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Authors: Mariane Sentenac[1], Samantha Johnson[2], Marie-Laure Charkaluk[1 3], Anna-Veera Seppänen[1], Ulrika Aden[4], Marina Cuttini[5], Rolf Maier[6], Mairi Männamaa[7], Jennifer Zeitlin[1], and the EPICE group*

Author affiliations

[1] Université de Paris, CRESS, INSERM, INRA, F-75004 Paris, France.

[2] Department of Health Sciences, University of Leicester, Leicester, Leicestershire, UK.

[3] Université Catholique de Lille, Lille, France; Service de néonatologie, Hôpital Saint Vincent de Paul, Groupement des Hôpitaux de l'Institut Catholique Lillois/Faculté de Médecine et Maïeutique, Lille, France.

[4] Department of Women's and Children's Health, Karolinska Institutet, Stockholm, Sweden

[5] Clinical Care and Management Innovation Research Area, Bambino Gesu Pediatric Hospital, Roma, Lazio, Italy.

[6] Children's Hospital, University Hospital, Philipps-Universitat Marburg, Marburg, Germany

[7] Department of Pediatrics, University of Tartu, Children's Clinic of Tartu University Hospital, Tartu, Estonia.

EPICE Research group: BELGIUM: Flanders (E Martens, G Martens, P Van Reempts); DENMARK: Eastern Region (K Boerch, A Hasselager, LD Huusom, O Pryds, T Weber); ESTONIA (L Toome, H Varendi); FRANCE: Burgundy, Ile-de France and Northern Region (PY Ancel, B Blondel, A Burguet, PH Jarreau, P Truffert); GERMANY: Hesse (RF Maier, B Misselwitz, S Schmidt), Saarland (L Gortner); ITALY: Emilia Romagna (D Baronciani, G Gargano), Lazio (R Agostino, I Croci, F Franco), Marche (V Carnielli), M Cuttini, , D DiLallo; ; NETHERLANDS: Eastern & Central (C Koopman-Esseboom, A van Heijst, J Nijman); POLAND: Wielkopolska (J Gadzinowski, J Mazela); PORTUGAL: Lisbon and Tagus Valley (LM Graça, MC Machado), Northern region (Carina Rodrigues, T Rodrigues), H Barros; SWEDEN: Stockholm (AK Bonamy, M Norman, E Wilson); UK: East Midlands and Yorkshire and Humber (E Boyle, ES Draper, BN Manktelow), Northern Region (AC Fenton, DWA Milligan); INSERM, Paris (J Zeitlin, M Bonet, A Piedvache).

Contact information for corresponding author:

Mariane Sentenac

INSERM 1153,

53 Avenue de l'Observatoire, 75014 Paris

Email address : mariane.sentenac@inserm.fr

Telephone number: 33 1 42 34 55 77

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ABSTRACT

Background

Socioeconomic factors influence language development in the general population, but the association remains poorly documented in very preterm (VPT) children. We aimed to assess the impact of maternal education on language development in VPT children, and effect modification by degree of perinatal risk.

Methods

Data were from the European EPICE population-based cohort of children born <32 weeks' gestational age (GA) in 2011/2012. Regions from six countries (Estonia, France, Germany, Italy, Sweden and UK) used a validated short form MacArthur Developmental Communicative Inventories Checklist to assess language at 2-years corrected age (CA). Perinatal variables were collected from clinical records. Developmental language delay (DLD) was defined as a) not combining words; and b) expressive vocabulary <10th percentile of norms for CA and sex. Perinatal risk (low, moderate, high) was determined using GA, small for gestational age and severe neonatal morbidities. We used multivariable modified Poisson models to estimate adjusted risk ratios (aRR) of DLD by maternal education with inverse weighting to account for non-response bias.

Results

Of 2741 VPT children, 24.6% were not combining words and 39.7% had a low expressive vocabulary. Low maternal education increased risks of DLD. Effects were attenuated in the highest perinatal risk group: a) not combining words, aRR=1.88 (95% confidence interval 1.26-2.80) for low perinatal risk versus 1.36 (1.10-1.67) for high perinatal risk; and b) low expressive vocabulary, aRR=1.44 (1.06-1.95) and 1.11 (0.97-1.27) respectively.

Conclusion

Low maternal education affects DLD for all VPT children, although the association appears attenuated among those with highest perinatal risk.

What is already known on this subject?

- Very preterm birth is associated with adverse neurodevelopmental outcomes in childhood, including poor language functioning
- Early language development is influenced by the family social environment, but research has been conducted principally in the general population.

What this study adds?

