

Birth order and infant health: evidence from maternal immunisation in New Zealand

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Annual Conference of the Austrian Economic Association (NOeG) 2025
University for Continuing Education Krems, 24 September 2025

IDI disclaimer

- ▶ Disclaimer: Access to the data used in this study was provided by Stats NZ under conditions designed to give effect to the security and confidentiality provisions of the Data and Statistics Act 2022. The results presented in this study are the work of the author, not Stats NZ or individual data suppliers. These results are not official statistics. They have been created for research purposes from the Integrated Data Infrastructure (IDI) which is carefully managed by Stats NZ. For more information about the IDI please visit <https://www.stats.govt.nz/integrated-data/>.

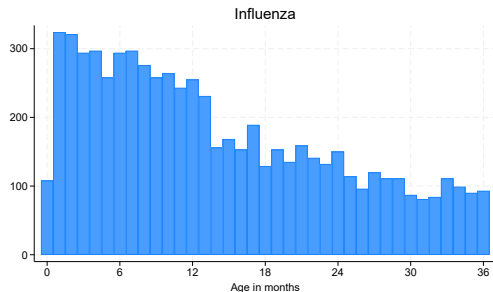
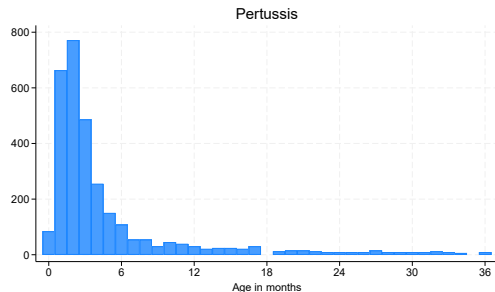
Introduction

- ▶ pregnancy and infancy are periods of increased vulnerability to infections
- ▶ maternal immunisations: protect pregnant women and their infants, but uptake remains low
 -  US survey: 47.2 % received influenza, 55.4 % Tdap during pregnancy (Razzaghi et al., [2023](#))
 -  NZ administrative data 2018: 30.8 % received influenza, 43.6 % Tdap (Howe et al., [2020](#))
- ▶ growing evidence that birth order affects early childhood health and parental behaviour
- ▶ parental investment and behavior
 -  time and financial constraints, parenting style (Price, [2008](#))
 -  mothers are less likely to attend pre-natal care and breastfeed later-born children (Buckles and Kolka, [2014](#); Brenøe and Molitor, [2018](#); Lehmann et al., [2018](#))
 -  later-born children are less likely to participate in preventive medical health checks and have lower childhood immunisation uptake (Pruckner et al., [2021](#); Lin et al., [2022](#))

Introduction

- ▶ biological reasons
 -  nutrition availability increases with each pregnancy
 -  later-born children are healthier at birth (Brenøe and Molitor, [2018](#); Pruckner et al., [2021](#); Björkegren and Svaleryd, [2023](#))
- ▶ family environment: influence of (older) siblings
 -  older children can 'bring home' common viruses or bacteria
 -  younger siblings have higher rates respiratory/infectious conditions in early life (Pruckner et al., [2021](#); Daysal et al., [2021](#))
- ▶ endogeneity and selection explanations
- ▶ this paper: studies the relationship between
 -  birth order and maternal immunisation against pertussis and influenza
 -  birth order and childhood hospitalisation due to these diseases

Pertussis and influenza hospitalisations in NZ



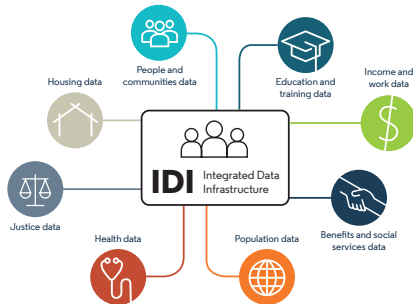
- ▶ repeated **pertussis** (= whooping cough) outbreaks in [New Zealand](#)
 - ▶ young infants face a higher risk of hospitalisation and death (Kandeil et al., [2020](#))
- ▶ annual **influenza** seasons
 - ▶ approximately 1 in 5 unvaccinated children and 1 in 10 unvaccinated adults infected by seasonal influenza annually (Somes et al., [2018](#))
- ▶ potential long-term effects: brain development (Al-Haddad et al., [2019](#)), socio-economic outcomes (Almond, [2006](#))

Maternal immunisation

- ▶ 2 benefits of vaccination during pregnancy
 -  protecting women during pregnancy and the fetus
 -  transfer of maternal antibodies to infants via placental transfer and/or breastfeeding
- ▶ vaccine effectiveness is high, particularly for preventing hospitalisation and death
- ▶ maternal immunisations recommended and funded in many countries, including NZ
 -  pertussis: for all pregnant women since 2013
 -  influenza: since 2010, (recommended from 1 April, before usual influenza virus activity)
 -  covid: recommended since June 2021
- ▶ childhood immunisation
 -  National Immunisation Schedule includes 3 acellular pertussis-containing vaccines in the first year of life
 -  influenza: recommended for everyone over 6 months of age; publicly funded for children only if they have certain chronic conditions

Integrated Data Infrastructure (IDI)

