Appendix

Appendix Table A.1: Distribution of mean of change in VPDs (Diphtheria, Pertussis, Tetanus, Measles) per 1000 u5 children by 5-unit increments of their respective percentile distributions (532 districts in India, change estimated as the difference between year 2016 and year 2013 values)

Percentile	Diphtheria	Pertussis	Tetanus	Measles
1st	-42.6	-25.5	-12.6	-165.8
5th	-6.6	-3.1	-2.2	-65.3
10th	-2.3	-0.8	-0.5	-33.2
25th	0	0	0	-13.6
50th	0	0	0	-0.1
75th	0	0	0	4.5
90th	0	0	0	20.8
95th	1.1	0	0.1	43.9
99th	14.4	3.1	5.3	135

Appendix Table A.2: Linear regression predicting Change in Measles as a function of Change in percentage of households with toilets, controlling for change in other covariates and baseline (pre-SBM) annual incidence of measles, by 6 administrative regions of India.

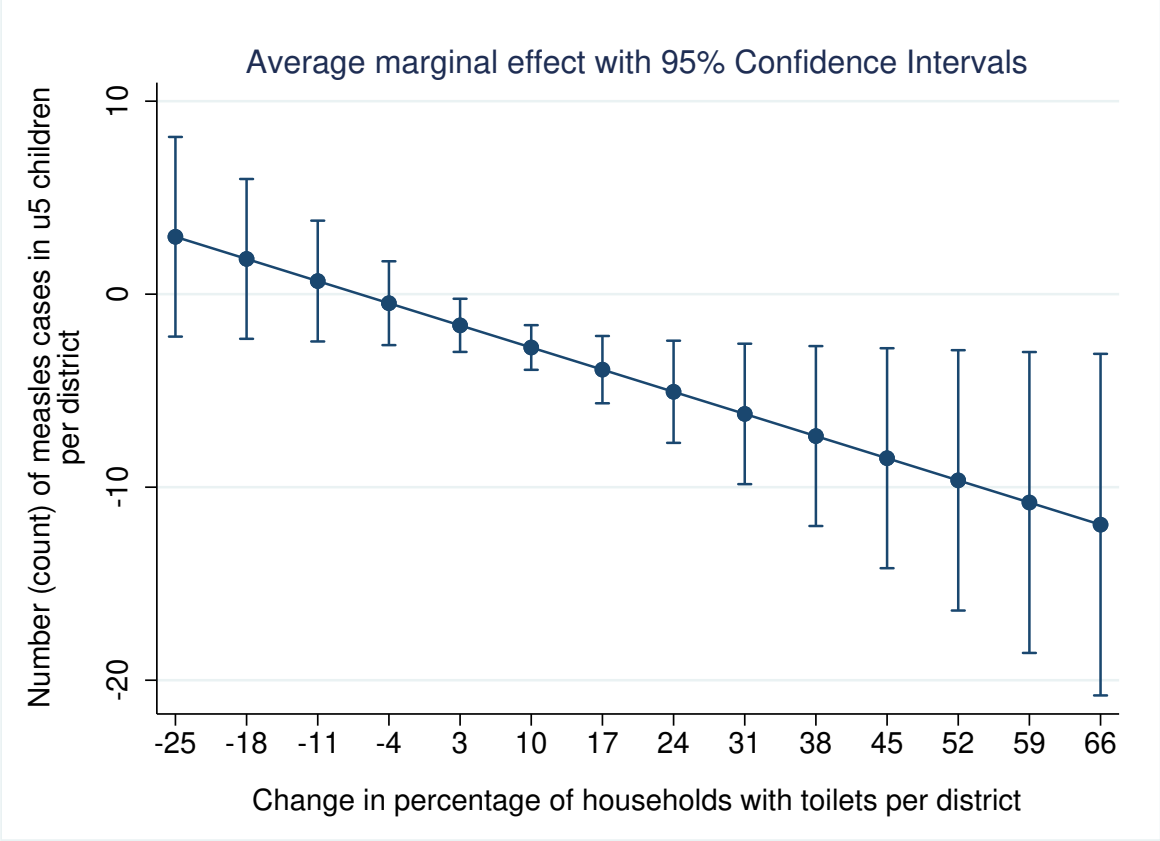
Covariates	**Central**		**Eastern**		**North Eastern**		**Northern**		**Southern**		**Western**	
	Coefficient	95% CI	Coefficient	95% CI	Coefficient	95% CI	Coefficient	95% CI	Coefficient	95% CI	Coefficient	95% CI
Change in percentage of households with toilets	**-1.223***	[-2.390 -0.057]	0.006	[-0.503 0.515]	**-0.475***	[-0.882 -0.068]	0.331	[-0.226 0.887]	-0.317	[-0.992 0.357]	0.202	[-0.544 0.949]
