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Early Life

Educational outcomes following breech delivery: a record-linkage study of 456 947 children

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Abstract

Background: Obstetric management of term breech infants changed dramatically following the Term Breech Trial which suggested increased serious neonatal morbidity following trial of labour. Short-term morbidity is a poor proxy of long-term neurological sequelae. We determined whether vaginal breech delivery was associated with educational outcomes.
Methods: We linked three Scotland-wide administrative databases at an individual level: the ScotXed school census; Scottish Qualifications Authority (SQA) examination results; and Scottish Morbidity Record (SMR02) maternity database. The linkage provided information on singleton children, born at term, attending Scottish schools between 2006 and 2011.
Results: Of the 456 947 eligible children, 1574 (0.3%) had vaginal breech deliveries, 12 489 (2.7%) planned caesarean section for breech presentation and 442 090 (96.9%) vaginal cephalic deliveries. The percentage of term breech infants delivered vaginally fell from 23% to 7% among children who started school in 2006 and 2011, respectively. Of children born by vaginal breech delivery, 1.5% had a low 5-min Apgar score ($\leq$3) compared with only 0.4% of those born by either breech caesarean section [adjusted odds ratio (OR) 6.16, 95% confidence interval (CI) 4.44–8.54, $p < 0.001$] or cephalic vaginal delivery (adjusted OR 3.84, 95% CI 2.99–4.93, $p < 0.001$). Children born by vaginal breech delivery had lower examination attainment than those born by either planned caesarean section for breech presentation (adjusted OR 1.16, 95% CI 1.02–1.32, $p = 0.020$) or vaginal cephalic delivery (adjusted OR 1.14, 95% CI 1.01–1.28, $p = 0.029$).
Conclusions: Vaginal delivery of term breech infants was associated with lower examination attainment, as well as poorer Apgar scores, suggesting that the adverse effects are not just short-term.

Key words: Apgar score, breech presentation, educational status, intellectual disability

Key Messages

- Infants presenting breech at term have been much less likely to undergo vaginal delivery since publication of the TBT trial.
- However, the trial has attracted criticism because of methodological weaknesses, short-term follow-up and reduced generalizability due to other changes in obstetric practice.
- Therefore, further evidence is required.
- In a large, national cohort study, we demonstrated that breech vaginal delivery at term was associated with poorer Apgar scores and lower educational attainment, suggesting that planned caesarean section should be considered in such cases.

Introduction

Management of breech presentation changed dramatically following publication, in 2000, of the Term Breech Trial (TBT).[1] The results suggested that trial of vaginal delivery increased the risk of neonatal morbidity, in comparison with planned caesarean section.[2] The findings were incorporated into clinical guidelines,[3–4] and led to a rapid decline in vaginal breech deliveries in countries with ready access to caesarean section. However, the TBT has attracted some criticism.[6–12]

First, the TBT included units with very different skill levels, and licensed obstetricians were present for only 87% of women undergoing trial of vaginal delivery compared with 98% of those delivered by planned caesarean section. Many participants had a trial of labour without pre- or early labour ultrasound and continuous fetal monitoring, and relatively slow progress was permitted without intervention. Therefore, the antenatal and intrapartum care may not have reflected current management of breech presentation. In Presentation et Mode d'Accouchement (PREMODA), a very large observational study conducted 5 years after the TBT, all participants had pre-labour ultrasound scans and continuous fetal monitoring, and there was a much lower tolerance of slow progress in labour.[13] The investigators reported no association between trial of vaginal delivery and perinatal morbidity or mortality. However, infants delivered following trial of vaginal delivery did have lower 5-min Apgar scores.

Second, it has been suggested that some of the 16 stillbirths and neonatal deaths that occurred in the TBT trial should be excluded from the analysis as they were not associated with the delivery method: two died before enrolment; one during sleep; seven had congenital anomalies; one severe vomiting and diarrhoea; and one a ruptured myelomeningocele.[14] Cunha-Filho and Passos recalculated the correct figures as two (0·2%) deaths following 1038 breech caesarean section and eight (0·8%) following 1034 vaginal deliveries ($p = 0{\cdot}12$).

