

## ORIGINAL ARTICLE

# Birth Weight and Special Educational Needs

Results of a Population-Based Study in Berlin

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## SUMMARY

**Background:** Preterm infants are at higher risk for developmental problems. The aim of this study is to quantify the relation between birth weight and special educational needs.

**Methods:** We analyzed data from the pre-school examinations of 134 313 children in Berlin aged 5 to 6 who were examined between 2007 and 2011.

**Results:** Special educational needs were diagnosed in 8058 children (6.0%), 4943 (61%) of whom had weighed 3000 g or more at birth. The percentage of children with special educational needs rose steadily with decreasing birth weight (2250–2499 g, 9.2%; 1250–1499 g, 21.1%; less than 750 g, 35.6%). Logistic regression analysis yielded odds ratios and 99% confidence intervals for special educational needs that ranged from 1.32 [1.17–1.47] for birth weight 2750–2999 g to 12.83 [7.48–22.03] for birth weight less than 750 g. Further risk factors were male sex (1.88 [1.75–2.03]), low social status (5.96 [5.21–6.82]), an immigrant background associated with poor German language skills in the family (1.63 [1.43–1.86]), and being raised by a single parent (1.21 [1.12–1.31]). On the other hand, nursery school and/or kindergarten enrollment for at least two years before entering school (0.82 [0.73–0.91]) and an immigrant background with good German skills in the family (0.39 [0.34–0.45]) were associated with lower rates of special educational needs.

**Conclusion:** The risk of special educational needs increases already with moderately decreased birth weight. The most important factor other than birth weight is the family's social status. Although children of very low birth weight have a much higher rate of special educational needs than other children, they still make up only a small percentage of all children with special educational needs.

### ► Cite this as:

Bettge S, Oberwöhrmann S, Brockstedt M, Bührer C: Birth weight and special educational needs—results of a population-based study in Berlin. *Dtsch Arztebl Int* 2014; 111: 337–44. DOI: 10.3238/arztebl.2014.0337

The increased risk for developmental abnormalities in very preterm infants, which at the latest becomes of daily importance when they start school, is well-documented in a number of cohort studies (1–5). These extend into adult life, especially in boys: male preterm babies with an extremely low birth weight of less than 1000g require on average an additional year of school before qualifying for a job or higher education, and their income as adults is 25% below controls with a normal birth weight (6). Even children who are born just a few weeks too early also are at increased risk of difficulties in school (7–12). Cohort studies across the entire spectrum of birth weights are time-consuming and do not contain sufficient numbers of infants with extremely low birth weights. Another problem is that socio-economic status correlates directly with both low birth weight (13, 14) and difficulties in school (15–18). Thus population-based cross-sectional studies are more suitable for analyzing the relationship between birth weight and need for special education.

The data from pre-school examinations (Einschulungsuntersuchungen) in Berlin capture an entire birth cohort at the age of five to six years. In this paper, the data from the years 2007 through 2011 are evaluated to quantify the relationship between special educational needs and low birth weight, to assess the impact of social factors and to calculate the population-attributable risk for special educational needs associated with low or very low birth weight.

## Methods

### Studies

The examinations required by the Berlin School Law (§55a) are carried out during the winter period before a child is scheduled to start school by the Child and Adolescent Health Services in the 12 districts of Berlin. The goal of the evaluation is to identify children who will benefit from special educational help as well as to initiate, if necessary, further diagnostic and therapeutic measures. The child's level of development is determined with a standardized instrument (S-ENS) (19). On the basis of the test results, history, current evaluation and in some cases additional diagnostic measures, special education measures are recommended if a child shows deficits in one or more of six categories: vision, hearing, physical and motor development, language development, autism, mental development, learning, and social-emotional development.

