The impact of preterm birth on mathematics achievement and schooling

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Colleagues and sponsors
Overview

- Preterm birth: Why it matters
- Cohort studies used
- Study 1: Cognition & mathematics across the gestation spectrum
- Study 2: Preterm birth & adult wealth
- Study 3: Delayed school entry – an intervention?
- Study 4: Teachers’ knowledge of preterm birth
- Recommendations
Definition of preterm birth

<table>
<thead>
<tr>
<th>Completed weeks of gestation</th>
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<tbody>
<tr>
<td>22</td>
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<td></td>
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<tr>
<td>All Preterm</td>
</tr>
<tr>
<td>Very Preterm</td>
</tr>
<tr>
<td>Moderate</td>
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<tr>
<td>Late</td>
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<td>Extremely</td>
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22 to 27 weeks
Babies born extremely preterm are at high risk for intellectual impairment and physical disability later in life. Although the vast majority attend mainstream school, just over half require some degree of special educational support.

22 to 31 weeks
Children born very preterm are at high risk for cognitive deficits and attention, behaviour and emotional problems at school age.

32 to 36 weeks
Most preterm babies are born late and moderately preterm. Even these babies born a few weeks early are at slightly higher risk of developmental problems than babies born at term.

Preterm birth
In the UK, around 7% of babies are born preterm each year. This means that two children in an average sized primary school class are likely to have been born preterm.
**Why preterm birth matters**

**Figure 1: Preterm births by gestational age and region for 2010**

- Preterm births <28 weeks
- Preterm births 28 to <32 weeks
- Preterm 32 to <37 weeks

**Preterm birth by the numbers:**
- 15 million preterm births every year and rising
- 1.1 million babies die from preterm birth complications
- 5-18% is the range of preterm birth rates across 184 countries of the world
- >80% of preterm births occur between 32-37 weeks of gestation and most of these babies can survive with essential newborn care
- >75% of deaths of preterm births can be prevented without intensive care
- 7 countries have halved their numbers of deaths due to preterm birth in the last 10 years

*Source: Blencowe et al National, regional and worldwide estimates of preterm birth rates in the year 2010 with time trends since 1990 for selected countries: a systematic analysis and implications*
Preterm birth rates are rising

Average annual percentage change for preterm birth by country, 1996–2008.* Data series begins in 2000

Adult outcomes of very preterm birth

- Cognitive problems remain and are related to widespread grey and white matter changes in the brain


From birth to adulthood - Melanie

26 weeks
30 cm
750 g
Cohort studies used

- Bavarian Longitudinal Study (BLS)
- EPICure Study
- 1958 National Child Development Study (NCDS)
- 1970 British Cohort Study (BCS70)
Study 1:
Cognitive ability and mathematics attainment across the full gestation spectrum

Cognitive and mathematics problems across the full gestation spectrum

- How does the degree of prematurity relate to children’s IQ, basic mathematics processing and mathematics attainment in primary school?

- Are the effects of prematurity on IQ and mathematics universal?
IQ, maths processing and attainment

- Same tests used in both samples
  
  **Kaufman Assessment Battery for Children (K-ABC)** at approx. two years of schooling in both samples
  - IQ: MPC score
  - Math attainment: Arithmetic subtest score

**Basic mathematics processing**
Same Mathematics Estimation Test (12 items) at age 8 (BLS) and age 11 (EPICure)
Statistical analysis

- **BLS**: piecewise linear regressions were fitted for IQ, mathematic processing and mathematic attainment
  - Change point analyses tested the week of GA at which children’s test performance differed significantly above and below

- **EPICure**: inserting their *observed* scores into the piecewise regressions fitted to the BLS sample
  - Prediction: the range of EPICure observed scores fell within these 50% (1 RMSE) and 75% (2 RMSEs) prediction intervals

- Analyses were controlled for family SES, child sex, and small for gestational age (SGA) birth
Prediction of IQ and maths development after preterm birth from BLS to EPICure: robust estimates

Identical IQ scores:

Similar basic maths processing (estimation):

Significantly better maths achievement in the UK

Mathematics attainment is more strongly associated with schooling

Prematurity has adverse effects on math attainment following birth at all gestations <36 weeks and on IQ and basic mathematics processing <34 weeks GA.

