Modelling standard grade attainment using the Scottish Longitudinal Study

An exploration of child development measures using linked Child Health Surveillance Programme Pre-School (CHSP-PS) records

31st March 2015

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**Introduction to study**

**SLS Project 2011_001**

A scoping study investigating low birth weight and its impact on child development, linking maternity, child surveillance and education data

http://sls.lscs.ac.uk/projects/view/2011_001/

For an introduction to the SLS, see Boyle et al. (2009)

**Context**

- Low birthweight (LBW) and socio-economic status has an impact on cognitive development (Shenkin et al. 2001 and 2004)
- Previous research into determinants of LBW (Dibben et al 2006; Fairley 2005)
- Extending understanding of LBW on physical and cognitive development and subsequent educational attainment.
- Cognitive ability and Pre-School years, GUS (Bradshaw 2011).
In twin studies, LBW a predictor of educational attainment, income and health in adulthood (Black et al. 2007, Royer 2009, Almond and Currie 2011).

There are strong associations between:
- parental education and educational attainment (Björklund and Salvanes 2011, Bukodi and Goldthorpe 2012, Chevalier et al. 2013)

Evidence that birthweight is stratified by parental occupation (Blumenshine et al. 2010). Children of parents in manual occupations are more likely to have low or very low birthweight (Macfarlane and Mugford 2000, Moser et al. 2003, Macfarlane et al. 2004, Maher and Macfarlane 2004, Dibben et al. 2006).

It is plausible that there is mediation of the low birthweight effect by socio-economic status (Currie and Hyson 1999).
Kirkegaard et al. (2006) - 5319 children born between January 1990 and June 1992

Gestational Age and Birth Weight in Relation to School Performance of 10-Year-Old Children: A Follow-up Study of Children Born After 32 Completed Weeks

- Association between birthweight and reading, as well as spelling and arithmetic disabilities, showed a graded relationship.

- Children who weighed less than 2500g had the highest risks.

- Children who weighed between 3000g and 3499g had an increased risk of all 3 learning disabilities compared with children who weighed between 3500g and 4000g.

- Association persisted after adjustment for:
  - potential cofounders
  - when the analyses were restricted to children born at term (suggesting that the association could not be explained by a low gestational age).
Low Birthweight (LBW)
  - Less than 2500g
Very Low Birthweight (VLBW)
  - Less than 1500g

Very few VLBW infants

Require additional controls for Gestational Age
  - Pre-Term (32 to <37 weeks)
  - Very Pre-Term (28 to <32 weeks)

Small for Gestational Age (SGA) – see Kramer et al. (2001)
  - Lowest 10% for each week of Gestational Age, Sex specific.
  - Thanks to Tom Clemens
Research Questions

- Is LBW associated with lower standard grade attainment?
  - Independent of other known correlates (such as parental occupation, parental education and other family background factors).
  - Is this also the case for Small for Gestational Age (SGA) infants?

- Are Child Development measures associated with standard grade attainment?
  - Do these indicators act as potential mediators of any supposed relationship between LBW and standard grade attainment?
Based on Woodside (see Eu 1986)

Indicators
- Gross Motor skills
- Fine motor or manipulative skills; vision
- Hearing and communication
- Social skills and behaviour

Classification
- Abnormal
- Doubtful / Uncertain
- Incomplete
- Normal
CHSP-PS Assessments (2)

Reviews

<table>
<thead>
<tr>
<th>Time Point</th>
<th>Description</th>
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<tbody>
<tr>
<td>t0</td>
<td>Public Health Nurse / Health Visitor First Visit</td>
</tr>
<tr>
<td>t1</td>
<td>6-8 Week Review</td>
</tr>
<tr>
<td>t2</td>
<td>8 to 9 Month Review</td>
</tr>
<tr>
<td>t3</td>
<td>21 to 24 Month Review (pre Hall 4)</td>
</tr>
<tr>
<td>t4</td>
<td>39 to 42 Month Review (pre Hall 4)</td>
</tr>
<tr>
<td>t5</td>
<td>48 Month Review/ Pre-school (pre Hall 4)</td>
</tr>
</tbody>
</table>