Change in percentage of households with electricity	0.526	[-0.067 1.119]	-0.300*	[-0.572 -0.029]	-0.032	[-0.452 0.388]	-0.150	[-0.617 0.317]	0.612	[-1.432 2.656]	-0.268	[-2.041 1.505]
Change in percentage of households with clean drinking water	-0.428	[-2.107 1.250]	0.381	[-0.122 0.884]	0.275	[-0.401 0.951]	-0.270	[-0.812 0.271]	-0.095	[-0.415 0.224]	-0.636	[-1.352 0.081]
Change in percentage of households with clean cooking fuel	0.545	[-0.303 1.393]	-1.094*	[-2.042 -0.146]	-0.216	[-0.892 0.459]	-0.113	[-0.469 0.242]	-0.220	[-0.492 0.052]	-0.162	[-0.735 0.410]
Change in percentage of women with 10^{th} grade or higher education	3.006**	[0.762 5.250]	1.834	[-0.657 4.325]	-0.252	[-1.100 0.595]	-0.127	[-1.143 0.889]	-0.329	[-0.818 0.160]	0.732	[-0.226 1.690]
Change in percentage of ≤ 1 year old children with measles vaccination	-0.233	[-1.039 0.573]	0.238	[-0.363 0.838]	-0.223	[-0.523 0.078]	-0.131	[-0.439 0.176]	0.311*	[0.012 0.610]	-0.350	[-1.409 0.709]
Change in percentage of births in hospitals	-0.087	[-0.740 0.565]	0.814*	[0.033 1.595]	0.205	[-0.239 0.648]	-0.312	[-0.929 0.305]	0.264	[-0.479 1.007]	0.254	[-0.936 1.444]
Baseline (pre-SBM) Measles per 1000 u5 children	-0.967***	[-1.156 -0.778]	-0.798***	[-0.910 -0.685]	-0.291	[-0.629 0.048]	-0.449	[-1.145 0.247]	-0.736***	[-0.975 -0.496]	-0.810***	[-1.161 -0.459]
N	121		107		80		85		103		36	

