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Executive functioning deficits in young adult survivors of bronchopulmonary dysplasia

[1]Aisling Gough PhD, [2]Mark A. Linden PhD, [2]Dale Spence PhD, [3]Henry L. Halliday MD, [4]Christopher C. Patterson PhD, and [5]Lorcan McGarvey MD.

[1]Reseach fellow, Centre for Public Health Institute of Clinical Sciences, Queens University Belfast & Royal Victoria Hospital Belfast, BT12 6BA, UK;
[2]Lecturer, School of Nursing and Midwifery, Queen's University Belfast, BT9 7BL, UK;
[3]Honorary Professor, Regional Neonatal Unit, Royal Maternity Hospital, Belfast Health and Social Care Trust, BT12 6BA, UK;
[4]Professor, Centre for Public Health, Queen's University Belfast, BT12 6BJ, UK;
[5]Senior lecturer, Centre for Infection & Immunity, Queen's University Belfast, BT9 7BL, UK.

ABSTRACT

Purpose: To assess long term impairments of executive functioning in adult survivors of bronchopulmonary dysplasia.

Method: Participants were assessed on measures of executive functioning, health related quality of life and social functioning. Survivors of bronchopulmonary dysplasia (n=63; 34 males; mean age 24.2 years) were compared to groups comprising preterm (without bronchopulmonary dysplasia) (< 1500 g; n=45) and full term controls (n=63). Analysis of variance was used to explore differences among groups for outcome measures. Multiple regression analyses were performed to identify factors predictive of long term outcomes.

Results: Significantly more bronchopulmonary dysplasia adults, compared with preterm and term controls, showed deficits in executive functioning relating to problem solving (OR 5.1, CI 1.4-19.3), awareness of behaviour (OR 12.7, CI 1.5-106.4) and organization of their

environment (OR 13.0, CI 1.6-107.1). Birth weight, health related quality of life and social functioning were predictive of deficits in executive functioning.

Conclusions: This study represents the largest sample of survivors into adulthood of bronchopulmonary dysplasia and is the first to show that deficits in executive functioning persist. Children with bronchopulmonary dysplasia should be assessed to identify cognitive impairments and allow early intervention aimed at ameliorating their effects.

INTRODUCTION

The global incidence of preterm birth has been estimated at 9.6% [1] and with improving neonatal care, there has been a marked increase in survival rates of even the most immature newborns.[2-4] Preterm birth is associated with numerous adverse health consequences including neurodevelopmental and cognitive impairment.[5, 6] Preterm infants born with very low birth weight (VLBW; <1500 g) are at a greater risk of developing cerebral palsy, have lower IQ, poorer academic achievement and are more likely to display a variety of behavioural problems, compared to fullterm peers.[6-8] As preterm birth disrupts normal fetal lung development, preterm neonates are also at risk of respiratory illness, in particular the chronic lung disease, bronchopulmonary dysplasia (BPD).[9] BPD was originally described in slightly preterm infants exposed to the injurious effects of high pressure ventilation and high concentrations of inspired oxygen. [10] Contemporary infants who develop BPD are more preterm with lung injury caused by inflammation and relative hyperoxia. [10-12] It has been proposed that BPD may exacerbate the adverse effects on neurodevelopmental outcome caused by preterm birth.[6 13 14] The exact reason for this is not known, however, hypoxia, inflammation, poor nutrition and stress have been suggested as potential causes.[13]

