Investigating Associations between Mode of Delivery and Later Educational Outcomes

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Outline

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This project was undertaken as part of the Big Data theme of the Better Start National Science Challenge, funded by the Ministry of Business, Innovation and Employment. The Big Data theme was led by the University of Otago.

Disclaimer

Disclaimer: The results in this report are not official statistics, they have been created for research purposes from the Integrated Data Infrastructure (IDI), managed by Statistics New Zealand. The opinions, findings, recommendations, and conclusions expressed in this report are those of the authors, not Statistics NZ. Access to the anonymised data used in this study was provided by Statistics NZ in accordance with security and confidentiality provisions of the Statistics Act 1975. Only people authorised by the Statistics Act 1975 are allowed to see data about a particular person, household, business, or organisation, and the results in this report have been confidentialised to protect these groups from identification. Careful consideration has been given to the privacy, security, and confidentiality issues associated with using administrative and survey data in the IDI. Further detail can be found in the Privacy impact assessment for the Integrated Data Infrastructure available from www.stats.govt.nz.
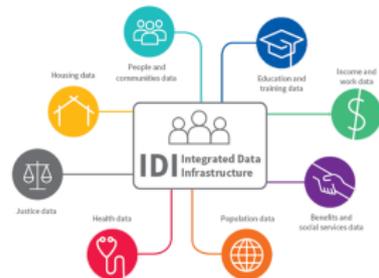
C-section:

- Lifesaving intervention, but may lead to short-term and long-term health effects for mothers and children.

- Increasing usage globally.

- In NZ: 23.7% in 2008 and 27.9% in 2017. (Elective C-section: 10.3% in 2008 and 12.6% in 2017.)

- It may alter the colonisation and composition of gut bacterial environment at an early age.

Background and motivation

Mixed findings:

Polidano, Zhu, and Bornstein (2017):
C-section born children underperform compared with vaginally delivered children on problem solving and vocabulary at age 4 – 5; grammar, numeracy, reading and writing at age 8 – 9.

Bentley et al. (2016):
Found association between pre-labour C-section delivery and higher risk of children being developmental high risk and developmentally vulnerable in language and cognitive skills, as well as basic numeracy.

Smithers, Mol, Wilkinson, and Lynch (2016):
Found no association between C-section and increased risk of poor school outcomes: reading, writing, spelling, grammar and numeracy, at age 8.

One possible mechanism

Gut microbiota:

- A huge diversity of microbes (bacteria, fungi and viruses) inhabit the human gastrointestinal tract.
- The acquisition and development can be influenced by gestational age, feeding method, host genetics and mode of delivery.

Cognitive development:

- The microbiota in the gastrointestinal tract communicate with the brain via bi-directional pathways that include the immune system signalling, the vagus nerve, and the neuroendocrine system particularly the HPA axis.

Our study

Participants: Children born in New Zealand between 1996 – 1998.
Mode of Delivery: Based on ICD-9 code from mothers' diagnostic records

Mode of Delivery	ICD-9 code	Explanation
Unassisted	73.59	Other manually assisted delivery
Assisted	72.0	Low forceps operation
	72.1	Low forceps operation with episiotomy
	72.2	Mid forceps operation
	72.3	High forceps operation
	72.4	Forceps rotation of fetal head
	72.5	Breech extraction
	72.6	Forceps application to aftercoming head
	72.7	Vacuum extraction
	72.8	Other specified instrumental delivery
	72.9	Unspecified instrumental delivery
C-section	74.0	Classical caesarean section
	74.1	Low cervical caesarean section
	74.2	Extraperitoneal caesarean section
	74.3	Removal of extratubal ectopic pregnancy
	74.4	Caesarean section of other specified type
	74.9	Caesarean section of unspecified type

Educational outcomes:

- NCEA Level 2 Percentile Score
- NCEA Level 2 Highest Endorsement
- University Entrance

Reasons for choosing these outcomes:

- Only educational data available at the national level
- To assess the long-term effect of C-section on cognitive development
- High school achievements are important factors in future employment

NCEA Level 2 Percentile Score:
A student's score in each standard is converted into an expected percentile, which is the mid-point of the percentile of students who received each grade for that standard across the country. The expected percentile score at each NCEA level is then calculated by averaging these estimates over all standards that the student took. This metric adjusts for the difficulty of the standard.

