Appendix

Detail of Cost-Effective Calculations

I followed a simple model to calculate the number of DALY resulting from malaria infection at age five. I assumed that all the malaria incidence occurs at age of five, and incidence lasts for seven days. Disability weights were obtained from the 2010 Global Burden of Disease.[8] Life expectancies at age five for males and females were obtained from WHO life table.[9] The case fatalities rate of malaria incidence under age five in Uganda was obtained from the Annual Malaria Report.[10]

Mechanism

Vector control

-net ownership and access

The use of mosquito nets to prevent malaria is a key strategy supported by the Ugandan government. In this study, I focused on whether mothers were more likely to own and use mosquito nets if they were more educated.

-IRS

Indoor residual spraying is another effective vector control strategy supported by the WHO. Due to the high burden of its cost, only 14 high-burden districts out of 110 districts were covered in 2014. Although the regional coverage is exogenously determined by the government regardless of maternal level of education, here I tested if such spraying was more likely to be done in a household with educated mothers.

Management of fever in children

The current policy suggests the diagnosis with microscopy or Rapid Diagnosis Test for all fever cases in children. The parasitological confirmation of the malaria species presence is required before the prescription of the anti-malarial drug.

The present study tests if children under the age of five, and with fever symptoms, were more promptly diagnosed and treated if they were raised by more educated mothers.

Malaria Knowledge

One possible pathway through which maternal schooling may change the behavior of the mother is because longer grade completion may lead to improved maternal knowledge on vector control and case management of fever in children. Here, I show whether educated females hold more information on causes of malaria, ways to avoid malaria, and the case management of children with fever.

Estimated results of mechanism analysis

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Figure 6 (main text) shows the analysis of the mechanism through which maternal schooling reduced the incidence of malaria among children. An extra year of maternal schooling was not associated with ownership of the mosquito net, but it was positively associated with net usage for children aged <5 years. An additional year of maternal schooling increases maternal knowledge on the method to avoid malaria. Maternal schooling was positively associated with the prompt treatment of children with fever, but this did not reach the conventional benchmark of statistical significance.

Economic explanation for behavioral change

Through what mechanism did mothers improve vector control and management of fever in children as they are educated? Although a detailed analysis is beyond the scope of the paper, I provide several economic explanations behind these behavioral change among educated mothers. First, longer years of maternal education may change the behavior of the mother, and reduce the child's malaria risk through the following mechanisms: 1) expanded access to financial resource through labor force participation, partnering with a husband from a higher SES; 2) higher ability to gather and process information, and better knowledge on health in general, and; 3) stronger decision making power within a marriage.[6, 7]

Robustness checks

Non-random attrition and consent rates

One possible source of bias to the current estimate is that the consent rates for child malaria blood testing may be non-random, and correlated with the exposure to the 1997 reform. It is also possible that the reform reduced the mortality of females, and selective mortality may bias the estimate. Figure S2 shows the probability of missing a child malaria biomarker, and it shows the size of the cohort by maternal birth year. It provides no evidence that either of these non-random selection elements biased my results. Furthermore, I tested whether the probability of missing a child malaria biomarker significantly increased in the 1983 cohort compared to the earlier cohorts in a regression. The results in Table S2 suggest no evidence supporting such concern.

Alternative explanation

The reform may improve fathers' educational attainment in the same cohort, and the risk of child malaria may decline owing to paternal, rather than maternal, education. However, an existing study has shown that educational attainment of the male cohort born ≥ 1982 did not disproportionately increase compared to the cohort born ≤ 1981.[7] Therefore, the observed decline in the probability of children's risk of malaria infection was not mediated by the change in fathers' education.

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Spillover effects

The reform may have spillover effects on the children of mothers who were not exposed to the reform. For example, the risk of malaria increases with the density of infected mosquitos in the neighborhood, and educated mothers may use better vector control methods. Under such a scenario, the risk of malaria infection may decline even in households in which mothers were not exposed to the reform. These mothers may be affected if they live in a neighborhood with exposed mothers. It is also possible that information spillover may affect unexposed mothers' behavior, therefore further reducing the malaria risk. However, both scenarios produce an underestimate of the true effect size of maternal education on child's malaria control. Therefore, the true effect of maternal education and cost-effectiveness of primary schooling intervention may be even greater than the current estimate.

Exclusion of pivotal cohort

Given the proportion of females attending primary education by age in 1996, I define the first cohort exposed to the reform as 1982 cohort. I, however, observed, in Figure 2 (main text), the rise in the probability of completing primary schooling among 1982 cohort were evident, but partial and were even more evident among 1983 cohort. Therefore, I tested the robustness of the estimates by excluding 1982 cohort as a sensitivity test.

