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Title: Delivery at 37 weeks' gestation is associated with a higher risk for child behavioural problems

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Abstract

Background: Advances in obstetric care have been accompanied by increasing rates of intervention which often involve elective delivery at 37 weeks, soon after term gestation has been achieved. **Aim:** The aim of this study was to examine the behavioural sequelae for children born at this early term gestational age compared with those born at later weeks. **Methods:** The Western Australian Pregnancy Cohort (Raine) Study provided comprehensive obstetric data from 2,900 pregnancies. Offspring were followed up at ages two, five, eight, 10, 14 and 17 years using the parent-report Child Behaviour Checklist (CBCL) with clinical cutoffs for overall, internalizing (withdrawn, somatic complaints, anxious/depressed) and externalizing (delinquent, aggressive) behaviour (T-score ≥ 60). We used longitudinal logistic regression models incorporating generalised estimating equations (GEE) with step-wise adjustment for ante-, peri- and postnatal confounding factors. **Results:** Approximately 9% of our cohort was born within the range of 37^{0/7} and 37^{6/7} weeks. Those born at 37 weeks' gestation were at increased risk for overall (OR=1.43, 95%CI= 1.02, 2.01) and externalizing (OR=1.42, 95%CI= 1.01, 2.01) behavioural problems in the fully-adjusted model when compared with infants born from 39 weeks onward. Infants born late preterm (34-36 weeks) and at 38 weeks did not show a significantly increased risk for behavioural problems. **Conclusion:** Infants born at 37 weeks' gestation are at increased risk for behavioural problems over childhood and adolescence compared to those born later in gestation. We suggest that 37 weeks' gestation may not be the optimal cutoff for defining perinatal risk as it applies to behavioural development.

Keywords: early term birth; behaviour; late preterm birth; CBCL; Raine Study

Abbreviations: OR (odds ratio), 95%CI (95% Confidence Intervals)

INTRODUCTION

The definition of term birth carries with it significant clinical implications with respect to the management of pregnancy complications and the timing of elective and indicated delivery ¹. 37 weeks' gestation has been conventionally viewed as the point that defines 'term pregnancy' but despite many studies finding long-term physical, behavioural and cognitive risks for preterm children, there have been few studies that have included examinations after this point ²⁻⁵. Early term births, defined as those births between 37 and 38 weeks' completed gestation, account for around 18% of all births, and up to a third of these are elective deliveries ^{3, 6}. Given the increased risks recently identified in relation to late preterm birth, some researchers have begun to question the wisdom of categorising births at 37 weeks' completed gestation as 'term' ⁷.

Behavioural research on this topic is sparse. One study found infants born at 37-38 weeks' gestation were at significantly higher risk for being on medication for Attention Deficit Hyperactivity Disorder (ADHD) later in life when compared with infants born after 39-41 weeks of gestation ⁸. Another study found non-significant increases in behaviour problem scores in six year old children born at 37-38 weeks compared with those born at 40 weeks' gestation ⁹, but little else is known about long-term behavioural outcomes for children born at 37 weeks' gestation. Recent studies examining child cognitive outcomes have found that even amongst children born at term, a lower gestational age (i.e. 37-38 weeks) was associated with poorer executive function ¹⁰, lower IQ ¹¹, and lower reading and math scores ¹². Further, a large population-based study observed a weaker intellectual

performance in term born male children with a lower gestational age right through to young adulthood¹³.

In terms of neonatal outcomes, a recent study found a higher risk for mortality for late preterm infants persisted for infants born at 37 and 38 completed weeks of gestation compared to those born at 40 weeks' gestation⁴. While the overall rate of mortality was low at these gestational ages, at 37 weeks' gestation the risk for mortality was more than 50% higher than at 40 weeks' gestation⁴. A Spanish study found that neonatal morbidity decreased commensurate with increasing gestational age with the lowest risk at 39 weeks' gestation¹⁴ and a large US study reported similar findings with newborn morbidity risk increasing two-fold with each week of gestation prior to 38 weeks¹⁵. Another US study found that the odds of having a low Apgar score following birth were higher for those born at 37 weeks when compared with 39 weeks (who had the lowest risk for all neonatal outcomes)¹⁶.