- In very preterm children, higher perinatal risk and lower maternal educational levels are both associated with DLD at 2 years corrected age, although the effect of maternal education may be stronger for children with lower perinatal risk.
- Very preterm children with mothers who have a low educational level have the highest rates of DLD, illustrating the need to incorporate clinical and social factors to identify children in need of services.

BACKGROUND

Very preterm (VPT) births (< 32 weeks' gestation) represent about 1% of all births or an estimated 50,000 of the 5 million births per year in Europe.[1] Considerable medical advances over recent decades in the fields of obstetrics and neonatology have improved the survival of these children and the number of survivors increases each year. There is a large body of literature investigating the risks of short and long term developmental difficulties for children born VPT, including sensory impairment, neurodevelopmental delays and impaired cognitive, behavioral, motor, and emotional functioning.[2 3] Such difficulties extend into adulthood and affect long-term health, occupational attainment, family formation and wealth.[4] In addition, there are multiple studies showing that growing up in a socially disadvantaged environment impacts the child's neurodevelopment in various domains.[5] As mothers with lower socioeconomic status have a higher incidence of VPT birth, a greater vulnerability to its consequences may exacerbate the social costs of VPT birth and perpetuate the transmission of health inequalities across generations.

Language is a pivotal function, important for developing social relationships and achieving academic success. Some authors have hypothesized that language exposure in early infancy, in terms of vocabulary quantity and quality, is particularly important because it mediates the relationship between the family socioeconomic environment and neurodevelopment in childhood.[6] There is evidence that language functioning is reduced in school-aged children born VPT compared to term controls.[7-9] Children born VPT experience more delays in language development in early childhood than children born at term, assessed through their lexicon size and word combination around 2 years of age.[10 11] While there is a solid evidence linking language development to the social environment in the general population, the relationship between the family's socioeconomic background and language development remains poorly documented in the VPT population as studies have been conducted on small and selective samples (i.e. monolingual singletons without severe conditions recruited from a single center study).[11-13]

To identify children at risk of delays in language development who would benefit from preventive interventions, more knowledge is needed about the association of social factors with language development among VPT children and whether social factors have a similar impact when well-known clinical risk factors predicting language delay,[14] such as lower gestational age and severe neonatal morbidities, are present. Our objective was to investigate the association of the family's socioeconomic background, as measured by maternal educational achievement, with expressive language development at 2 years of corrected age (CA) by degree of perinatal risk, in children born VPT in 13 regions of 6 European countries.

METHODS

Study design and population

We used data from the Effective Perinatal Intensive Care in Europe (EPICE) cohort, a population-based, prospective cohort study of children born from 22+0 weeks to 31+6 weeks of gestation in 2011/2012 in 19 regions in 11 European countries.[15] Data were abstracted from obstetrical and neonatal records using a common protocol based on standardised definitions and the children were followed up at 2 years of CA using a parent-report questionnaire.

For this study, we included regions from the 6 countries that had validated instruments in national languages of the short-form MacArthur Developmental Communicative Inventories Checklist (MCDI-SF): Estonia (entire country); France (Burgundy, Ile-de-France and the Northern regions), Germany (Hesse and Saarland); Italy (Emilia-Romagna, Lazio and Marche regions), Sweden (Stockholm County) and the UK (East Midlands, Northern and Yorkshire and the Humber regions). Only children for whom the national language was the main language spoken by the child or at home, either alone or in association with a second language were included in our analysis. Children with difficulties hearing with aids were also excluded. Out of the 5363 live births included in the cohort in these 6 countries, 4638 (87%) were alive at 2 years CA and 3101 (67%) participated in the follow up study (see **Figure S1** for the complete flowchart). Our final study sample consisted of 2741 children.

Ethical approvals were obtained in each country as required by national legislation. The European study was also approved by the French Advisory Committee on Use of Health Data in Medical Research and the French National Commission for Data Protection and Liberties. Consent to participate was obtained from all mothers in the follow-up study.

Measures

Developmental language delay

Information on language development was collected from the parental questionnaire at 2 years CA. Two dichotomous indicators of developmental language delay (DLD), absence of combining words and low expressive vocabulary,[16] were derived from the adapted versions in national languages of the short-form MCDI-SF. The first indicator of DLD ('not combining words') was defined according to the answer to a single item ("Has your child started to put together words yet, such as "Daddy gone" or "Doggie bite"? with responses coded as: not yet combining words vs often/sometimes). The second indicator ('low expressive vocabulary') was derived from the assessment of vocabulary production (100-word checklist) providing a sub-score ranging from 0-100 based on the number of words the child could say. Using normative data by age and sex,[17] children were classified as having DLD when their vocabulary score was under the 10th percentile (corresponding to 26 and 39 words for boys and girls, respectively, at 24 months).[16]