Controlling for birth order

The reform may change women's fertility pattern and thus composition of the children may differ between exposed and non-exposed cohort. To obtain a conservative estimate, I tested the robustness of my findings by controlling for the full set of birth order indicators to control for the birth-order-specific effects on children's risk of malaria infection. In sum, the results are similar, further confirming that maternal education improves child malaria control.

Estimated results of robustness checks

Table S3 shows the robustness of the findings to using additional controls, using a narrower bandwidth, excluding the pivotal cohort, and the placebo test. Using a linear term in year of birth with reform indicator interaction, quadratic term of year of birth, extra year of maternal schooling was associated with 6 percentage point reduction in child's malaria risk. Controlling for birth order of the children, or by implementing a narrower window size, an additional year of maternal schooling reduces the probability that her child contracts malaria by 8-9 percentage points on average. Excluding the 1982

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cohort, an additional year of maternal schooling reduces the probability that a child contracts malaria by 7 percentage points. I found no effects of the reform on females with no schooling, whereas I found the exposure to the reform reduced the incidence of the child malaria by 5 percentage points in the full sample.

Lastly, using the exposure to Malawi 1994 free primary education reform as the instrumental variable, IV 2SLS estimates shows that an extra year of maternal schooling in Malawi was associated with a decline in the probability that a child would contract malaria at the time of the survey by 8.8 percentage points. (Details are discussed in the next subsection)

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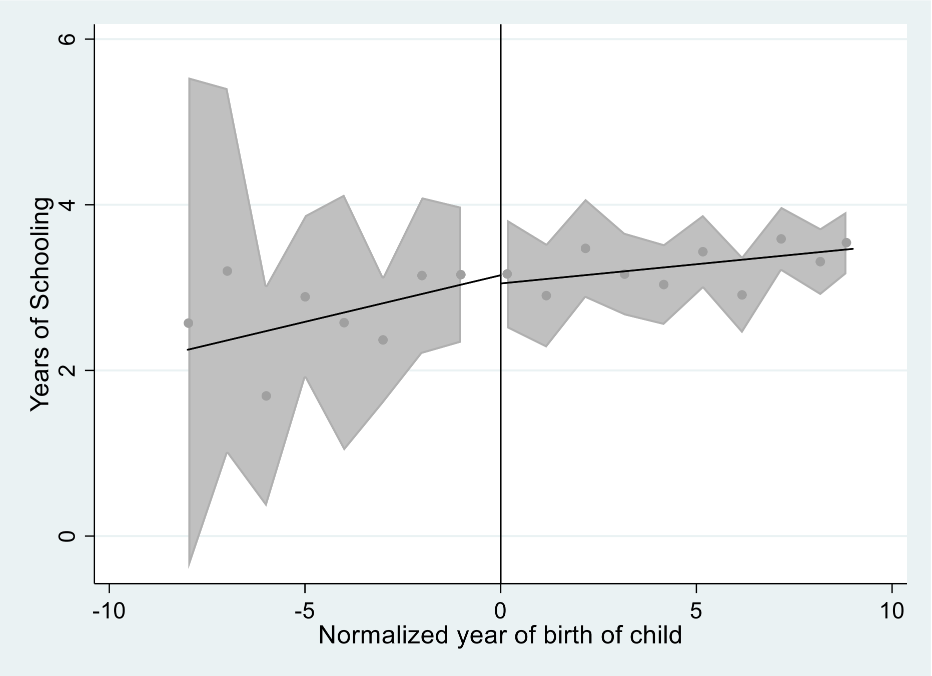
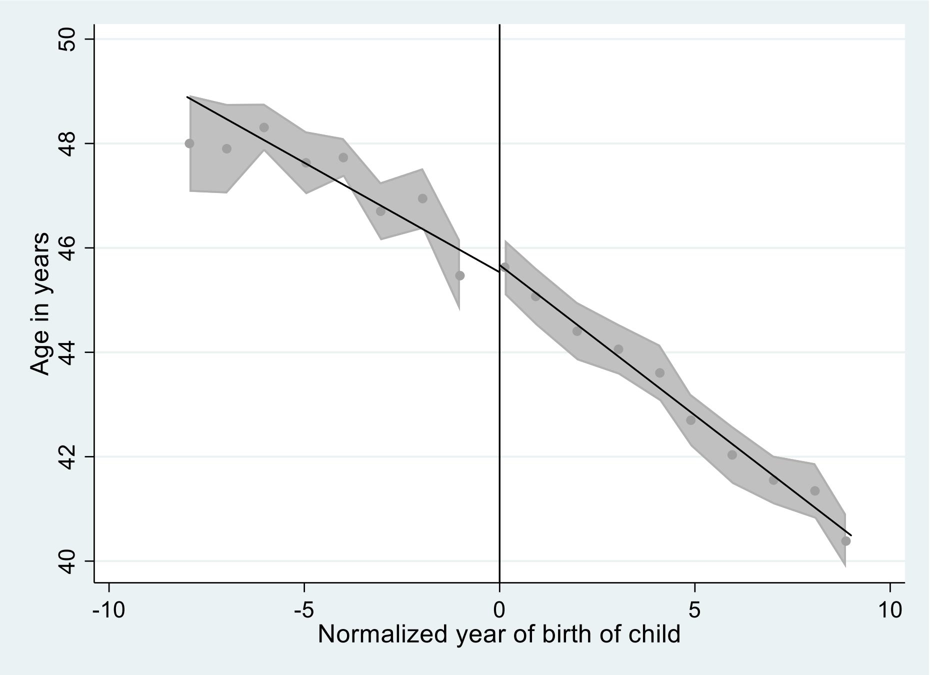
Figure S1: Characteristics of mothers

