Vaccination as investment in education

A difference-in-differences analysis of measles vaccination on education

Alvaro Gerns

University of Geneva

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Section 1

Current state of scientific community

Literature review: Channels of vaccination on economic growth

Narrow economic benefits in form of cost-effectiveness analysis:

- Health gains through reduced mortality and morbidity:
  - Bangladesh Measles SIA: $19.2/DALY, with a vaccine cost of 0.02 US dollar (Bishai 2010)
  - Measles in SEAR-D region: $240/DALY, with a vaccine cost of 0.12 US dollar (Edejer et al. 2005)
- Healthcare cost saving for health care system and household:
  - Measles eradication studied in Brazil, Colombia and Tajikistan has been found to be cost-saving, that is, resulting in net savings to the health system. (Bishai 2010)
- Care-related productivity gains by saving parents' productive time of taking care of sick child. (Broughton 2007)

Broad economic benefits in form of cost-benefit analysis:

- **Outcome-related productivity gains**
- Behaviour-related productivity gains through extended life expectancy. (Meij et al. 2009), (Bloom, Canning, and Weston 2005)

Outcome-related productivity gains

- Reduced infant mortality leads to forecasted annual earning of 4.61 - 14.10 US dollar/child. (Bloom, Canning, and Weston 2005)
- Significant test score differences between 10-year-old children in Indonesia that received measles, polio, TB and DPT compared to children with no vaccination. (Bloom, Canning, and Shenoy 2012)
- Mother-fixed effects study of measles vaccination in South Africa in 1995 on schooling. (Anekwe et al. 2015)
  - Results: 0.188 grades gained for each vaccinated child.
  - Limitations: Collecting vaccination status at 12 months while measles-second-dose (MCV2) was given at 23 months in South Africa.
- Maternal tetanus vaccination on schooling attainment in Bangladesh (Canning et al. 2011)
  - RCT conducted in 1974 administering cholera vaccine to the control group and tetanus toxoid to the treatment group.
  - Initial goal of the RCT was looking at cholera effectiveness which only showed 3 month protection.
  - Result for children of parents with no schooling: Children vaccinated gained on average 0.25 completed school years.

Section 2

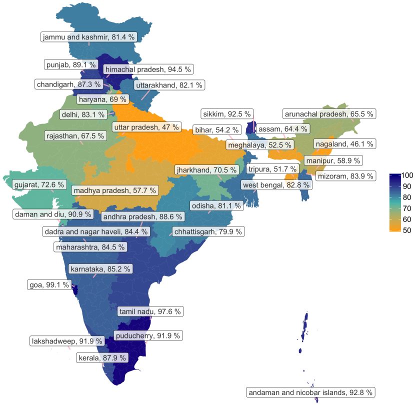
Country context and policy

Country context and policy

1. Before 2010 India was the last country in the world with only 1 dose of Measles-containing vaccine. National coverage was at around 70%, which jointly with 85% vaccine effectiveness made 40% of the annual birth cohort susceptible to measles. A single dose of MCV being insufficient for heard immunity (95%).
2. 47% of estimated global measles deaths occurred in India, while 95% of those cases happened within 10 states.
3. In 2008 The National Technical Advisory Group on Immunization (NTAGI) recommended MCV2 introduction through catch-up campaigns in states with low coverage and routine delivery for states with high coverage. The threshold was set at 80%.
4. In 2010 the campaign was launched in 3 phases targeting 130 million children from 9 months to 10 years, irrespective of their vaccination status. The campaign ended in 2013.

A

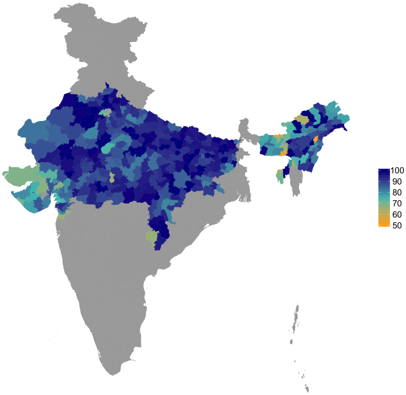
MCV1 coverage in 2010 at state level



Source: DLHS-3, except Nagaland CES-06

B

Campaign coverage rates at district level



Source: Ministry of Health and Family Welfare
Note: Non-campaign-states in grey

Section 3

Methodology

Data and approach used

National Family Health Survey (NFHS-4) 2015/2016:

- 618.254 children from 6 to 20 years
- 622 districts and 32 states/union territories

Treatment region: 411.620 children in 354 districts of 14 states

Control region: 206.634 children in 266 districts of 18 states

Age at end of campaign	Above 10 years	Below 10 years
Control region	0	0
Treatment region	0	1

Note: Additional information on the location and duration of the campaigns in each state were provided by the Ministry of Health and Family Welfare of India.