NCEA Level 2 Highest Endorsement:
A Level 2 certificate endorsement has three levels: Excellence, Merit and No Endorsement (either not achieved or achieved). A student must gain 50 credits at Excellence to be endorsed with Excellence. If this student failed to obtain an Excellence endorsement but gained 50 credits at Merit or above, then he or she would be endorsed with Merit.

University Entrance: the minimum requirement to be admitted to a New Zealand university and is a binary variable (Yes/No). Requirements for UE include: NCEA Level 3, three subjects at Level 3, made up of 14 credits in each of three approved subjects, 10 credits focusing on literacy at Level 2 or above and 10 credits focusing on numeracy at Level 1 or above. Credits can be accumulated over more than one year and one may have multiple UE results. If a participant had multiple UE results, the better one was selected.

Confounders: NZDep2013, household income, maternal education, mother's marital status, birth weight, gestational age, child's ethnicity, birth order, maternal age and birth year.

Participants

Birth record from DIA	Mode of delivery added	Educational outcomes added	Other sociodemographic variables added
N = 173838	N = 144219	N = 112026	N = 112026
$N_c^* = 349098$	$N_c^* = 289263$	$N_c^* = 225621$	$N_c^* = 225621$
			$N_m^* = 43656$

Linked to MoH   Linked to MoE   Linked to 2013 Census
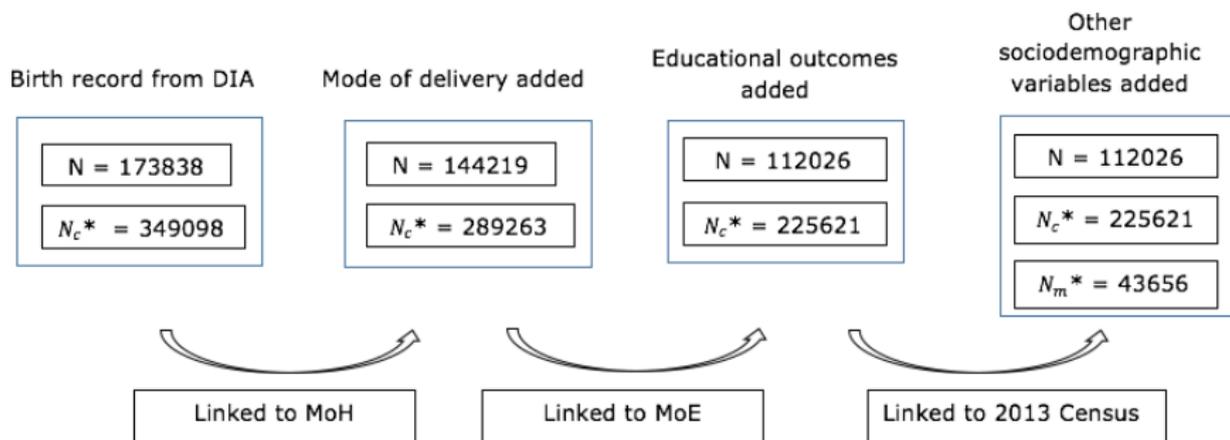
N: count of children in three-year cohort

N_c^*: count of children in six-year cohort

N_m^*: count of mothers with two or more children in six-year cohort

Bivariate analysis:

	Unassisted	C-section	Assisted
Percentile Score			
Estimate in % (95% CI)	Ref	2.2 (1.8, 2.5)	3.7 (3.3, 4.1)
Excellence			
OR (95% CI)	Ref	1.26 (1.20, 1.33)	1.49 (1.41, 1.58)
Merit			
OR (95% CI)	Ref	1.19 (1.15, 1.24)	1.30 (1.25, 1.36)
UE			
OR (95% CI)	Ref	1.33 (1.29, 1.37)	1.53 (1.47, 1.59)

Covariate-adjusted analysis:

	Unassisted	C-section	Assisted
Percentile Score			
Estimate in % (95% CI)	Ref	-0.3 (-0.6, 0.0)	0.5 (0.1, 0.8)
Excellence			
OR (95% CI)	Ref	0.95 (0.89, 1.01)	1.06 (0.99, 1.13)
Merit			
OR (95% CI)	Ref	0.98 (0.93, 1.02)	1.04 (0.99, 1.09)
UE			
OR (95% CI)	Ref	1.00 (0.96, 1.04)	1.09 (1.04, 1.14)

Conclusion

- We did not find evidence supports that C-section is significantly associated with educational outcomes after adjusting for confounders (covariate-adjusted analysis).

