	.8	822	2.7	9634	32	19 642	65.3
36 y or older	16 657	4.9	68	.4	19	.1	18	.1	69	.4	94	.6	83	.5	82	.5	433	2.6	4933	29.6	11 291	67.8
20–35 y	270 630	79.8	753	.3	379	.1	246	.1	517	.2	1335	.5	1231	.5	1343	.5	5804	2.1	74 681	27.6	190 145	70.3
Maternal marital status																						
Not married	106 641	31.4	303	.3	155	.2	136	.1	276	.3	921	.9	524	.5	887	.8	3202	3	38 542	36.1	64 897	60.9
Married	232 530	68.6	669	.3	331	.1	202	.1	412	.2	925	.4	1006	.4	958	.4	4503	1.9	58 318	25.1	169 709	73
Maternal education																						
Less than high school	93 601	27.6	303	.3	135	.1	134	.1	256	.3	836	.9	505	.5	753	.8	2922	3.1	34 409	36.8	56 270	60.1
High school	143 974	42.5	392	.3	225	.2	129	.1	280	.2	723	.5	640	.4	730	.5	3119	2.2	39 711	27.6	101 144	70.3
More than high school	101 596	30	277	.3	126	.1	75	.1	152	.2	287	.3	385	.4	362	.4	1664	1.6	22 740	22.4	77 192	76
Poverty																						
Yes	157 058	46.3	513	.3	238	.2	177	.1	427	.3	1311	.8	892	.6	1262	.8	4820	3.1	57 441	36.6	94 797	60.4
No	182 113	53.7	459	.3	248	.1	161	.1	261	.1	535	.3	638	.4	583	.3	2885	1.6	39 419	21.7	139 809	76.8
Prenatal care																						
No	10 938	3.2	52	.5	23	.2	26	.2	40	.4	144	1.3	78	.7	119	1.1	482	4.4	3998	36.6	6458	59
Yes	328 233	96.8	920	.3	463	.1	312	.1	648	.2	1702	.5	1452	.4	1726	.5	7223	2.2	92 862	28.3	228 148	69.5
Previous pregnancy experience																						
Previous failed pregnancy	93 722	27.6	311	.3	133	.1	96	.1	214	.2	476	.5	437	.5	552	.6	2219	2.4	26 763	28.6	64 740	69.1
No previous pregnancy	106 203	31.3	288	.3	167	.2	109	.1	195	.2	547	.5	432	.4	551	.5	2289	2.2	27 478	25.9	76 436	72
One or more previous successful pregnancies	139 246	41.1	373	.3	186	.1	133	.1	279	.2	823	.6	661	.5	742	.5	3197	2.3	42 619	30.6	93 430	67.1

PI indicates physically impaired; SI, sensory impaired; PMH, profoundly mentally handicapped; TMH, trainable mentally handicapped; EMH, educable mentally handicapped; LD, learning disabled; EH, emotionally handicapped; SE, special education; AP, academic problems; RC, regular classroom.

TABLE 4. Adjusted Generalized Odds Ratios and 95% Confidence Intervals for the Effects of Perinatal and Sociodemographic Predictors on Educational Outcomes