Not only is there a relative lack of long-term follow-up studies focusing on behavioural outcomes for children born early term, but many of the existing studies have not collected detailed information on mediating factors such as labour onset or maternal and infant characteristics, making it impossible to interpret findings regarding early term births conditional on this context¹⁷. There is a need to explore the risks that may be associated with early term births (i.e. at weeks 37 and 38) using prospectively collected data with high quality obstetric information^{1,3}. What is broadly lacking is adequate empirical evidence to describe the characteristics of labour onset and the onward longer term developmental

outcomes of children born in this gestational epoch. The aim of this study was to evaluate the long-term behavioural outcomes for infants born early term compared with 39 or more completed weeks of gestation with adjustment for labour onset and infant and family characteristics.

METHODS

Participants

The Western Australian Pregnancy Cohort (Raine) Study recruited 2,900 pregnancies at the State tertiary maternity hospital (King Edward Memorial Hospital; KEMH) between May 1989 and November 1991, with an average gestational age of 18 weeks. The full summary of enrolment methods has been published elsewhere ¹⁸. Participants provided data regarding psychosocial and demographic characteristics at enrolment, which was then updated with further data collection at 34 weeks' gestation. A trained midwife recorded detailed obstetric data from the participants' medical records including the mode of delivery and type of labour onset. Mothers and their children were followed up at ages one, two, three, five, eight, 10, 14 and 17 years with questionnaires and physical assessments. Caregivers of the children provided informed consent at enrolment and again at each follow-up. The protocols for the study were approved by the Human Research Ethics Committees at KEMH and/or Princess Margaret Hospital for Children in Perth, Western Australia.

Attrition bias

We were able to recruit 90% of the eligible women who had been approached to participate in this study. The initial cohort was representative of the KEMH population ¹⁸. Those who

were socially disadvantaged were less likely to remain in the study; however, the sample was found to be comparable to the Western Australian population on various sociodemographic measures at later follow-ups ¹⁹. At the 17-year follow-up, 1,754 study adolescents and their families completed all or part of the follow-up (414 deferred participation, 184 were unable to be traced, 480 had withdrawn and 36 were deceased). This provided a response rate after 17 years of more than 60% of the original sample of 2,868 live born children.

Behavioural problems

The 118 item CBCL for Ages 4-18 (CBCL/4-18) was administered at the five, eight, ten, 14 and 17 year follow-ups and completed by the primary caregiver ²⁰. The Child Behaviour Checklist for Ages 2-3 (CBCL/2-3), a 99-item, empirically validated measure of child behaviour by parent report was used at the two-year follow-up ²¹. The CBCL demonstrated good sensitivity (83% overall) and specificity (67% overall) to a clinical psychiatric diagnosis and good test-retest reliability in a Western Australian clinical calibration ²². The CBCL/4-18 produces a raw score that was transformed into T-scores (standardised by age and sex) for total, internalizing (withdrawal, somatic complaints, anxious/depressed) and externalizing (delinquency, aggression) behaviour as specified by the manual for each of the follow-up years ²⁰. The recommended clinical cutoff scores ($T \geq 60$) were applied to the CBCL T-scores, to obtain three binary variables indicative of borderline clinically significant and clinically significant scores on the total, internalizing and externalizing problem scales ²⁰. Scoring above this cutoff is referred to as 'behavioural morbidity' or 'behavioural problems' in this study.

Preterm Birth

We prospectively calculated the gestational age for each pregnancy in the cohort (N= 2,868). The calculation was based on the date of the mother's last menstrual period unless the estimated age differed from that calculated from the ultrasound biometry by more than seven days, in which case the estimation from the imaging study was used. Gestational age was categorised into a five level variable representing preterm (<34 weeks' gestation), late preterm (34-36 weeks' gestation), 37 weeks' gestation, 38 weeks' gestation and 39 or more completed weeks of gestation. The reference category in our analyses was 39 or more completed weeks of gestation.

Statistical Analyses

Frequency data were compared between gestational age categories and the percentage of children experiencing clinically significant total, internalizing and externalizing behavioural scores were calculated. We restricted our analyses to only include singleton births. We used logistic regression models incorporating generalized estimating equations (GEE; accounting for repeated observations of the same individuals over time) to estimate the odds ratios describing the effect of gestational age on CBCL outcomes at ages two, five, eight, 10, 14 and 17 combined. We examined interaction effects between gender of the child and gestational age and between labour onset and gestational age; however, there were no significant interactions ($p < 0.05$). Our logistic regression model firstly examined univariate relationships, followed by the inclusion of all variables measured during

pregnancy, and finally the inclusion of the peri- and postnatal variables. SPSS 15.0 was used for the analyses ²³.