Third, neonatal morbidity is a poor proxy for long-term neurodevelopmental outcome. Older cohort studies that have examined both short- and long-term outcomes of breech presentation have reported worse early outcomes following trial of vaginal delivery, based on cord blood pO_2[12] and pH,[15] Apgar scores,[15,16] serious perinatal morbidity[17] and admission to a neonatal intensive care unit,[16] but no differences at 1–12 years of age in terms of developmental delays,[17] psychomotor development and skills,[18] neurodevelopmental handicaps[15] or long-term morbidity.[16] Studies on specific causes of intellectual disability, such as cerebral palsy and autistic spectrum disorder, have produced conflicting results.[16,19,20] A total of 923 (80%) of the TBT participants were followed up to 2 years of age.[21] There was no difference in the composite outcome of death or parental report of neurodevelopmental delay [(RR)1.09, 95% CI 0.52–2.30, $p = 0.85$].[21] The TBT investigators have not reported longer-term outcomes. The aim of our study was to determine whether vaginal breech delivery is associated with adverse educational outcomes.

Methods

School census

In Scotland, an annual census is conducted at the start of every school year of all children who are attending local authority-maintained or grant-aided schools [http://www.scotland.gov.uk/Publications/2012/12/2355/0 section 2.1]. It covers both primary and secondary schools, and includes mainstream schools, special schools and special classes and units within mainstream schools. All eligible schools provide data to the pupil census. Children on long-term illness absence are included, but adults (>19 years of age) who attend courses located in schools are excluded. Data are collected in the management information system of each school and returned, via their local authority, to ScotXed which collates and holds the data on behalf of the Learning

Directorate of the Scottish Government. The information collected includes the schoolchild's Scottish Candidate Number, limited personal identifiers (date of birth, sex and postcode of resident) and whether the schoolchild has a record of additional support needs (ASN).

ASN is defined as a schoolchild being unable to benefit fully from school education without help beyond that normally given to schoolchildren of the same age, and may occur for a number of reasons. In our study, we defined ASN as a record of ASN due to: learning disability, dyslexia, other specific learning difficulties, other moderate learning disabilities, visual impairment, hearing impairment, deaf-blindness, physical or motor impairments, language or speech disorder, autistic spectrum disorder or social, emotional and behavioural difficulties. We excluded from the definition other causes of ASN such as: a more able pupil, bereavement, young carer or interrupted learning. Under the Education (Additional Support for Learning) (Scotland) Acts of 2004 and 2009, both schools and local authorities have a statutory duty to identify, provide and review provision for children with ASN. Support may comprise a personal learning plan, individualized educational programme or a coordinated support plan, depending on the needs of the individual child. Since ascertainment of ASN and record of the underlying reason were obtained from anonymous, routinely collected educational data, we were not able to corroborate either.

Examinations database

Prior to sitting external examinations, Scottish schoolchildren are required to register with the Scottish Qualifications Authority (SQA). The SQA maintains a database of all children who have been entered for a qualification and the results attained. Children's Scottish Candidate Numbers and results are passed to ScotXed for analytical purposes. Scottish schoolchildren usually sit external examinations over a 2- (Senior 4 and 5) or 3- (Senior 4, 5 and 6) year period. This usually equates to them being 15–16, 16–17 or 17–18 years of age at the time of examination. The subjects and number of examinations sat varies and the children can sit examinations at different levels or combinations of levels including: Standard, Intermediate, National, Higher and Advanced Higher. In order to be able to compare the results attained at different levels of examination and produce an overall measure of achievement, the Scottish Credit and Qualifications Framework (SCQF) has produced a unified points scale which allocates a tariff for each examination result based on the level at which it was sat and the grade achieved. The SCQF summates these tariffs for each child and then categorizes the total into: low, basic, broad general and high attainment.