NHS Scotland - Information Services Division (ISD)

## CHSP-PS Cohort Construction

<table>
<thead>
<tr>
<th>Dataset</th>
<th>n</th>
<th>n in SMR02</th>
<th>% in SMR02</th>
<th>Sequential Merge</th>
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<tbody>
<tr>
<td>SMR02 Mother's Characteristics at Birth of Child.</td>
<td>63886</td>
<td>63886</td>
<td>100%</td>
<td>63886</td>
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<tr>
<td>Public Health Nurse / Health Visitor First Visit</td>
<td>15419</td>
<td>14486</td>
<td>96.3%</td>
<td>14846</td>
</tr>
<tr>
<td>6-8 Week Review</td>
<td>15250</td>
<td>14684</td>
<td>96.3%</td>
<td>13645</td>
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<tr>
<td>8 to 9 Month Review</td>
<td>15995</td>
<td>15284</td>
<td>95.6%</td>
<td>12570</td>
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<tr>
<td>21 to 24 Month Review (pre Hall 4)</td>
<td>19108</td>
<td>18037</td>
<td>94.4%</td>
<td>11667</td>
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<tr>
<td>39 to 42 Month Review (pre Hall 4)</td>
<td>21245</td>
<td>19875</td>
<td>93.6%</td>
<td>10316</td>
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<tr>
<td>48 Month Review/ Pre-school (pre Hall 4)</td>
<td>20851</td>
<td>19465</td>
<td>93.4%</td>
<td>8617</td>
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<tr>
<td>School Review Results - P1</td>
<td>7845</td>
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<td>93.2%</td>
<td>4119</td>
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<tr>
<td>School Review Results - P7</td>
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<td>92.0%</td>
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<tr>
<td>School Review Results - S3</td>
<td>3962</td>
<td>3572</td>
<td>90.2%</td>
<td>0</td>
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</table>
## Scottish Longitudinal Study

### Table 2 Data currently held in the SLS

<table>
<thead>
<tr>
<th>Census</th>
<th>Vital events</th>
</tr>
</thead>
</table>
| 1991 Census data for SLS members including:  
- Age, sex, marital status  
- Family, household or communal establishment type  
- Family and household structure  
- Housing, including tenure, rooms and amenities  
- Country of birth  
- Ethnicity  
- Educational qualifications  
- Economic activity  
- Occupation, industry and social class  
- Migration  
- Limiting long-term illness  
- Mode of transport used in commuting  

   1991 Census data for those living in the same household as a SLS member  
   Similar information as collected for sample members |

   New entry datasets  
   - New births into the sample  
   - Immigrants into the sample |

   Vital events to SLS members  
   - Births to sample mothers/fathers  
   - Stillbirths to sample mothers/fathers  
   - Infant mortality of children of sample mothers/fathers  
   - Marriages of sample members  
   - Divorce of sample members  
   - Deaths of sample members  
   - Widow(er)hoods of sample members  
   - Emigration out of Scotland of SLS members  
   - Re-entries into Scotland after previous emigrations of SLS members  

   Hospital episodes  
   - Information on inpatients and day cases discharged from NHS hospitals (SMR01)  
   - Information on people admitted to mental illness specialties (SMR04) |

   Cancer registrations  
   All cancers for sample members |

2001 Census data for SLS members  
Similar data to 1991, but additional information collected in 2001 includes:  
- Self-rated health  
- Religion currently and in childhood  
- Caregiving  
- Distance to work  

2001 Census data for those living in the same household as a SLS member  
Similar information as collected for sample members.

Source: Boyle et al. (2009: 388) – Table 2
Sample Construction

- SMR02 data contains 63,886 records
- H05 Qualifications data contains 10,679 records (years 2007-2010)

- There are 9,656 cases (90.4% of records) in H05 Qualifications Table which have linked records in SMR02.