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**TABLE 1**

**Characteristics of children with or without special educational needs, as assessed by the pre-school examinations (Einschulungsuntersuchungen) in Berlin 2007–2011 (n = 134 313)**

Variable	No special educational needs (n = 126 137)		Special educational needs (n = 8058)		Percentage of children with special educational needs	p
	n	%	n	%	%	
<b>Birth weight</b>						
<750g	94	0.1	52	0.6	35.6	<0.001
750–999g	196	0.2	78	1.0	28.5	
1000–1249g	265	0.2	55	0.7	17.2	
1250–1499g	336	0.3	90	1.1	21.1	
1500–1749g	478	0.4	90	1.1	15.8	
1750–1999g	884	0.7	142	1.8	13.8	
2000–2249g	1654	1.3	191	2.4	10.4	
2250–2499g	3171	2.5	323	4.0	9.2	
2500–2749g	6308	5.0	534	6.6	7.8	
2750–2999g	11 829	9.4	883	11.0	6.9	
3000–4500g	89 934	71.3	4850	60.2	5.1	
>4500g	1598	1.3	93	1.2	5.5	
No information	9390	7.4	677	8.4	6.7	
<b>Sex</b>						
Female	6671	48.9	2755	34.2	4.3	<0.001
Male	64 466	51.1	5303	65.8	7.6	
No information	0	0.0	0	0.0		
<b>Social status group</b>						
Lower	23 653	18.8	3026	37.6	11.3	<0.001
Middle	57 390	45.5	3071	38.1	5.1	
Upper	31 808	25.2	730	9.1	2.2	
No information	13 286	10.5	1231	15.3	8.5	
<b>Immigration background</b>						
Yes	43 645	34.6	2879	35.7	6.2	0.022
No	82 124	65.1	5126	63.6	5.9	
No information	368	0.3	53	0.7	12.6	
<b>German skills</b>						
Mother tongue	82 124	65.1	5126	63.6	5.9	<0.001
Immigrant family – child and parent have good skills	21 847	17.3	537	6.7	2.4	
– child or parent have poor skills	11 123	8.8	801	9.9	6.7	
– child and parent have poor skills	9569	7.6	1286	16.0	11.8	
No information	1474	1.2	308	3.8	17.3	
<b>Single parent</b>						
Yes	31 725	25.2	2789	34.6	8.1	<0.001
No	90 304	71.6	4997	62.0	5.2	
No information	4108	3.3	272	3.4	6.2	

Variable	No special educational needs (n = 126 137)		Special educational needs (n = 8058)		Percentage of children with special educational needs	p
	n	%	n	%	%	
<b>Nursery school/kindergarten</b>						
≤2 years	15 523	12.3	1564	19.4	9.2	<0.001
>2 years	108 968	86.4	6263	77.7	5.4	
No information	1646	1.3	231	2.9	12.3	
<b>Child has own television</b>						
Yes	16371	13.0	1377	17.1	7.8	<0.001
No	100 858	80.0	6022	74.7	5.6	
No information	8908	7.1	659	8.2	6.9	

The birth weight is obtained from the health records of the child or mother; in order to circumvent recall bias, undocumented statements by the parents are not considered.

The social history is acquired using a standardized parental questionnaire. Based on voluntary statements by both parents regarding education and job training, as well as employment status, a social status index is calculated and the child placed in one of three groups. In addition, the child is categorized as having an “immigration background” if one of these three conditions is met:

- The child is not a German citizen
- Both parents were born outside of Germany or did not have German citizenship at birth
- One parent was born outside Germany or did not have German citizenship at birth and the family language is not German.

In addition, the German skills of the child and the accompanying parent (familial German skills) are assessed on the basis of vocabulary and grammar and placed into one of four categories (none/scattered words/fluent with numerous mistakes/good to very good). Finally, the family status (does the child live with both parents, regardless of their marital status), number of months of nursery school/kindergarten, and whether a child has his or her own television set are ascertained. Detailed information regarding the pre-school examinations can be found in the annual report of the Berlin Senate Department for Health and Social Services (Senatsverwaltung für Gesundheit und Soziales) (20).