Executive functioning (EF) refers to a number of higher order cognitive processes that include planning, initiation of behaviour and problem solving, which are important for social interaction, behavioural and emotional control.[15 -17] These processes enable individuals to make changes to their health and lifestyle and so are also important for overall quality of life[18] and social functioning.[19] There is conflicting evidence regarding factors predictive of EF outcome. Studies in preterm adolescents and young adults[20' 21] suggest that perinatal factors are not predictive while some evidence suggests that certain maternal factors are (education and scholastic achievement). [18, 21, 22] Children with a history of BPD may be at particular risk of impairments in EF. In a study of children with BPD, duration of oxygen therapy in the neonatal period predicted IQ, perceptual organization deficits, and reduced performance on motor proficiency tasks.[23] Taylor and colleagues[24] also reported an inverse correlation between oxygen duration and measures of planning and working memory, suggesting that BPD survivors are at risk of EF deficits. Impairment in EF is also related to attention problems[17] which have been demonstrated in children with BPD,[23, 25] supporting the notion that such deficits might exist in adult survivors. Having been documented for over 40 years, the original cases of BPD survivors are now in their third and fourth decades of life. To date, no studies have explored whether impairments in executive functioning exist in adult survivors of BPD. The aim of this study was to undertake such an evaluation in adults who were born preterm and developed BPD. We hypothesized that adult survivors of BPD would have greater impairment in executive functioning than preterm and term controls.

METHODS

Study design and participants

The study population comprised 110 preterm adult survivors previously cared for in the Regional Neonatal Intensive Care Unit (NICU) of the Royal Maternity Hospital, Belfast in

Northern Ireland between January 1978 and April 1993. The index group comprising subjects who developed BPD (n=63) were compared to preterm controls (n=45) also cared for in the NICU but who did not develop BPD or receive mechanical ventilation or prolonged respiratory support. A second control group (n=63) comprised gender and birth date matched (within two weeks of the index group) full term individuals, born in the same hospital. The tracing and recruitment of study participants is detailed in the online supplement. Briefly, individuals were identified from hospital records and traced through the Business Services Organization (BSO) of the Department of Health, Social Services and Public Safety and subsequently via their General Practitioner (GP). Admission protocols at the regional NICU in Northern Ireland served to define preterm controls and BPD patients. BPD was defined according to requirement for supplemental oxygen >28 postnatal days and radiographic changes (1979 workshop) and severity (mild, moderate or severe) defined according to oxygen requirements at 36 wk postmenstrual age (PMA) (ref NICHD/NHLBI Workshop summary) respectively. Individuals with physical or mental disability such that they could not complete questionnaires were excluded.

Birth weights were obtained from labor and maternal records, and gestational age was based on maternal report of last menstrual period and early pregnancy ultrasound scans. Variables such as social functioning and health related quality of life (HRQoL) were included in the analysis. [26] All participants gave written informed consent and the study was approved by Office for Research Ethics Committees Northern Ireland (ORECNI) (08/NIR02/22).

Outcome measures

Health and Lifestyle

Participants received a health and lifestyle questionnaire which enquired about their educational attainment and demographics. A score was estimated for socioeconomic status (SES) was calculated using the Northern Ireland Statistics and Research Agency [27] multiple deprivation index, determined by the participant's current post code. This index divides the region into 566 electoral wards using information from domains such as income, employment, health, education and access to services. These wards are then ranked, where 1 represents the most deprived, and 566 represents the least deprived. [28]

Social Functioning

The Social Functioning Questionnaire (SFQ)[29] was an eight item self-report tool used to assess perceived social functioning. Participants were asked to rate the extent to which they had experienced problems on a four point scale ranging from 0 to 3 (0= Most of the time, 1= Quite often, 2= Sometimes, 3= Not at all). Examples of these items include 'I complete my tasks at work and at home satisfactorily', 'I feel lonely and isolated from other people', 'I get on well with my family and other relatives'. Scores ranged from 0-24, with higher scores illustrating greater social dysfunction. A SFQ score of 10 or more meets criteria for poor social functioning or impairment[29]. The questionnaire has 'good test-retest and inter-rater reliability as well as construct validity'.[29]

