Planned Birth Before 39 Weeks and Child Development: A Population-Based Study

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abstract

OBJECTIVE: To investigate the association of gestational age and mode of birth with early child development.

METHODS: Population-based record linkage cohort study was conducted among 153 730 live-born infants of ≥32 weeks' gestation with developmental assessments at school age, in New South Wales, Australia, 2002 to 2007. Children were assessed in 5 domains: physical health and well-being, language and cognition, social competence, emotional maturity, and general knowledge and communication. Children scoring in the bottom 10% of national domains were considered developmentally vulnerable, and children developmentally vulnerable for ≥2 domains were classified as developmentally high risk (DHR), the primary outcome. Robust multivariable Poisson models were used to obtain individual and combined adjusted relative risks (aRRs) of gestational age and mode of birth for DHR children.

RESULTS: Overall, 9.6% of children were DHR. The aRR (95% confidence interval) of being DHR increased with decreasing gestational age (referent: 40 weeks); 32 to 33 weeks 1.25 (1.08–1.44), 34 to 36 weeks 1.26 (1.18–1.34), 37 weeks 1.17 (1.10–1.25), 38 weeks 1.06 (1.01–1.10), 39 weeks 0.98 (0.94–1.02), ≥41 weeks 0.99 (0.94–1.03), and for labor induction or prelabor cesarean delivery (planned birth; referent: vaginal birth after spontaneous labor), 1.07 (1.04–1.11). The combined aRR for planned birth was 1.26 (1.18–1.34) at 37 weeks and 1.13 (1.08–1.19) at 38 weeks.

CONCLUSIONS: Early (at <39 weeks) planned birth is associated with an elevated risk of poor child development at school age. The timing of planned birth is modifiable, and strategies to inform more judicious decision-making are needed to ensure optimal child health and development.

WHAT'S KNOWN ON THIS SUBJECT: Fetal brain development accelerates after 32 weeks' gestation, and children born before 39 weeks have elevated risk of poor development. Internationally, modal gestational age has decreased due to increasing numbers of planned births (prelabor cesarean delivery and labor induction).

WHAT THIS STUDY ADDS: Poor child development is exacerbated by early planned birth. This timing is potentially modifiable, and benefits of waiting should be communicated to clinicians, mothers, and families, and strategies should be developed to inform more judicious clinical decision-making.

Fetal growth and development is a continuum, with the optimal time of birth at 39 to 40 weeks' gestation. Fetal brain development accelerates rapidly in the later stages of pregnancy from 32 weeks' gestation, making it vulnerable to disruption from shortened gestation.[1,2] There is growing evidence that, in addition to preterm birth (≤37 weeks' gestation), infants born early term (37–38 weeks) have a greater risk of neurodevelopmental impairment or poor school performance compared with infants born at the optimal time.[3–7] Early childhood development is also important for future educational achievement, health, and well-being,[8] with 11% to 17% of children aged 4 to 6 years considered to be developmentally high risk (DHR) by school age.[9–12]

Gestational age at birth arises after the spontaneous onset of labor or is determined by a clinical decision that birth should occur. In the latter case, these planned births are performed by induction of labor or prelabor cesarean delivery. Internationally, significant changes in clinical practice have seen an increase in planned births before 39 to 40 completed weeks' gestation, particularly at 37 to 38 weeks, and a decrease in modal gestational age from 40 to 39 weeks.[13–17] This "left-shift" in gestational age has been attributed to increasing primary and repeat cesarean delivery, greater use of labor induction, and the clinical perception that birth just before the optimal date carries little significant morbidity.[17,18] If poorer neurodevelopmental outcomes are a possible consequence of early planned birth, and waiting is at all possible, then there is an urgent need to inform clinicians, mothers, and families to ensure judicious decision-making in curtailing pregnancy.

To date, there has been no investigation of the potential impact of early planned birth on child development, specifically the contribution of mode of birth. This study used record linkage of population birth, hospital, and development data to investigate the association of gestational age and mode of birth with development at school age.

METHODS

Study Population and Data Sources

The study population included all live births from 32 weeks' gestation between 2002 and 2007 in New South Wales (NSW), Australia. The study cohort consisted of births that subsequently had measures of early development in their first year of full-time school in 2009 or 2012.