Maternal educational level

The highest level of education achieved by the mother was collected at the 2 year follow up. The International Standard Classification of Education[18] was used, and respondents were then classified into one of nine streams: (0) early childhood education, (1) primary, (2) lower secondary, (3) upper secondary, (4) post-secondary non-tertiary, (5) short cycle tertiary, (6) bachelor degree or equivalent, (7) master degree or equivalent, and (8) doctoral degree or equivalent. To take into account cross-national differences in educational systems, these nine levels were grouped into three categories: (1) low (ISCED 0-2), (2) medium (ISCED 3-5), and (3) high (ISCED 6-8). In cases where the child did not live with the mother and she did not reply to the questionnaire, the guardian's educational level was collected (n=12).

Perinatal risk

A composite variable was derived from perinatal characteristics to represent three levels of perinatal risk, as defined previously for the cohort[19]. High risk was defined as at least one of the following criteria: GA<28 weeks, severe neonatal morbidity (bronchopulmonary dysplasia, defined as need for supplemental oxygen or ventilation at 36 weeks' postmenstrual age, retinopathy of prematurity stages III–V diagnosed before discharge, intraventricular haemorrhage III or IV, cystic periventricular leukomalacia, or necrotising enterocolitis needing surgery), and severe congenital anomaly.[20] Low risk included children born at 30-31weeks GA with no severe morbidity, no congenital anomaly and a birthweight over the 10th percentile for gestational age using intrauterine curves.[21] All other children were considered moderate risk (i.e. not in the high risk group at 28-29 weeks' GA or at 30-31 weeks' GA with birthweight <10th percentile and/or a non-severe congenital anomaly).

Other covariates

The following potential confounders were considered in our analysis: maternal age at birth (<35 vs ≥35 year-olds), number of previous births (i.e. parity),whether the mother was foreign born (yes/no),[22] the child's CA at assessment (<21 months, 22-26 months, ≥27 months), sex, multiple birth (twin or more) and bilingualism. Additional variables were used to describe the sample. The proportions of missing data are provided in **Table S1**; these were low for most variables (<2%) with the highest being 4.5% for mother's country of birth.

Statistical analyses

We compared responders to non-responders at the 2-year follow-up using logistic regression models adjusted for country. Proportions of perinatal and sociodemographic characteristics in the study sample were compared by maternal educational level by performing Wald tests adjusted for country. The prevalence of DLD was estimated for both criteria, overall and stratified by level of maternal educational and perinatal risk. For both DLD indicators, we estimated risk ratios (RRs) for DLD for maternal education level overall and stratified by perinatal risk (low, moderate, high) by performing modified Poisson regression models with a log link and a robust variance estimator[23]. Multilevel mixed-effects generalized linear models with random intercepts at the country and the mother levels were included to account for the correlation within countries and twins or higher order births, respectively. Models were adjusted for age at assessment, maternal age, child sex, parity, multiple births, bilingualism, and mother's country of birth. We tested for the presence of multiplicative interactions between maternal education levels and perinatal risk groups for both outcomes by adding a product term to the models. The presence of an interaction was suggested by a P-value <0.10 for at least one of interaction coefficient.

The effects of potential bias due to selective attrition were accounted for using inverse probability weighting (IPW)[24] in all analyses. Weights were derived from a logistic regression as the probability of response at 2 years CA derived from relevant sociodemographic and perinatal characteristics.[24] Each responder was weighted by the inverse of this probability. Missing data on covariates were first imputed using multiple imputation by chained equations (5 complete datasets generated). All analyses were performed using Stata version 15.0

(StataCorp, College Station, TX, USA), and the LINCOM command was used to compute effect sizes stratified for each level of perinatal risk.

RESULTS

Baseline characteristics by follow-up status are provided in **Table 1**. Non-responders were more likely to have younger mothers, foreign mothers and mothers with a previous birth. They were also more likely to be singleton and have bronchopulmonary dysplasia.

Information on maternal educational level was available for 96.5% (n=2645) of the unweighted sample. Overall, 18.8% of mothers had a lower secondary level of education and 33.9% had completed a postgraduate degree or higher. **Table 2** shows maternal and child characteristics among participants by maternal educational attainment.