**Data base**

The pre-school examination data are collected locally, aggregated and forwarded yearly to the Senate Department for Health and Social Services. The analysis in this paper is based on the pooled data from 134 313 children evaluated between 2007 and 2011.

In addition, the number of children born in Berlin between 2002 and 2006 who died during the first year of life, stratified by year of birth and birth weight, was

provided by the Statistical Office for Berlin-Brandenburg (Amt für Statistik Berlin-Brandenburg).

The study was approved by the ethics commission of the Charité, Berlin (#EA2/132/13).

**Statistical analysis**

The groups of children with and without special educational needs were compared on the basis of birth weight as well as other personal and familial features using the chi-square test. The effect of these variables was estimated with univariate logistic regression analysis using special educational needs as a dependent variable. Since the birth weight showed a non-linear relationship to the dependent variable, it was considered a categorical variable in the regression analysis. Ten weight groups were formed from under 750 g to over 3000 g—in segments of 250 g—and compared to the two larger groups of 3000 to 4500 g and over 4500 g. Since the immigration background and German language skills of the child and parents showed multicollinearity, they were combined. The length of time in nursery school/kindergarten was entered as a categorical variable—either „longer than two years“ or „two years or less“.

The influence of birth weight (divided into 12 groups) on special educational needs was determined and controlled for other relevant variables using multiple logistic regression analysis. In addition, the district of residence was controlled for, as there are differences in the percentage of children with special educational needs between the 12 Berlin districts that are not completely explained by differences in the social structure. The variables district, sex, social status and the combined marker immigration background with German language skill were a block entry. Stepwise forward entry was employed for living with a single parent, duration of nursery school/kindergarten and own television set, using the Wald test as a selection criterion.

The goodness of fit of the regression model was measured with the Hosmer–Lemeshow test; Nagelkerke R<sup>2</sup> was used as a measure of variance explanation.

**TABLE 2**

**Results of the multivariate regression analysis for special educational needs**

Variable	OR	(99% CI)	p
<b>Birth weight</b>			
<750g	12.83	(7.48–22.03)	<0.001
750–999g	7.08	(4.60–10.89)	<0.001
1000–1249g	3.93	(2.48–6.22)	<0.001
1250–1499g	4.63	(3.22–6.64)	<0.001
1500–1749g	3.66	(2.60–5.16)	<0.001
1750–1999g	2.48	(1.85–3.33)	<0.001
2000–2249g	1.76	(1.37–2.25)	<0.001
2250–2499g	1.83	(1.53–2.19)	<0.001
2500–2749g	1.43	(1.24–1.65)	<0.001
2750–2999g	1.32	(1.17–1.47)	<0.001
3000–4500g (reference)	1.00		
>4500g	1.10	(0.81–1.50)	0.410
<b>Sex</b>			
Female (reference)	1.00		
Male	1.88	(1.75–2.03)	<0.001
<b>Social status group</b>			
Lower	5.96	(5.21–6.82)	<0.001
Middle	2.36	(2.09–2.66)	<0.001
Upper (reference)	1.00		
<b>Immigration background and German skills</b>			
German (reference)	1.00		
Immigrant family: – child and parent have good German skills	0.39	(0.34–0.45)	<0.001
– child or parent has poor German skills	0.96	(0.84–1.10)	0.475
– child and parent have poor German skills	1.63	(1.43–1.86)	<0.001
<b>Single parent</b>			
Yes	1.21	(1.12–1.31)	<0.001
No (reference)	1.00		
<b>Nursery school/kindergarten</b>			
≤ 2 years (reference)	1.00		
>2 years	0.82	(0.73–0.91)	<0.001

OR, Odds Ratio; 99% CI, 99% confidence interval

The level of significance was set at  $p < 0.001$  and the relationship between independent and dependent variables was determined as an odds ratio (OR) with a 99% confidence interval (CI). All statistical analyses were performed with SPSS (IBM), version 19.0.