- In terms of assisted vaginally delivered children, from covariate-adjusted analysis, they were associated with improved educational outcomes (NCEA Level 2 Percentile Score and UE). However, such associations did not persist in sibling fixed effects analysis. Why?

Acknowledgements

Thank you

Bentley, J. P., Roberts, C. L., Bowen, J. R., Martin, A. J., Morris, J. M., & Nassar, N. (2016). Planned Birth Before 39 Weeks and Child Development: A Population-Based Study. *Pediatrics*, *138*(6).

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Smithers, L. G., Mol, B. W., Wilkinson, C., & Lynch, J. W. (2016). Implications of Caesarean Section for Children's School Achievement: A Population-Based Study. *Australian and New Zealand Journal of Obstetrics and Gynaecology*, *56*(4), 374-380.

NCEA Level 2 Percentile Score:

Table: Example illustration.

Endorsement Level	Frequency	Percentage	Cumulative Percentage	Expected Percentile
Not achieved	20	20%	20%	10%
Achieved	50	50%	70%	45%
Merit	20	20%	90%	80%
Excellence	10	10%	100%	95%

Example: if a student undertook five standards and received one excellence, two merits, one achieved and one not achieved, and each of these standards had population distribution as shown above, then the student's percentile score would be: $\frac{95+80+80+45+10}{5} = 62$. However, the actual population distribution for each standard would be different, this simplified example is given for illustration purposes only.

Our study

NCEA Level 2 Highest Endorsement: A Level 2 certificate endorsement has three levels: Excellence, Merit and No Endorsement (either not achieved or achieved). A student must gain 50 credits at Excellence to be endorsed with Excellence. If this student failed to obtain an Excellence endorsement but gained 50 credits at Merit or above, then he or she would be endorsed with Merit.

Average percentage of endorsement achievement 2008 - 2018
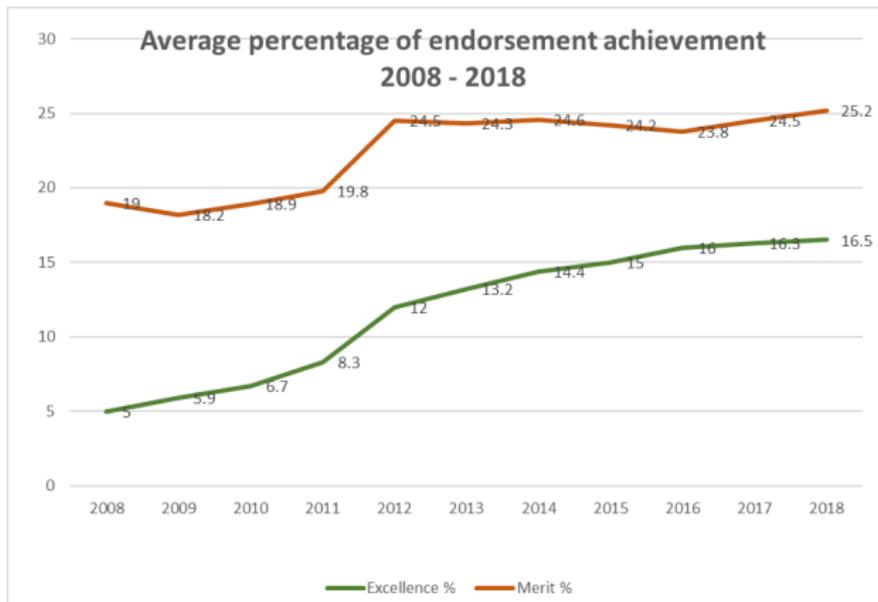
Sibling fixed effects analysis: enlarged six-year cohort (1993 – 1998)

	Unassisted	C-section	Assisted
Percentile Score *Estimate in % (95% CI)*	Ref	0.6 (-0.1, 1.2)	0.5 (0.0, 0.3)
Excellence *OR (95% CI)*	Ref	1.36 (0.93, 2.01)	1.24 (0.94, 1.63)
Merit *OR (95% CI)*	Ref	1.13 (0.98, 1.32)	1.07 (0.96, 1.19)
UE *OR (95% CI)*	Ref	1.08 (0.95, 1.22)	1.09 (0.99, 1.19)