* p<0.05, ** p<0.01, *** p<0.001

Appendix Table A.3: Mean of change in (1) measles per 1000 u5 children and (2) percentage of households with toilets, by India's administrative regions.

Region	Mean change in measles per 1000 u5 children	Mean change in district-level percentage of households with toilets
central	-7.44	7.97
eastern	-14.68	5.50
north eastern	-0.60	9.93
northern	-0.96	7.76
southern	-3.91	4.23
western	5.80	0.57

Appendix Figure A.1: Average marginal effect (with 95% Confidence Intervals) of change in percentage of household with toilets on counts of u5 measles cases per district in India



Appendix Table A.4: Linear regression predicting Change in Measles as a function of Change in percentage of households with toilets, controlling for change in other covariates including vitamin A supplementation among u5 children and baseline (pre-SBM) annual incidence of measles. (N= 532).

	Coefficient	95% Confidence Interval	
Change in percentage of households with toilets	**-0.365***	**-0.675**	**-0.054**
Change in percentage of households with electricity	0.149	-0.007	0.306
Change in percentage of households with clean drinking water	-0.197	-0.435	0.041
Change in percentage of households with clean cooking fuel	-0.153	-0.406	0.099
Change in percentage of women with 10th grade or higher education	0.508	-0.024	1.040
Change in percentage of ≤ 1 year old children with measles vaccination	-0.065	-0.277	0.148
Change in percentage of births in hospitals	0.201	-0.066	0.469
Change in percentage of u5 children who received Vitamin A supplementation	-0.190*	-0.365	-0.016
Baseline (pre-SBM) Measles per 1000 u5 children	-0.768***	-0.898	-0.638

* p<0.05, ** p<0.01, *** p<0.001

Appendix Table A.5: Relation between change in percentage of households with toilets, change in stunting among under 5 years old children and their effect on change in measles among under 5 years old children estimated using structural equation modelling (N = 532).

Structural Equation Modelling Step 1: ***Direct effect*** of change in percentage of households with toilets on change in percentage of u5 children who are stunted.			
Outcome = Change in percentage of u5 children who are stunted	Coefficient	95% Confidence intervals	
Change in percentage of households with toilets	**-0.053***	**-0.104**	**-0.002**
Change in percentage of households with electricity	-0.114	-0.484	0.256
Change in percentage of households with clean drinking water	-0.081*	-0.161	-0.001
Change in percentage of households with clean cooking fuel	0.014	-0.062	0.089
Change in percentage of women with 10th grade or higher education	-0.214**	-0.329	-0.100
Change in percentage of ≤ 1 year old children with measles vaccination	-0.035	-0.091	0.021
Change in percentage of births in hospitals	0.042	-0.036	0.120
Change in percentage of u5 children who received Vitamin A supplementation	-0.028	-0.069	0.012
Structural Equation Modelling Step 2: ***Direct effect*** of change in percentage of households with toilets and change in percentage of u5 children who are stunted on change in measles among u5 children			
Outcome = Change in measles among u5 children	Coefficient	95% Confidence intervals	
Change in percentage of u5 children who are stunted	**0.012***	**0.023**	**0.002**
Change in percentage of households with toilets	**-0.320***	**-0.617**	**-0.044**
Change in percentage of households with electricity	0.147	0.008	0.286
Change in percentage of households with clean drinking water	-0.211	0.537	0.115
Change in percentage of households with clean cooking fuel	-0.168	0.477	0.140
Change in percentage of women with 10th grade or higher education	0.502	0.033	0.970
Change in percentage of ≤ 1 year old children with measles vaccination	-0.073	0.302	0.155
Change in percentage of births in hospitals	0.239	0.081	0.558
Change in percentage of u5 children who received Vitamin A supplementation	-0.203	-0.368	-0.038

Baseline (pre-SBM) Measles per 1000 u5 children	-0.772***	0.842	-0.701
Structural Equation Modelling Step 3: ***Indirect effect*** of change in percentage of households with toilets on change in measles among u5 children that passes through change in stunting among u5 children			
Outcome = Change in measles among u5 children	Coefficient	95% Confidence intervals	
Change in percentage of households with toilets	**-0.042***	**-0.081**	**-0.004**
Change in percentage of households with electricity	-0.023	-0.065	0.019
Change in percentage of households with clean drinking water	0.023	-0.020	0.065
Change in percentage of households with clean cooking fuel	0.008	-0.009	0.025
Change in percentage of women with 10th grade or higher education	0.002	-0.013	0.016
Change in percentage of ≤ 1 year old children with measles vaccination	0.004	-0.006	0.015
Change in percentage of births in hospitals	0.005	-0.008	0.019
Change in percentage of u5 children who received Vitamin A supplementation	-0.004	-0.012	0.005
Baseline (pre-SBM) Measles per 1000 u5 children	(no path)	(no path)	(no path)
Structural Equation Modelling Step 4: ***Total effect*** of change in percentage of households with toilets on change in measles among u5 children (if there is no mediator in our model)			
Outcome = Change in measles among u5 children	Coefficient	95% Confidence intervals	
Change in percentage of u5 children who are stunted	**0.012***	**0.023**	**0.002**
Change in percentage of households with toilets	**-0.362***	**-0.617**	**-0.044**
Change in percentage of households with electricity	0.124	-0.024	0.271
Change in percentage of households with clean drinking water	-0.188	-0.513	0.136
Change in percentage of households with clean cooking fuel	-0.161	-0.468	0.147
Change in percentage of women with 10th grade or higher education	-0.503	-0.168	0.161
Change in percentage of ≤ 1 year old children with measles vaccination	-0.069	-0.298	0.159
Change in percentage of births in hospitals	0.244	-0.075	0.563