Birth records for 2002 to 2007 were obtained from the NSW Perinatal Data Collection, a population-based statutory surveillance system that includes all live births and stillbirths of ≥20 weeks' gestation or ≥400 g birth weight if gestational age is unknown. The birth record captures information on maternal characteristics, pregnancy, labor and delivery factors, and infant outcomes. Maternal and infant hospital admission records were obtained from the NSW Admitted Patient Data Collection and used to supplement information recorded at the time of birth. Admission records include demographic, facility, diagnosis, and procedure information for every inpatient admitted to any public or private hospital in NSW. Development for children in their first year of full-time school (aged 4–6 years) was ascertained from the Australian Early Development Census (AEDC) developmental assessment instrument.[19] The AEDC is a triennial census that was first implemented in 2009. The AEDC is the Australian adaptation of the Canadian Early Development Index.[20] Teachers assess and record information on nearly 100 characteristics for each child, which are then combined and aggregated to calculate scores

for 5 domains and 16 subdomains. AEDC records for 2009 and 2012 were available for this study. Birth, hospital, and development records for individuals were probabilistically linked by the NSW Centre for Health Record Linkage.[21] The study was approved by the NSW Population and Health Services Research Ethics Committee (reference number 2012-12-430).

Gestational Age and Mode of Birth

The study exposures of interest were gestational age and mode of birth, which are reliably reported in birth data.[22] Gestational age, reported in completed weeks as determined by the best clinical estimate including early ultrasound and last menstrual period, was categorized as 32 to 33, 34 to 36, 37, 38, 39, 40 (referent), and ≥41 weeks. Mode of birth (vaginal birth or cesarean delivery) and onset of labor (spontaneous, labor induction, or prelabor cesarean section) were combined to create 5 mutually exclusive groups, with vaginal birth after spontaneous labor as the referent group. Planned births (labor induction or prelabor cesarean delivery) were also classified and compared with infants born after spontaneous labor.

Early Childhood Development

The AEDC instrument assesses development in 5 main domains: physical health and well-being, language and cognitive skills, social competence, emotional maturity, and communication skills and general knowledge.[23] Each domain contains a number of related but distinct developmental subdomains. The AEDC instrument has been through extensive development and testing and shown to be reliable and valid.[24–26] For each domain and subdomain, children scoring in the bottom 10% nationally were considered developmentally vulnerable (DV) for the corresponding aspect of development.[27] Children identified

TABLE 1 Birth and Child Assessment Characteristics by DHR Status, NSW 2009 and 2012

