Fertility and Early-Life Mortality: Evidence from Smallpox Vaccination in Sweden

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Introduction

- An important question in the development and growth literature is whether and how mortality reductions affect fertility (Acemoglu and Johnson, 2007; Wilson, 2015).
- It is, however, difficult to obtain the causal effect of early-life mortality on fertility, as the two are arguably determined by the same unobservables.
- We address this by proposing a way to get at the causal effect of early-life mortality on fertility.
  - Differences-in-Differences (DD) IV for infant mortality:
  - Exploit the timing of introduction of the vaccination method in Sweden (1801) combined with pre-intervention smallpox mortality rates at county level.

Main findings

- A one-standard-deviation higher level of pre-vaccination smallpox mortality is associated with a decrease in infant mortality of about 20 deaths per 1000 live births
- In the reduced form, the shock had negative effect on gross fertility, but no statistically significant effects on the number of surviving children and "natural" population growth
- Our second stage results: a decline in infant mortality has
  1. a negative effect on 'gross' fertility
  2. no effects on surviving children and 'natural' population growth

Historical Background

- Smallpox was a highly virulent infectious (endemic) disease, which mainly killed infants and young children
- Inoculation did not do much in Sweden according to Sköld (1996) and on our own evidence
  - Inoculation with smallpox vs. vaccination (i.e. inoculation with cowpox)
- Vaccination was invented in 1796 by Edward Jenner (published in 1798) and introduced in Sweden at the end of 1801.
- Vaccine required paying a fee, but often not asked for, and not required for the poor.

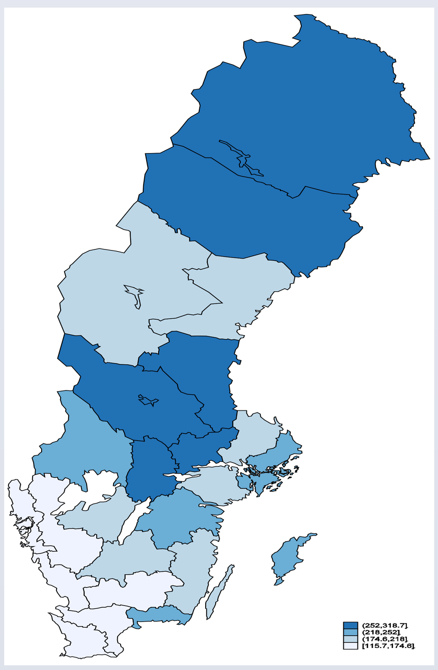

Figure 1:

Spatial distribution of smallpox mortality, 1795-1801

- 1801: Smallpox vaccination was first carried out by Eberhard Zacharia Munch of Rosenschöld.
- 1802: Non-medics practiced vaccination (e.g. clergy), but no guidelines. 1803: most physicians and surgeons had taken up the practice of vaccination.
- 1804: Every parish was instructed to appoint a vaccinator and statistics on vaccination and mortality were gathered - the clergy would often appoint the church assistant as vaccinator.
- 1805: Royal letter instructed that all church assistants must learn to vaccinate.
- In 1816, compulsory vaccination for children below 2 years was passed by law, and non-compliance could be punished by fines or prison (we use this to construct an additional IV).

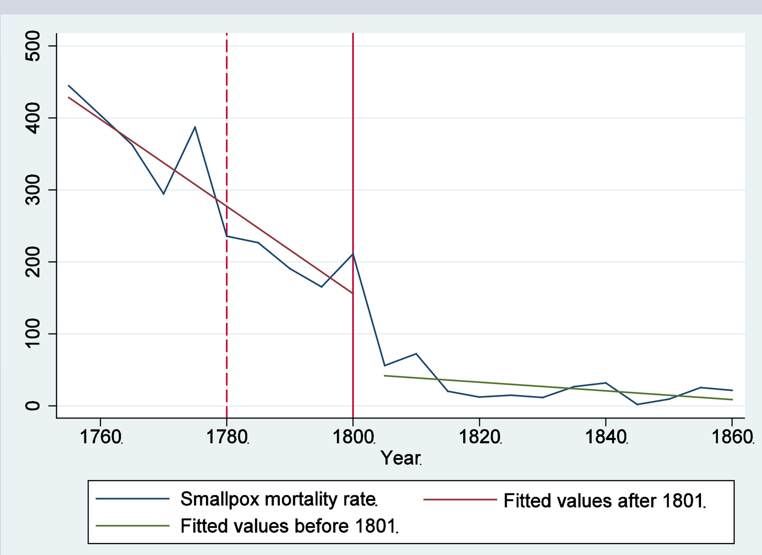

Figure 2:

Smallpox mortality in Sweden, 1749-1860

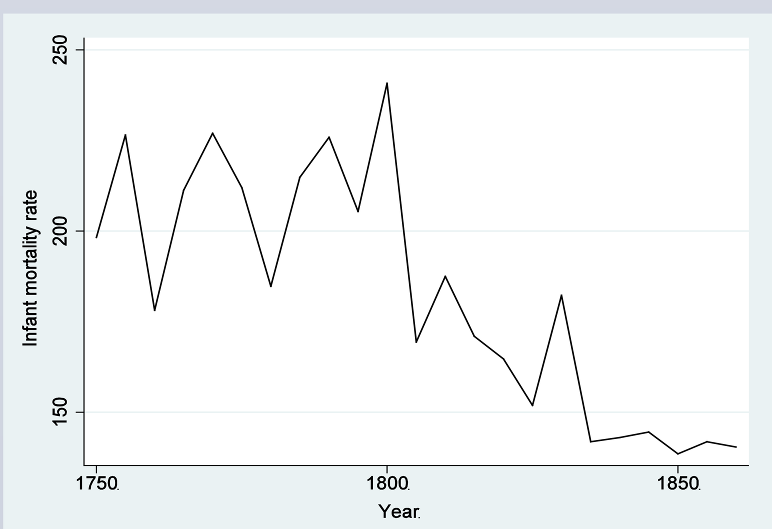

Figure 3:

Infant mortality in Sweden, 1750-1860

Empirical Strategy

- Main estimation equation:

$$y_{ijt} = \alpha\, infant\ mortality_{ijt} + \boldsymbol{X_{ijt}}\beta + \delta_j + \tau_t + \varepsilon_{ijt},$$

  - y_{ijt} is the outcome: net and gross fertility and "natural" population growth in parish i of county j at period t.
  - $infant\ mortality_{ijt}$ is the number of deaths in the age interval 0-1 per 1000 live births.
  - δ_j and τ_t are county and time fixed effects.
  - ε is the error, which is clustered at the county level.
  - we use data every fifth year.
- We use the introduction of vaccination to obtain the causal effect of infant mortality. DD first stage:
  - 1. diff: compare infant mortality in parishes before and after vaccination.
  - 2. diff: treatment heterogeneity between the counties (and thus parishes) as measured continuously by smallpox mortality just before the shock.
  - Notice, in the 2. diff: Take-up of the new technology is endogenous → focus on counties that stood to benefit the most → intention-to-treat design
- First-stage relationship:

$$infant\ mortality_{ijt} = \pi_1(S_{PreI,j} \times 1[\tau > 1801]) + \pi_2(S_{preII,j} \times 1[\tau > 1815]) +$$
$$\boldsymbol{X_{ijt}}\beta + \delta_j + \tau_t + \epsilon_{ijt},$$

  - $S_{PreI,j}$ is smallpox mortality in 1795-1801
  - $S_{preII,j}$ smallpox mortality in 1811-1815 (before vaccination law)
  - If the shocks decreased infant mortality: $\pi_1, \pi_2 < 0$

Results

First Stage:

- Magnitude: 1-SD increase in intensity → decline in infant mortality of 20 (5) deaths per 1000 live births
- No pretreatment trend related to our treatment measure
- Results also robust to county specific linear trends

Table 1: Baseline first-stage results

	Dependent variable: infant mortality				
	(1)	(2)	(3)	(4)	(5)
vaccination	-0.327***	-0.370***			-0.439***
	(0.121)	(0.117)			(0.118)
law 1816			-0.248**	-0.228**	-0.543***
			(0.110)	(0.114)	(0.104)
Controls $(\times I^{t>1801})$:					
initial mortality		0.0538***		0.0471***	0.0540***
		(0.0145)		(0.0174)	(0.0146)
intial population		3.826		0.940	3.474
		(3.365)		(2.852)	(3.380)
Observations	10,878	10,878	10,878	10,878	10,878

Table 2: reduced form evidence

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Dependent variable:							
	birth rate		surviving children (age 1)		surviving children (age 5)		natural population growth	
vaccination	-0.0197***	-0.0204***	-0.00635	-0.00467	0.00112	0.000359	-0.000217	-1.78e-05
	(0.00682)	(0.00654)	(0.00498)	(0.00484)	(0.00510)	(0.00551)	(0.00715)	(0.00771)
law 1816		-0.00532		0.0133		-0.00598		0.00157
		(0.0208)		(0.0188)		(0.0262)		(0.0407)
Controls $(\times I^{t>1801})$:								
initial mortality	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
intial population	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	10,878	10,878	10,878	10,878	9,015	9,015	10,877	10,877

Infant mort. and Fertility:

- The results on the gross fertility is positive and also statistically significant.
- The effect on the number surviving children is mostly positive, but not significant (not shown on poster)
- Over-identification is not rejected at conventional level of significance.

Table 3: Infant mortality and fertility

	Dependent variable: birth rate				
	(1)	(2)	(3)	(4)	(5)
infant mortality	-0.00162	-0.00172	0.0533***	0.0421***	0.0443***
	(0.00134)	(0.00128)	(0.0176)	(0.0141)	(0.0138)
Anderson-Rubin [p-value]	-	-	[0.008]	[0.011]	[0.0011]
Controls $(\times I^{t>1801})$:					
initial mortality	No	Yes	Yes	Yes	Yes
intial population	No	Yes	Yes	Yes	Yes
female population share	No	No	No	No	Yes
Instruments:					
vaccination	-	-	Yes	Yes	Yes
law 1816	-	-	No	Yes	Yes
Kleibergen-Paap					
F-statistic	-	-	9.47	16.00	16.87
Hansen-J [p-value]	-	-	-	[0.376]	[0.247]
Observations	10,878	10,878	10,878	10,878	9,549

References

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