In our cohort at 2 years CA, 24.6% (95% confidence interval (CI) 22.8-26.5) of children were not combining words, 39.7% (95%CI 37.6-41.9) had a low expressive vocabulary, and 41.9% (95%CI 39.9-44.0) were not combining words or had low expressive vocabulary. Prevalence of DLD by maternal educational level and by perinatal risk are shown in **Figure 1** and **Table 3**. Children of mothers with low education were more likely to experience DLD at 2 years than other children, based on both DLD criteria (**Figure 1a**): 30.0% of children were not combining words when the mother had a low educational level compared to 21.8% when the mother had high educational level; these proportions were 46.0% and 34.4% for low expressive vocabulary, respectively. DLD was also more prevalent in the highest perinatal risk group for both indicators (not combining words: 29.4%; low expressive vocabulary: 48.1%) compared to the low risk group (18.0% and 34.0%, respectively) (**Figure 1b**).

The distribution of DLD stratified by level of perinatal risk and maternal education is given in **Table 3**. The highest percentage of DLD was reported for children in the high-risk group who had mothers with low education (not combining words: 36.4%; low expressive vocabulary: 52.8%). After adjustment for potential confounding factors (**Table 3**), a low versus a high maternal educational level was related to an elevated risk of DLD for both criteria. There was evidence for multiplicative interaction between maternal education and perinatal risk only for low expressive vocabulary, although estimates of risk were higher for children with low versus high perinatal risk for both DLD criteria. The risk for not combining words for children who had mothers with low education, compared to those with mothers with high education, was 1.88 (95%CI 1.26-2.80) for low perinatal risk, versus RR=1.36 (95%CI 1.10-1.67) for high perinatal risk (p-value for the interaction term 'high risk x low education'=0.252). Similarly, for low expressive vocabulary, RR was 1.44 (95%CI 1.06-1.95) for children with low perinatal risk compared to RR=1.11 (95%CI 0.97-1.27) for children with high perinatal risk (p-value for the interaction term 'high risk x low education' and for low expressive vocabulary=0.056).

DISCUSSION

We used a large population-based cohort of children born very preterm in Europe to investigate delay in expressive language development at 2 years CA in relation to the mother's educational level. We found that almost 42% of children born VPT were classified as having DLD in our study sample with regard to the ability to combine words or their expressive vocabulary. A higher risk of DLD was observed among children whose mothers had low educational levels, corresponding to lower secondary schooling or less, compared to those whose mothers had high educational levels, defined as a bachelor degree or more. DLD was more prevalent among children with higher perinatal risk; maternal educational level affected DLD across all degrees of perinatal risk, but the effect appeared to be attenuated among children at higher risk. Nonetheless, children with high perinatal risk and mothers with a high educational level had similar levels of DLD as children with low perinatal risk and mothers with a low educational level.

Our findings confirm previous research showing that children born VPT experience delays in early language acquisition. About one quarter of children were not combining words around 2 years CA and almost 40% had a low expressive vocabulary, which is consistent with previous findings. According to the lexicon size criteria, 24.1% of Italian children born ≤33 weeks[25] and 29.4% of French children born ≤34 weeks (EPIPAGE 2 study)[10] were classified under the 10th percentile of the adapted MCDI-SF based on national normative values, while an absence of word combination was 21.6%.[10] Consistent with previous studies,[8 10 26] we also found an increasing risk for DLD among children with higher perinatal risk, defined in our study as lower GA and/or severe neonatal morbidity. Compared to children born at term, children born VPT are at higher risk for atypical brain development, and developmental impairments in various domains.[2 3 27] Aggravating factors may be linked to the unnatural sensory environment during the third trimester of pregnancy when language acquisition begins through exposure to receptive language;[28 29] the neonatal unit provides less exposure to parental voices and interactions and has elevated levels of other noises.

Maternal educational level had an independent impact on language delay for the VPT children in our study, corroborating previous research.[12 26 30]. The family and social environment of the child in his or her early years has been shown to be crucial for language acquisition and vocabulary development at 2-3 years of age,[22] with an increasing effect in early adolescence,[12] but our understanding of the causal pathways remains limited. The home literacy environment, including the availability of books in the home and the time spent reading or sharing picture books daily or engaging in informal play opportunities, has been related to early language skills.[31 32] Parenting stress and involvement could be a further explanation for social inequalities in language acquisition among children born very preterm.[26] Being in a low-income household has been associated atypical brain development in childhood,[33] and financial resources mediate the relationship between maternal education and children's vocabulary size.[34] Finally, the type of childcare has been linked to the extent and diversity of vocabulary in early childhood, with consistent findings that care in daycare centers protects against late language acquisition compared to family-based care.[31 34 35]

Our study produced novel results showing a stronger association between maternal educational level and DLD when perinatal risk was lower. Previous studies exploring the interaction between perinatal risk and social factors have focused on other cognitive outcomes or different populations and produced contradictory results. One study found no interaction with gestational age, although it was not focused only on children born very preterm;[22] another found the highest probability of language problems among children with lower GA from the most deprived areas.[30] Finally, one study [36] found that the association with higher maternal educational level and better cognitive outcomes at 3 to 4.5 years in VPT children increased in the presence of brain injury. Differences in the study populations and risk groups may explain these discordant results. It is important to explore interactions between clinical and social risks in future research as health professionals caring for VPT children need to understand how they interact in order to provide follow-up care and early interventions adapted to risk levels.