Universal neurodevelopmental factors explain the effect of gestation at birth on basic cognitive abilities (IQ and basic mathematics processing).

EPICure study children had higher mathematics attainment scores than predicted by BLS data.

Mathematic attainment may be improved by schooling.
Recommendation

- Follow-up assessments should include moderate and very preterm children
- Follow-up should extend into the preschool and primary school years
Study 2: Preterm birth and adult wealth

Background

- Large registry-based studies show preterm children are less likely to complete high school and go to university.
- Preterm birth has been linked to lower job-related income, lower occupational status and decreased wealth in adulthood.
- Lack of longitudinal research – what are the mechanisms leading to decreased wealth in adult life?
Key questions

- What is the impact of preterm birth on wealth in adulthood?
- Do preterm children’s poor reading and mathematics skills adversely affect their wealth as adults?
Methods

- Data from two national birth cohort studies:
  - NCDS – 17,500 people born in 1958 (n=8573 in analyses, 66%)
  - BCS70 – 17,000 people born in 1970 (n=6698 in analyses, 58%)

- Both cohorts have comparable data on:
  - IQ, mathematics and reading in middle childhood (age 7-11 years)
  - Educational qualifications in young adulthood (age 33-34 years)
  - Adult wealth at 42 years of age

- Structural equation modelling used to:
  - Create latent variables for wealth, IQ, reading and mathematics
  - Create a path model to explore the mediating effects of IQ, reading and mathematics in middle childhood and educational qualifications in young adulthood
Impact of preterm birth on adult wealth

Pathways to lower wealth

Discussion

- Preterm birth affects individuals into adulthood
- Developmental cascade whereby preterm children’s poorer school performance leads to lower qualifications and wealth in adulthood
- Poorer primary school mathematics skills are particularly important for later wealth
- Consistent findings across cohorts suggest that the pathways leading to poor adult outcomes are time invariant, same for children born today
Recommendation

- Follow-up should be extended to the preschool and primary years

- Improving preterm children's attainment at primary school, particularly in mathematics, may enhance their outcomes across the lifespan

- Interventions at school age are needed
Study 3: 
Delayed school entry . . . 
An intervention for preterm children to improve academic attainment?

doi:10.1111/dmcn.12713
Background

General Population:

- Summer born children are the youngest in the class and have poorer academic achievement than the oldest in the class
- Effects persist until early secondary school and have even been shown to be related to adult income
- Either school attainment scores are adjusted (weighted) according to age or children may be permitted to defer or delay school entry
- Who decides: Parents (redshiriting) or teachers (deferral or delayed entry)
Background

- In most countries school entry is determined by birth date
- Preterm children are born up to 4 months before their due date
- They more often have a range of developmental problems
- Some are doubly disadvantaged: according to EDD they would start school a year later but have to enter a year earlier according to actual birth date
- Triple jeopardy: developmental risk, early admission and summer born

DOB  EDD

February  March  April  May  June  July  August  September  October
Achievement goals, gestation at birth, birth date and sex

Percentage of children (95% CI) according to gestation at birth not reaching a good overall achievement level by child age within class and for boys and girls (Foundation stage profiles rated by teachers)

Delayed school entry: Pros and cons

**PROS**
- Reduce psychological pressure and negative feedback for child
- Teachers may not be able to provide differential support to less “mature” children
- Children “mature” to be ready for school

**CONS**
- May not receive the intellectual stimulation being held back
- This may especially be the case where families are disadvantaged
- Costly – another year of child care for parents to pay
Mixed evidence and design problems

- **Selection bias:**
  - DSE: more often behaviour problems, special needs, summer born males or socially disadvantaged
  - Redshirting (parents keep child back)
  - Thus DSE were not comparable to appropriate age entries (ASE)

- **Small samples:**
  - statistical power issues
Natural experiment: Bavaria

- School entry age: 6 years chronological age
- 3-12 months before school entry: school entry test by community paediatrician
- Recommendation for DSE by paediatrician and agreed with school
- Parents cannot delay school entry (no redshirting)
Design