- There are the same number of records are also present in the 2001 Census extract (Includes information on Sex and Ethnicity).

- 7,941 records are also present in Extract 6 (2001 Census Information on Parental Qualifications and Occupations)

- 7,028 records with complete cases
  - Inclusion of CHSP-PS measures reduces this to 5,201 cases
  - Further details provided
Sample construction (2)

- **SMR02 Maternity Inpatient and Day Case dataset**
  - \( n = 63,886 \)

- **Sex and Ethnicity of SLS member (Census 2001)**

- **Parental RGSC and Parental Highest Qualification (Census 2001)**

- **Scottish Qualifications Authority (SQA) data for those gaining Standard Grades in S4 in school years 2007/8 – 2010/11**
  - \( n = 10,679 \)

Data included in analysis
  - \( n = 7,941 \)
CHSP-PS Measures

- Different number of visits and assessments per individual
- Derived measures
  - Any Abnormality
  - Any Doubtful/Uncertain
CHSP-PS

Descriptive Statistics

CHSP-PS Development Indicators

Gross Motor Skills

Fine Motor Skills

Hearing

Social

Source: SLS, n=5,201
After MacKay et al. (2010)

Special Educational Needs and Gestational Age

Source: MacKay et al. (2010: 7) – Figure 1
Estimated Gestation

Priority
Conditional

Definition
The number of completed weeks of pregnancy, as judged by the clinician (doctor or midwife), usually on the basis of an ultrasound measurement.

Recording Rules
Enter the Estimated Gestation in the boxes provided. If the Estimated Gestation is not known enter 99.

Points to Note
1. This field should be completed for Delivery and Abortion episodes and may be completed for Other (includes missed abortion) episodes, otherwise it should be left blank.
2. Records staff must not base this Estimated Gestation simply on the interval between the dates of LMP and delivery. The clinician’s estimate will take account of other factors, including scans.

Cross-Checks
1. Estimated Gestation MUST be present if Certainty of Gestation is present.
2. The record will be queried if the Estimated Gestation falls outwith the range 01-45 weeks.
3. Gestation is cross-checked with Birthweight.
4. Gestation is cross-checked with Outcome of Pregnancy.
5. Gestation is cross-checked with Condition on Discharge and MUST be completed if Condition on Discharge = 2 or 3 (Abortion or Delivery episode).

CHSP-PS: Gross Motor Skills

Gross Motor Skills:
Prevalence of Abnormal/Doubtful by Estimated Gestation

Source: SLS, n=5,768
CHSP-PS: Fine Motor Skills

Fine Motor Skills:
Prevalence of Abnormal/Doubtful by Estimated Gestation

Source: SLS, n=5,768
CHSP-PS:
Hearing

Hearing:
Prevalence of Abnormal/Doubtful by Estimated Gestation

Source: SLS, n=5,768
CHSP-PS: Social

Social:
Prevalence of Abnormal/Doubtful by Estimated Gestation

Source: SLS, n=5,768
Education Data in the SLS

- Education data linked from ScotXed (2007-2011)
  - Schools Census
  - SQA Attainment
  - Absences
  - Exclusions

http://sls.lscs.ac.uk/guides-resources/what-data-are-included/education-data/

- See Raab (2013)

- Focused on Standard Grade attainment.

Source: Raab (2013: 23)
Standard Grade Attainment

- Standard Grades: central qualifications undertaken by pupils in secondary schools in Scotland (historically).

- No single recognised measure of school attainment at Standard Grade level.