Maternity database

The Scottish Morbidity Record (SMR02) collects information on all women discharged from Scottish maternity hospitals, including personal identifiers, maternal and infant characteristics, clinical management and obstetric complications, which is held by the NHS National Services Scotland, Information Services Division. The SMR02 is subjected to regular quality assurance checks and has been more than 99% complete since the late 1970s. In the SMR02, gestational age at birth is defined as completed weeks of gestation on the basis of the estimated date of delivery recorded in each woman's clinical record. Gestational age has been confirmed by ultrasound in the first half of pregnancy in more than 95% of women in the UK since the early 1990s. If the gestational age calculated by ultrasound differs from that calculated by last menstrual period by more than 7 days, the former is used.[22]

Previous miscarriage was defined as previous delivery of a conceptus showing no signs of life before 24 weeks of gestation, excluding therapeutic abortions. Previous therapeutic abortion was defined as previous therapeutic termination of pregnancy, by any means, prior to 24 weeks of gestation. In our study, 5-min Apgar score was treated as an ordinal variable (0–3, 4–6 and 7–10). Children's postcodes of residence were used to determine their level of socioeconomic deprivation, using the Scottish Index of Multiple Deprivation (SIMD). The SIMD is derived from 38 indicators across seven domains (income, employment, health, education, skills and training, housing, geographical access and crime) using information collected from the population census applied at the datazone level (median population 769) [http://www.scotland.gov.uk/Topics/Statistics/SIMD].

Record linkage

In Scotland, the education and health sectors use different unique identifiers which are not currently mapped. The education sector uses the Scottish Candidate Number (SCN) and the health sector uses the Community Health Index (CHI) Number. Therefore, record linkage was undertaken using probabilistic matching. The pupil identifiers contained within the pupil censuses for 2006/07 to 2011/12 inclusive were matched to the CHI database (a list of all patients registered with a Scottish general practitioner) to create an SCN-CHI look-up key for the study participants. The SMR02 is the mother's delivery record, and hence it contains the mother's rather than the child's CHI. ISD receives a record of all statutory birth registrations from National Records of Scotland and uses the identifiers available to append both the child's and the mother's CHI numbers onto these records. Using this

'look-up' facility, 98% of children's CHI numbers were successfully linked to their mothers' CHI numbers. Maternal CHI and date of birth/delivery were then used to identify the relevant SMR02 records. Full details of the linkage methodology have been reported elsewhere.[23]

Inclusion and exclusion criteria

Inclusion in this study was restricted to children who attended school during the academic years 2006/07 to 2011/2012 inclusive. We excluded individuals who were aged <4 years or >19 years at the time of the school census, and births where the maternal height was missing or recorded as less than 100 cm or greater than 200 cm, maternal age was less than 10 years, the birthweight was recorded as less than 400 g or greater than 5 000 g or the gestation at delivery was recorded as less than 37 weeks or greater than 44 weeks. We excluded modes of delivery other than vaginal breech, cephalic vaginal and caesarean section of a child with breech presentation. We also excluded emergency caesarean section which, in the SMR02 database, is defined as any unplanned caesarean section irrespective of whether a woman was already in labour and, if in labour, irrespective of whether this was spontaneous in onset or induced. Multiple births were excluded because the SMR02 record does not record infant name. Therefore, in the case of multiple births, we could not ensure that the School Census record was linked to the correct child. Schoolchildren who had contributed to more than one annual pupil census were classified as having ASN if ASN was recorded in any year.

Statistical analyses

The SMR02 data were used to determine presentation at delivery (breech vs cephalic) and mode of delivery (vaginal vs caesarean section). These fields were combined to classify schoolchildren into vaginal breech delivery, planned caesarean section for breech presentation and vaginal cephalic delivery. The characteristics and outcomes of the three groups were summarized using frequencies and percentages for categorical data and medians and interquartile ranges for continuous data. The three groups were compared using Pearson chi square tests for categorical data and Kruskal-Wallis tests for continuous data.