| | | DHR[a] | |
| | | Yes | No |
	N (Column %[b])	n (Row %)	n (Row %)
Total	153 359 (100.0)	14 654 (9.6)	138 705 (90.4)
Gestational age, wk			
32–33	1235 (0.8)	163 (13.2)	1072 (86.8)
34–36	7348 (4.8)	963 (13.1)	6385 (86.9)
37	8857 (5.8)	1021 (11.5)	7836 (88.5)
38	25 608 (16.7)	2486 (9.7)	23 122 (90.3)
39	37 951 (24.7)	3372 (8.9)	34 579 (91.1)
40	44 832 (29.2)	4078 (9.1)	40 754 (90.9)
≥41	27 528 (18.0)	2571 (9.3)	24 957 (90.7)
Mode of birth			
Spontaneous onset of labor, vaginal birth	78 925 (51.5)	7848 (9.9)	71 077 (90.1)
Spontaneous onset of labor, cesarean delivery	10 957 (7.1)	1029 (9.4)	9928 (90.6)
Induction of labor, vaginal birth	31 085 (20.3)	2892 (9.3)	28 193 (90.7)
Induction of labor, cesarean delivery	7210 (4.7)	683 (9.5)	6527 (90.5)
Prelabor cesarean delivery	25 182 (16.4)	2202 (8.7)	22 980 (91.3)
Maternal age groups, y			
<20	5739 (3.7)	1120 (19.5)	4619 (80.5)
20–24	21 625 (14.1)	3136 (14.5)	18 489 (85.5)
25–29	42 120 (27.5)	3885 (9.2)	38 235 (90.8)
30–34	51 940 (33.9)	3859 (7.4)	48 081 (92.6)
35–39	26 505 (17.3)	2122 (8.0)	24 383 (92.0)
≥40	5419 (3.5)	531 (9.8)	4888 (90.2)
Married including de facto			
No	23 932 (15.6)	3888 (16.2)	20 044 (83.8)
Yes	127 779 (83.3)	10 597 (8.3)	117 182 (91.7)
Unknown	1648 (1.1)	169 (10.3)	1479 (89.7)
Mother Australian born			
No	40 514 (26.4)	4290 (10.6)	36 224 (89.4)
Yes	112 749 (73.5)	10 356 (9.2)	102 393 (90.8)
Private obstetric care			
No	100 397 (65.5)	11 851 (11.8)	88 546 (88.2)
Yes	52 258 (34.1)	2737 (5.2)	49 521 (94.8)
Unknown	704 (0.5)	66 (9.4)	638 (90.6)
Socioeconomic quintile at birth			
1 (least disadvantaged)	29 837 (19.5)	1599 (5.4)	28 238 (94.6)
2	29 394 (19.2)	2299 (7.8)	27 095 (92.2)
3	30 933 (20.2)	2962 (9.6)	27 971 (90.4)
4	29 280 (19.1)	3215 (11.0)	26 065 (89.0)
5 (most disadvantaged)	33 521 (21.9)	4545 (13.6)	28 976 (86.4)
Smoking during pregnancy			
No	129 516 (84.5)	10 475 (8.1)	119 041 (91.9)
Yes	23 841 (15.5)	4179 (17.5)	19 662 (82.5)
Any hypertension			
No	138 968 (90.6)	13 161 (9.5)	125 807 (90.5)
Yes	14 391 (9.4)	1493 (10.4)	12 898 (89.6)
Any diabetes			
No	143 879 (93.8)	13 604 (9.5)	130 275 (90.5)
Yes	9480 (6.2)	1050 (11.1)	8430 (88.9)
Parity			
0	63 489 (41.4)	5505 (8.7)	57 984 (91.3)
1	52 761 (34.4)	4389 (8.3)	48 372 (91.7)
≥2	36 983 (24.1)	4745 (12.8)	32 238 (87.2)
Antenatal care <20 wk			
No	15 636 (10.2)	2379 (15.2)	13 257 (84.8)
Yes	135 951 (88.6)	12 005 (8.8)	123 946 (91.2)
Unknown	1772 (1.2)	270 (15.2)	1502 (84.8)
Plurality			
Singleton	149 144 (97.3)	14 206 (9.5)	134 938 (90.5)

as having special needs or aged <4 years were not assigned a domain category. The primary study outcome was children who were DHR, defined as being DV on ≥2 of the 5 main domains.[23] DV for selected domains and subdomains was considered a priori as separate secondary study outcomes and included the physical health and well-being domain, the language and cognitive development domain, and the gross and fine motor skills, basic literacy, and basic numeracy subdomains.

Confounders

We considered a number of possible confounders of the association between developmental outcomes and gestational age and mode of birth. These included, from birth records, maternal age, parity, timing of first antenatal visit, plurality, small for gestational age,[28] 5-minute Apgar score <7, sex, and socioeconomic status[29]; from birth and hospital records, maternal diabetes or hypertension, smoking during pregnancy, maternal country of birth, and private obstetric care; from hospital records, marital status at birth and major congenital conditions; and from development records, age at assessment, assessment year, and English as a second language. (See Table 1 for categorizations.)

Statistical Analysis

Gestational age, mode of birth, developmental outcomes, and confounders were described in contingency tables. Multivariable logistic regression with progressive backward elimination was used to construct a model for each of the developmental outcomes, with gestational age and mode of birth adjusted for potential confounders. Variables were retained if they were significant at $P < .05$ or if they were confounders based on a change in the adjusted associations of ≥10%. Once final models were determined,