- N: 999 of BLS with full data
- 104 (DSE); 895 (ASE)
- 12 measures < 5 years (Before any DSE/ASE decision) for propensity score matching: Sex, SES, neonatal complications, Birth weight, gestation, SGA, parent-child interaction, IQ, vocabulary, language, attention span, behaviour regulation and visuomotor coordination
- 99 (DSE) matched to 895 (ASE)
- 53 (preterm DSE); 287 (preterm ASE)
- Control for confounders: Preschool rhyming and numerical tests
Outcome measures

- Teacher ratings of maths, reading and writing (average or below vs above average) and attention at end of year 1
- Standard assessment of academic achievement with standardised maths, reading and writing (Psychologists, blind to DSE status) at 8;5 years of age
- > 1 hour video-taped observation during IQ test- rating of task orientation (scale: 6 items; 9 point scales) of TRCB at 8;5 years of age
Effect of child age within class on Year 1 teacher ratings of reading achievement
Total sample: DSE vs. ASE (vertical line: 1) shown with 95% CI (fully adjusted model)

Preterm children only: DSE vs. ASE (vertical line: 1) shown with 95% CI (fully adjusted model)

Conclusions

- Delayed school entry has no advantage on teacher ratings (same school experience but older)
- Delayed school entry has clear disadvantage to performance at the same age (less school experience)
- Findings are similar for all and preterm children only but for attention (worse at age-based assessment)
Interpretation

- Inadequacy of the model of “maturation” of school skills for preterm children
  
- (a) Basic abilities (IQ, Attention) are more stable over time from preschool age in preterm children – do not outgrow or “mature” out of them

- (b) Preterm children are more sensitive or vulnerable to poor parenting (teaching?) than term children
Recommendations

- Current best evidence does not support the case for delayed school entry of preterm children
- ASE school entry may be facilitated by increased special support in school
- The current mixed evidence supports the need for a RCT for preterm children only
Study 4:
Teachers’ knowledge and information needs regarding preterm birth

Background

- Growing number of preterm children
- Almost all teachers will be responsible for supporting children born preterm
- Teachers’ knowledge and preparation about health conditions is crucial for appropriate educational management
- Teachers lack training and knowledge about effect of health conditions on children’s adaptation at school
Key questions

- What do teachers and educational psychologists know about the developmental and educational outcomes of children born preterm?

- What are their information needs related to the educational management of preterm children?
Methods & respondents

- Electronic survey of teaching staff in all schools in England
  - Email to the head teacher to cascade to all staff
  - Study posters sent to all schools in 4 local counties
  - Promoted via social media
  - **Respondents:** 585 teaching staff with complete data
    (93% teachers; 82% in mainstream schools; 21% had SEN role)

- Electronic survey of educational psychologists in the UK
  - Email sent to all members of the Association for Educational Psychologists (AEP)
  - Promoted via social media
  - **Respondents:** 212 educational psychologists with complete data
    (91% with complete data)
The survey

- Demographic questions

- Preterm Birth Knowledge Scale (PB-KS); 33 statements, e.g.
  - Of all the subjects studied at school, very preterm children are likely to have the greatest difficulties in mathematics
  - Almost all children born very preterm who attend mainstream school will have a statement of SEN
  - Children born very preterm are likely to be inattentive and withdrawn
  - Total PB-KS score (range 0-33)

- 7 items to assess opinions about educational management, training and information needs, e.g.
  - I feel adequately equipped to support the learning and development of children born very preterm
  - I have received sufficient training in this area

Results: Specific areas of knowledge

Mean PB-KS Scores:
Teachers 14.7 (5.5)
Psychologists 17.1 (5.0)
Clinicians 26.0 (3.6)
Results: Opinions and training

Discussion

- Teachers and educational psychologists recognise the role they have to play in supporting preterm children, but lack knowledge and formal training.

- Why is this so important?
  - Current follow-up arrangements
  - Complex learning difficulties
  - Preterm phenotype means problems may be missed

- Information about preterm children’s outcomes and strategies to support their learning are needed.
**Recommendation**

- Training teachers about the long term consequences of preterm birth is needed to enable them to understand the special constellation of problems faced by children born preterm.

