SUPPLEMENTARY APPENDICES FOR ONLINE PUBLICATION

Supplement to: **All-Cause Mortality Reductions from Measles Catch-Up Campaigns in Africa**

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APPENDIX A: DATA

DHS survey data. We collected data on child deaths across Africa from the Demographic and Health Surveys (DHS). We combined data from multiple DHS surveys for 25 countries (listed in Table A1) that met the two following criteria:

1. The country had a Measles Initiative (MI) campaign.
2. At least one DHS survey round was fielded after the first MI campaign.

The surveys ask each mother (respondent) for the dates of birth for each of her children (a “birth history”).In addition, for each birth, they ask the mother whether the child is still alive; if the child is not alive, the surveys ask the child’s age at the time of the child’s death (or the date the child died). These birth histories were used to construct a child-level data file with 893,524 observations using 52 surveys conducted in 1997 or later (see Table I in the paper). This approach excludes anyone born before January 1991 (539,533 people). The process is straightforward because the DHS files have the same variable names and coding schemes (with some exceptions).

Variation in the campaign timing entails samples for each country spanning different time periods. For example, our baseline sample includes children born in Tanzania (the country with the earliest campaign) in 1996, whereas most countries in the sample do not include children born before 1997. Similarly, the timing of the last DHS round determines the youngest child we observe in each country for a full 60 months. Figure 1 in the paper demonstrates this variation. Figure A1 demonstrates geographic variation in the dates of the SIAs.

We then reshaped this file into a panel data file with one observation for each month for each child’s first 60 months or until the date of the interview (whichever occurred first). The reshaped data have 42,434,559 observations (47.5 months per child, on average). We also collapsed the panel data into cohort-month cells that aggregated data by cohort—children born in the same sub-national region in the same month. Regression models with this cohort-level information were similar to the panel data regressions and yielded qualitatively similar findings.

The DHS surveys have a complex sampling frame. Unless otherwise noted, we use in all analyses the weights provided in the survey to calculate point estimates and standard errors. However, we adjust survey weights in instances in which we have more than one survey per country. Although there was only one survey round at a time in each country, the birth histories overlap (some cohorts are covered by multiple surveys). Thus, we sum all instances in which country-birth month cohorts were included in a survey sample and divide the DHS weight by this sum (i.e., for cohorts included in only one survey wave, the DHS weight is divided by one; for those included in two waves, the DHS weights are divided by two). We thus avoid over-weighting cohorts based on overlapping surveys.

Dates in the Ethiopia surveys were converted from the Ethiopian calendar to the Gregorian calendar by shifting dates by seven years, eight months.

Merging with MI campaign data. In addition to the DHS survey data, we used campaign dates and geographic information available on the Measles Initiative website in January 2010 (http://www.measlesinitiative.org/) and, in some cases, provided by American Red Cross staff.

There were nationwide campaigns in 18 of the 25 countries in our sample. The remaining 7 countries were covered by 2 or more regional campaigns (17 regional campaigns total). The campaigns occurred between September 2001 and December 2007, although most were between 2001 and 2004.

Although we refer to “countries” in the text for ease of exposition, sub-national regions with different campaign dates were always treated separately (for example, when creating “country” fixed effects or trends or when clustering standard errors).

Table A1 lists the dates of each county's campaign (that is, each SIA). It also provides the routine measles vaccination rate from 2000 (reported by the World Bank Indicators), and estimates of the number of children vaccinated and the percentage of the target population vaccinated (estimated by MI staff).

When merging the two data sets, we could merge the campaign dates using country or region indicators (in some cases, after reconciling region names using publicly available information and maps). In a few cases, the data could not be merged. For the Democratic Republic of the Congo, three regions (North Kivu and the two Kasai regions) were covered in campaigns prior to 2005. We know the remaining regions were covered in a series of campaigns in 2004–2006, but we were not able to determine the specific dates of the campaigns; we excluded these 23,377 observations. We excluded 3,274 observations from two geographic areas in Cameroon's first DHS round (CM3) that were combined into macroregions and could not be matched to campaign dates. We excluded any data that could not be matched to a campaign date in this survey. For Nigeria, cannot be merged to the correct campaign date because the North-Central and South-Central regions are called "Central" in the first DHS survey (NG3), ; therefore, 2,250 observations were dropped.