The three outcomes analysed were Apgar score, record of ASN and level of educational attainment. Generalized ordinal logistic regression models were used for Apgar and educational attainment using the gologit2 user written command for Stata. Tests for non-proportional odds for the educational and Apgar outcomes were conducted using a likelihood ratio test. Binary logistic regression analysis was used for record of ASN. The model was run for any ASN and then repeated excluding children with autistic spectrum disorder from the analysis. All the models were run univariately and then multivariately, adjusting for the potential confounding effects of infant sex, maternal age and height, marital status, SIMD, parity, sex- gestation-specific birthweight centile, previous spontaneous and therapeutic abortions, gestation at delivery, smoking during pregnancy, and year of delivery. Interaction tests were performed. We ran the models initially using cephalic vaginal deliveries as the referent category and then re-ran them using caesarean section as the referent category. Therefore the results for vaginal breech deliveries could readily be compared with both of these groups. The *p*-values for all tests were two-sided and are reported to three decimal places. All statistical analyses were undertaken using Stata v13.0 (Stata Corporation,TX, USA).

Permission to access, link and analyse these data was granted by the Scottish Privacy Advisory Committee (reference 02/12) and the CHI Advisory Group. The South-East of Scotland Multi-Centre Research Ethics Committee confirmed that NHS ethical approval was not required. Written data sharing agreements were established between the University of Glasgow and both ScotXed and SVQ.

Results

The school censuses, undertaken between October 2006 and October 2011 inclusive, collected data on 1 011 585 children. Of these, 839 168 (83.0%) were linked to SMR02 data. We excluded 382 221 children from the study: 28 were aged <4 or >19 years at the time of the census; 35 893 were not singleton births; 182 466 had emergency caesarean deliveries, or the mode of delivery was other than vaginal breech, caesarean section for breech presentation or cephalic vaginal; 1780 had a birthweight <400 g or >5000 g; 45 776 had an estimated gestation at delivery of ≤36 weeks or >44 weeks; 116 269 had missing data on maternal height; and 9 had maternal age recorded as <10 years. Therefore, the study population comprised 456 947 children. Of these, 1574 (0.3%) had vaginal breech deliveries, 12 489 (2.7%) caesarean section for breech presentation and 442 884 (96.9%) cephalic vaginal deliveries. The percentage of breech infants delivered vaginally fell from 23% to 7% among children who started school in 2006 and 2011, respectively. Year of birth ranged from 1989 to 2006, with 308 916 (67.6%) children born before 2000, 22 568 (4.9%) in 2000 and 125 463 (27.5%) after 2000.

Of the children born by vaginal breech delivery, 1.5% had a low Apgar score (≤3) compared with only 0.4% of those born by either cephalic vaginal delivery or planned caesarean section for breech presentation ($p < 0.001$) (Table 1). After adjusting for potential confounders, the risk