-Education –mothers of cohort women



-Age –mothers of cohort women



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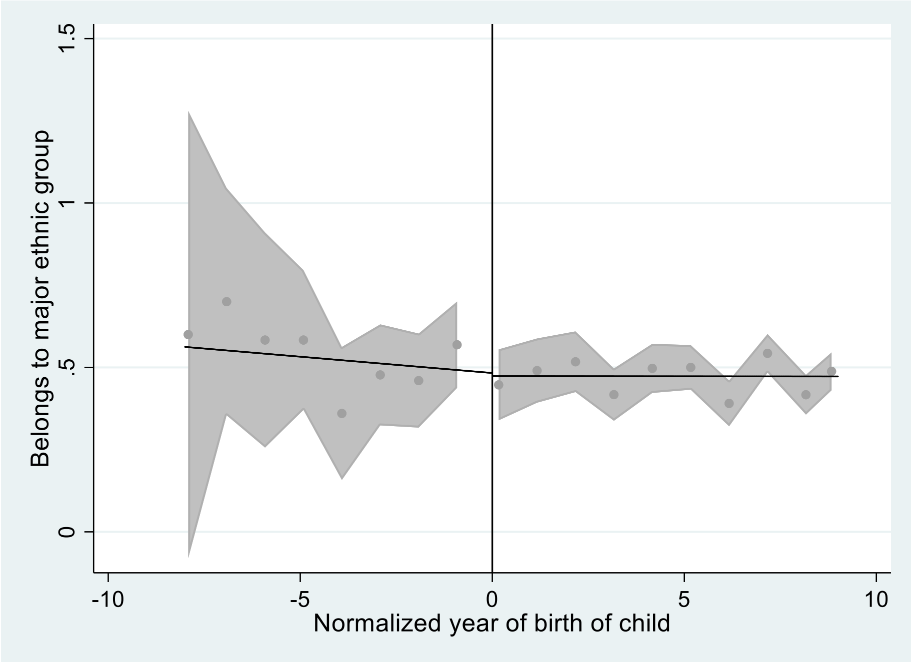
-Ethnicity –mothers of cohort women