TABLE 1 Continued

| | | DHR[a] | |
| | | Yes | No |
	N (Column %[b])	n (Row %)	n (Row %)
Multiple	4215 (2.7)	448 (10.6)	3767 (89.4)
Small for gestational age			
No	137 987 (90.0)	12 546 (9.1)	125 441 (90.9)
Yes	15 301 (10.0)	2102 (13.7)	13 199 (86.3)
5 min Apgar score <7			
No	151 469 (98.8)	14 418 (9.5)	137 051 (90.5)
Yes	1543 (1.0)	187 (12.1)	1356 (87.9)
Major congenital conditions			
No	147 963 (96.5)	14 078 (9.5)	133 885 (90.5)
Yes	5396 (3.5)	576 (10.7)	4820 (89.3)
Sex			
Male	77 626 (50.6)	10 196 (13.1)	67 430 (86.9)
Female	75 725 (49.4)	4458 (5.9)	71 267 (94.1)
Age at assessment, y/mo			
<5	12 301 (8.0)	1691 (13.7)	10 610 (86.3)
5 to 5/5	61 844 (40.3)	6661 (10.8)	55 183 (89.2)
5/6 to 5/11	65 595 (42.8)	4992 (7.6)	60 603 (92.4)
≥6	13 619 (8.9)	1310 (9.6)	12 309 (90.4)
English as a second language			
No	128 175 (83.6)	11 111 (8.7)	117 064 (91.3)
Yes	25 184 (16.4)	3543 (14.1)	21 641 (85.9)
Year of assessment			
2009	73 090 (47.7)	7316 (10.0)	65 774 (90.0)
2012	80 269 (52.3)	7338 (9.1)	72 931 (90.9)

[a] DV on ≥2 domains.

[b] Column percentages may not add to 100% because of missing data.

robust Poisson generalized estimating equations with a log-link and exchangeable correlation were used to estimate adjusted relative risks (aRRs) and to account for the similarity of children assessed by the same teacher. Individual and combined adjusted associations for gestational age and by mode of birth or planned birth were calculated. To address confounding by indication for early planned birth, we repeated the analysis for low-risk pregnancies, defined as women aged 20 to 34 years without diabetes or hypertension with a liveborn, singleton infant born at ≥37 weeks' gestation, cephalic presenting, and with a birth weight for gestational age and sex between the 10th and 90th percentiles.[28] In addition, for multiparous women the previous pregnancy had to be low-risk, with the exception of noncephalic presentation. All analyses were performed in SAS 9.4 (SAS Institute, Inc, Cary, NC).

RESULTS

Of the 204 156 children with a 2009 or 2012 AEDC assessment, 162 872 (80%) had a linked birth record between 2002 and 2007. Children with no recorded gestational age or mode of birth or a gestational age <32 weeks (n = 1770; 1.1%) or no assigned domain category (n = 8405; 5.2%) were excluded (n = 9142; 5.6%), providing a study cohort of 153 730 children with an average assessment age of 5.5 years (SD = 0.35). Overall, 5.6% of infants were born at 32 to 36 weeks' gestation and 22.5% at 37 to 38 weeks. Planned birth accounted for 41.4% of all births (Table 1). Among births at 37 weeks, planned birth accounted for almost half (48.4%), and at 38 weeks they made up more than half (55.2%) (Supplemental Fig 2).

Overall, 9.6% of children were DHR and were more likely to be male, small for gestational age, or born to mothers with lower maternal age, with greater socioeconomic disadvantage, or who smoked during pregnancy (Table 1). The proportion of DHR children decreased with increasing gestational age: 13.1% of preterm (<37 weeks) births, 10.2% of early-term (37–38 weeks) births, and 9.0% of term (39–40 weeks) births (Table 1). The percentage of DV children ranged from 5.3% for language and cognitive skills to 8.4% for physical health and well-being (Table 2). As with DHR, the proportion of DV children for each of the selected measures decreased with increasing gestational age and was lowest at 39 to 40 weeks (Table 2). The decreasing proportion of DHR or DV children with increasing gestational age was also apparent by labor onset (Supplemental Fig 3).

For all outcomes the observed proportion of DHR or DV children varied by the mode of birth and was higher for vaginal birth after spontaneous labor (DHR 9.9%, DV 5.5%–8.5%) and lower for labor induction (DHR 9.3%, DV 5.2%–8.3%) and prelabor cesarean delivery (DHR 8.7%, DV 4.8%–8.0%) (Tables 1 and 2). However, after adjustment for confounders, compared with vaginal birth after spontaneous labor, all modes of birth that involved obstetric interventions were consistently associated with a higher risk of being DHR or DV. The increased risk of being DHR or DV associated with labor induction (6%–18%) was similar to that of prelabor cesarean delivery (5%–12%) (Table 3). Cesarean section after labor induction was consistently associated with the largest increase in risk (14%–18%). The adjusted risk of being DHR or DV decreased with increasing gestational age to 39 to 40 weeks. Infants born at 37 weeks' gestation (14%–16%) and 38 weeks' gestation (1%–8%) had a higher risk of being DHR or DV compared with those born at 40 weeks (Table 3).