Table 1. Comparison of case mix and crude outcomes by mode of delivery

		Vaginal cephalic N = 442 884 N (%)	Vaginal breech N = 1574 N (%)	Breech caesarian N = 12 489 N (%)	*p*-value
Infant sex	female	221 943 (50.1)	899 (57.1)	6932 (55.5)	
	male	220 934 (49.9)	675 (42.9)	5 557 (44.5)	<0.001
	missing	7	0	0	
Marital status	not married	174 316 (40.6)	528 (34.3)	4359 (36.0)	
	married	254 759 (59.4)	1013 (65.7)	7749 (64.0)	<0.001
	missing	13 809	33	381	
SIMD5	1 (deprived)	124 492 (28.2)	459 (29.3)	3075 (24.7)	
	2	93 178 (21.1)	316 (20.2)	2537 (20.4)	
	3	81 425 (18.5)	263 (16.8)	2336 (18.8)	
	4	74 819 (17.0)	263 (16.8)	2398 (19.3)	
	5 (affluent)	67 469 (15.3)	267 (17.0)	298 (16.9)	<0.001
	missing	1 501	6	45	
Parity	nulliparous	279 039 (63.2)	1100 (70.0)	5648 (45.4)	
	multiparous	162 750 (36.8)	469 (29.9)	6 98 (54.6)	<0.001
	missing	1 095	5	43	
Gestation at delivery (weeks)					
	37	20 225 (4.6)	168 (10.7)	964 (7.7)	
	38	49 685 (11.2)	327 (20.8)	5350 (42.8)	
	39	95 161 (21.5)	390 (24.8)	4600 (36.8)	
	40	157 058 (35.5)	464 (29.5)	1149 (9.2)	
	41	102 181 (23.1)	193 (12.3)	366 (2.9)	
	42	18 018 (4.1)	30 (1.9)	57 (0.5)	
	43	461 (0.1)	2 (0.1)	3 (0.02)	
	44	95 (0.02)	0 (0.0)	0 (0.0)	<0.001
Previous spontaneous abortion					
	0	355 667 (80.3)	1271 (80.8)	9823 (78.7)	
	1	68 231 (15.4)	238 (15.1)	1990 (15.9)	
	2+	18 941 (4.3)	65 (4.1)	674 (5.4)	<0.001
	missing	51	0	2	
Previous therapeutic abortion					
	0	3 947 549 (89.1)	1401 (89.0)	11133 (89.2)	
	1	41 305 (9.3)	151 (9.6)	1158 (9.3)	
Smoked during pregnancy	2+	6782 (1.5)	22 (1.4)	196 (1.6)	0.977
	missing	48	0	2	
5-min Apgar score					
	0–3	1732 (0.4)	23 (1.5)	44 (0.4)	
	4–6	3077 (0.7)	47 (3.0)	45 (0.4)	
	7–10	434 588 (98.9)	1493 (95.5)	12 285 (99.3)	<0.001
	missing	3 487	11	115	
ASN (including ASD)	yes	35 920 (8.1)	133 (8.5)	971 (7.8)	
	no	406 962 (91.9)	1441 (91.6)	11 518 (92.2)	0.351
ASN (excluding ASD)	yes	33 166 (7.5)	124 (7.9)	896 (7.2)	
	no	409 722 (92.5)	1450 (92.1)	11 593 (92.8)	0.351
Highest examination attainment					
	low	15 724 (7.2)	82 (7.7)	335 (5.8)	
	basic	85 178 (38.7)	421 (39.5)	1971 (33.8)	
	broad general	52 916 (24.1)	244 (22.9)	1482 (25.4)	
	high	66 111 (30.1)	318 (29.9)	2038 (35.0)	<0.001
		Med (IQR)	Med (IQR)	Med (IQR)	
Maternal age (years)		28 (24–32)	28 (25–32)	29 (26–33)	<0.001
Maternal height (cm)		163 (158–167)	163 (159–167)	162 (157–167)	<0.001
Birthweight (g)		3440 (3120–3760)	3160 (2860–3 460)	3260 (2980–3 580)	<0.001

SIMD, Scottish Index of Multiple Deprivation; ASN, additional support needs: ASD, autistic spectrum disorder; med, median; IQR, interquartile range

Table 2. Univariable and multivariable generalized ordinal logistic regression of the association between mode of delivery and 5-min Apgar score

	5-min Apgar score			
	<7		<4	
	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value
Univariable (n = 453 334)				
Vaginal cephalic	1.0		1.0	
Breech caesarean	0.65 (0.53–0.81)	<0.001	0.90 (0.67–1.22)	0.505
Vaginal breech[a]	4.23 (3.32–5.38)	<0.001	4.23 (3.32–5.38)	<0.001
Multivariable[b] (n = 436 600)				
Vaginal cephalic	1.0		1.0	
Breech caesarean[a]	0.62 (0.50–0.77)	<0.001	0.62 (0.50–0.77)	<0.001
Vaginal breech	3.84 (2.99–4.93)	<0.001	3.84 (2.99–4.93)	<0.001

OR, odds ratio; CI, confidence interval.

[a]Proportional odds assumption was satisfied, therefore same results for different comparisons.