-Wealth–mothers of cohort women

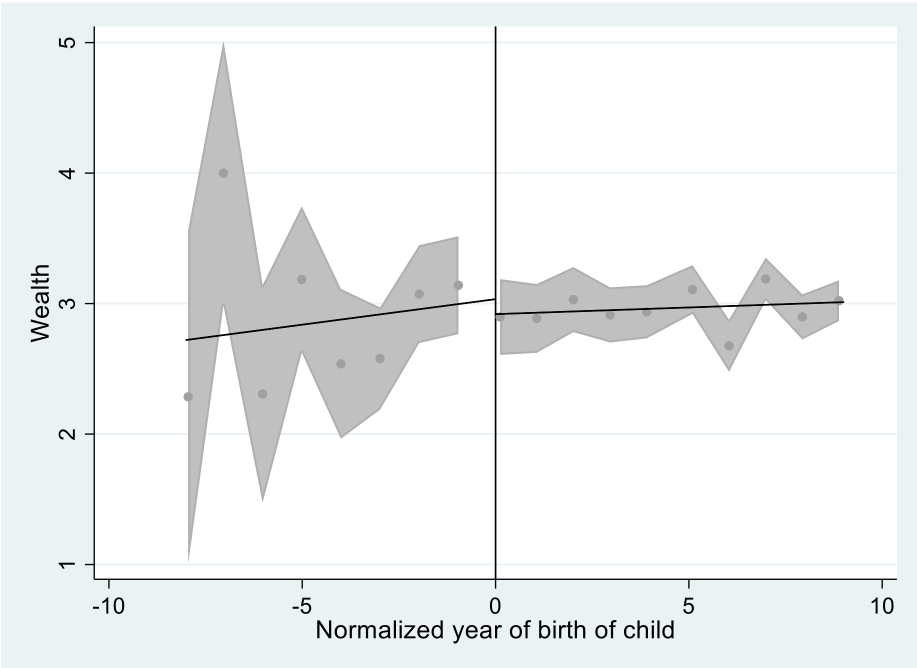


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Figure S2 Change in the cohort size and probability of missing child malaria biomarker by maternal birth year

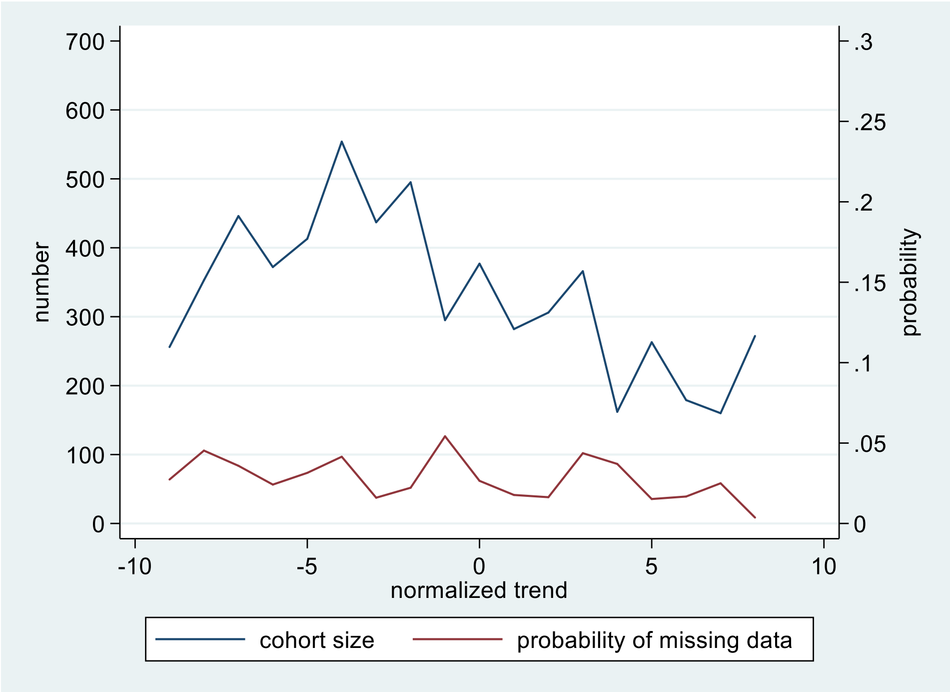

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Table S1 Association between length of maternal schooling and child malaria status

Outcome: child malaria positive	(1)	(2)	(3)
Years of education	-0.022***		
	(0.001)		
1 if completed at least 7 years of schooling		-0.152***	-0.094***
		(0.012)	(0.019)
1 if completed at least 6 years of schooling			-0.055**
			(0.025)
1 if completed at least 5 years of schooling			0.048
			(0.029)
1 if completed at least 4 years of schooling			-0.039
			(0.032)
1 if completed at least 3 years of schooling			-0.087**
			(0.035)
Observation	5,316	5,316	5,316

Table S2 ITT effects of the reform on the probability of missing child malaria biomarker

Outcome: missing malaria data	(1)
Reform indicator (1 if born in 1983 or later)	0.000
	(0.000)
Observation	5,316

Note: MIS 2009, 2014 provides information. Robust standard errors in parenthesis.