Executive Functioning

The Behavior Rating Inventory of Executive Function for Adults (BRIEF-A[30]) is a standardized 75-item self-report measure. The tool yields 9 clinical scales relating to domains of EF. These include; Inhibit (impulsivity and inhibitory control), Shift (movement between tasks and ability to change focus), Emotional Control (modulation of emotional responses), Self-Monitor (awareness of own behaviour and the affect on others), Initiate (ability to

independently generate ideas and start new tasks), Working Memory (ability to hold and encode information for task completion), Plan/Organize (ability to plan ahead and set goals), Task Monitor (assessment of performance both during and after tasks) and Organization of Materials (orderliness of belongings at home and work). The scales form two composite scores; Behavior Regulation Index (BRI; ability to retain regulatory control of behaviour and emotions) and the Metacognition Index (MI; ability to systematically solve problems). A summary score termed the Global Executive Composite (*GEC*) is derived from these indices. T scores $\geq$ 65 indicate executive dysfunction. The validity and reliability of the BRIEF-A have been previously reported with the scale being successfully employed in Alzheimer's, Multiple Sclerosis, and Traumatic Brain Injury populations.[30]

Statistical analyses

Data were analysed using SPSS Version 18 (SPSS Inc; Chicago, Illinois). Differences between groups for continuous variables were analysed by independent samples *t* test or analysis of variance (ANOVA) while dichotomous variables were compared using *chi*-squared analysis. Multiple linear regressions were performed on BRIEF-A composite scores, and the global executive composite score, to estimate the predictive power of independent variables pertaining to HRQoL, educational attainment and social factors.

RESULTS

Characteristics (including perinatal factors) of the three study groups are illustrated in Table 1 which includes the combined characteristics of the BPD and non-BPD groups under the heading Preterm. The BPD group were significantly lighter and younger than both the non-BPD and term controls. In this group 32 (51%) were classified as having mild BPD, 23 (36%)

as moderate and 8 (13%) as severe. No significant differences were found between the groups for current smoking status, SES or third level educational attainment.

Insert table 1 about here

To explore the potential effects of changes in neonatal care over the 15 year period from which our sample was drawn, the BPD group was divided into three equal time periods. Table 2 shows that those individuals born in the most recent period (BPD 3) were younger (mean gestational age 26.8 wk), lighter (mean birth weight 842 g) and required a greater duration of intermittent positive pressure ventilation (IPPV) (mean 977 hours). As anticipated, infants born in the later periods were more likely to have been given surfactant and exposed to antenatal steroids. There was a greater proportion of moderate and severe BPD in the later periods.

Insert table 2 about here

Executive Functioning

Table 3 shows that a greater percentage of BPD participants scored in the clinically significant range ($\geq$ 65) on all scales and composites, with the exception of the Emotional Control subscale where they equalled (18%) the non-BPD group.

Compared to preterm non-BPD controls, a greater proportion of BPD adults scored in the clinical range on almost all BRIEF-A measures; significantly so, on the Self-Monitor, Planning and Organization and the Organization of Materials subscales. After adjusting for SES and educational attainment, these differences remained significant.

When compared with term controls, significantly more BPD adults scored in the clinical range on the Shift, Self-Monitor, MI, Initiate, and Organization of Materials subscales ($p<$ 0.05 see table 3). After adjusting for SES and educational attainment, these differences remained. Overall, 22% of the BPD group displayed deficits, as identified by the GEC, compared with 13% non-BPD and 10% of term controls.

Insert table 3 about here

The executive functioning of preterm individuals as a whole (BPD and non-BPD) were compared with term controls to show statistically significant differences on the MI (p=.042) and Initiate subscales (p=.039). For the majority (11 out of 12) of scales, the preterm group scored in the clinically significant range by more than a two-fold difference compared to the term controls (19% vs. 10% respectively). When adjustments were made for SES and educational attainment these statistically significant differences remained.

Perinatal variables

Perinatal characteristics of the BPD group described in table 1 were selected for multivariate regression with the composite scores from the BRIEF-A. Regression models (table 4) for the MI and GEC were statistically significant; [MI: $F(5,54)=3.588$, p=.012; GEC: $F(5,54)=3.118$, p=.023], and showed that birth weight and duration of IPPV were predictive of EF ($p<.05$).