Change in percentage of u5 children who received Vitamin A supplementation	-0.207	-0.372	-0.041
Baseline (pre-SBM) Measles per 1000 u5 children	-0.727***	-0.842	-0.701

* p<0.05, ** p<0.01, *** p<0.001

Step 4 in Table A.5 shows that the total effect coefficient of change in percentage of households with toilets on change in measles among u5 children is -0.362. This is the effect or association we would observe if there was no mediator in our analytic model. The direct effect coefficient of change in percentage of households with toilets on change in measles among u5 children is -0.320, which is smaller than the total effect coefficient (Step 2). The indirect effect of change in percentage of households with toilets on change in measles among u5 children that passes through change in percentage of u5 children who are stunted is -0.042 (Step 3), indicating that stunting may only serve as a partial mediator in this analysis.

We can also interpret results from our structural equation modelling as ratios:

Proportion of total effect mediated = -0.042/-0.362 = 0.116 or about 12%. Put simply, about 12% of the total effect of change in percentage of households with toilets on change in measles among u5 children appears to be mediated by change in stunting among u5 children over our study period.

Appendix table A.6: Linear regression predicting log transformed change in measles as a function of change in percentage of households with toilets, controlling for change in other covariates and baseline (pre-SBM) annual incidence of measles (N = 532).

	Coefficient	95% confidence intervals	
Change in percentage of households with toilets	**-0.013***	**-0.023**	**-0.003**
Change in percentage of households with electricity	0.004	-0.001	0.009
Change in percentage of households with clean drinking water	-0.002	-0.004	0.000
Change in percentage of households with clean cooking fuel	-0.006	-0.014	0.002
Change in percentage of women with 10th grade or higher education	0.003	-0.003	0.009
Change in percentage of ≤ 1 year old children with measles vaccination	-0.001	-0.003	0.001
Change in percentage of births in hospitals	0.002	-0.002	0.005
Change in percentage of u5 children who received Vitamin A supplementation	-0.003	-0.008	0.003
Baseline (pre-SBM) Measles per 1000 u5 children	-0.027***	-0.042	-0.011

* p<0.05, ** p<0.01, *** p<0.001

Appendix Table A.7: Linear regression predicting z-scaled change in measles as a function of change in percentage of households with toilets, controlling for change in other covariates and baseline (pre-SBM) annual incidence of measles (restricted to outcome distribution within ±3 standard deviations or z scores of -3 to +3). (N = 509)

	Coefficient	95% confidence intervals	
Change in percentage of households with toilets	**-0.007***	**-0.011**	**-0.002**
Change in percentage of households with electricity	0.001	-0.002	0.004
Change in percentage of households with clean drinking water	-0.002	-0.006	0.003
Change in percentage of households with clean cooking fuel	-0.004	-0.008	0.001
Change in percentage of women with 10th grade or higher education	0.000	-0.008	0.008
Change in percentage of ≤ 1 year old children with measles vaccination	-0.001	-0.006	0.003
Change in percentage of births in hospitals	0.006	0.001	0.011
Change in percentage of u5 children who received Vitamin A supplementation	-0.002	-0.006	0.002
Baseline (pre-SBM) Measles per 1000 u5 children	-0.027***	-0.035	-0.018

* p<0.05, ** p<0.01, *** p<0.001