Figure 1 presents the combined aRRs for the association of mode of birth and

gestational age with being DHR. The pattern of increasing risk with each mode of birth and shorter gestation is apparent. For example, the combined aRRs demonstrate that compared with vaginal birth after spontaneous labor at 40 weeks' gestation, all other modes of birth at <37 weeks' gestation increased the risk of being DHR by 30% to 43%, at 37 weeks by 22% to 33%, and at 38 weeks by 10% to 20%. For planned birth at 37 to 38 weeks' gestation compared with spontaneous vaginal birth at 39 to 40 weeks, the risk of being DHR increased by 17% (aRR 1.17; 95% confidence interval [CI], 1.12–1.22). The pattern of increasing risk with each mode of birth and shorter gestation was similar for the other DV secondary outcomes (Supplemental Fig 4).

To address the potential for confounding by indication, we repeated the main analysis by using a subgroup of 54 848 (35.7%) women with low-risk pregnancies (Supplemental Table 4 and Supplemental Fig 5). The association between gestational age and developmental outcomes remained similar to the main results. However, the associations between DHR, DV in basic literacy, and DV in gross and fine motor skills and birth at 37 weeks' gestation strengthened. The association between developmental outcomes and mode of birth varied slightly. For infants born via vaginal birth after labor induction or by cesarean section after spontaneous labor, the risk of poor development attenuated. In contrast, the aRR between prelabor cesarean delivery and all developmental outcomes became similar to, or stronger than, the risk for cesarean delivery after labor induction. In these analyses, the estimated associations were less precise because of the reduced sample size.

DISCUSSION

We have demonstrated that early planned birth is independently

TABLE 2 Cognitive and Physical Developmental Vulnerability by AEDC Domain for Gestational Age and Mode of Birth, NSW 2009 and 2012

	Number and Row Percentage of Children				
	Language and Cognitive Skills, $N = 153\,547$	Basic Literacy, $N = 153\,514$	Basic Numeracy, $N = 153\,321$	Physical Health and Well-Being, $N = 153\,621$	Gross and Fine Motor Skills, $N = 153\,548$
	n (Row %)	n (Row %)	n (Row %)	n (Row %)	n (Row %)
Total	8118 (5.3)	8552 (5.6)	12 509 (8.2)	12 861 (8.4)	9737 (6.3)
Gestational age, wk					
32–33	101 (8.2)	91 (7.4)	171 (13.9)	167 (13.5)	148 (12.0)
34–36	579 (7.9)	552 (7.5)	872 (11.9)	851 (11.6)	640 (8.7)
37	564 (6.4)	617 (7.0)	871 (9.8)	926 (10.4)	697 (7.9)
38	1370 (5.3)	1414 (5.5)	2024 (7.9)	2179 (8.5)	1632 (6.4)
39	1892 (5.0)	2024 (5.3)	2913 (7.7)	3025 (8.0)	2307 (6.1)
40	2210 (4.9)	2350 (5.2)	3460 (7.7)	3477 (7.7)	2632 (5.9)
≥41	1402 (5.1)	1504 (5.5)	2198 (8.0)	2236 (8.1)	1681 (6.1)
Mode of birth					
Spontaneous onset of labor, vaginal birth	4362 (5.5)	4660 (5.9)	6776 (8.6)	6748 (8.5)	4987 (6.3)
Spontaneous onset of labor, cesarean delivery	546 (5.0)	585 (5.3)	872 (8.0)	894 (8.1)	670 (6.1)
Induction of labor, vaginal birth	1677 (5.4)	1743 (5.6)	2509 (8.1)	2582 (8.3)	1972 (6.3)
Induction of labor, cesarean delivery	326 (4.5)	337 (4.7)	502 (7.0)	612 (8.5)	481 (6.7)
Prelabor cesarean delivery	1207 (4.8)	1227 (4.9)	1850 (7.3)	2025 (8.0)	1627 (6.5)