Table A1: Measles routine vaccination rates, Measles Initiative SIAs, SIA coverage rates, and DHS surveys

Country	Measles routine vaccination rate, 2000[a]	Date of SIA[b]: National SIA	Date of SIA[b]: Regional SIA(s)	Num. of children vaccinated[b]	Campaign vaccination rate[b,c]	Date of DHS survey(s)[d]	Number of observations in DHS[d]: Unweighted N	Unweighted Pct	Weighted Pct.
Benin	70%		Dec-01, Jan-03	950,780; 2,299,583	106%, 105%	Nov-06, Nov-01, Aug-96	40,218	7.42	6.88
Burkina Faso	48%	Dec-01		4,943,115	96%	Dec-03, Mar-99	20,326	3.75	3.92
Cameroon[b]	49%		Jan-02, Dec-02	2,789,542; 4,570,817	93%, 90%	Sep-04, Jul-98	14,143	2.61	3.01
Congo (Brazzaville)	34%	Oct-04		1,356,625	78%	Nov-05	7,273	1.34	1.89
Congo Democratic Republic[e]	46%		Dec-02, Oct-05, Nov-06, Dec-06	5,554,824; 6,957,653; 6,966,200	96%, 89%, 97%, 96%	Sep-07	11,205	2.07	3.20
Ethiopia	33%		Nov-02, Jan-03, May-05	2,277,988; 5,101,007; 7,422,074	76%, 98%, 91%	Aug-05, Jun-00	28,141	5.19	5.52
Ghana	90%		Dec-01, Dec-02	790,798; 12,595,255	99%, 102%	Nov-08, Nov-03, Feb-99	15,135	2.79	1.98
Guinea	42%	Nov-03		3,202,848	98%	Jun-05, Aug-99	14,900	2.75	2.82
Kenya	78%	Jun-02		13,302,991	98%	Mar-09, Sep-03, Jul-98	25,881	4.77	3.75
Lesotho	74%	Apr-03		178,522	87%	Jan-10, Feb-05	15,410	2.84	2.34
Madagascar	57%	Sep-04		7,546,229	99%	Jul-09, Jun-04, Dec-97	35,541	6.55	6.20
Malawi	73%	Aug-02		1,906,985	120%	Feb-05, Nov-00	29,743	5.49	4.89
Mali	49%	Dec-01		4,998,491	99%	Dec-06, Jun-01, May-96	43,844	8.09	7.44
Namibia	69%	Jun-03		318,240	94%	Mar-07, Dec-00	14,015	2.58	2.50
Niger	37%	Dec-04		5,071,149	99%	Jun-06, Jul-98	16,742	3.09	4.34
Nigeria[e]	33%		Dec-05, Jun-06	28,538,974; 26,353,793	95%, 83%	Nov-08, Aug-03, May-99	59,370	10.95	10.91
Rwanda	74%	Feb-03		3,082,583	101%	Apr-08, Aug-05, Nov-00	34,995	6.45	4.08
São Tomé and Principe	69%	Dec-07		64,487	101%	Jan-09	2,987	0.55	0.72
Senegal	48%	Jan-03		4,854,077	98%	Jun-05	19,802	3.65	4.85
Sierra Leone	37%	Nov-03		2,404,882	93%	Jun-08	13,133	2.42	3.49
Swaziland	92%	Jun-02		127,829	81%	Mar-07	5,755	1.06	1.47
Tanzania	78%	Sep-01		3,687,390	104%	Feb-05, Nov-96	15,601	2.88	3.71
Uganda	57%	Nov-01		13,457,127	116%	Oct-06, Mar-01	24,101	4.45	4.28
Zambia	85%		Oct-02, Jun-03	729,469; 4,955,647	112%, 108%	Oct-07, Jun-02, Jan-97	21,419	3.95	3.46
Zimbabwe	75%	Jul-02		1,537,263	85%	Apr-06, Dec-99	12,518	2.31	2.37

[a] First dose measles immunization coverage rate among 12- to 23-month-old children. Source: World Development Indicators catalog, WHO and UNICEF (http://www.who.int/immunization_monitoring/routine/en).