Control Variables

We adjusted for numerous potential confounders in our models based on variables previously found to be associated with both our predictor and outcome variables. Important factors identified previously include parity, maternal age at conception, education, race, total family income, cigarette smoking, alcohol use, gender of the child and the experience of stressful events, measured using a stressful life events scale ^{24, 25}. These data were all collected from the mother at 18 weeks' gestation, with the exception of child gender. We also adjusted for peri- and postnatal variables including maternal gestational diabetes, hypertensive disorders of pregnancy, Apgar score at five minutes (continuous score used in model), percentage of optimal birthweight ²⁶, length of stay in special care nursery (SCN) and duration of any breast feeding (continuous months). We also adjusted for type of labour onset, which was categorized as either spontaneous (spontaneous and spontaneous following premature rupture of membranes (PROM)) or induced/Caesarean section (CS) (elective CS, non-elective CS after PROM, induced following artificial rupture of membranes, and induced following PROM).

RESULTS

After restricting our analyses to only include singleton children, gestational age data were available for 2,796 live births from the original cohort of 2,868 live born children. Approximately two thirds of our sample were born at 39 weeks' gestation or later (66%,

n=1,850), with 451 (16%) children born at 38 weeks' gestation and 238 (8.5%) born at 37 weeks' gestation. There were 171 (6%) children born late preterm at 34-36 weeks' gestation and 86 (3%) born at less than 34 weeks of completed gestation.

There was a significant linear by linear association between a diagnosis of hypertensive diseases of pregnancy (gestational hypertension and preeclampsia) or gestational diabetes and a lower gestational age (Table 1). The maternal experience of a higher number of stressful life events was linked to earlier birth and infants born earlier were more likely to have a lower Apgar score at 5 minutes. Infants who were born following an induced labour or elective Caesarean section (CS) were also more likely to have a lower gestational age than those born following spontaneous labour onset. Infants born at less than 34 and between 34 and 36 weeks were more likely to be admitted to the special care nursery for a longer duration than infants born at 37 weeks' gestation or later.

The number and percentage of study children with total, internalizing and externalizing behavioural problems within each gestational age category at each follow-up is presented in Table 2 and the percentages for total morbidity ($T \geq 60$) at each follow-up are graphed in Figure 1. In early to middle childhood, the rates of overall behavioural problems were highest in those born at less than 34 weeks' gestation, with 37.5% of children born at <34 weeks' gestation having a behavioural problem at age five and 35.2% having a behavioural problem at age eight. Among the children born at 37 weeks' gestation, 22.7%, 21.6% and 21.2% had clinically significant behavioural problems at five, eight and ten years of age respectively. Children born at 37 weeks' gestation had the highest rates of behavioural

problems of all gestational age categories at age 14 (19%) and 17 (12%) years (Table 2; Figure 1).

In the logistic regression models implemented through GEE we found that being born prior to 34 weeks' completed gestation was significantly associated with a higher risk for total and internalizing problems from the age of 2-17 years in our unadjusted models when compared with infants born at 39 or more completed weeks of gestation (Table 3). This effect was significant in the partially adjusted model for total and externalizing problems; however, it was no longer statistically significant ($p < 0.05$) following the inclusion of all variables, including length of admission to the special care nursery, into the model. For those children born in the late preterm period (34-36 weeks), there was no significant increased risk for later behavioural problems, and the effect size was largely unchanged following adjustment from Model 1 to Model 2, which included obstetric and perinatal factors. Infants born at 37 weeks' were at an increased risk for total [OR=1.43, 95%CI= 1.02, 2.01, two-tailed $p=0.040$] and externalizing [OR=1.42, 95%CI= 1.01, 2.01, two-tailed $p=0.045$] problems in our fully adjusted models compared with those born at 39 or more weeks' gestation. There were no significant differences in risk for behavioural problems observed between those born at 38 weeks' and those born at 39 or more weeks' gestation over the 15 years of follow-up.

DISCUSSION

Despite infants born at early term gestation being considered 'term', the long-term behavioural outcomes for these children have been severely under-researched. We have

conducted a 17-year longitudinal behavioural follow-up of children using prospectively collected data on gestational age and with the ability to adjust for obstetric risk factors and the type of labour onset. We found that children born at 37 weeks' gestation had a close to one and a half times higher odds ratio for clinically significant total and externalizing CBCL scores (indicating behavioural morbidity) across childhood and adolescence compared with those born at 39 or more weeks' gestation. We did not find that children born late preterm (34-36 weeks) were at a significantly increased risk for behavioural problems from age 2-17 years compared with those born at 39 or more weeks' gestation, nor did we find an increased risk for children born at 38 weeks' gestation. Infants born at less than 34 completed weeks of gestation had an increased odds ratio of around two times the risk for total, internalizing and externalizing problems than infants born at 39 or more weeks' gestation, although this relationship was not significant following adjustment and our sample size was small.