The major strength of this study is the use of a large population-based, prospective cohort study of children born VPT in Europe, as well as the use of two different indicators based on common criteria used in the general population to define DLD.[16] Our study also has some limitations. First, 65% of eligible children were included in the follow-up study and loss to follow-up was more common for children with younger and migrant mothers. We used inverse weighting techniques to adjust for potential bias using data at baseline, but we were not able to fully control for socioeconomic status because this information was not available at birth. Associations with maternal education were strengthened after considering bias due to attrition, suggesting that any remaining bias may be attenuating true effects. We also excluded 353 children for whom the main language spoken by the child or at home was different from the national language and our results cannot be generalized to these children. We used common norms to identify children with a low expressive vocabulary because local norms were not available for our age group in all participating countries. We assessed language at two years and delayed language development may not be abnormal at a later time point. However, a recent report shows that DLD, in particular in children born VPT, is stable over childhood.[37] Finally, although the ISCED/UNESCO classification[18] aims to standardize educational levels, educational systems differ across countries. To address this limitation, we used a classification adopted in previous European studies of maternal education and perinatal outcome and included country as a random effect.[38 39]

Both social disadvantage and perinatal risk factors were strong predictors of DLD in early childhood in a large population-based study of children born VPT in Europe. Early interventions for language delay that integrate social and clinical risks may be one strategy for mitigating the longer term consequences of preterm birth. Future research is needed to clarify potential interactions between maternal education and perinatal risks.

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TABLES AND FIGURES

Table 1 – Baseline characteristics of responders (n=3101) and non-responders (n=1537) at 2 years corrected age

	Non-responders at 2 years	Responders at 2 years	Wald test p-value (adjusted for country)
	n=1,537	n=3,101	
Perinatal characteristics			
Gestational age (%)			
22 weeks	0.07	0	0.207
23-27 weeks	23.2	24.9	
28-31 weeks	76.7	75.0	
Birthweight (%)			
< 1000 grams	26.5	28.2	0.316
Multiple pregnancy (%)	26.5	33.1	0.001
Maternal age at birth (%)			
≥ 35 years old	21.2	31.9	0.000
Previous birth			
0	48.2	59.9	0.000
1	24.9	23.6	
2 or more	26.9	16.6	
Neonatal morbidity (%)			
SGA < 10th	32.3	32.9	0.659
BPD	18.0	13.0	0.018
ROP stage III-V	3.5	3.4	0.466
IVH III°-IV°/cPVL	6.1	5.9	0.584
NEC needing surgery	2.1	1.6	0.918
Severe congenital anomaly (%)	1.2	1.2	0.869
Perinatal risk			
Low level	27.2	26.9	0.554
Moderate level	37.1	38.8	
High level	35.7	34.3	
Male (%)	54.7	52.4	0.375
Mothers born in the country (%)	66.24	81.77	0.000
Countries*			
Estonia	0.1	4.5	0.000
France	7.6	31.8	
Germany	14.4	14.0	
Italy	15.4	23.6	
UK	57.6	20.8	
Sweden	4.9	5.3	

* For example: among children who were not followed at 2 years CA, 0.1% were from Estonia, while among children who were followed up at 2 years CA, 4.5% were from Estonia

Abbreviations: SGA: small for gestational age (i.e. birthweight over the 10^{th} percentile for gestational age using intrauterine curves); BPD: bronchopulmonary dysplasia; ROP: retinopathy of prematurity; IVH: intraventricular haemorrhage; cPVL:cystic periventricular leukomalacia; NEC: necrotising enterocolitis

Table 2 –Sociodemographic and clinical characteristics by levels of maternal education, sample weighted to account for non-response bias