Factor Levels	Reference Category	Educational Outcome							
		PI	SI	PMH	TMH	EMH	LD	EH	AP
Perinatal Factors									
Birth weight	3000–4749 g								
450–749 g		52.22* (21.16,128.9)	82.60* (21.11,323.2)	64.61* (19.92,209.5)	63.08* (16.61,239.5)	22.22* (9.62,51.29)	14.24* (5.29,38.35)	2.31 (.17,31.93)	2.51* (1.84,3.41)
750–999 g		41.59* (18.53,93.33)	42.50* (11.27,160.2)	29.72* (9.68,91.28)	12.84* (3.15,52.34)	15.23* (7.33,31.67)	8.25* (3.45,19.73)	3.48 (.34,35.77)	1.85* (1.47,2.31)
1000–1499 g		22.17* (10.45,47.02)	10.55* (2.82,39.54)	14.56* (5.31,39.91)	5.53* (1.48,20.69)	6.37* (3.23,12.55)	4.61* (2.20,9.63)	1.6 (.16,15.77)	1.51* (1.30,1.75)
1500–2499 g		4.35* (2.11,8.99)	2.83 (.82,9.81)	4.75* (1.89,11.92)	3.1 (6.91,10.55)	2.62* (1.40,4.90)	1.82 (.96,3.47)	1.42 (.15,13.39)	1.26* (1.13,1.40)
2500–2999 g		1.85 (.90,3.80)	1.67 (.49,5.70)	2.17 (.87,5.41)	2.03 (.60,6.85)	1.54 (.83,2.86)	1.26 (.67,2.37)	1.2 (.13,11.32)	1.1
4750–6049 g		1.33 (.72,2.46)	.89 (.31,2.49)	3.23* (1.48,7.08)	.63 (.22,1.77)	.99 (.58,1.70)	.88 (.50,1.56)	1.42 (.02,130.3)	.98 (.87,1.11)
Congenital anomaly	No								
Yes		6.81* (5.70,8.14)	2.53* (1.74,3.68)	5.29* (3.86,7.25)	4.18* (3.26,5.37)	2.44* (2.02,2.95)	1.50* (1.14,1.97)	1.19 (.91,1.57)	1.20* (1.14,1.26)
Complications of labor	No								
Yes		1.49* (1.30,1.70)	.9 (.74,1.09)	1.62* (1.30,2.03)	1.24* (1.06,1.45)	1.20* (1.09,1.32)	1.03 (.93,1.15)	1.13* (1.02,1.24)	.93* (.92,.95)
Sociodemographic Factors									
Race/ethnicity	White								
Black		.53 (0.44,.63)	.79 (.62,1.01)	1.74* (1.32,2.30)	1.47* (1.22,1.78)	1.41* (1.26,1.59)	.91 (.80,1.05)	1.26* (1.06,1.48)	1.78* (1.74,1.82)
Other		.73* (.58,.92)	1.03 (.77,1.38)	1.55* (1.09,2.20)	1.27 (1.00,1.63)	.81* (.68,.97)	1.23* (1.05,1.43)	.82* (.75,.89)	2.28* (2.23,2.34)
Gender	Female								
Male		1.68* (1.47,1.91)	1.73* (1.44,2.07)	1.39* (1.12,1.73)	1.94* (1.66,2.27)	1.99 (1.81,2.19)	2.88* (2.58,3.23)	4.35* (3.88,4.88)	1.46* (1.43,1.48)
Maternal age	20–35 y								
11–17 y		.96 (.71,1.30)	.88 (.57,1.37)	1.05 (.68,1.62)	.59* (.42,.84)	.84 (.70,1.00)	.85 (.67,1.07)	.91 (.75,1.10)	.90* (.87,.94)
18–19 y		1 (.79,1.27)	1.31 (.97,1.77)	1.19 (.83,1.70)	.73 (.55,.98)	.96 (.82,1.11)	.69 (.56,.85)	1.14 (.98,1.32)	.96* (.93,.98)
36 y or older		1.50* (1.16,1.93)	.88 (.55,1.40)	1.21 (.75,1.96)	2.39* (1.85,3.09)	1.38* (1.12,1.71)	1.2 (.96,1.50)	1.16 (.92,1.45)	1.15* (1.11,1.19)
Maternal marital status	Married								
Not married		1 (.85,1.18)	.97 (.77,1.22)	.91 (.69,1.19)	1.03 (.85,1.24)	1.24* (1.11,1.39)	1.05 (.93,1.20)	1.40* (1.25,1.56)	1.11* (1.08,1.13)
Maternal education	More than high school								
Less than high school		1.19 (.98,1.45)	1.17 (.88,1.56)	1.85* (1.32,2.57)	1.75* (1.39,2.21)	2.23* (1.91,2.60)	1.39* (1.19,1.62)	1.58* (1.37,1.83)	1.45* (1.42,1.49)
High school		.97 (.83,1.14)	1.23 (.98,1.54)	1.17 (.87,1.57)	1.2 (.98,1.48)	1.39* (1.21,1.61)	1.11 (.97,1.27)	1.12 (.98,1.28)	1.13* (1.11,1.15)
Poverty	No								
Yes		1.67* (1.44,1.93)	1.31* (1.06,1.60)	.99 (.77,1.26)	1.75* (1.47,2.09)	2.29* (2.04,2.57)	1.87* (1.66,2.11)	2.34* (2.09,2.62)	1.47* (1.44,1.50)
Prenatal care	Yes								
No		1.14 (.85,1.52)	1.13 (.73,1.75)	1.4 (.92,2.13)	1.17 (.84,1.63)	1.38* (1.15,1.65)	1.30* (1.02,1.64)	1.45* (1.20,1.76)	1.02 (.98,1.07)
Previous pregnancy experience	One or more previous successful pregnancies								
Previous failed pregnancy		1.03 (.88,1.20)	.96 (.77,1.21)	.97 (.75,1.27)	1.07 (.89,1.28)	.86* (.76,0.96)	.95 (.84,1.07)	1.14* (1.02,1.27)	.97* (.95,.99)
No previous pregnancy		.92 (.78,1.09)	1.07 (.85,1.34)	.97 (.74,1.29)	1.04 (.85,1.27)	.9 (.80,1.01)	.88 (0.77,1.01)	.95 (0.84,1.07)	.86* (.84,.88)

scribe these effects and associated 95% confidence intervals are presented in Table 4.