associated with poor child development. This finding is significant because early birth due to planned birth now accounts for almost half of births before 39 to 40 weeks' gestation. The decision for planned birth is predicated on beliefs that it is safer for the baby or mother to deliver early. It is of paramount importance to ensure that there are no unintended harms from such a significant shift in clinical practice. Although increased risks of poor health in childhood are associated with early planned birth, early childhood development is another important aspect of child well-being that predicts adult social, educational, and health outcomes. To our knowledge this is the first study to investigate the combined risk of mode of birth and gestational age and demonstrate the increased risk of poorer early childhood development with early planned

birth. We found not only that the risk of poor development increased for every additional week a child is born before 39 to 40 weeks' gestation but that it increased more for modes of birth other than vaginal birth after the spontaneous labor, even among women whose pregnancies we were able to identify as being low risk.

For gestational age, our findings agree with other population-based record linkage studies showing an association between decreasing gestational age and poorer childhood neurodevelopmental and cognitive outcomes.[3,4,6,30–32] However, our results extend this existing knowledge revealing that poor development is exacerbated in the case of planned birth, where a considered decision made to deliver an infant determines gestational age. Because the timing of planned birth is modifiable, delaying birth may

TABLE 3 aRR of Children Being DHR or DV by AEDC Domain for Gestational Age and Mode of Birth, NSW 2009 and 2012

	DHR,[a] N = 152 758	Language and Cognitive Skills,[a,b] N = 152 853	Basic Literacy,[a] N = 152 912	Basic Numeracy,[a,c] N = 152 719	Physical Health and Well-Being,[b,c] N = 152 925	Gross and Fine Motor Skills,[b,c] N = 152 852
	aRR (95% CI)	aRR (95% CI)	aRR (95% CI)	aRR (95% CI)	aRR (95% CI)	aRR (95% CI)
Gestational age, wk						
32–33	1.25 (1.08–1.44)	1.36 (1.12–1.65)	1.18 (0.97–1.43)	1.47 (1.27–1.69)	1.51 (1.31–1.75)	1.80 (1.54–2.10)
34–36	1.26 (1.18–1.34)	1.33 (1.22–1.45)	1.23 (1.13–1.34)	1.30 (1.21–1.39)	1.32 (1.23–1.42)	1.33 (1.23–1.44)
37	1.17 (1.10–1.25)	1.15 (1.06–1.26)	1.19 (1.10–1.29)	1.14 (1.07–1.23)	1.26 (1.17–1.34)	1.26 (1.17–1.36)
38	1.06 (1.01–1.10)	1.06 (0.99–1.13)	1.05 (0.98–1.11)	1.01 (0.96–1.07)	1.08 (1.03–1.13)	1.06 (1.00–1.12)
39	0.98 (0.94–1.02)	1.03 (0.97–1.09)	1.03 (0.98–1.09)	1.02 (0.97–1.07)	1.04 (0.99–1.09)	1.04 (0.99–1.10)
40	Referent	Referent	Referent	Referent	Referent	Referent
≥41	0.99 (0.94–1.03)	0.98 (0.92–1.05)	0.99 (0.94–1.05)	0.99 (0.94–1.04)	1.02 (0.97–1.07)	1.00 (0.94–1.06)
Mode of birth						
Spontaneous onset of labor, vaginal birth	Referent	Referent	Referent	Referent	Referent	Referent
Spontaneous onset of labor, cesarean delivery	1.04 (0.98–1.11)	1.09 (1.01–1.19)	1.10 (1.01–1.18)	1.11 (1.04–1.19)	1.02 (0.96–1.09)	0.99 (0.92–1.07)
Induction of labor, vaginal birth	1.06 (1.02–1.10)	1.15 (1.09–1.21)	1.10 (1.05–1.16)	1.09 (1.04–1.14)	1.06 (1.01–1.10)	1.07 (1.01–1.12)
Induction of labor, cesarean delivery	1.14 (1.06–1.22)	1.18 (1.06–1.32)	1.12 (1.01–1.25)	1.14 (1.04–1.24)	1.16 (1.07–1.25)	1.14 (1.04–1.25)
Prelabor cesarean delivery	1.07 (1.02–1.12)	1.12 (1.05–1.19)	1.05 (0.99–1.12)	1.09 (1.03–1.14)	1.06 (1.01–1.11)	1.10 (1.04–1.16)