	Level of maternal education			Wald test p-value adjusted for country
	Low education n=516	**Medium education n=1169**	**High education n=960**	
Perinatal characteristics				
Gestational age (%)				
< 28 weeks	25.0	24.6	24.2	0.81
28-31 weeks	75.0	75.4	75.8	
Birthweight (%)				
< 1000 grams	30.1	27.7	26.6	0.79
Multiple pregnancy (%)	30.3	29.8	36.6	<0.001
Maternal age at birth (%)				
≥ 35 years old	27.3	23.1	37.4	<0.001
Previous birth				
0	48.7	54.9	65.8	
1	24.7	22.9	24.3	<0.001
2 or more	26.5	22.3	9.9	
Severe neonatal morbidity (%)				
SGA < 10th	37.6	32.1	31.2	0.51
BPD	12.7	18.8	14.8	0.33
ROP stages III to V	3.3	3.9	2.9	0.43
IVH stages III-IV or cPVL	6.2	7.9	4.9	0.09
NEC needing surgery	1.6	2.0	1.8	0.71
Severe congenital anomaly (%)	1.4	0.9	1.2	0.75
Perinatal risk				
Low level	25.1	27.6	29.2	
Moderate level	40.7	34.9	38.1	0.51
High level	34.3	37.5	32.7	
Male (%)	48.6	50.5	52.7	0.34
Mothers born in the country (%)	71.7	82.9	84.5	<0.001
Information available at follow-up				
Single mother (%)	15.9	12.9	5.1	<0.001
Sibling (%)	62.8	64.7	58.7	0.09
Main childcare (%)				
Parents or other family	84.4	66.9	56.5	
Daycare, nursery or nanny	11.1	19.6	31.1	<0.001
Other	4.5	13.5	12.4	
Corrected age at assessment (%)				
<21 months	1.6	1.3	0.6	<0.001
22-26 months	74.6	83.7	89.7	

>=27 months	23.8	15.0	9.8	
Bilingualism (yes)	27.9	20.6	20.4	0.38
Countries				
Estonia	2.5	3.1	4.5	-
France	29.7	22.8	21.9	
Germany	36.9	4.3	11.9	
Italy	19.5	23.4	21.4	
UK	10.7	41.8	32.9	
Sweden	0.7	4.7	7.2	

Abbreviations: SGA: small for gestational age (i.e. birthweight over the 10^{th} percentile for gestational age using intrauterine curves); BPD: bronchopulmonary dysplasia; ROP: retinopathy of prematurity; IVH: intraventricular haemorrhage; cPVL:cystic periventricular leukomalacia; NEC: necrotising enterocolitis

Table 3 - Prevalence of DLD and relative risks (RR) for DLD by maternal educational level and level of perinatal risk

	n	% DLD	(95%CI)	RR1*	(95%CI)	RR2**	(95%CI)
DLD according to criteria 1: No word combination							
Low perinatal risk							
Low education	129	26.2	(18.6 ; 35.5)	1.92	(1.33 ; 2.78)	1.88	(1.26 ; 2.80)
Medium education	305	17.5	(13.2 ; 22.9)	1.13	(0.99 ; 1.27)	1.14	(1.02 ; 1.26)
High education	267	16.1	(11.9 ; 21.2)	1		1	
Moderate perinatal risk							
Low education	201	26.8	(20.9 ; 33.6)	1.35	(0.98 ; 1.87)	1.51	(1.12 ; 2.05)
Medium education	427	26.9	(22.5 ; 31.7)	1.29	(0.88 ; 1.89)	1.31	(0.92 ; 1.85)
High education	369	20.2	(16.3 ; 24.6)	1		1	
High perinatal risk							
Low education	167	36.4	(29.0 ; 44.5)	1.31	(1.16 ; 1.48)	1.36	(1.10 ; 1.67)
Medium education	382	27.8	(22.7 ; 33.5)	0.91	(0.69 ; 1.19)	0.97	(0.67 ; 1.39)
High education	291	28.9	(23.7 ; 34.8)	1		1	
DLD according to criteria 2: Low expressive vocabulary							
Low perinatal risk							
Low education	109	45.8	(36.4 ; 55.5)	1.54	(1.10 ; 2.16)	1.44	(1.06 ; 1.95)
Medium education	286	33.1	(27.1 ; 39.8)	1.07	(0.83 ; 1.39)	1.04	(0.81 ; 1.34)
High education	262	30.4	(24.8 ; 36.5)	1		1	
Moderate perinatal risk							
Low education	195	41.8	(34.6 ; 49.2)	1.41	(1.14 ; 1.74)	1.32	(1.02 ; 1.69)
Medium education	415	35.9	(31.0 ; 41.1)	1.19	(0.99 ; 1.42)	1.23	(1.02 ; 1.47)
High education	364	29.9	(25.3 ; 34.9)	1		1	
High perinatal risk							
Low education	150	52.8	(44.1 ; 61.4)	1.20	(0.99 ; 1.44)	1.11	(0.97 ; 1.27)
Medium education	366	49.0	(42.9 ; 55.2)	1.09	(0.95 ; 1.27)	1.04	(0.85 ; 1.28)
High education	289	43.8	(37.7 ; 50.1)	1		1	