- Number of Credit Passes (Standard Grades 1 & 2)

- Standard Grade Points Score (inverted)
  - 7 points = Grade 1 (Highest)
  - 1 point = Grade 7 (Lowest)

See Croxford et al. (2007)
Standard Grade Score 1

Standard Grade Points Score (S4)

Source: SLS, n=9,656
Standard Grade Score 2

Standard Grades (S4)
Number of Credit Passes

Source: SLS, n=9,656
Standard Grade by Estimated Gestation

Standard Grade Score
by Estimated Gestation

Source: SLS, n=7,941
Standard Grade by Low Birthweight

Standard Grade Score by Birthweight

Source: SLS, n=7,941
Descriptive Statistics (2)

Standard Grade Score: Development Indicators

Source: SLS, n=5,201
Models

- LBW Models
- SGA Models
- LBW Models with interaction between birthweight and estimated gestation (Appendix)
LBW Models (1)

Standard Grade Attainment Model

Birthweight and Estimated Gestation (1)

- **Sex of Child**
  - Male
  - Female

- **Estimated Gestation**
  - Full Term (37 weeks or more)
  - Preterm (32-37 weeks)
  - Very preterm (Less than 32 weeks)

- **Birthweight**
  - Greater than 2500g
  - Low (<2500g)
  - Very low (<1500g)

- **Marital Status**
  - Married
  - Other

- **Smoking history at booking**
  - 0. Never
  - 1. Current
  - 2. Former
  - 9. Not known

- **Maternal Age**
  - Below 21
  - 21-29
  - Above 30

- **Parity**
  - Nulliparous
  - Multiparous

Source: SLS, n=7,068, R-Squared = 0.20

Controls: Parental RGSC, Parental Highest Qualification, Mode of Delivery, Maternal Height
LBW Models (2)

Standard Grade Attainment Models

Birthweight and Estimated Gestation (2)

- **Sex of Child**: Male, Female
- **Estimated Gestation**: Full Term (37 weeks or more), Preterm (32-37 weeks), Very preterm (Less than 32 weeks)
- **Birthweight**: Greater than 2500g, Low (<2500g), Very low (<1500g)
- **Marital Status**: Married, Other
- **Smoking history at booking**: 0. Never, 1. Current, 2. Former, 9. Not known
- **Maternal Age**: Below 24, 25-29, Above 30
- **Parity**: Nulliparous, Multiparous

Source: SLS, n=5,229, R-Squared: Model 2 = 0.20, Model 3 = 0.21

Controls: Parental RGSC, Parental Highest Qualification, Mode of Delivery, Maternal Height
LBW Models (3)

Standard Grade Attainment Models

Estimated Gestation
- Full Term (37 weeks or more)
- Preterm (32-37 weeks)
- Very preterm (Less than 32 weeks)

Birthweight
- Greater than 2500g
- Low (<2500g)
- Very low (<1500g)

CHSP Gross Motor Skills
- A Abnormal
- D Doubtful or uncertain
- I Not done/incomplete
- N Normal

CHSP Fine Motor Skills
- A Abnormal
- D Doubtful or uncertain
- I Not done/incomplete
- N Normal

CHSP Hearing
- A Abnormal
- D Doubtful or uncertain
- I Not done/incomplete
- N Normal

CHSP Social
- A Abnormal
- D Doubtful or uncertain
- I Not done/incomplete
- N Normal

Source: SLS, n=5,229, R-Squared: Model 2 = 0.20, Model 3 = 0.21
Controls: Parental RGSC, Parental Highest Qualification, Mode of Delivery, Maternal Height
SGA Models (1)

Standard Grade Attainment Model

Small for Gestational Age (1)

Sex of Child
- Male
- Female

Small for Gestational Age
- Not SGA
- SGA

Marital Status
- Married
- Other

Smoking history at booking
- 0. Never
- 1. Current
- 2. Former
- 9. Not known

Maternal Age
- Below 24
- 25-29
- Above 30

Parity
- Nulliparous
- Multiparous

Source: SLS, n=7,028, R-Squared = 0.20

Controls: Parental RGSC, Parental Highest Qualification, Mode of Delivery, Maternal Height
SGA Models (2)