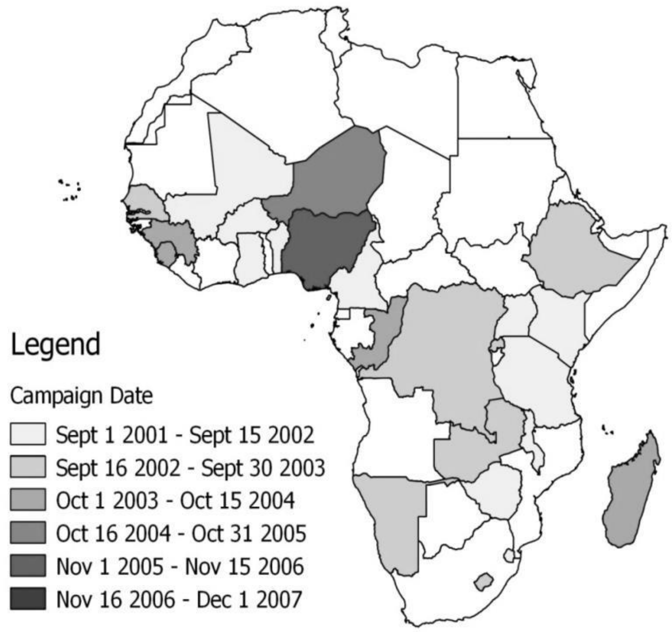
[b] Source: MI publications, correspondence with MI staff, and MI administrative data.

[c] Vaccination rate is calculated as the number of children reached divided by the target population (typically all children aged 9 months-15 years) calculated by MI staff. In some cases, coverage rate can be greater than 100% where target population estimates were inaccurate or vaccination of children outside target age ranges took place.

[d] Source: Tabulations with DHS data. The reported date of DHS surveys is the last interview date in the survey data.

[e] One or more regions were excluded from the data because it was unclear when the SIA occurred in the regions.

Figure A1: Map of countries with Measles Initiative SIA and DHS surveys



Notes: Countries listed in Appendix Table A1 are shaded by the date of the national SIA or first regional SIA.

APPENDIX B: BENCHMARK COMPARISON OF RESULTS

The model by Wolfson et al. (2007) uses the data set most comparable to our study's because it comprises data from 1999 through 2005. It estimates the number of age-specific cases in each country by (1) multiplying the number of cases by a "notational efficiency" ratio in countries with better surveillance systems, or (2) simply assuming that all unvaccinated children are infected. It then multiplies the number of cases by country- and age-specific case-fatality ratios from Stein *et al*. (2003), which ranged from 2% to 6%. Markov simulations are used to estimate confidence intervals. This approach is known as a natural history model. As Table B1 shows, the study estimates that Africa's measles mortality rate fell from 19.4% of non-vaccinated children to 4.8%, which we interpret as roughly a (2.91 - 1.44 =) 1.47 percentage point change in all-cause mortality. Using data from 2000 through 2010 and a more sophisticated (but similar) state-space model, Simons *et al*. (2012) estimate the number of worldwide measles deaths somewhat lower than that estimated by Wolfson *et al*. (2007). Simons *et al*. (2012) estimate that 187,000 deaths were averted by the SIAs in Africa in 1999—about two-thirds of Wolfson *et al*.'s (2007) estimate for 1999. The back-of-the-envelope implied change in the Africa-wide measles mortality rate (Table B1, row 6) is also lower in the study by Simons *et al*. (2012, Table B1, final columns).

Note that our estimates of the effect of the SIAs on measles mortality is an estimate of the average effect across the children in the countries in our study. To compare our estimates (2.4 percentage points in the child-level model and 3.0 percentage points in the panel data model) to Table B1, our estimates can be multiplied by the fraction of African children in countries with an SIA (in each respective year).

Table B1: Benchmark Comparison

	Wolfson et al. (2007)		Simons et al. (2012)	
	1999	2005	2000	2012
1. Births (millions) [a]	26.9	29.9	27.4	32.7
2. Routine MCV coverage	50%	65%	56%	76%
3. Number of measles deaths (95% CI)	506,000 (370,000-658,000)	126,000 (93,000-164,000)	337,000 (216,600-653,000)	186,675 (8,900-258,100)
4. Measles mortality rate (deaths per year / 100 live births per year)[b]	1.88	0.42	1.23	0.57
5. Number of deaths averted	387,000	871,000	197,900	569,300
6. Implied change in all-cause mortality rate (deaths per year / 100 live births per year)[c]	1.44	2.91	0.72	1.74

Source: Wolfson et al. (2007) Tables 1 and 2 and Simons et al. (2012) table unless otherwise noted.

[a]Total population times the crude birth rate, from the World Development Indicators (http://data.worldbank.org, September 2012).

[b] Row (3) divided by row (1) times 100.

[c] Row (5) divided by row (1) times 100.

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