These data support three recent editorials suggesting the accepted definition of 37 weeks' gestation as 'low risk' may not be the most appropriate cutoff ^{5, 7, 27}. A further study concluded the period of time between 37 and 41 weeks' gestation was less homogenous than is presumed by the accepted definition of 'term' ³. While there is an accumulating number of rigorous studies that have examined the long-term outcomes for preterm children, very little research examining long-term behavioural outcomes for early term children has been published ²⁸. In addition, many studies examining long-term risks have demarcated risk at less than 37 weeks' gestation with the use of binary or categorical variables ⁴, preventing analysis of outcomes for those infants born at 37 or 38 weeks'

gestation ². Our results show that there is a significantly higher risk for behavioural problems for those children born at 37 weeks' gestation when compared with those born at 39 weeks or later. The only other study of which we are aware to have investigated the behavioural outcomes of children born at 37 weeks' gestation found they had an increased risk for being prescribed ADHD medication during childhood ⁸.

Contributing to the importance of the current findings is our adjustment for multiple potential confounders and the relatively long duration of follow-up. Type of labour onset (spontaneous or induced/elective CS), obstetric complications, duration of breast feeding, length of admission to the special care nursery, gender, and multiple sociodemographic factors are of relevance to both timing of birth and later behavioural outcomes ²⁸. We do acknowledge that despite our efforts to account for early life factors that may be associated with both gestational age and child behaviour, there are potentially other factors later in childhood that remain unmeasured and unaccounted for in this study that may have influenced our results, for example, parenting ²⁹, life stress ³⁰ and family functioning ³¹.

Contrary to expectations, our results showed that late preterm infants were at no greater risk for behavioural problems from age 2-17 years compared with those born at 39 or more weeks' gestation. This was even more surprising considering our significant results for infants born at 37 weeks' gestation. It remains possible that obstetric factors leading to intervention at 37 weeks' gestation, beyond those that we could measure, may have contributed to poorer outcomes. We were able to allow for the potential confounding effects of gestational diabetes and hypertensive disorders and the duration of special care

nursery admission, but there may have been other factors that led to intervention and that were evident to the obstetricians and women but could not be captured by general review of the medical records. Previous studies have found that late preterm infants born at low birthweight were at an increased risk for behavioural problems by the age of eight years ³², though it is notable that the few neurobehavioural studies in this area have mostly evaluated risk in early childhood only ³³. Another possible explanation for the current finding is that late preterm children may be more likely to receive behavioural support through therapeutic intervention or adaptive parenting styles, given the widespread public knowledge that preterm children are more likely to experience behavioural and learning problems, together with their more salient risk profile (e.g. in our study 44% of late preterm infants spent at least one day in the special care nursery following birth) ³⁴.

A major strength of our study was the use of longitudinal data collected over the course of 17 years, from pregnancy to the beginning of adulthood with adjustment for important potential confounding and mediating variables (including gender and labour onset). Furthermore we were able to categorise gestational age without the use of binary or broad classifications of ‘term’ pregnancy. The use of the same valid and reliable behavioural measure (Child Behaviour Checklist; CBCL) at six different time points throughout childhood and adolescence reduced the chance of measurement error ³⁵. Although logistic regression models are robust despite small sample sizes, our sample sizes within the analyses were small for some of the gestational age groups (e.g. <34 weeks’ gestation). The observational nature of this study only permits speculation as to the mechanisms explaining

our results; however, the heterogeneity of the reasons for preterm birth makes the development of randomised controlled trial in this area extremely difficult ³⁶.