Insert table 4 about here

Social variables

Health Related Quality of Life, social functioning, SES and educational attainment were regressed onto BRIEF-A composites for the BPD group (Table 5). All models were statistically significant; [BRI: $F(4,60)=8.303$, $p<.001$; MI: $F(4,60)=11.720$, $p<.001$; GEC: $F(4,60)=11.152$, $p<.001$], with HRQoL ($p<.05$), social functioning ($p<.001$) and educational attainment ($p<.05$) predicting EF outcome.

Insert table 5 about here

DISCUSSION

This study is the first to reveal that adults born preterm who developed BPD, display deficits in EF, compared with non-BPD preterm and Term born peers. Given the increasing prevalence of preterm birth, and survival of those most likely to develop BPD, our findings have important implications for healthcare, social wellbeing and cognitive rehabilitation.

This study has demonstrated that significantly more BPD adults scored in the clinical range of EF on a number of scales, highlighting difficulties with initiation of activities, moving between tasks and planning and organization. The Self-Monitoring and Organization of Materials subscales demonstrated the most profound differences between the groups, with BPD subjects at an almost tenfold increase in risk of scoring in the clinically significant range compared to non-BPD participants. BPD adults may therefore have difficulty with monitoring their behaviour and organizing their resources for home and work. This would have significant implications for education, employment and home life. As this is the first study to report deficits in EF in adult survivors of BPD, it is difficult to draw on comparisons with previous findings which have largely focused on preterm participants in childhood or

adolescence [6 15]. In a study of adolescents born preterm (age 16 years; mean birth weight, 961 g; mean gestation, 28 wk) Luu and colleagues,[21] found difficulties with initiation of new tasks, generating new ideas and MI, as measured by the BRIEF-A, in the preterm group compared with term controls. When we aggregated data for our preterm participants (BPD and non-BPD) and compared to term controls we found that significantly more preterm than term participants scored in the clinically significant range on both the MI and Initiate subscales. Furthermore, on all but one scale (Inhibit) there was close to, or above, a twofold increase in risk of displaying problems with EF.

Adolescents born preterm have been shown to experience difficulties with scholastic achievement, and are more likely to require special education assistance, or repeat a year at school.[31] Our findings show that educational attainment is predictive of EF in adult survivors of BPD. In contrast to the findings of Luu et al.,[21] we found that birth weight was a significant predictor of both the ability to systematically solve problems (MI) and overall EF (GEC). Consistent with others[19], we found that social functioning was predictive of EF. While BPD adults scored lower on overall social functioning, more non-BPD adults scored within the clinical range. Reduced HRQoL was also shown to be predictive of EF in BPD adults. EF impacts on the individual's quality of life by limiting the ability to plan, initiate, inhibit and organize changes to behaviour, highlighting that cognition is an important determinant for overall quality of life[18].

The cognitive and EF outcomes of preterm survivors have been largely confined to childhood studies.[6 15] The first suggestion of impaired EF in very preterm adults (assessed at mean age, 22.3 years; mean birth weight 1296 g, mean gestational age, 29.5 wk) showed that deficits in EF primarily related to initiation, inhibition and mental flexibility[20]. Our findings are

therefore in accordance with what is currently known regarding impaired EF in preterm adults.[20 21] However, our study extends what is already known to provide information on the longer term outcome of those who develop BPD.

BPD participants in this study were recruited across a fifteen year period and represent a cohort that were subject to changes in treatment e.g. introduction of surfactant and antenatal and postnatal steroids. To assess whether these changes had a significant impact on our findings the study group was divided into periods of five year intervals. Analysis showed differences in regard to administration of surfactant and postnatal steroids in accordance with medical developments. Infants born after the introduction of these treatments had improved survival rates, reflected by greater numbers of survivors of severe BPD in the most recent time period. It is therefore likely that the statistically significant findings in EF stem from participants from this period. These individuals are more comparable to survivors of BPD born today, suggesting that contemporary infants born with BPD will exhibit deficits in EF as adults.

Strengths and Limitations of the study

A considerable strength of this study was our ability to trace and study in adulthood (aged 18-34 years) a group of carefully characterized preterm infants with BPD and compare them with preterm and term controls, all of whom were cared for in the same hospital. Whilst our sample size could be considered relatively small, findings from our recent systematic review indicate it as considerably larger than any study in this population to date.[32] In addition, this work is the first to provide an insight into EF deficits in adult survivors of BPD.