All models adjusted for maternal age at birth, marital status at birth, private obstetric care, socioeconomic status at birth, smoking during pregnancy, maternal hypertension, maternal diabetes, parity, timing of first antenatal visit, plurality, small for gestational age, age at assessment, English as a second language, and sex.
[a] Model also adjusted for assessment year.
[b] Model also adjusted for maternal country of birth.
[c] Model also adjusted for major congenital conditions.

improve neurologic development. The biological underpinning for an elevated risk of poor development is multifactorial and related to the curtailment of brain development, resulting in reduced gray matter volume, underdevelopment of neural and physiologic pathways critical to supporting brain growth postnatally, and subsequent learning difficulties arising from behavioral disorders.[1,2]

Although early birth may be indicated and of demonstrated short-term benefit for selected high-risk pregnancies (eg, hypertension, prolonged pregnancy, suspected fetal growth restriction, prelabor rupture of membranes at term), for many conditions evidence is lacking or suggests little benefit (eg, suspected fetal macrosomia, maternal diabetes, preterm prelabor rupture of membranes).[33–39] Furthermore, clinical research suggests that the threshold for planned birth and the gestational age for intervening has decreased.[17,18] Numerous reasons have been used to justify early planned birth, including litigation, patient and provider perception

of safety versus risk, reduced perinatal mortality, increased fetal monitoring, maternal age, obesity, and convenience. Despite these justifications and the increasing trend in planned births, national stillbirth and neonatal mortality rates have remained stable, and there has been no change in the risk of stillbirth from 36 to 40 weeks' gestation.[40] Furthermore, recent studies from the United States have demonstrated that reducing planned delivery before 39 weeks' gestation has not increased the rates of stillbirth.[41,42]

The study findings support clinical guidelines and policies recommending that labor induction or prelabor cesarean delivery for nonmedical reasons should not be routinely carried out before 39 to 40 weeks' gestation. Despite a specific maternity policy to this effect introduced in our own setting in 2007, there has been no appreciable change in practice.[43,44] There also exists substantial practice variation in the use and timing of labor induction or prelabor cesarean delivery.[44–46] Alternative measures

that encourage the peer review of medical indications for early birth and support education for health care providers have been shown to be effective in reducing rates of early planned birth and may be more successful by ensuring stronger thresholds for medical indication.[47]

The increased risk of poor child development is among many short- and long-term risks to an infant born a bit early. Therefore, the potential benefits and harms of early birth for the mother and infant must be balanced against those for continuing the pregnancy. This includes increased risk of neonatal and infant morbidity, pediatric emergency department visits, childhood hospitalizations, and health care costs.[48–51] There are also studies suggesting that these effects, including poorer cognitive outcomes, may persist into adolescence and adulthood.[52,53] The findings of this study add to the growing clinical and epidemiologic evidence that prolonging pregnancy (increasing gestational age), even at term (from 37–38 weeks), can benefit brain

BENTLEY et al

maturity at birth and potentially improve long-term health and cognitive outcomes.[1,2,4,6,7,54]

To support informed decision-making with their pregnancy care provider, it is important for women and their families to have readily available and accessible information about the optimal duration of pregnancy and any increased risk of poorer development or other adverse outcomes associated with early planned birth.[55] This information is relevant given recent research reporting that >90% of women indicated the earliest gestational age for safe delivery was before 39 weeks.[56,57] Furthermore, another study reported that almost half of women thought a cesarean delivery without medical indication should be performed upon request, despite minimal knowledge about the risks and benefits of one.[58] We advocate policies and strategies that support informed and shared decision-making for women, their families, and clinicians. Nevertheless, there are instances where the spontaneous onset of labor occurs before 39 weeks or planned birth is unavoidable, and it is important that appropriate interventions and support in early childhood are developed and provided for these potentially vulnerable children.