[b]Adjusted for infant sex, maternal age, maternal height, marital status, area deprivation index, parity, birthweight centile, previous spontaneous and therapeutic abortions, estimated gestational age, smoking during pregnancy and year of delivery.

of having a low Apgar score remained higher following vaginal breech delivery than vaginal cephalic deliveries (Table 2). In contrast, breech infants delivered by planned caesarean section were at reduced risk of having a low Apgar score after adjusting for potential confounders (Table 2). Re-running the model, using planned caesarean section for breech presentation as the referent category, confirmed that vaginal delivery of breech infants was associated with an increased risk of a low Apgar score (adjusted OR 6.16, 95% CI 4.44–8.54, $p < 0.001$).

In our study, 37 024 (8.1%) children had a record of ASN: 5233 (1.2%) due to learning disability; 6012 (1.3%) dyslexia; 3460 (1.3%) other specific learning difficulties; 5733 (0.1%) other moderate learning disabilities; 633 (0.1%) visual impairment; 694 (0.2%) hearing impairment; 20 deaf-blindness; 1382 (0.3%) physical or motor impairments; 2440 (0.5%) language or speech disorder; 2838 (0.6%) autistic spectrum disorder; and 8581 (1.9%) social, emotional and behavioural difficulties. The percentages of children with a record of ASN were similar between breech vaginal, cephalic vaginal and caesarean breech deliveries (Table 1). However, when adjusted for potential confounders, ASN was more common among children born by breech vaginal delivery than those born by cephalic vaginal delivery (Table 3). Referent to planned caesarean section for breech presentation, the adjusted odds ratios for vaginal breech presentation were 1.13 (95% CI 0.92–1.37, $p = 0.239$) inclusive of ASD cases and 1.12 (95% CI 0.91–1.37, $p = 0.274$) excluding them.

Of the 456 947 children with linked birth data, 226 818 (49.6%) were sufficiently old to have sat external examinations. Of the children born by vaginal breech delivery, 70.1% did not achieve a high level of attainment. This figure was comparable to children born by cephalic vaginal delivery, 69.9% of whom did not achieve a high level of attainment (Table 1). However, after adjustment for potential confounders, children born by vaginal breech delivery had lower levels of attainment than those born by cephalic vaginal delivery (Table 4). Children delivered by planned caesarean section for breech presentation achieved better attainment levels on univariate analysis, but were no different from children born by vaginal cephalic delivery following adjustment for potential confounders (Table 4). Referent to children born by caesarean section for breech presentation, those born by vaginal breech delivery were more likely to achieve lower examination results (adjusted OR 1.16, 95% CI 1.02–1.32, $p = 0.020$)

There were no statistical interactions between year of birth and either Apgar score ($p = 0.141$) or ASN ($p = 0.400$), nor were there statistical interactions between infant sex and either ASN ($p = 0.285$) or ASN excluding ASD ($p = 0.349$). Therefore, sub-group analyses were not required.

When we re-ran the analyses, including all infants delivered from 24 weeks of gestation, the results were very similar. In comparison with breech infants delivered by caesarean section, those delivered vaginally were at increased risk of Apgar score <7 (adjusted OR 6.96, 95% CI 5.37–9.02, $p < 0.001$), Apgar score <4 (adjusted OR 4.09, 95% CI 2.82–5.92, $p < 0.001$) and lower educational attainment (adjusted OR 1.17, 95% CI 1.04–1.31, $p = 0.008$). There was no significantly increased risk of ASN.

Discussion

Children born by breech vaginal delivery had poorer Apgar scores and poorer educational attainment than both

Table 3. Univariable and multivariable binary logistic regression of the association between mode of delivery and a record of additional support needs

	Univariable (n = 456 947)		Multivariable[a] (n = 440 130)	
	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value
Including autistic spectrum disorder				
Vaginal cephalic	1.0		1.0	
Breech caesarean	0.96 (0.89-1.02)	0.175	1.05 (0.98-1.13)	0.150
Vaginal breech	1.05 (0.88-1.25)	0.623	1.18 (0.98-1.42)	0.072
Excluding autistic spectrum disorder				
Vaginal cephalic	1.0		1.0	
Breech caesarean	0.95 (0.89-1.02)	0.188	1.06 (0.98-1.14)	0.113
Vaginal breech	1.06 (0.88-1.27)	0.558	1.18 (0.98-1.43)	0.077

OR, odds ratio; CI, confidence interval.