With modern medical advances, survivors of BPD born today are likely to differ from some of those who took part in our study. However, we have provided the first report of EF impairments in adult survivors of BPD, which are applicable to contemporary BPD adults. Our cohort included few individuals with more severe forms of the disease (12.7%) which is likely explained by low survival rates in the earlier periods. However, medical advances mean that survival rates of infants who develop severe BPD are increasing, and future research should explore EF impairments among these individuals.

Conclusions

Impairments in EF for preterm survivors extend into adulthood with greater deficits found in BPD adults. These deficits include difficulties with planning, initiating new tasks and monitoring the outcome of behaviours. Such deficits affect the day to day lives of these individuals and have consequences for their social functioning, educational attainment and quality of life. Screening children with BPD might identify cognitive deficits, and allow rehabilitation strategies to be put into place early in life, to improve scholastic attainment and social functioning.

Most research to date has focused on the respiratory outcomes of BPD survivors, with relatively little consideration given to the psycho-social impact. As this directly affects their life circumstances it represents an area which requires greater research focus.

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Table 1: *Perinatal and demographic characteristics of the BPD and Control groups*

	BPD (n=63)	Non-BPD (n=45)	Preterm (n=108)	Term (n=63)	BPD vs. Non-BPD *p* value	BPD vs. Term *p* value	Preterm vs. Term *p* value
Male Gender	34 (54%)	15 (33%)	49 (45.4%)	31 (49%)	0.034	0.593	0.628
Age at Study Entry (years)	24.2 (4.1)	25.0 (3.8)	24.5 (4.0)	26.0 (3.9)	0.275	**0.013**	**0.022**
Gestational Age (wk)	27.3 (2.1)	31.0 (2.5)	28.9 (2.9)	39.7 (1.3)[a]	<0.001	<0.001	<0.001
Birth Weight (g)	970 (267)	1230 (222)	1078 (279)	3544 (434)[e]	<0.001	<0.001	<0.001
Hospital Stay (days)	102.40 (43.98)	49.84 (27.60)[a]	80.66 (45.80)[a]	-	<0.001	-	-
Median Apgar Score 1	5.0 (3-6)[b]	6 (4-7)	5 (4-7)	-	0.005	-	-
Median Apgar Score 5	8 (7-9)[c]	8 (8-9)	8 (7-9)	-	<0.001	-	-
Antenatal Steroids	16 (25%)	17 (39%)[a]	33 (30.6%)[a]	-	0.145	-	-
Maternal Smoking	12 (26%)[f]	9 (29%)[g]	21 (26.9%)[h]	-	0.733	-	-
Postnatal Steroids	20 (32%)	-	-	-	-	-	-
Median Duration O_2 >60% (h)	11 (2-55)[e]	-	-	-	-	-	-
Median Duration IPPV (h)	765 (403-1298)[a]	-	-	-	-	-	-
Surfactant	19 (30%)	-	-	-	-	-	-
BPD severity							
Mild	32 (51%)	-	-	-	-	-	-
Moderate	23 (36%)	-	-	-	-	-	-
Severe	8 (13%)	-	-	-	-	-	-
Social Deprivation[a]					0.413	0.411	0.489
Least Deprived	24 (39%)	14 (33%)	38 (36%)	28 (49%)	-	-	-
Moderately Deprived	16 (26%)	6 (14%)	22 (21%)	6 (11%)	-	-	-
Most Deprived	22 (35%)	23 (53%)	45 (43%)	23 (40%)	-	-	-
Social Deprivation Score	304.0 (190.8)	236.4 (207.4)	276.3 (199.6)	291.8 (206.8)	-	-	-
3rd Level Education	26 (41%)	19 (41%)[a]	44 (41.1%)[a]	32 (51%)	0.970	0.284	0.221
Current Smoker	11 (18%)	8 (18%)	19 (18%)	15 (24%)	0.966	0.912	0.326

[a]n=1 missing data, [b]n=2 missing data, [c]n=3 missing data, [d]n=5 missing data, [e]n=7 missing data, [f]n=11 missing data, [g]n=15 missing data, [h]n=31 missing data; Continuous variables are reported as Mean (SD) or Median (IQR); categorical variables are reported in frequencies and percentages.