The clinical and social implications of these results are considerable given 37 weeks' gestation is currently considered term and therefore 'low risk' ¹⁷. Early term induction tripled in frequency from 1991-2006 in the US and was most prevalent in non-Hispanic white women even after controlling for demographic and medical risk factors ⁶. There are suggestions that increases in labour induction rates for early term deliveries exceed the rates that would be expected due to improved ultrasound dating or increased rates of direct and indirect obstetric complications (e.g. maternal obesity), indicating physician or patient-determined factors may be responsible ³⁷. However changes in the rates of obstetric intervention leading to preterm or early term birth are also influenced by a higher rate of multiple births due to assisted reproductive technology, delayed childbearing, better surveillance of pregnancy, and advances in the prevention of stillbirths and fetal distress ¹⁷. Prolonging delivery in this context holds the potential for devastating consequences, for example eclampsia, fetal compromise or stillbirth, therefore the obstetric provider often must weigh the risks and benefits of early delivery versus expectant management of the patient ⁴. It should be noted that while the rates of late preterm and early term births have increased, there has been a substantial concurrent decrease in the rates of stillbirth and neonatal mortality ³⁸.

Conclusion

In summary the current study found that children born at 37 weeks' gestation are at increased risk for behavioural problems from age two to 17 years when compared with children born at 39 weeks' gestation or more. These results suggest the clinical practice of demarcating risk at 37 weeks' gestation based on a strict definition of term gestation may be inviting intervention at too early a gestational age, resulting in unintended consequences for long-term child and adolescent mental health.

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References

- 1 Fleischman AR, Oinuma M, Clark SL. Rethinking the Definition of "Term Pregnancy". *Obstetrics and Gynecology*. 2010; **116**: 136-9.
- 2 Moster D, Lie RT, Markestad T. Long-term medical and social consequences of preterm birth. *N. Engl. J. Med.* 2008; **359**: 262-73.
- 3 Reddy UM, Bettgowda VR, Dias T, *et al.* Term pregnancy: a period of heterogeneous risk for infant mortality. *Obstet. Gynecol.* 2011; **117**: 1279-87.
- 4 Zhang X, Kramer MS. Variations in Mortality and Morbidity by Gestational Age among Infants Born at Term. *Journal of Pediatrics*. 2009; **154**: 358-62.
- 5 Clark SL, Fleischman AR. Term pregnancy: time for a redefinition. *Clin. Perinatol.* 2011; **38**: 557-64.
- 6 Murthy K, Grobman WA, Lee TA, Holl JL. Trends in induction of labor at early-term gestation. *Am. J. Obstet. Gynecol.* 2011; **204**.
- 7 Kirby RS, Wingate MS. Late preterm birth and neonatal outcome: is 37 weeks' gestation a threshold level or a road marker on the highway of perinatal risk? *Birth*. 2010; **37**: 169-71.
- 8 Lindstrom K, Lindblad F, Hjern A. Preterm birth and Attention-Deficit/Hyperactivity Disorder in schoolchildren. *Pediatrics*. 2011; **127**: 858-65.
- 9 Yang S, Fombonne E, Kramer MS. Duration of gestation, size at birth and later childhood behaviour. *Paediatric and Perinatal Epidemiology*. 2011; **25**: 377-87.
- 10 Phua DY, Rifkin-Graboi A, Saw SM, *et al.* Executive functions of six-year-old boys with normal birth weight and gestational age. *PLoS One*. 2012; **7**: e36502.
- 11 Yang S, Platt RW, Kramer MS. Variation in child cognitive ability by week of gestation among healthy term births. *American Journal of Epidemiology*. 2010; **171**: 399-406.
- 12 Noble KG, Fifer WP, Rauh VA, *et al.* Academic Achievement Varies With Gestational Age Among Children Born at Term. *Pediatrics*. 2012.
- 13 Yang S, Bergvall N, Chattingius S, Kramer MS. Gestational age differences in health and development among young Swedish men born at term. *International Journal of Epidemiology*. 2010; **39**: 1240-9.
- 14 Guasch XD, Torrent FR, Martinez-Nadal S, *et al.* Late preterm infants: A population at underestimated risk. *An. Pediatr.* 2009; **71**: 291-8.
- 15 Shapiro-Mendoza CK, Tomashek KM, Kotelchuck M, *et al.* Effect of late-preterm birth and maternal medical conditions on newborn morbidity risk. *Pediatrics*. 2008; **121**: E223-E32.
- 16 Cheng YW, Nicholson JM, Nakagawa S, *et al.* Perinatal outcomes in low-risk term pregnancies: do they differ by week of gestation? *Am. J. Obstet. Gynecol.* 2008; **199**.
- 17 Kramer MS. Late Preterm Birth: Appreciable Risks, Rising Incidence. *Journal of Pediatrics*. 2009; **154**: 159-60.
- 18 Newnham JP, Evans SF, Michael CA, *et al.* Effects of frequent ultrasound during pregnancy: A randomised controlled trial. *Lancet*. 1993; **342**: 887-91.
- 19 Robinson M, Mattes E, Oddy WH, *et al.* Prenatal stress and risk of behavioural morbidity from age two to 14 years: The influence of the number, type and timing of stressful life events. *Development and Psychopathology*. 2011; **23**: 507-20.