[a]Adjusted for infant sex, maternal age, maternal height, marital status, area deprivation index, parity, birthweight centile, previous spontaneous and therapeutic abortions, estimated gestational age, smoking during pregnancy and year of delivery.

Table 4. Univariable and multivariable generalized ordinal logistic regression of the association between mode of delivery and examination level attained

	Educational attainment					
	<Basic		<Broad general		<High	
	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value
Univariable (n = 226 820)						
Vaginal cephalic	1.0		1.0		1.0	
Breech caesarean	0.79 (0.75-0.82)	<0.001	0.79 (0.75-0.82)	<0.001	0.79 (0.75-0.82)	<0.001
Vaginal breech	1.04 (0.93-1.16)	0.470	1.04 (0.93-1.16)	0.470	1.04 (0.93-1.16)	0.470
Multivariable[a] (n = 225 710)						
Vaginal cephalic	1.0		1.0		1.0	
Breech caesarean	0.98 (0.93-1.03)	0.443	0.98 (0.93-1.03)	0.443	0.98 (0.93-1.03)	0.443
Vaginal breech	1.14 (1.01-1.28)	0.029	1.14 (1.01-1.28)	0.029	1.14 (1.01-1.28)	0.029

OR, odds ratio; CI, confidence interval.

[a]Adjusted for infant sex, maternal age, maternal height, marital status, area deprivation index, parity, birthweight centile, previous spontaneous and therapeutic abortions, estimated gestational age, smoking during pregnancy and year of delivery.

children born by cephalic vaginal delivery and those born by planned caesarean section for breech presentation. Children born by planned caesarean section for breech presentation had better Apgar scores than children born by cephalic vaginal delivery, and were comparable in terms of risk of ASN and educational attainment.

Concerns relating to vaginal breech delivery pre-dated the TBT. In 1995, a meta-analysis of nine studies of breech presentation (two randomized trials and seven observational studies) reported that trial of vaginal delivery carried a higher risk of birth injury (1.0% vs 0.1%) and birth injury or perinatal death (1.2% vs 0.1%) than planned caesarean section.[24] Subsequently, two large observational studies, conducted in California[25] and Sweden,[26] reported higher rates of neonatal[25] and infant[26] mortality, neonatal morbidity,[25] birth injury,[26] neonatal convulsions[26] and lower scores.[26] The TBT, conducted in 2000, was a large, multicentre randomized controlled trial and was therefore thought to provide more robust evidence. In the TBT, 4.1% of breech presentation infants who underwent trial of vaginal delivery suffered neonatal morbidity compared with only 0.5% of those delivered by planned caesarean section.[1] In the absence of more recent trials, the 2011 Cochrane meta-analysis was based on the 2396 women who participated in the TBT and two earlier trials;[27] none of which reflect current obstetric practice.

The TBT produced dramatic changes in obstetric practice. In The Netherlands, there was an abrupt drop in the use of trial of vaginal delivery immediately after publication of the TBT: from 50% to 20% of breech presentations.[4] This was accompanied by a drop in perinatal mortality from 0.35% to 0.18% and in fetal trauma from

0.29% to 0.08%. However, the Netherlands study also demonstrated improvements in outcomes following emergency caesarean section and vaginal breech delivery following the TBT, suggesting that the improvements in obstetric care extended beyond increased use of planned caesarean section. Similarly, in Scotland there has been a decline in delivery-related perinatal and neonatal deaths following breech presentation of term, singleton infants, which can only be partly explained by increased use of caesarean section.[5]