Table 2: *Perinatal and demographic characteristics of the BPD group by time period*

	BPD Group 1: 1978-1982 (n=11)	BPD Group 2: 1983-1987 (n=22)	BPD Group 3: 1988-1993 (n=30)
Male Gender	6 (55%)	10 (46%)	18 (60%)
Birth weight (g)	1115 (223)	1072 (244)	842 (244)
Gestational age (wk)	28.6 (1.3)	27.5 (2.0)	26.8 (2.2)
Median Duration IPPV (h)	242 (116-551)[a]	917 (345-1514)	824 (551-1310)[a]
Median Duration O_2 >60% (h)	59 (22-86)	24 (3-63)[b]	5 (2-20)[c]
Median Apgar1	5.0 (3-7)	4.0 (3-5)[a]	5.0 (4-6)
Median Apgar5	7.0 (6-9)[b]	7.5 (7-8)[b]	8.0 (7-9)
Maternal Smoker	3 (60%)	2 (12%)	7 (28%)
Surfactant	0 (0%)	1 (5%)	18 (60%)
Antenatal Steroids	1 (9%)	4 (18%)	11 (37%)
Postnatal Steroids	0 (0%)	2 (9%)	18 (60%)
BPD Severity			
Mild	7 (64%)	12 (55%)	13 (43%)
Moderate	4 (36%)	8 (36%)	11 (37%)
Severe	0 (0%)	2 (9%)	6 (20%)

[a]n=1 missing data, [b]n=2 missing data, [c]n=6 missing data; Continuous variables are reported as Mean (SD) or Median (IQR), categorical variables are reported in frequencies and percentages.

Table 3: *Proportion of BPD and Control participants who scored in the clinically significant range of the BRIEF-A*

Scores >65 n(%)	BPD (n=63)	Non-BPD (n=45)	Term (n=63)	BPD vs. Non-BPD Unadjusted Odds ratio (95% CI); *p*	BPD vs. Non-BPD Adjusted Odds ratio (95% CI); *p*[a]	BPD vs. Term Unadjusted Odds ratio (95% CI); *p*	BPD vs. Term Adjusted Odds ratio (95% CI); *p*[a]
BRI	13 (21%)	4 (9%)	6 (10%)	2.67 (0.8 to 8.8); 0.108	3.40 (1.0 to 12.1); 0.058	2.47 (0.9 to 7.0); 0.088	2.52 (0.9 to 7.4); 0.091
Inhibit	8 (13%)	5 (11%)	8 (13%)	1.16 (0.4 to 3.8); 0.803	1.22 (0.4 to 4.2); 0.754	1.00 (0.4 to 2.9); 1.00	0.98 (0.3 to 2.8); 0.967
Shift	11 (18%)	4 (9%)	3 (5%)	2.17 (0.6 to 7.3); 0.212	2.37 (0.7 to 8.3); 0.177	**4.23 (1.1 to 16.0); 0.033**	**4.29 (1.1 to 16.7); 0.036**
Emotional Control	11 (18%)	8 (18%)	5 (8%)	0.98 (0.4 to 2.7); 0.966	1.09 (0.4 to 3.1); 0.877	2.45 (0.8 to 7.5); 0.117	2.79 (0.9 to 9.1); 0.087
Self-Monitor	12 (19%)	1 (2%)	3 (5%)	**10.35 (1.3 to 82.8); 0.028**	**12.69 (1.5 to 106.4); 0.019**	**4.71 (1.3 to 17.6); 0.021**	**4.69 (1.2 to 18.0); 0.024**
MI	13 (21%)	4 (9%)	3 (5%)	2.67 (0.8 to 8.8); 0.108	2.56 (0.7 to 8.8); 0.135	**5.13 (1.4 to 19.3); 0.016**	**5.13 (1.4 to 19.3); 0.016**
Initiate	12 (19%)	3 (7%)	2 (3%)	3.29 (0.9 to 12.5); 0.079	3.07 (0.8 to 11.8); 0.104	**7.18 (1.5 to 33.6); 0.012**	**7.02 (1.5 to 33.6); 0.015**
Working-Memory	15 (24%)	7 (16%)	10 (16%)	1.70 (0.6 to 4.6); 0.297	1.61 (0.6 to 4.4); 0.356	1.66 (0.7 to 4.0); 0.267	1.67 (0.7 to 4.1); 0.261
Plan/Organize	13 (21%)	2 (4%)	7 (11%)	**5.59 (1.2 to 26.2); 0.029**	**5.20 (1.1 to 25.1); 0.040**	2.08 (0.8 to 5.6); 0.149	2.06 (0.8 to 5.6); 0.157
Task Monitor	11 (18%)	4 (9%)	6 (10%)	2.17 (0.6 to 7.3); 0.212	2.11 (0.6 to 7.4); 0.241	2.01 (0.7 to 5.8); 0.198	1.91 (0.7 to 5.6); 0.237
Organization of Materials	13 (21%)	1 (2%)	4 (6%)	**11.44 (1.4 to 91.0); 0.021**	**12.96 (1.6 to 107.1); 0.017**	**3.84 (1.2 to 12.5); 0.026**	**3.75 (1.1 to 12.4); 0.030**
GEC	14 (22%)	6 (13%)	6 (10%)	1.86 (0.7 to 5.3); 0.246	1.85 (0.6 to 5.4); 0.263	2.71 (1.0 to 7.60); 0.057	2.71 (1.0 to 7.7); 0.061