Difference-in-Differences approach

2×2 DID regression:

$$Y_{ijt} = \beta_0 + \beta_1 * Cohort_t + \beta_2 * Region_j + \beta_3 * Interaction_{jt} + \beta_4 * X_{ijt} + \epsilon_{ijt} \qquad (1)$$

where,

Y_{ijt} captures educational attainment as the highest school grade a child completed until the day of the interview,

$Cohort_t$ captures observable age differences,

$Region_j$ is the full set of regional effects,

$Interaction_{jt}$ is the Region-Cohort interaction with the coefficient of interest β_3,

X_{ijt} are the individual specific covariates and

$\epsilon_{ijt} = \theta_i + \phi_t + \gamma_{ijt}$ represents the error term with

θ_i as time-invariant individual-specific effects

ϕ_t as unobserved time effects and

γ_{ijt} as temporary individual-specific effects.

Required assumptions in the DID setting

1. Selection into treatment is independent of temporary individual-specific shocks. In other words:

$$E(\epsilon_{ijt}|Treatment_{it}) = E(\theta_i|Treatment_{it}) + \phi_t$$

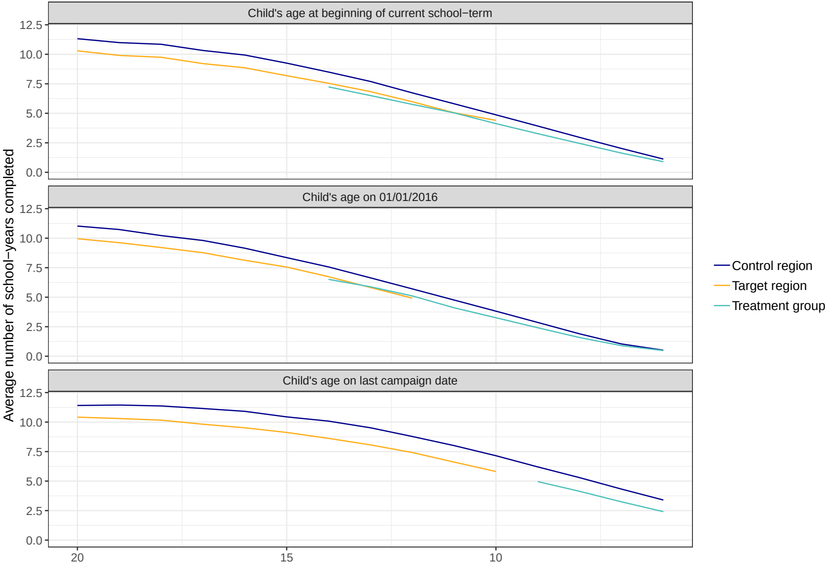
2. Common trend assumption, which requires in the absence of treatment both groups to follow a parallel trend over time. In other words, this time trend $\phi_{t_1} - \phi_{t_0}$ should be the same in both groups.

Table 1: Robustness scenarios

	Dependent variable: School-years completed		
	Non-campaign states with pseudo campaign dates of:		
	Phase 1	Phase 2	Phase 3
	(1)	(2)	(3)
Constant	-3.542^{***}	-3.637^{***}	-3.779^{***}
	(0.539)	(0.500)	(0.454)
Low-performing region	-0.740^{***}	-0.744^{***}	-0.631^{***}
	(0.150)	(0.141)	(0.148)
DID coefficient	0.107	0.287^{***}	0.420^{***}
	(0.100)	(0.081)	(0.064)
Young cohort	-0.447^{***}	-0.583^{***}	-0.684^{***}
	(0.145)	(0.131)	(0.123)
Female	0.097^{***}	0.091^{***}	0.082^{**}
	(0.036)	(0.035)	(0.035)
School-calendar age	0.749^{***}	0.761^{***}	0.768^{***}
	(0.029)	(0.029)	(0.028)
Mother years education	0.066^{***}	0.062^{***}	0.058^{***}
	(0.008)	(0.008)	(0.009)
Mother age	0.0005	0.001	0.001
	(0.001)	(0.001)	(0.001)
Wealth Index	0.269^{***}	0.255^{***}	0.235^{***}
	(0.030)	(0.030)	(0.033)
Rural	0.365^{***}	0.350^{***}	0.323^{***}
	(0.080)	(0.081)	(0.085)
Observations	365,318	367,510	370,055
Adjusted R^2	0.619	0.607	0.605
Note:	*p<0.1; **p<0.05; ***p<0.01		