Children with VLBW were much more likely to be placed in all SE classes (except EH) or in the AP group than were children with normal birth weight. Likewise, children with congenital anomalies were at a much higher risk for all adverse educational outcomes (except EH) than were children without congenital anomalies. The magnitudes of the effects of VLBW and especially ELBW on placement in the most severe SE types (PI, SI, PMH, and TMH) were much greater than of those of any other factor. A similar observation can be made for EMH and LD, although the difference is less dramatic. Birth weight between 1500 g and 2500 g also increased the risk for adverse educational outcomes with significant effects observed for PI, PMH, EMH, and AP. Marginally LBW (2500–3000 g) and high birth weight (>4750 g) had no significant effect on any type of educational disability, except PMH in the case of high birth weight.

Gender was an important factor, with males being at a significantly higher risk for each type of educational problem, especially EH. Poverty was also a significant risk factor for AP and all types of SE except PMH. Blacks were at significantly higher risk to be placed in PMH, TMH, EMH, EH, and AP than whites. Individuals of other race were more likely to be placed in PMH, LD, and AP than whites and less likely to be placed in EMH and EH. Whites were at higher risk for PI than either blacks or other. Less than a high school education was associated with an increased risk of AP and all types of SE except PI and SI.

The children of unmarried mothers were more likely to be placed in the milder educational disabilities categories (EMH, EH, and AP) than those whose mothers were married. The children of mothers who did not receive prenatal care were at increased risk for EMH, LD, and EH. Maternal teen age was found to significantly decrease the odds for TMH, LD, and AP. Older maternal age was associated with an increased risk for AP, PI, EMH, and especially TMH. Children of mothers with no previous pregnancy experience were at a lower risk for AP.

Impact Analysis

The calculated excess/deficit numbers are provided in Table 5. The numbers in the SE total column were obtained by adding the numbers in the first 7 columns corresponding to the 7 different SE classifications. The total column was obtained by adding the SE total and the AP columns. Total rows were included for predictors with 3 or more levels and were obtained by adding the rows for all risk levels of those predictors.

The overall excess numbers for all sociodemographic factors except maternal age were greater than those attributed to birth weight, congenital anomaly, or prenatal care (Table 5). The difference was very dramatic for AP, where non-white race, poverty, male gender, and low maternal education (less than high school and high school) had a >10 times greater impact than LBW (<2500 g), the perinatal variable with the greatest impact. For example, the excess number of AP classifications attributable to non-white race was 18 972, compared with 971 attributable to LBW. This means that if the risk for AP among non-whites had been the same as the risk for AP among whites, then 18 972 cases of AP in the studied population could have been prevented. In contrast, if the risk among LBW children for AP had been the same as among normal birth weight children, only 971 cases of AP could have been avoided. There were an excess number of AP cases among children of unmarried mothers (3142) and among children of older mothers (392) and a deficit of AP cases among children of teenage mothers.

The excess numbers of SE cases attributable to male gender (2695) and poverty (1886) were also several times higher than those attributable to LBW (933). But the impact of LBW on SE placement was greater than the impact of congenital anomaly, complications of labor, low maternal education (less than high school and high school), single marital status, prenatal care, and maternal age. LBW and congenital anomaly were associated with an increased number of occurrences of all SE types.

Overall, there was a deficit of SE cases among blacks and others relative to whites. However, an excess number of blacks experienced mental handicaps. There was an excess for all types of SE placement among males, with the greatest impact being on EH placement. Excess numbers of poverty children were found in all SE classes except PMH. Low maternal education was associated with an excess number of cases in all SE categories except PI. No prenatal care and unmarried marital status were associated with excess occurrences of EMH and EH.

DISCUSSION

Nearly one third of Florida's kindergarten students between 1992 and 1995 required SE placement or intervention for AP. In this study, we investigated risk factors that contributed to this high percentage with emphasis on comparing the effects and the impact of perinatal and sociodemographic factors.

Effects

In the analysis we found that perinatal variables (birth weight, congenital anomaly, and complications of labor) influenced all educational outcomes but the effect was generally greater on the most severe SE types (PI, SI, PMH, TMH, and even EMH). Relative to the magnitude of the effects of perinatal factors, sociodemographic factors were more important for LD, EH, AP, and to a lesser extent for EMH.