Estimates computed using the inverse probability of participating at the 2 years of follow-up (IPW approach) based on baseline characteristics

*RR1: adjusted for age at assessment

**RR2: adjusted for age at assessment, sex, maternal age, parity, multiple birth, bilingualism, and country of birth

In models 2, for not combining words, the P-values for interaction terms were 0.45 (low education x moderate perinatal risk), 0.25 (low education x high perinatal risk), 0.34 (medium education x moderate perinatal risk), 0.42 (medium education x high perinatal risk). For low expressive vocabulary, the P-values for interaction terms were 0.38 (low education x moderate perinatal risk), 0.06 (low education x high perinatal risk), 0.30 (medium education x moderate perinatal risk), 0.99 (medium education x high perinatal risk).

Figure legends

Figure 1 – Prevalence of DLD at 2 years in children born VPT by level of maternal education (a) and by level of perinatal risk (b)

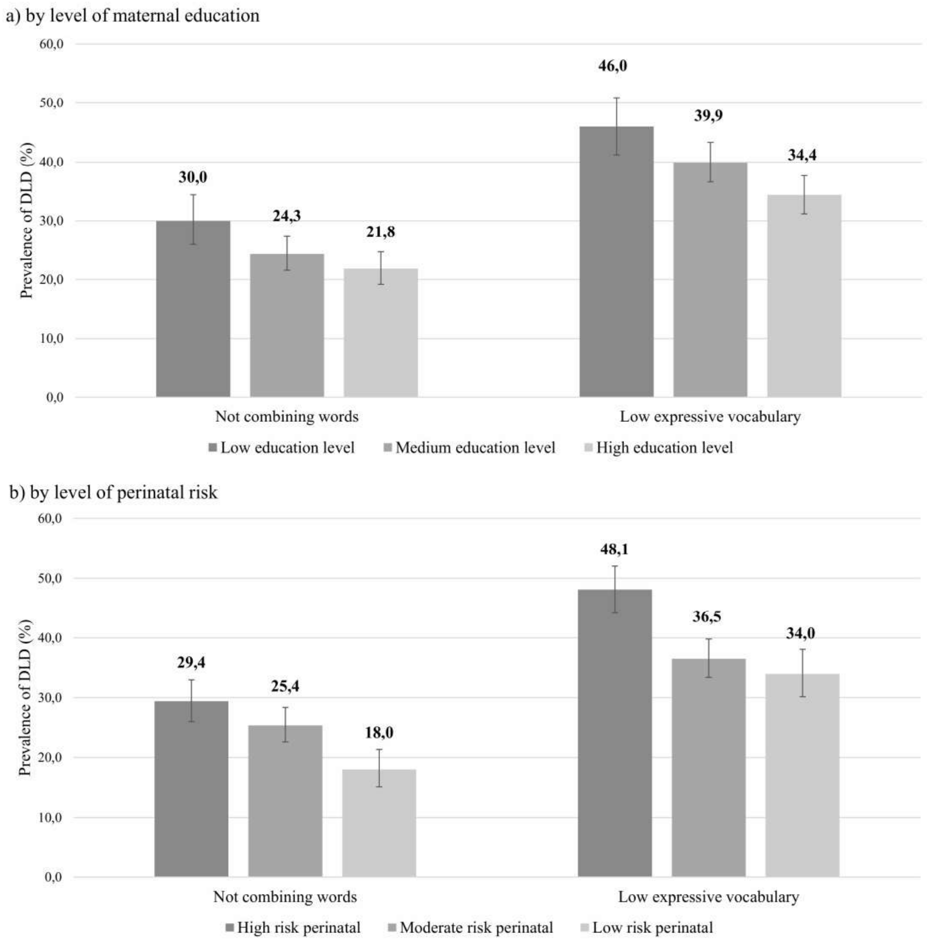

Figure 1 – Prevalence of DLD at 2 years in children born VPT by level of maternal education (a) and by level of perinatal risk (b)

250x250mm (300 x 300 DPI)