Table S3 Robustness check

	Exposure	Outcome	Effect estimate (SE)
Model 1: 2SLS, slope change in year of birth	Years of schooling	Malaria positive	-6.3† (2.6)
Model 2: 2SLS, quadratic in year of birth	Years of schooling	Malaria positive	-6.3† (2.9)
Model 3: 2SLS, quadratic in maternal age	Years of schooling	Malaria positive	-6.4* (3.9)
Model 4: 2SLS, control birth order	Years of schooling	Malaria positive	-9.3* (5.4)
Model 5: 2SLS, narrow window	Years of schooling	Malaria positive	-8.2* (4.8)
Model 6: 2SLS, exclude 1982 cohort	Years of schooling	Malaria positive	-7.4‡ (3.4)
Model 7: 2SLS, Malawi	Years of schooling	Malaria positive	-7.1‡ (2.6)
Model 8: ITT, education = 0	Reform exposure	Malaria positive	-0.7 (5.0)

Coefficient and standard errors are multiplied by 100 and reported on a percentage point scale. Models 1–6 were estimated by instrumental variable two stage least square (IV-2SLS) method, in which binary indicator for being born 1982 or later was used as an excluded instrumental variable for maternal years of schooling. Model 7 was estimated by IV 2SLS method, in which binary indicator for being born 1979 or later was used as an excluded instrumental variable for maternal years of schooling. Model 8 is estimated by ordinary least square method. All model controls for full set of children's age-in-months indicators, a linear term of maternal year of birth, indicator for survey year, indicator for survey month, indicator for child sex, indicator for ethnic groups, and maternal age. *p < .1, †p < .05, ‡p < .01. No weights were used.

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Table S4 Uganda

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Years of education	-0.075*	-0.063**	-0.063**	-0.064*	-0.093*	-0.082*	-0.074**	-0.007	-0.048**
	(0.039)	(0.026)	(0.029)	(0.036)	(0.054)	(0.048)	(0.034)	(0.050)	(0.024)
1 if born in 1982 or later									
Basic covariates									
i.child age	✓	✓	✓	✓	✓	✓	✓	✓	✓
c.YOB	✓	✓	✓	✓	✓	✓	✓	✓	✓
i.survey year	✓	✓	✓	✓	✓	✓	✓	✓	✓
i.survey month	✓	✓	✓	✓	✓	✓	✓	✓	✓
i.ethnicity	✓	✓	✓	✓	✓	✓	✓	✓	✓
c.mother's age	✓	✓	✓	✓	✓	✓	✓	✓	✓
Additional controls									
c.YOB#i.reform		✓							
c.YOB^2			✓						
c.mother's age^2				✓					
i.birthorder					✓				
Narrower bandwidth									
1973<YOB<1992	✓	✓	✓	✓	✓				
1974<YOB<1991						✓			
exclude 1982 cohort							✓		
sub sample, no schooling								✓	
all sample									✓
Observation	5,316	5,316	5,316	5,316	5,316	4,841	4,974	1,249	5,316

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Table S4 Malawi

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Years of education	-0.088**	-0.111*	-0.112*	-0.098*	-0.068**	-0.135**	-0.064*		
	(0.043)	(0.067)	(0.064)	(0.058)	(0.031)	(0.062)	(0.038)		
1 if born in 1980 or later								-0.033	-0.074**
								(0.088)	(0.031)
Basic covariates									
i.child age	✓	✓	✓	✓	✓	✓	✓	✓	✓
c.YOB	✓	✓	✓	✓	✓	✓	✓	✓	✓
i.survey year	✓	✓	✓	✓	✓	✓	✓	✓	✓
i.survey month	✓	✓	✓	✓	✓	✓	✓	✓	✓
i.ethnicity	✓	✓	✓	✓	✓	✓	✓	✓	✓
c.mother's age	✓	✓	✓	✓	✓	✓	✓	✓	✓
Additional controls									
c.YOB#i.reform		✓							
c.YOB^2			✓						
c.mother's age^2				✓					
i.birthorder					✓				
Narrower bandwidth									
1973<YOB<1992	✓	✓	✓	✓	✓				
1974<YOB<1991						✓			
exclude 1982 cohort							✓		
sub sample, no schooling								✓	
all sample									✓
Observation	3,185	3,185	3,185	3,185	3,185	2,822	3,343	543	3,185

Table S5: Descriptive statistics (mean) for the complier subpopulation and whole sample

	Sample	Compliers
Lives in Kampala [0,1]	0.091	0.110
Lives in urban area [0,1]	0.132	0.234
Belongs to major ethnic group [0,1]	0.419	0.331
Wealth [1,5]	2.728	2.304

Note: MIS 2009 and 2014 provides information. Values are calculated by the procedure proposed by Marbach and Hangartner (2019), with *ivdesc* command of STATA15. See Marbach and Hangartner (2019) for the details.

Table S6: The effects of the reform exposure on the probability of being childless

Outcome: 1 if Woman has no child at the time of the survey	(1)
Reform indicator (1 if born in 1983 or later)	-0.122
	(0.072)
Observation	4,968

Note: MIS 2009, 2014 provides information. Robust standard errors in parenthesis.

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