Categorical variables are reported in numbers (%); [a]: adjusted for social deprivation and educational attainment; CI: Confidence Interval

Table 4: *Regression model of BPD perinatal variables predictive of composite measures of executive functioning*

Variable		*β*	*P*	Model Adjusted R^2; *p*
BRI				.092; *p=.065*
	Birth weight, grams	-.242	.141	
	Gestational Age, weeks	-.120	.465	
	Duration IPPV, hours	**-.338**	**.020**	
	Duration O2 >60%, hours	-.016	.907	
MI				**.161; *p=.012***
	Birth weight, grams	**-.383**	**.018**	
	Gestational Age, weeks	-.076	.631	
	Duration IPPV, hours	-.264	.056	
	Duration O2 >60%, hours	-.091	.489	
GEC				**.136; *p=.023***
	Birth weight, grams	**-.329**	**.043**	
	Gestational Age, weeks	-.108	.502	
	Duration IPPV, hours	**-.300**	**.033**	
	Duration O2 >60%, hours	-.059	.659	

BRI: Behavior Rating Inventory; MI: Metacognition; GEC: Global Executive Composite; Duration IPPV: duration of intermittent positive pressure ventilation (IPPV); *β*: standardized regression coefficients

Table 5: *Regression model of BPD social variables predictive of composite measures of executive functioning*

Variable	*β*	*p*	Model Adjusted R^2; *p*
BRI			**.327; <.001**
EQ-5D	**-.278**	**.014**	
Social Functioning	**.396**	**.001**	
SES	-.095	.399	
Educational attainment	-.184	.107	
MI			**.417; <.001**
EQ-5D	**-.310**	**.004**	
Social Functioning	**.404**	**<.001**	
SES	.047	.650	
Educational attainment	**-.324**	**.003**	
GEC			**.404; <.001**
EQ-5D	**-.317**	**.003**	
Social Functioning	**.417**	**<.001**	
SES	-.027	.801	
Educational attainment	**-.254**	**.019**	

BRI: Behaviour Rating Inventory; MI: Metacognition; GEC: Global Executive Composite; ED-5D: Euroqol 5 Dimensions health-related quality of life; SF: Social Functioning; SES: Socio-economic status; *β*: standardized regression coefficients