- New teaching approaches need to be developed to deal with the special educational and social needs of preterm children in the classroom.
Summary of Recommendations

- **Follow-up assessments** into the late preschool and primary school years
- **Interventions** around school entry
- **Delayed school entry** not recommended – RCT needed
- **Training teachers** about preterm birth
- **New teaching approaches**
Questions?
Why preterm birth matters

Figure 2: Global burden of preterm birth in 2010

11 countries with preterm birth rates over 15% by rank:

1. Malawi
2. Congo
3. Comoros
4. Zimbabwe
5. Equatorial Guinea
6. Mozambique
7. Gabon
8. Pakistan
9. Indonesia
10. Mauritania
11. Botswana

Preterm birth rate, year 2010

- <10%
- 10% - <15%
- 15% or more
- Data not available
- Not applicable

The boundaries and names shown and the designations used on this map do not imply the expression of any opinion whatsoever on the part of the World Health Organization concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its borders or boundaries. Dotted lines on maps represent approximate border lines for which there may not yet be full agreement.

Data Source: World Health Organization
Map Production: Public Health Information and Geographic Information Systems (GIS)
World Health Organization

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Cost of preterm birth

Bavarian Longitudinal Study

- Prospective longitudinal study of neonatal at-risk children
- Children born in South Bavaria (02/1985 - 03/1986) and admitted to a hospital within 10 days of birth; controls were recruited from the same hospitals.
- Assessments
EPICure Study

- National Study of children born <26 weeks gestation in 1995
- 98% of neonatal units in UK and Ireland participated (276 nurseries; 171 neonatal units)

4004 deliveries reported (20-25 weeks)
1289 live births
314 discharged
308 alive at 2 ½ years of age: 283 (92%)
308 alive at 6 years of age: 241 (78%)
307 alive at 11 years of age: 219 (71%)
National Child Development Study (NCDS)

- Also known as the 1958 Birth Cohort Study
- National study following the lives of 17,500 babies born in England, Scotland and Wales in a single week of 1958
- Data collected on health, physical and educational development, economic circumstances, employment, family life, health behaviour, wellbeing and social participation
- Data collected at birth and assessment waves at age 7, 11, 16, 23, 33, 42, 46, 50 & 55 years
1970 British Cohort Study (BCS 70)

- National study following the lives of 17,200 babies born in England, Scotland and Wales in a single week of April 1970
- Data are collected on health, physical, educational and social development, employment and economic circumstances, family life and social participation
- Data collected at birth and assessment waves at age 5, 10, 16, 26, 30, 34, 38 and 42 years
IQ and mathematics attainment: K-ABC

- Same tests used in both samples
  - Kaufman Assessment Battery for Children (K-ABC) at approx. two years of schooling in both samples
  - IQ: MPC score
  - Math attainment: Arithmetic subtest score

- Tests were standardized according to full term control children in each sample (standardized control mean 100; SD 15)
Basic mathematics processing

- Same Mathematics Estimation Test (12 items) at age 8 (BLS) and age 11 (EPICure)

- Item responses were scored for accuracy and summarized into a total score

- Test scores were standardized based on full term controls in each study separately (standardized control mean 100; SD 15)
## Methods

<table>
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<tr>
<th>Wealth</th>
<th>NCDS &amp; BCS70</th>
<th>NCDS</th>
<th>BCS70</th>
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<th>BCS70</th>
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<th>BCS70</th>
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<tr>
<td>Family income</td>
<td>Non-verbal and verbal general ability test (11)</td>
<td>British Ability Scales 4 subtests (10)</td>
<td>Southgate Group Reading Test (7)</td>
<td>Edinburgh Reading Test (10)</td>
<td>Arithmetic test (7)</td>
<td>Friendly Maths Test (10)</td>
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<td>Family social class (occupation)</td>
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<td>-</td>
<td>Teacher rating of reading ability (7)</td>
<td>Teacher report of extra help with reading (10)</td>
<td>Teacher rating of number skills (7)</td>
<td>Teacher report of extra help with maths (10)</td>
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<td>Housing tenure</td>
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<td>Teacher report of reading level (7)</td>
<td>Maternal rating of child’s difficulty with reading (10)</td>
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<td>Maternal rating of child’s difficulty with maths (10)</td>
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Results: Information needs