Prenatal care and previous pregnancy experience had estimated effects more characteristic of sociodemographic rather than perinatal variables (ie, pronounced effect on the milder types of SE and/or AP). Apart from the previous failed pregnancy category, the previous pregnancy experience variable was determined by the number of older siblings (a sociodemographic factor). Furthermore, it is quite plausible that no prenatal care reflects more a social, cultural, or behavioral effect rather than a medical one. Thus,

TABLE 5. Excess/Deficit Cases of Special Education and Academic Problems Associated With Perinatal and Sociodemographic Factors

Factor Levels	Reference Category	Educational Outcome									
		PI	SI	PMH	TMH	EMH	LD	EH	SE Total	AP	Total
Perinatal factors											
Birth weight category	3000–4749 g										
450–749 g		18	14	9	18	16	8	0	83	25	108
750–999 g		37	17	10	9	32	11	5	121	31	152
1000–1499 g		80	16	20	14	49	23	3	205	101	306
1500–2499 g		128	35	52	66	154	56	33	524	814	1338
Total (450–2499 g)		263	82	91	107	251	98	41	933	971	1904
2500–2999 g		78	37	39	83	130	47	46	460	941	1401
4750–6049 g		2	0	3	−1	0	−1	4	7	−8	−1
Congenital anomaly	No										
Yes		134	16	36	52	62	13	3	316	172	488
Complications of labor	No										
Yes		163	−18	66	57	125	26	83	502	−1630	−1128
Sociodemographic factors											
Race/ethnicity	White										
Black		−279	−66	42	45	109	−148	12	−285	11 390	11 105
Other		−76	−16	6	−5	−102	−20	−107	−320	7582	7262
Total		−355	−82	48	40	7	−168	−95	−605	18 972	18 367
Gender	Female										
Male		177	97	29	170	478	665	1079	2695	11 465	14 160
Maternal age	20–35 y										
11–17 y		0	−2	3	−27	−27	−14	−8	−75	−453	−528
18–19 y		2	15	7	−20	−6	−47	34	−15	−279	−294
36 y or older		20	−4	2	38	22	10	7	95	392	487
Total		22	9	12	−9	−11	−51	33	5	−340	−335
Maternal marital status	Married										
Not married		−28	34	14	37	181	40	49	327	3142	3469
Maternal education	More than high school										
Less than high school		7	2	49	85	397	82	198	820	6919	7739
High school		−28	34	14	37	181	40	49	327	3142	3469
Total		−21	36	63	122	578	122	247	1147	10 061	11 208
Poverty	No										
Yes		152	25	−36	140	638	336	631	1886	11 904	13 790
Prenatal care	Yes										
No		5	2	7	5	37	16	35	107	6	113
Previous pregnancy experience	One or more previous successes										
Previous failed pregnancy		11	−4	−1	16	−73	−18	72	3	−609	−606
No previous pregnancy		−12	18	3	16	−31	−35	−1	−42	−2978	−3020
Total		−1	14	2	32	−104	−53	71	−39	−3587	−3626

throughout the discussion these variables will be grouped with the other sociodemographic factors.

Differences in the effects of perinatal and sociodemographic risk factors on educational outcomes have been observed previously in morbidity studies for groups of neonatal intensive care unit graduates.[37] It has been suggested that perinatal factors result in structural damage that leads to classification in the most severe SE categories, whereas placement in the least severe educational outcomes is more influenced by sociodemographic factors.[37,56] This hypothesis is supported in the present study, in which the delineation between the effects of perinatal and sociodemographic variables, measured by estimated odds ratios, is even more pronounced. The reference groups in this study are much larger and consist of much healthier children than in any neonatal intensive care unit sample. Hence, the independent effects of perinatal variables are much greater than when compared with reference groups of children at high perinatal risk at birth. This is especially clear from the effects of VLBW and ELBW, which confirm that LBW is an important predictor of placement in SE. Although many significant effects of sociodemographic factors for the severe SE types were observed, the magnitudes of the estimated odds ratios for PI, SI, PMH, and TMH for sociodemographic factors were much smaller than those of perinatal factors.

Interestingly, contrary to the impression from the raw percentages, maternal teen age was associated with decreased risk for TMH, LD, and AP and did not increase the odds of the remaining types of educational problems when controlling for the other risk factors. This finding suggests that children of younger mothers seem to experience more educational disabilities not as a result of the mother's young age but as a result of the confounding influence of factors, such as low maternal education, single marital status, and poverty, which are associated highly with teenage pregnancies. This finding clearly exemplifies the need to control for confounding factors through a multivariable analysis.

Children of mothers ≥36 years of age were found to be at a higher risk for PI, TMH, EMH, and AP. With increasing numbers of women giving birth at older ages, the impact of this factor is likely to increase.