- 20 Achenbach TM, Manual for the Child Behavior Checklist/4-18 and 1991 Profile Burlington: University of Vermont, Department of Psychiatry; 1991.
- 21 Achenbach TM, Edelbrock C, Howell CT. Empirically based assessment of the behavioural/emotional problems of 2- and 3-year-old children. *Journal of Abnormal Child Psychology*. 1987; **15**: 629-50.
- 22 Zubrick S, Silburn S, Gurrin L, *et al.* Western Australian Child Health Survey: education, health and competence Perth, Western Australia: Australian Bureau of Statistics and the Telethon Institute for Child Health Research (ISBN 0 642 17239 0); 1997.
- 23 SPSS Inc. SPSS 15.0 for Windows Chicago; 2006.
- 24 Tennant C, Andrews G. A scale to measure the stress of life events. *Australian and New Zealand Journal of Psychiatry*. 1976; **10**: 27-32.
- 25 Savitz DA, Dole N, Herring AH, *et al.* Should spontaneous and medically indicated preterm births be separated for studying aetiology? *Paediatr. Perinat. Epidemiol.* 2005; **19**: 97-105.
- 26 Blair E, Liu Y, de Klerk N, Lawrence D. Optimal fetal growth for the Caucasian singleton and assessment of appropriateness of fetal growth: An analysis of a total population perinatal database. *BMC Pediatrics*. 2005; **5**: 13.
- 27 Osrin D. The implications of late-preterm birth for global child survival. *Int. J. Epidemiol.* 2010; **39**: 645-9.
- 28 Gouyon JB, Vintejoux A, Sagot P, *et al.* Neonatal outcome associated with singleton birth at 34-41 weeks of gestation. *International Journal of Epidemiology*. 2010; **39**: 769-76.
- 29 Miller-Lewis LR, Baghurst PA, Sawyer MG, *et al.* Early childhood externalising behaviour problems: Child, parenting, and family-related predictors over time. *Journal of Abnormal Child Psychology*. 2006; **34**: 891-906.
- 30 Melchior M, Moffitt TE, Milne BJ, *et al.* Why do children from socioeconomically disadvantaged families suffer from poor health when they reach adulthood? A life-course study. *American Journal of Epidemiology*. 2007; **166**: 966-74.
- 31 Robinson M, Kendall GE, Jacoby P, *et al.* Lifestyle and demographic correlates of poor mental health in early adolescence. *Journal of Paediatrics and Child Health*. 2011; **47**: 54-61.
- 32 Gray RF, Indurkha A, McCormick MC. Prevalence, stability, and predictors of clinically significant behavior problems in low birth weight children at 3, 5, and 8 years of age. *Pediatrics*. 2004; **114**: 736-43.
- 33 Woythaler MA, McCormick MC, Smith VC. Late Preterm Infants Have Worse 24-Month Neurodevelopmental Outcomes Than Term Infants. *Pediatrics*. 2011; **127**: E622-E9.
- 34 Pulver LS, Denney JM, Silver RM, Young PC. Morbidity and discharge timing of late preterm newborns. *Clinical Pediatrics*. 2010; **49**: 1061-7.
- 35 Warnick EM, Bracken MB, Kasl S. Screening efficiency of the Child Behavior Checklist and Strengths and Difficulties Questionnaire: A systematic review. *Child and Adolescent Mental Health* 2008; **13**: 140-7.
- 36 Chauhan SP. Late preterm births: irreducible because $E = mc^2$. *Am. J. Obstet. Gynecol.* 2011; **204**: 459-60.

- 37 Reddy UM, Ko C-W, Raju TNK, Willinger M. Delivery Indications at Late-Preterm Gestations and Infant Mortality Rates in the United States. *Pediatrics*. 2009; **124**: 234-40.
- 38 Ananth CV, Gyamfi C, Jain L. Characterizing risk profiles of infants who are delivered at late preterm gestations: does it matter? *Am. J. Obstet. Gynecol*. 2008; **199**: 329-31.