**Results**

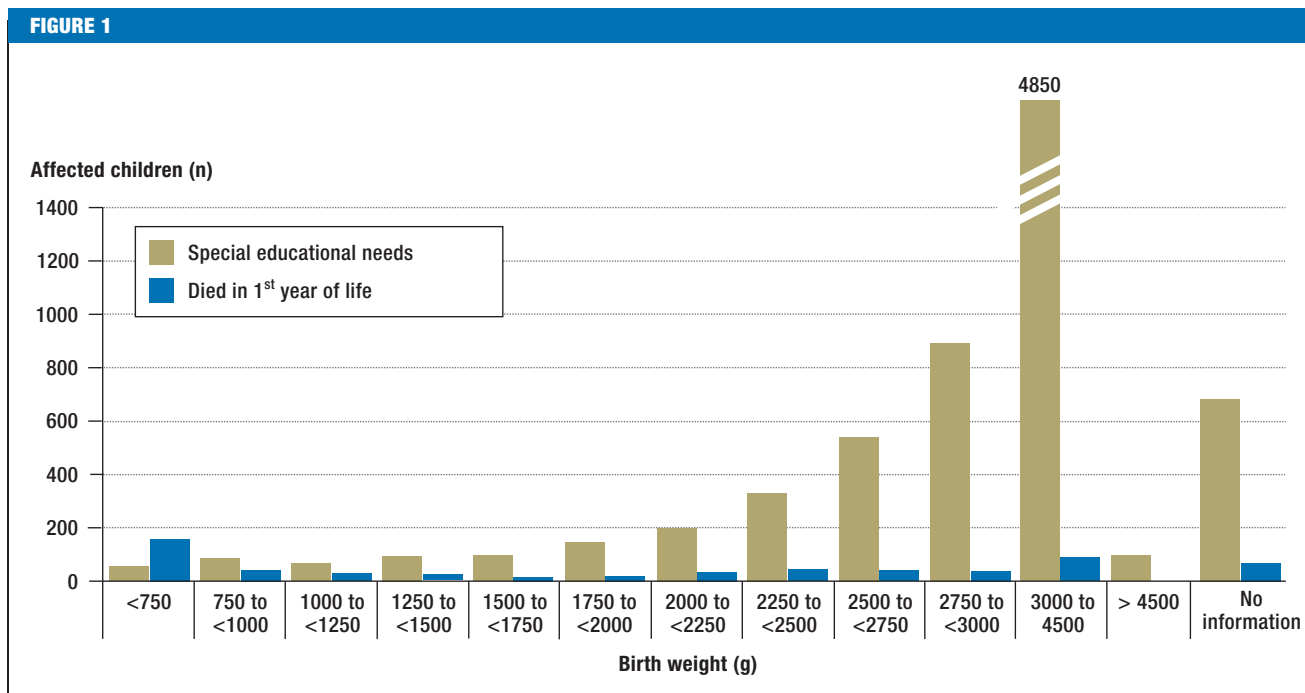
Between 2007 and 2011 a total of 134 313 children were evaluated; for only 118 children (0.1%), data on special educational needs were unavailable. Special educational needs were diagnosed in 8058 children (6.0%). Although there was some yearly variation, the main factors were language problems (55–74% of children with special education needs), cognitive (19–30%) and motor development (17–26%); difficulties with vision (1.5–3.7%), hearing (3.1–4.7%) or autism (4.6–5.6%) played a lesser role.

The median age at time of evaluation was higher in children with special educational needs (70 months) than in those without (68 months), because of the much higher rate of special educational needs in children who had been placed back a year (36.2%) versus those starting school on schedule (4.5%).