SUPPLEMENTAL MATERIAL

Figure S1- Flowchart of the study selection

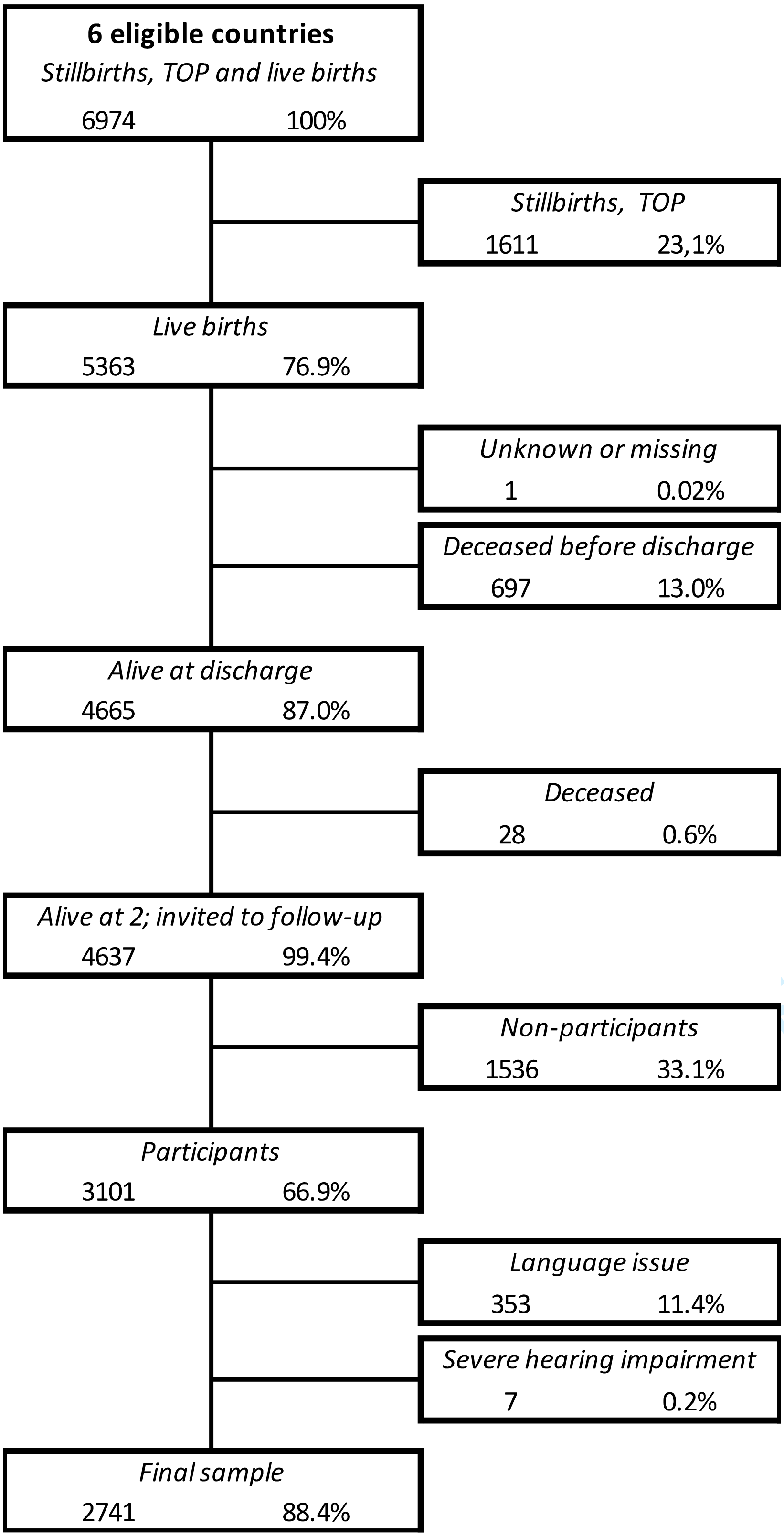

Table S1 – Percentage of missing data for main variables in the analyzed sample (n=2741)

	% of missing
Outcomes	
Word combination	1.8
Expressive vocabulary	5.8
Perinatal characteristics	
Gestational age (%)	0
Birthweight (%)	0
Multiple pregnancy (%)	0
Maternal age at birth (%)	0.3
Previous birth	1.2
Neonatal morbidity (%)	
SGA < 10th	0
BPD	0
ROP stages III to V	1.4
IVH stages III-IV or cPVL	0.7
NEC needing surgery	0
Severe congenital anomaly (%)	0
Perinatal risk	2.5
Socioeconomic and demographic characteristics	
Maternal education level	3.5
Boy (%)	0
Single mother (%)	0.8
Sibling (%) – (after excluded France)	0.8
Main childcare (%)	0.7
Foreign mothers born in the country (%)	4.5
Follow up information	
Corrected age at assessment (%)	0.1
Bilingualism (yes)	0

Abbreviations: SGA: small for gestational age (i.e. birthweight over the 10^{th} percentile for gestational age using intrauterine curves); BPD: bronchopulmonary dysplasia; ROP: retinopathy of prematurity; IVH: intraventricular haemorrhage; cPVL:cystic periventricular leukomalacia; NEC: necrotising enterocolitis