None	2032	67.9	69.8	69.7	76.9	73.2	
1+ daily	745	32.1	30.2	30.3	23.1	26.8	
Alcohol intake in pregnancy							<i>0.120</i>
None	1507	60.3	56.2	60.9	58.1	52.1	
Once/week	651	15.4	19.5	23.1	20.0	25.1	
2-6 times/week	498	15.4	20.1	12.2	19.1	18.3	
Daily +	119	9.0	4.1	3.8	2.9	4.5	
Stress Events in Pregnancy							<i>0.013</i>
None	550	11.4	18.5	20.3	20.0	23.2	
1-2 events	1018	34.3	40.7	42.0	42.8	40.3	
3+ events	928	54.3	40.7	37.7	37.1	36.5	
Hypertensive Diseases							<i><0.001</i>
None	2163	67.9	63.3	73.1	77.4	80.4	
Gestational Hypertension	537	10.3	27.2	22.7	19.3	18.6	
Preeclampsia	77	21.8	9.5	4.2	3.3	1.0	
Gestational Diabetes							<i>0.026</i>
No	2741	97.7	95.9	97.1	97.6	98.5	
Yes	55	2.3	4.1	2.9	2.4	1.5	
Apgar score at 5 minutes							<i><0.001</i>
Critically low (0-3)	2	1.4	-	0.4	-	-	
Fairly low (4-7)	110	31.5	10.1	3.4	1.1	3.1	
Generally normal (8-10)	2648	67.1	89.9	96.2	98.9	96.9	
Length of stay in SCN							<i><0.001</i>
No stay	2482	10.5	56.1	86.6	92.0	94.9	
<=1 week	203	7.0	27.5	12.2	7.5	4.7	
1-4 weeks	67	34.9	14.6	1.3	0.4	0.4	
>4 weeks	44	47.7	1.8	-	-	-	

Breast feeding duration								<i>0.001</i>
	< 6 months	1129	65.1	52.4	49.0	49.9	45.9	
	≥6 months	1239	34.9	47.6	51.0	50.1	54.1	
Labour Onset								<i><0.001</i>
	Induced or elective Cesarean	1231	49.4	67.5	59.7	55.2	37.5	
	Section	1540	50.6	32.5	40.3	44.8	62.5	
	Spontaneous							

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^aSingleton births only, missing data not shown, row percentages for each variable presented. p-value refers to linear by linear association determined by chi square test.

Table 2: Number and percentage of participants with total, internalizing (int) and externalizing (ext) behavioural problems at each follow-up according to gestational age*

	Year 2 Problems			Year 5 Problems			Year 8 Problems			Year 10 Problems			Year 14 Problems			Year 17 Problems		
	n (%)			n (%)			n (%)			n (%)			n (%)			n (%)		
	N=1948			N=2122			N=2035			N=1974			N=1742			N=1370		
	Total	Int	Ext	Total	Int	Ext	Total	Int	Ext	Total	Int	Ext	Total	Int	Ext	Total	Int	Ext
<34 weeks	10 (22.2)	7 (15.6)	11 (24.4)	21 (37.5)	15 (26.8)	16 (28.6)	19 (35.2)	17 (31.5)	12 (22.2)	11 (21.2)	11 (21.2)	6 (11.5)	7 (14.9)	8 (17.0)	8 (17.0)	3 (9.4)	4 (12.5)	3 (9.4)
34-36 weeks	25 (21.7)	12 (10.4)	24 (20.9)	26 (19.4)	26 (19.4)	27 (20.1)	28 (23.0)	23 (18.9)	22 (18.0)	24 (19.5)	25 (20.3)	17 (13.8)	10 (9.4)	12 (11.3)	11 (10.4)	6 (7.0)	8 (9.3)	6 (7.0)
37 weeks	18 (11.8)	19 (12.4)	19 (12.4)	40 (22.7)	29 (16.5)	43 (24.4)	35 (21.6)	29 (17.9)	31 (19.1)	33 (21.2)	39 (25.0)	28 (17.9)	27 (19.0)	16 (11.3)	30 (21.1)	13 (12.4)	14 (13.3)	12 (11.4)
38 weeks	28 (9.5)	29 (9.8)	31 (10.5)	57 (17.6)	48 (14.9)	56 (17.3)	47 (14.9)	56 (17.7)	50 (15.8)	39 (13.0)	47 (15.6)	31 (10.3)	39 (14.8)	39 (14.8)	42 (15.9)	14 (6.7)	18 (8.6)	14 (6.7)
39+ weeks	143 (10.7)	99 (7.4)	173 (12.9)	307 (21.4)	264 (18.4)	289 (20.2)	263 (19.0)	269 (19.5)	253 (18.3)	190 (14.2)	227 (16.9)	166 (12.4)	161 (13.6)	145 (12.3)	179 (15.1)	100 (10.7)	103 (11.0)	121 (12.9)

* Percentages represent those participants with behavioural problems compared with those without behavioural problems at each follow-up, singletons only

Figure 1: Percentages of participants scoring above the clinical cut-point for total CBCL morbidity ($T \geq 60$) at each follow-up by gestational age with standard error bars.