When separating the children into three age groups (<5½ years, 5½ to <6½ years, ≥ 6½ years), the differences between the age group <5½ years and the group 5½ to <6½ years (reference group) in both bivariate and multivariate analysis were not significant, while the age group ≥ 6½ years showed an OR of 9.61 (bivariate analysis, pairwise deletion of missing values), 11.20 (bivariate analysis, listwise deletion of missing values) and 8.36 (multivariate analysis). In the multivariate analysis, the ORs for low birth weight dropped when age was added as variable (<750 g: from 12.83 to 9.37; 750–999 g: from 7.08 to 5.65).

Documented birth weights were available for 92.5% of the children. A total of 8106 children had a birth weight under 2500 g (6.0%) including 1169 (0.95%) under 1500 g and 421 (0.3%) under 1000 g. The rate of missing data depended markedly on the variable ranging from 0% for sex to 10.8% for social status (Table 1). Voluntary answers in the parental questionnaire caused the highest percentage of missing items. A total of 105 388 children (78.5%) had complete data sets and could be included in the multivariate analysis.

Children with a normal birth weight (3000 to 4500 g) had the lowest rate of special educational needs (5.1%). Below a birth weight of 3000 g, the rate of special educational needs increased directly as the birth weight decreased. The only exception was the group with birth weights from 1000 g to 1249 g, who had a lower rate of special educational needs than those weighing 1250 g to 1499 g (17.2% versus 21.1%,  $p = 0.179$ ). Children with a birth weight under 750 g had an almost seven-fold higher rate of special educational needs than those with a normal birth weight (3000 to 4500 g). Children with a birth weight over 4500 g had a slightly higher rate of special educational needs than those in the normal group (5.5% versus 5.1%,  $p = 0.479$ ).



Number of children 5 to 6 years of age examined between 2007 and 2011 with special educational needs and those children born between 2002 and 2006 who died in the first year of life arranged according to birth weight

Even though the total group was almost equally divided between boys and girls, the boys accounted for almost 2/3 of the children with special educational needs. In addition, children from a family with low social status, with a single parent or with their own television also had an increased rate of special educational needs. The rates of special educational needs did not differ between immigrant and native German children. When the familial German skills were taken into account, immigrant children whose families lacked German skills had a higher rate of special educational needs, while those from families with good German skills had a much lower rate. Furthermore, children who had attended nursery school/kindergarten for more than 2 years had a lower rate than those with less exposure.

In univariate logistic regression analyses, the influence of different variables on the rate of special educational needs was estimated. Because of the large number of cases where individual data was missing (21.5%) the analyses were carried out both with pairwise and listwise deletion of missing values. Similar odds ratios, however, were obtained by either method (*eTable*).

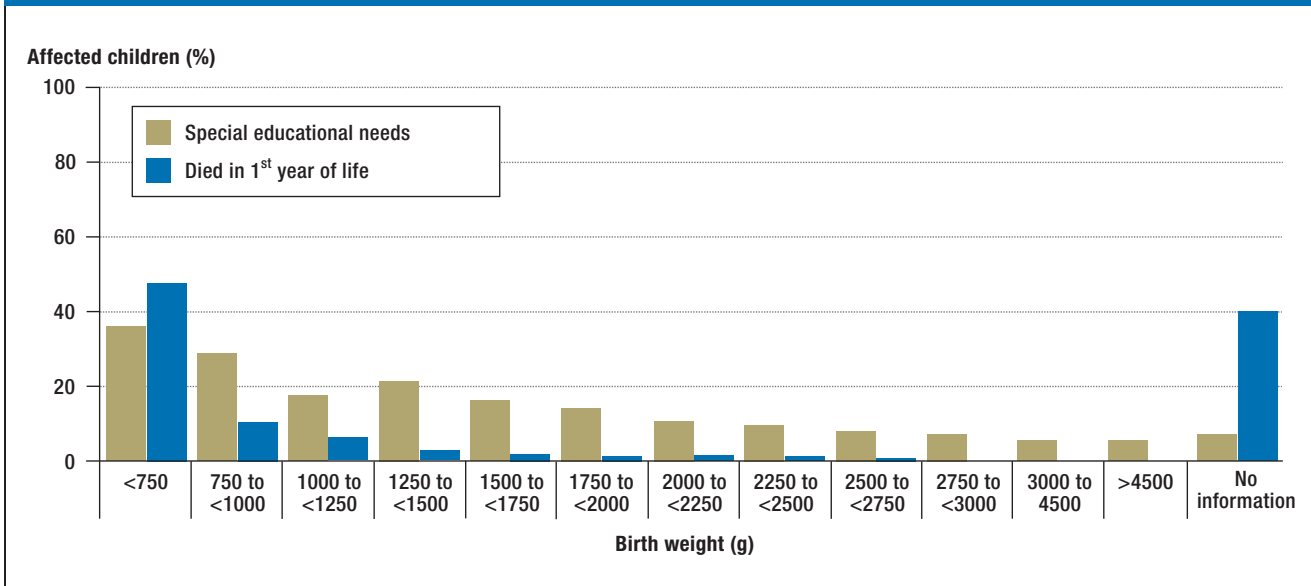
The multivariate regression analysis included in addition to birth weight (in 12 groups) and district, all the variables which had shown in the univariate analysis a significant association with special educational needs (*Table 2*). Except for the variable “own television set”, all the others remained significantly associated with special educational needs in the multivariate analysis. Thus, the variable “own television set” was