The sample size in this study, although large, was not sufficient to test interactions. The interaction of VLBW with sociodemographic factors is especially important to assess. In future studies, we specifically would like to test such interaction effects on AP, mental retardation, and emotional handicaps, and we need to secure larger datasets for this purpose.

Impact

Because of the very low prevalence of certain perinatal risk factors compared with sociodemographic risk factors, it was important to study the relative impact of perinatal and sociodemographic variables. The odds ratios obtained from the main effects analysis reflect the magnitude of effects independent of prevalence, whereas the excess/deficit numbers, obtained from the impact analysis, depend both on the prevalence of risk factors and on the magnitude of the observed effects.

Of all perinatal factors, LBW had the greatest impact on SE. Although the likelihood of disability among ELBW children was high, the study showed that the excess attributable to birth weight <1000 g was only 2.6% of the total population of students with disabilities and only 1% of the population with AP. The impact of VLBW (<1500 g) on SE placement was comparable to the impact of birth weight between 1500 g and 2500 g and to the impact of congenital anomaly. It was also much smaller than the impact of most sociodemographic factors. Nevertheless, although the long-term impact of LBW and congenital anomaly on society is small, the impact on individual families is not.[57] Because prematurity is the primary cause for VLBW, prevention of extreme prematurity is an important goal because of its potential to decrease the need for SE services.

Of all sociodemographic variables, gender was the one with the greatest impact on SE. It had a >2 times greater impact than LBW and a >10 times greater impact than ELBW. This finding is consistent with other published studies[26,30,32,44,52] and justifies more research efforts to determine the causes of and remedies for excess numbers of poor outcomes among boys.

As expected, sociodemographic risk factors (especially poverty, race, maternal education, and gender) had a much greater impact on AP than perinatal predictors. The same was true, but to a lesser extent, for the mild SE types (EMH, LD, and EH). In contrast, birth weight and congenital anomaly had a greater impact on PI, SI, and PMH. Although perinatal variables have a great impact on the most severe, but least prevalent, SE types, the important finding of this study is that the majority of children in SE classes are not there because of adverse events in the perinatal period but because of adverse effects of their sociodemographic conditions.

CONCLUSIONS

Results are consistent with previous findings[37] that adverse perinatal conditions lead to severe educational disabilities, although less severe outcomes are influenced more by sociodemographic factors. Overall sociodemographic factors have a greater total impact on adverse educational outcomes than perinatal factors.

Sociodemographic factors have the greatest impact on placement in AP, the most numerous and the least severe educational placement category. In 1995, Sun et al[58] showed that the likelihood of transition to an SE classification dramatically increased for children placed in AP and that children placed in SE in kindergarten remained there throughout school. Thus, the impact of factors affecting AP placement would be magnified as children progress further in school. Of the sociodemographic effects with the greatest impact on AP, maternal education and poverty are perhaps the most readily modifiable. It is encouraging that the recently initiated Early Head Start and Even Start programs target these populations of children. The pediatric community should develop a systematic referral process that identifies at risk children who might most benefit from these programs.

Traditionally pediatricians are trained to recognize high risk medical conditions and may not have been made sufficiently aware of the more subtle effects associated with prolonged exposure to adverse sociodemographic conditions. This study underscored the long-term negative consequences of these risk factors on children's educational performance. Noting the presence of such risk factors during routine health checkups may serve as a first step toward identifying and referring families to early intervention programs that combine medical, social, and educational services.

Appendix

The impact of each of the risk factors was assessed via excess/deficit numbers, which were calculated from the following formula:

$$E_{jl} = \sum_{c} n_{cl}(P_{jcl} - P_{jcr}),$$

where n_{cl} is the number of children in the l^{th} level of the risk factor under consideration for a fixed combination c of levels of the other factors, P_{jcl} and P_{jcr} are the model based estimates of the probabilities that the j^{th} outcome occurs given the l^{th} level and the r^{th} (reference) level of the risk factor, respectively, and the c^{th} combination of levels of the other factors. The level of each factor perceived a priori to be the lowest risk level was taken as the reference category. In cases in which this turned out to be a misperception, E_{jl} would be negative for at least 1 l and should be interpreted as a deficit and not an excess.

Excess/deficit numbers are the numerators in the formulae for standardized attributable risk with the a priori higher risk population as the standard population. To obtain standardized attributable risk, the excess/deficit numbers (Table 5) must be divided by the sample size for the predictor level of interest (Table 3). For example, the standardized attributable risk for LD attributable to birth weight 450 to 749 g is 8/9 = .89 or 89%.

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