- ▶ population-wide research database managed by StatsNZ
- ▶ linked micro-data from government agencies, NGOs, surveys
 - ▶ births from Department of Internal Affairs (DIA)
 - ▶ vaccine type and date from Aotearoa Immunisation Register (AIR) (*replaced the National Immunisation Register*)
 - ▶ hospital discharge records from Ministry of Health (MoH) with diagnostic information
 - ▶ National Maternity Collection: visits to lead maternity carer



Empirical strategy

$$Y_{im} = \alpha + \sum_j \beta_j I(BO_{im} = j) + \gamma X_i + \delta_m + \epsilon_{im},$$

Y_{im}	outcome of pregnancy/child i of mother m
$BO_{im} = j$	birth order indicators ($j = 2, 3, 4+$)
X_i	sex, year-by-month of birth
δ_m	mother fixed effects

- ▶ exploit within-family variation in birth order to account for time-constant unobserved factors at the family level (e. g., genetic endowment, SES)
- ▶ main sample: children born between 2015-2023 for maternal immunisations
 -  mother with at least 2 births
 -  excluding mothers with multiple births → birth order = order of pregnancies
- ▶ alternative specification with linear birth order effect
- ▶ assumption: family size is exogenous to children's health endowment

Effects of birth order on immunisations

	(1) Maternal Tdap	(2) Maternal Influenza	(3) All infant immunisations
Birth order 2	-0.069*** (0.004)	-0.013*** (0.004)	-0.016*** (0.001)
Birth order 3	-0.112*** (0.007)	-0.043*** (0.007)	-0.031*** (0.002)
Birth order 4	-0.163*** (0.012)	-0.099*** (0.011)	-0.057*** (0.004)
N	209,049	209,049	503,118
Mean	0.426	0.322	0.913

Notes: Births between 2015 and 2023 in columns 1-2, and births between 2008 and 2023 in column 3. Regressions include mother fixed effects, year by month of birth fixed effects, and a female indicator. The mean of the dependent variable is displayed at the bottom of the table. Standard errors in parentheses are clustered at the mother level. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Why do maternal immunisations decrease with birth order?

- ▶ mothers may believe immunisation during an earlier pregnancy provides sufficient protection
 - ▶  **test:** use a sample of mothers who received maternal immunisation during their first pregnancy and had at least two subsequent pregnancies
 - ▶  would expect a higher vaccine uptake for the third pregnancy compared to the second
- ▶ adverse effects of immunisation at earlier pregnancies?
 - ▶  medical literature suggests severe side-effects are rare
 - ▶  **test:** control for hospitalisations during previous pregnancy
- ▶ significant birth order effects also **number of visits to LMC** and **ultrasounds** during pregnancy
 - ▶  less recommendations/opportunities for vaccinations
 - ▶  but controlling for number of visits does not affect birth order effects substantially
 - ▶  generally lower uptake of services during pregnancy → parental behaviour and resources (time constraints)?

Effects of birth order on infant hospitalisations for infectious diseases

	Pertussis		Influenza		RSV	
	≤12 months	≤3 months	≤12 months	≤3 months	≤12 months	≤3 months
Birth order 2	39.7** (13.1)	29.3** (11.4)	49.9** (17.8)	46.4*** (9.3)	1237.7*** (43.8)	846.2*** (29.6)
Birth order 3	79.0** (26.5)	72.5** (23.3)	104.4** (36.1)	69.5*** (18.8)	1827.3*** (85.0)	1201.8*** (57.8)
Birth order 4	109.0* (42.7)	81.1* (37.1)	227.0*** (60.7)	97.0** (31.5)	2538.4*** (139.0)	1594.1*** (92.2)
N	897,852	897,852	897,852	897,852	897,852	897,852
Mean	129.3	95.6	250.6	74.8	1665.3	792.2

Notes: Coefficients and Standard errors scaled to per 100,000 children. Births between 2000 and 2022. Regressions include mother fixed effects, year by month of birth fixed effects, and a female indicator. The mean of the dependent variable is displayed at the bottom of the table. Standard errors in parentheses are clustered at the mother level. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Effects of birth order on infant hospitalisations for infectious diseases

- ▶ large effects of birth orders on pertussis and influenza hospitalisations
- ▶ are infections higher *because* of lower maternal immunisations?
 - ▶  no: birth order effects for infant hospitalisations due to RSV
- ▶ is it because of worse general health of later born?
 - ▶  no, they have higher birth weight
 - ▶  consistent with literature, later-born children are healthier at birth
- ▶ 'contagion effect': having older siblings increases exposure

Summary & discussion

- ▶ large decrease of uptake of maternal immunisations with each subsequent pregnancy
- ▶ three-fold disadvantage for later-born children
 -  lower uptake of maternal immunisation
 -  lower uptake of childhood immunisations
 -  increased exposure to infectious diseases
- ▶ infants who would benefit the most from protection tend to miss out most often
- ▶ work in progress
 -  heterogeneity analysis by child/family characteristics
 -  robustness checks: controlling for health-at-birth, age of mother
 -  effects on mother? hospitalisation during pregnancy by birth order
 -  (covid vaccine?)

Thank you!

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