dropped in the optimized model, accounting for 11.6% of the total variance.

An extremely low birth weight had the strongest association with special educational needs of all the variables; the OR was 12.83 for children with a birth weight <750 and 7.08 for children with a birth weight 750–999 g. Children from families in a lower social status group had an almost 6-fold increased risk of special educational needs as compared to those from a family in an upper social status group. The OR in univariate and multivariate analysis were remarkably similar, although the associations between special educational needs and nursery school/kindergarten attendance, single parent, and immigration background plus German skills were somewhat less prominent with the multivariate approach.

The rates of special educational needs among 5- to 6-year-olds in the time period 2007 to 2011 were compared with the rates of mortality during the first year of life for children born between 2002 and 2006, as provided by the state statistical office. The rates of special educational needs declined steadily with an increasing birth weight; in contrast, the high mortality in preterm children with a birth weight under 750 g (47.3%) dropped dramatically to 10.2%, 6.3% and 2.6% for those with weights of 750 to 999 g, 1000 to 1249 g and 1250 to 1499 g, respectively (*Figure 1*). A different pattern emerged when looking at absolute numbers. While the vast majority of deaths during the first year involved preterm infants with a birth weight under 1500g (43.5%), the majority of children with special

FIGURE 2



Percentage of children 5 to 6 years of age with special educational needs examined between 2007 and 2011 and those children born between 2002 and 2006 who died in first year of life in comparison to the total number of children with special educational needs, or children who died in the first year of life

educational needs came from the group with normal birth weight (Figure 2). Only 275 (3.4%) of the children requiring special education were preterm babies with a birth weight under 1500 g; in contrast, 4850 (60.2%) had a birth weight of 3000 to 4500 g.

**Discussion**

Our data document an increased rate of special educational needs even in children who have a slightly reduced birth weight below 3000 g, with rates increasing as the birth weight further drops. The total rate of special educational needs established in the Berlin preschool examinations of 6.0% is somewhat higher than the 4.9% in the only comparable study, where teachers in Scottish schools determined the need for children of various ages in their classes (8). The increase in rates of special educational needs with decreasing birth weight or decreasing gestational age was similar in both studies. In Berlin, 31% of the children with a birth weight under 1000 g needed special education, while in Scotland 29.5% of those with a gestational age of 24 to 27 weeks required help.