Table 3: Adjusted logistic regression analysis showing effect of increasing gestational age on clinically significant CBCL T-scores (binary indicator, $T \geq 60$) for total, internalizing and externalizing behaviour for ages 2-17 years

CBCL Morbidity	Gestational Age				
	<34 weeks	34-36 weeks	37 weeks	38 weeks	39+ weeks
Total					
Unadjusted OR	1.88**	1.22	1.26	0.84	reference
(95% CI)[†]	[1.24, 2.83]	[0.88, 1.69]	[0.96, 1.66]	[0.67, 1.06]	
<i>p</i>	<i>0.003</i>	<i>0.226</i>	<i>0.099</i>	<i>0.138</i>	
Model 1 OR	2.66**	1.25	1.44*	1.02	reference
(95% CI)[†]	[1.45, 4.85]	[0.86, 1.82]	[1.05, 1.98]	[0.79, 1.31]	
<i>p</i>	<i>0.002</i>	<i>0.238</i>	<i>0.025</i>	<i>0.891</i>	
Model 2 OR	2.15	1.23	1.43*	1.00	reference
(95% CI)[†]	[0.69, 6.71]	[0.78, 1.93]	[1.02, 2.01]	[0.77, 1.30]	
<i>p</i>	<i>0.187</i>	<i>0.378</i>	<i>0.040</i>	<i>0.979</i>	
Internalizing					
Unadjusted OR	1.62*	1.11	1.17	0.96	reference
(95% CI)[†]	[1.07, 2.45]	[0.81, 1.53]	[0.89, 1.55]	[0.77, 1.19]	
<i>p</i>	<i>0.023</i>	<i>0.516</i>	<i>0.261</i>	<i>0.686</i>	
Model 1 OR	1.88	1.06	1.20	1.11	reference
(95% CI)[†]	[0.95, 3.71]	[0.74, 1.52]	[0.88, 1.64]	[0.88, 1.41]	
<i>p</i>	<i>0.069</i>	<i>0.756</i>	<i>0.247</i>	<i>0.380</i>	
Model 2 OR	1.98	1.18	1.18	1.15	reference
(95% CI)[†]	[0.55, 7.16]	[0.77, 1.80]	[0.85, 1.64]	[0.90, 1.47]	
<i>p</i>	<i>0.297</i>	<i>0.462</i>	<i>0.330</i>	<i>0.266</i>	
Externalizing					
Unadjusted OR	1.38	1.07	1.17	0.82	reference

	(95% CI) [†]	[0.92, 2.09]	[0.77, 1.50]	[0.88, 1.56]	[0.65, 1.03]	
	<i>p</i>	0.124	0.685	0.282	0.083	
Model 1 OR	2.01*	1.21	1.44*	1.03	reference	
	(95% CI) [†]	[1.08, 3.73]	[0.85, 1.72]	[1.04, 1.99]	[0.81, 1.32]	
	<i>p</i>	0.027	0.298	0.027	0.794	
Model 2 OR	1.74	1.25	1.42*	1.04	reference	
	(95% CI) [†]	[0.64, 4.71]	[0.82, 1.92]	[1.01, 2.01]	[0.81, 1.34]	
	<i>p</i>	0.278	0.297	0.045	0.765	

* significant at $p < 0.05$ ** significant at $p < 0.005$ [†]odds ratio and 95% confidence intervals

Model 1 adjusted for maternal smoking in pregnancy, maternal alcohol intake at 18 weeks, maternal age at conception, maternal education at pregnancy, parity, total family income, maternal race, number of stressful life events during pregnancy and gender

Model 2 adjusted for Model 1 plus diagnoses of gestational diabetes and hypertensive disorders of pregnancy, percentage of optimal birthweight, Apgar score at 5 minutes, length of stay in SCN, duration of breast feeding and type of labour onset