Our findings of reduced Apgar score among schoolchildren born by vaginal breech delivery is consistent with previous studies, including studies such as PREMODA, that reflect current obstetric practice.[13] Our study demonstrated lower attainment in external examinations among children born by vaginal breech delivery. Previous studies of the impact on educational outcomes have been few in number, reflected outdated obstetric practice and produced conflicting results. Roemer and Rowland analysed school success scores in 648 schoolchildren, based on a subjective measure of overall school performance provided by teachers using a four-point ordinal scale, rather than examination results.[28] but the researchers did not adjust for confounders. The same study reported higher unadjusted IQ scores following vaginal breech delivery than cephalic spontaneous vaginal delivery,[28] but the results have been contradicted by other studies that reported no association with IQ.[28–31] A study of Danish male conscripts reported that IQ scores were 3.3 points (95% CI 1.8–4.7) lower following breech, compared with cephalic, presentation but they reported no difference within the breech presentation sub-group when they compared vaginal delivery and caesarean section.[29] A small Norwegian study reported that the IQ scores of 42 male conscripts aged 18 years who had vaginal breech deliveries were not statistically different from conscripts as a whole.[30] A subsequent, much larger, study of 8738 Norwegian male conscripts demonstrated no difference in IQ scores when they compared breech vs cephalic presentation, nor when they compared breech presentations by vaginal vs caesarean delivery.[31]

Our findings did not demonstrate a clear association between vaginal breech delivery and risk of ASN. Compared with vaginal cephalic delivery, the association was of comparable magnitude to that with educational attainment. However, there was no clear association in comparison with planned caesarean section for breech delivery. ASN measures more severe neurodevelopment adversity than low educational attainment. It is also a composite outcome, comprising a number of underlying problems. Our study lacked sufficient statistical power to study the underlying problems as separate outcomes. Whereas some previous studies have suggested an association of vaginal breech delivery with specific disabilities such as cerebral palsy[19,33] and autistic spectrum disorder,[32] others have found no association.[16,20] In a large observational study conducted in Australia, vaginal breech delivery was associated with increased risk of mild to moderate intellectual disability after adjustment for potential confounders, but not with severe intellectual disability.[20]

Our study was large and non-selective, including children across the whole of Scotland. We used existing databases but these are subjected to regular quality assurance checks. In our study, we were able to analyse breech infants born by both vaginal delivery and planned caesarean section and to adjust for a wide range of potential confounders. We had access to both early outcomes (Apgar) and later outcomes (ASN and educational attainment) in the same cohort.

A total of 17% of children could not be linked to an SMR02 record. The most common reason is likely to be birth in the UK but outside Scotland. In our study, 0.3% of the children who could be linked to their birth records were born by breech vaginal delivery. We obtained an identical figure for all Scottish births when similar exclusion criteria (multiple pregnancy, preterm delivery and very low birthweight) were applied, suggesting that our study was representative of Scottish births. We adjusted for potential confounders, but as with any observational study, residual confounding is possible. For example, we adjusted for an area-level measure of socioeconomic deprivation, but did not have access to data on individual level measures. In particular, it is not possible to differentiate between complications due to the mode of delivery and those due to the underlying reason for breech presentation. Breech infants delivered by planned caesarean section achieved outcomes comparable to or better than those delivered by cephalic vaginal delivery, but it is possible that they differed from vaginal breech deliveries in ways other than those recorded and included as covariates in the multivariable analyses. Our study excluded multiple pregnancies, preterm deliveries and very low birthweight infants. Therefore, our results should not be generalized to these groups. Our study used as outcomes ASN and educational attainment. These are wider than some of the definitions used in previous studies, such as specific diseases. Therefore, the findings should be viewed as complementing these studies rather than being compared directly with them.

Conclusions

Our findings suggest that the association between vaginal breech delivery and neonatal morbidity may perpetuate into later years, resulting in poorer educational attainment. Further research is required into whether vaginal breech

delivery is associated with more serious educational problems, such as ASN, and whether this is due to specific underlying causes.

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