**Limitations**

There are some limitations to our analysis, mainly because it is based on routinely collected data. Since we had no information on gestational age, we cannot distinguish between preterm birth and small for gestational age infants. We had no information on the severity of the disability necessitating special education. The evaluating physicians were not blinded with regard to birth weight or other data. The information on the family structure, social status and language skills are confined to the time of exami-

nation—in the formative years before there could have been a completely different picture. The demographic features of a large city with a high percentage of immigrants and many families in precarious social situations makes a comparison with more rural areas difficult.

**Strengths of study**

The study has a number of strengths which counterbalance the limitations. All children were studied with the same tools in a standardized fashion before starting school. Since the examination is legally required, all children were studied, eliminating the selection bias typical of cohort studies. In addition, the study addressed all birth weights and thus made it possible to study children with only marginally decreased or elevated birth weights.

**Conclusion**

The results support the known risk factors of male sex and lower social status (21, 22), while more than two years in nursery school/kindergarten was associated with a reduced risk. A study from the USA showed that quality of child care has a positive effect on the cognitive and language skills before starting school (23). This positive effect increases as the social situation of the child becomes more difficult (24), but the influence of the parents is greater than that of the child care center (25). Attending nursery school/kindergarten can reduce the amount of time a child spends watching television, a factor that shows a negative association with school performance (26, 27).

In our study, the influence of television was only seen in the univariate analysis. The effects of attending nursery school/kindergarten, immigration background,

German skills and single-parent household (28, 29) were all less significant in the multivariate analysis, presumably because all vary in close alignment with the social status.

In addition, the data show that an immigration background per se does not influence the rate of special educational needs; instead it only plays a role when coupled with poor German skills in the family. Limited languages skills make it difficult for families to take advantage of health screening and other support for children (30).

The Federal Joint Committee (Gemeinsamer Bundesausschuss) mandates a standardized developmental-neurological evaluation at two years of age for all children with a birth weight under 1500 g. However, the prognostic validity of an evaluation of such young children is limited (31, 32). Except for severe neurological problems, the disabilities that play a role in learning, social integration and later work experience can first be identified in the later pre-school age (33).

The increased risk of special educational needs for extremely low birth weight children supports the demands of medical speciality groups for a standardized evaluation of children with a birth weight under 1000 g at five years. Nonetheless, restricting the evaluation to infants below 1000 g birth weight would miss over 95% of the children who are judged to have special educational needs.

This underscores the importance of evaluating all pre-school children. If it ever becomes possible to overcome data protection rules and combine perinatal and neonatal information with the already available information, this would provide additional important information about the risk factors for special educational needs.

#### KEY MESSAGES

- In pre-school examinations in Berlin, special educational needs were diagnosed in around 6% of all children.
- The percentage of children with special educational needs rose from 5.1% for children of normal birth weight (3000 to 4500 g) continuously to 36% for children with a birth weight under 750 g. The effect of the birth weight was already measurable with weights just below 3000 g.
- Other important risk factors were lower family social status, male sex and (in children with an immigration background) poor German skills in the child and parent.
- Children who spent more than two years in nursery school/kindergarten required less special education, as did children from an immigrant background with good familial German skills.
- Considering the entire population, children with a low birth weight account for only a small proportion of all those with special educational needs.

#### Acknowledgment

The authors thank their colleagues in the Child and Adolescent Health Services in Berlin for the close collaboration over many years in collecting, validating, and further refining the pre-school examination data.

#### Conflict of interest statement

Prof. Bührer has received travel costs and honoraria for expert opinions, lectures, and advisory work from Chiesi, Danone, MCI and Nestlé Nutrition Institute.

The other authors declare that no conflict of interest exists.

Manuscript received on 26 November 2013, revised version accepted on 11 March 2014.