This study examined a large population-based cohort of children by using validated measures of early childhood development and reliably reported information for gestational age, mode of birth, and potential confounders.[22,24,26,59] Developmental outcomes were collected independently and prospectively of gestational age and mode of birth, and missing data were minimal. Follow-up through record linkage provided a cohort covering >80% of all children assessed in NSW in 2009 and 2012, with the remainder having been born outside NSW. Because of the

Developmentally high risk
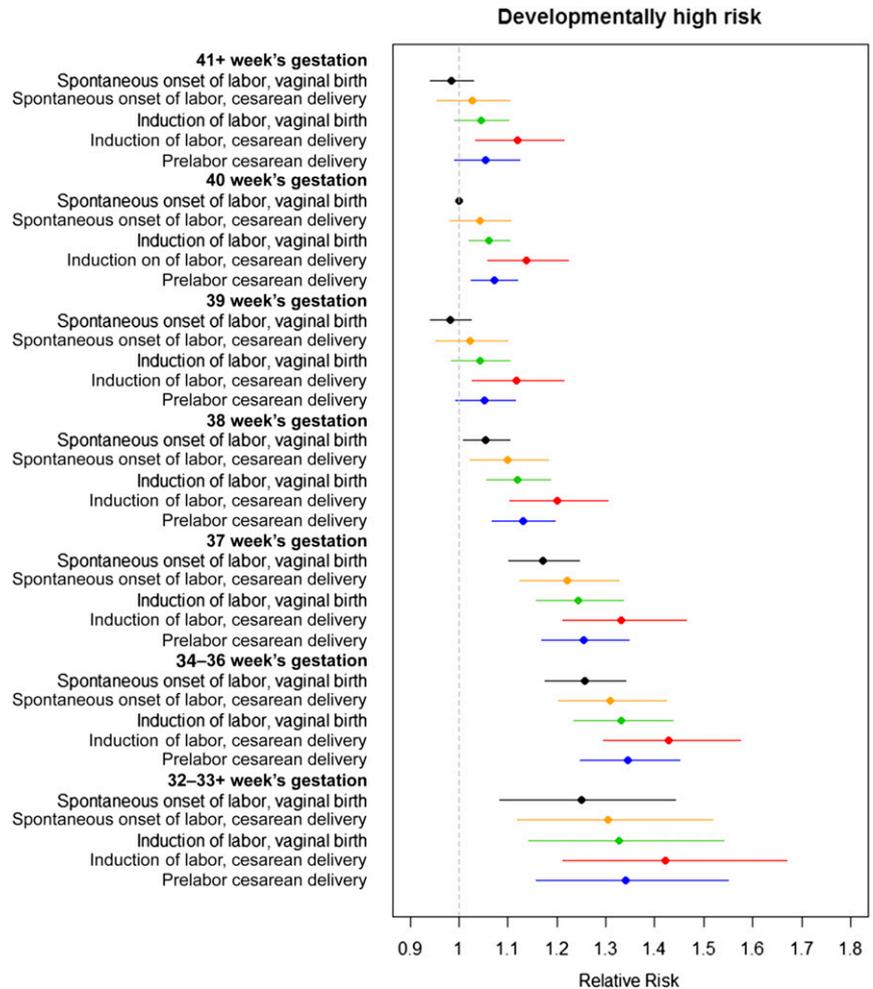
FIGURE 1

Combined aRR of children being DHR for gestational age and mode of birth, NSW 2009 and 2012. Referent group: vaginal birth after spontaneous labor at 40 weeks. Adjusted for maternal age, marital and socioeconomic status, private obstetric care, smoking during pregnancy, maternal hypertension or diabetes, parity, timing of first antenatal visit, plurality, small for gestational age, child age, English as a second language, sex, and assessment year.

limitations of using administrative data, we were unable to obtain information on every potentially relevant confounder. However, face validity is demonstrated with others studies investigating childhood development adjusting for factors we could not and reporting similar findings to ours for gestational age.[3] The association between planned birth and development may be subject to confounding by indication.[60] However, because the exact indications for planned birth are not captured in the data, we examined the association between a subgroup of low-risk pregnancies

and obtained results consistent with the main analysis.

CONCLUSIONS

Early planned birth is associated with an elevated risk of poor child development. Because the timing of planned birth is modifiable, delaying birth for an additional week or more may have significant long-term benefits. Strategies and interventions to support and encourage more judicious decision-making, weighing the risks and benefits for early planned birth, are needed to

ensure optimal child health and development.

ABBREVIATIONS

AEDC: Australian Early Development Census
aRR: adjusted relative risk
CI: confidence interval
DHR: developmentally high risk
DV: developmentally vulnerable
NSW: New South Wales

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