Age on educational attainment shows parallel trends

Figure 3: Average number of school−years completed by different age types



Note: Age at end of campaign considers Phase 2−dates for the control region

$t \times 2$ DID regression with $t(6, 20)$:

$$Y_{ijt} = \beta_0 + \beta_1 D_{ijt} + \beta_2 Age_t + \beta_3 DAge_{ijt} + \beta_4 Region_{ij} + \beta_5 RegionAge_{jt} + \beta_6 X_{ijt} + \epsilon_{ijt} \quad (2)$$

where,

$\boldsymbol{Y_{ijt}}$ captures educational attainment as the highest school grade a child completed until the day of the interview,

$\boldsymbol{Age_t}$ captures grade-level time heterogeneity with age at start of the school year in which the interview was conducted

$\boldsymbol{Region_j}$ captures fixed regional effects,

$\boldsymbol{Interaction_{jt}}$ is the Treatment-Age interaction with the coefficient of interest $\boldsymbol{\beta_3}$,

$\boldsymbol{RegionAge_{jt}}$ captures time-varying regional effects,

$\boldsymbol{X_{ijt}}$ are the individual specific covariates and

$\boldsymbol{\epsilon_{ijt} = \theta_i + \phi_t + \gamma_{ijt}}$ represents the error term with

$\boldsymbol{\theta_i}$ as time-invariant individual-specific effects

$\boldsymbol{\phi_t}$ as unobserved time effects and

$\boldsymbol{\gamma_{ijt}}$ as temporary individual-specific effects.

Table 2: Regression Results Model 2

	Dependent variable: School-years completed		
	Core	Core	Placebo
	(1)	(2)	(3)
Constant	-3.096^{***}	-5.146^{***}	-0.966^{*}
	(0.149)	(0.266)	(0.546)
Treatment	-3.206^{***}	-3.455^{***}	
	(0.592)	(0.575)	
DID coefficient	0.233^{***}	0.251^{***}	
	(0.044)	(0.044)	
School-calendar age	0.788^{***}	0.791^{***}	0.476^{***}
	(0.017)	(0.019)	(0.036)
Age-region interaction	-0.201^{***}	-0.225^{***}	-0.039
	(0.044)	(0.043)	(0.048)
Region	2.225^{***}	2.883^{***}	0.125
	(0.664)	(0.648)	(0.736)
Female		0.129^{***}	0.144^{**}
		(0.041)	(0.072)
Mother years education		0.073^{***}	0.140^{***}
		(0.009)	(0.014)
Mother age		0.005^{***}	-0.009^{***}
		(0.002)	(0.002)
Wealth Index		0.348^{***}	0.674^{***}
		(0.031)	(0.045)
Rural		0.412^{***}	0.712^{***}
		(0.113)	(0.199)
Observations	617,816	617,816	231,326
Adjusted R^2	0.667	0.696	0.263
Note:	*p<0.1; **p<0.05; ***p<0.01		

Results

1. For every 4 children vaccinated against measles there is on average one additional school year gained.
2. The campaign costed 59.1 million USD and reached around 118.83 million children, which can be translated into an investment of 0.50 USD/vaccinated child, or 2 USD for gaining one additional year of schooling, comparable with the deworming cost of 3.5 USD for one additional school year.
3. In terms of wage gain a country-specific mincerian equation estimates a 2.63% increase on wages due to an additional year of schooling. (Mitra 2019)
4. Large difference in treatment effect by socioeconomic groups, with the poorest quintile of the population gaining 0.36 additional school years by receiving vaccination, while the richest quintile gains only an additional 0.14 years of schooling through vaccination.

Limitations

1. Model assumes linear effects, while effect of vaccination most-likely non-linear on different school-years.
2. Migration that occured between the campaign and the data collection might introduce confounding if affecting our age group.
3. Results are only valid for children between 6 and 14 years, given the treatment cohort.
4. Future research should expand on this study analyzing the same cohort on the effects of vaccination on secondary and tertiary education as well as labor market outcomes.

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Thank you