Standard Grade Attainment Models

Sex of Child
- Male
- Female

Small for Gestational Age
- Not SGA
- SGA

Marital Status
- Married
- Other

Smoking history at booking
- 0. Never
- 1. Current
- 2. Former
- 9. Not known

Maternal Age
- Below 24
- 25-29
- Above 30

Parity
- Nulliparous
- Multiparous

Source: SLS, n=5,021, R-Squared: Model 2 = 0.20, Model 3 = 0.21
Controls: Parental RGSC, Parental Highest Qualification, Mode of Delivery, Maternal Height
SGA Models (3)

Standard Grade Attainment Models

Small for Gestational Age
- Not SGA
- SGA

CHSP Gross Motor Skills
- A Abnormal
- D Doubtful or uncertain
- I Not done/incomplete
- N Normal

CHSP Fine Motor Skills
- A Abnormal
- D Doubtful or uncertain
- I Not done/incomplete
- N Normal

CHSP Hearing
- A Abnormal
- D Doubtful or uncertain
- I Not done/incomplete
- N Normal

CHSP Social
- A Abnormal
- D Doubtful or uncertain
- I Not done/incomplete
- N Normal

Source: SLS, n=5,021, R-Squared: Model 2 = 0.20, Model 3 = 0.21
Controls: Parental RGSC, Parental Highest Qualification, Mode of Delivery, Maternal Height
Research Questions Revisited

- Is LBW/SGA associated with lower standard grade attainment?
  - Independent of other known correlates (such as parental occupation, parental education and other family background factors).
  - Is this also the case for Small for Gestational Age (SGA) infants?

- Are Child Development measures associated with standard grade attainment?
  - Do these indicators act as potential mediators of any supposed relationship between LBW and standard grade attainment?
Conclusions

- This presentation has demonstrated potential use of the CHSP-PS measures to model Standard Grade attainment using the Scottish Longitudinal Study.

- LBW has a weaker association with standard grade attainment (controlling for estimated gestation).
  - Borderline statistical significance (at p<0.05)
  - Larger standard error of the estimate.

- SGA is associated with lower Standard Grade attainment (age 15/16).
  - Independent of Parental RGSC, Parental Education, Sex of Child, Marital Status of Mother, Smoking History at Booking, Maternal Age at Birth, Parity, Mode of Delivery, Maternal Height, and CHSP-PS measures of development.

- CHSP-PS measures have weaker association due to small sub-sample sizes
- Little mediation of SGA effect on Standard Grade attainment (age 15/16).

- Requires further investigation
Different distribution of birthweights by groups (e.g. smokers and non-smokers).

Effect of birthweight is not, therefore uniform. What is a “Low” birthweight for one group is not “Low” for another.

See Wilcox (2001, 2006)

SGA makes an attempt to correct for the lowest birthweights for each week of gestational age.

However, still an imperfect measure:
- Z-Scores? (Schisterman et al. 2009)
- Using a model-based definition to identify thresholds? (Juarez 2014)
Next Steps

Sensitivity Analysis
- Revisit LBW & VLBW
- Number of Standard Grade credit passes

Random effects model (see Goldstein et al. 1994)
- Repeated measures data (CHSP-PS Assessments)
- Unbalanced design (not recorded at every time point)
The help provided by staff of the Longitudinal Studies Centre – Scotland (LSCS) is acknowledged. The LSCS is supported by the ESRC/JISC, the Scottish Funding Council, the Chief Scientist’s Office and the Scottish Government. The authors alone are responsible for the interpretation of the data. Census output is Crown copyright and is reproduced with the permission of the Controller of HMSO and the Queen’s Printer for Scotland.