Translated from the original German by Walter Burgdorf, MD

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eTABLE

**Comparison of univariate and multivariate regression analysis of risk factors for special educational needs**

Variable	Univariate analysis— exclusion of missing data:						Multivariate analysis		
	pair-wise			list-wise			controlled for city district		
	OR	(99% CI)	p	OR	(99% CI)	p	OR	(99% CI)	p
<b>Birth weight</b>									
<750 g	10.26	(6.56–16.04)	<0.001	10.90	(6.64–17.87)	<0.001	12.83	(7.48–22.03)	<0.001
750–999 g	7.38	(5.22–10.44)	<0.001	6.87	(4.59–10.29)	<0.001	7.08	(4.60–10.89)	<0.001
1000–1249 g	3.85	(2.62–5.65)	<0.001	4.10	(2.66–6.33)	<0.001	3.93	(2.48–6.22)	<0.001
1250–1499 g	4.97	(3.65–6.76)	<0.001	5.08	(3.60–7.17)	<0.001	4.63	(3.22–6.64)	<0.001
1500–1749 g	3.49	(2.59–4.71)	<0.001	3.76	(2.71–5.23)	<0.001	3.66	(2.60–5.16)	<0.001
1750–1999 g	2.98	(2.35–3.77)	<0.001	2.61	(1.97–3.46)	<0.001	2.48	(1.85–3.33)	<0.001
2000–2249 g	2.14	(1.75–2.62)	<0.001	1.89	(1.49–2.41)	<0.001	1.76	(1.37–2.25)	<0.001
2250–2499 g	1.89	(1.62–2.21)	<0.001	1.93	(1.63–2.30)	<0.001	1.83	(1.53–2.19)	<0.001
2500–2749 g	1.57	(1.39–1.77)	<0.001	1.57	(1.36–1.80)	<0.001	1.43	(1.24–1.65)	<0.001
2750–2999 g	1.38	(1.26–1.53)	<0.001	1.39	(1.25–1.55)	<0.001	1.32	(1.17–1.47)	<0.001
3000–4500 g (reference)	1.00			1.00			1.00		
>4500 g	1.08	(0.82–1.42)	0.479	1.15	(0.85–1.55)	0.246	1.10	(0.81–1.50)	0.410
<b>Sex</b>									
Female (reference)	1.00			1.00			1.00		
Male	1.84	(1.73–1.96)	<0.001	1.82	(1.69–1.96)	<0.001	1.88	(1.75–2.03)	<0.001
<b>Social status group</b>									
Lower	5.57	(5.00–6.21)	<0.001	5.80	(5.16–6.52)	<0.001	5.96	(5.21–6.82)	<0.001
Middle	2.33	(2.09–2.60)	<0.001	2.36	(2.10–2.65)	<0.001	2.36	(2.09–2.66)	<0.001
Upper (reference)	1.00			1.00			1.00		
<b>Immigration background and German skills</b>									
German (reference)	1.00			1.00			1.00		
Immigrant family: child and parent have good German skills	0.39	(0.35–0.44)	<0.001	0.42	(0.37–0.48)	<0.001	0.39	(0.34–0.45)	<0.001
Child or parent has poor German skills	1.15	(1.04–1.28)	<0.001	1.38	(1.23–1.55)	<0.001	0.96	(0.84–1.10)	0.475
Child and parent had poor German skills	2.15	(1.98–2.34)	<0.001	2.60	(2.34–2.89)	<0.001	1.63	(1.43–1.86)	<0.001
<b>Single parent</b>									
Yes	1.59	(1.49–1.69)	<0.001	1.66	(1.54–1.79)	<0.001	1.21	(1.12–1.31)	<0.001
No (reference)	1.00			1.00			1.00		
<b>Nursery school/kindergarten</b>									
≤ 2 years (reference)	1.00			1.00			1.00		
>2 years	0.57	(0.53–0.62)	<0.001	0.57	(0.52–0.62)	<0.001	0.82	(0.73–0.91)	<0.001
<b>Child has own television</b>									
Yes	1.41	(1.30–1.53)	<0.001	1.53	(1.39–1.67)	<0.001	Not included in multivariate model		
No (reference)	1.00			1.00					

99% CI, 99% confidence interval; OR, odds ratio