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Project: Administrative Data Research Centre - Scotland
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Appendix
LBW Models Interaction (1a)

Standard Grade Attainment Model
Birthweight and Estimated Gestation - Interactions (1a)

Source: SLS, n=7,068, R-Squared = 0.20
Controls: Parental RGSC, Parental Highest Qualification, Sex, Marital Status, Smoking History, Mode of Delivery, Maternal Age, Parity, Maternal Height
LBW Models Interaction (2a)

Standard Grade Attainment Models

Birthweight and Estimated Gestation Interactions (2a)

- Full Term
  - Full Term (37 weeks or more) # Greater than 2500g
  - Full Term (37 weeks or more) # Low (<2500g)

- Preterm
  - Preterm (32-37 weeks) # Greater than 2500g
  - Preterm (32-37 weeks) # Low (<2500g)
  - Preterm (32-37 weeks) # Very low (<1500g)

- Very Preterm
  - Very preterm (Less than 32 weeks) # Greater than 2500g
  - Very preterm (Less than 32 weeks) # Low (<2500g)
  - Very preterm (Less than 32 weeks) # Very low (<1500g)

Source: SLS, n=5,229, R-Squared: Model 2 = 0.20, Model 3 = 0.2

Controls: Parental RGSC, Parental Highest Qualification, Sex, Marital Status, Smoking History, Mode of Delivery, Maternal Age, Parity, Maternal Height, CHSP-PS Indicators
LBW Models Interaction (3a)

Standard Grade Attainment Models

Birthweight and Estimated Gestation Interactions (3a)

CHSP Gross Motor Skills
- A Abnormal
- D Doubtful or uncertain
- I Not done/incomplete
- N Normal

CHSP Fine Motor Skills
- A Abnormal
- D Doubtful or uncertain
- I Not done/incomplete
- N Normal

CHSP Hearing
- A Abnormal
- D Doubtful or uncertain
- I Not done/incomplete
- N Normal

CHSP Social
- A Abnormal
- D Doubtful or uncertain
- I Not done/incomplete
- N Normal

Source: SLS, n=5,229, R-Squared: Model 2 = 0.20, Model 3 = 0.21
Controls: Parental RGSC, Parental Highest Qualification, Sex, Marital Status, Smoking History, Mode of Delivery, Maternal Age, Parity, Maternal Height, Birthweight, Estimated Gestation
The Scottish Low Birthweight Study

The Scottish low birthweight study: I. Survival, growth, neuromotor and sensory impairment

The Scottish Low Birthweight Study Group*

Abstract
Of all 908 livebirths weighing less than 1750 g at birth who were born in Scotland in 1984, 896 (99%) were enrolled in a prospective study to document survival and determine the prevalence of neuromotor and sensory impairments and disability.

At the age of 4.5 years, 636 (71%) had survived and 611 (96%) were assessed. Overall 16% were disabled; 47 had cerebral palsy (52.5/1000 livebirths), seven were blind (7.8/1000 livebirths), and 11 were deaf and using aids (12.3/1000 livebirths). Among those not overtly disabled, the prevalence of poor neuromotor competence was high and related to birth weight.

All growth measures had mean values below the standard population mean indicating a downward shift in the distribution which was related to birth weight. In addition the height distribution was negatively skewed.

The Scottish Low Birthweight Study: II. Language attainment, cognitive status, and behavioural problems

The Scottish Low Birthweight Study Group*

Abstract
Of the 636 survivors of a total geographically based population born in Scotland in 1984, who weighed less than 1750 g at birth, 611 (96%) were assessed at 4.5 years to determine the prevalence of language, cognitive, and behavioural problems.

Language development was significantly related to birth weight, gestational age, and social class for comprehension, less so for expressive language.

Mean (SD) intelligence quotient (IQ) on the British ability scales was 92.9 (14.7). Within this population there were no significant differences between birthweight groups. Overall they performed poorly on visual recognition, verbal comprehension and number skills subscales—in the latter those with birth weights <1000 g were significantly worse than the heavier children. Only 5% had IQs <70, but a further 3% could not be tested because of other physical disability. Among those with normal IQs were groups of children who exhibited patterns of skill deficits in different subscales raising the possibility of specific learning difficulties.

Poor attention span was reported in 47%, and parents said the study children had more behavioural problems than their siblings.


