Private Health Investments under Competing Risks: Evidence from Malaria Control in Senegal

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UNU-WIDER Seminar

October 18, 2017

Motivation

- Malaria has long been the leading cause of child death in Africa.
  - 700,000 deaths in 2000.
  - 25% of post-neonatal deaths.
  - Perceived by parents as the main threat to children.
  - First component of out-of-pocket health expenditures.
- Recent large scale interventions to control the disease.
  - Roll-Back Malaria partnership.
  - High subsidies for anti-malaria products:
    - Preventive: Insecticide-Treated Nets (ITN)
    - Curative: Artemisinin-based Combination Therapy (ACT)
  - Large impact on child survival (Cogneau and Rossi, 2017)

Annual trends in infant mortality in Sub-Saharan Africa

Table: Stylized fact: trends in child mortality

	High prevalence Poor	*High prevalence Rich*	*Low prevalence Poor*	*Low prevalence Rich*
Linear trend before Roll-Back Malaria	-0.0014	-0.0038^{***}	-0.0054^{***}	-0.0044^{***}
	(0.0015)	(0.0013)	(0.0007)	(0.0010)
Linear trend after Roll-Back Malaria	-0.0053^{***}	-0.0042^{***}	-0.0057^{***}	-0.0043^{***}
	(0.0007)	(0.0005)	(0.0005)	(0.0005)
Observations	134806	196943	296879	317598
pvalue Before=After	0.033	0.765	0.698	0.950

DHS in : Benin, Burkina Faso, Cameroon, DRC, Ethiopia, Ghana, Guinea, Kenya, Liberia, Malawi, Mali, Namibia, Nigeria, Rwanda, Senegal, Sierra Leone, Uganda, Zambia, Zimbabwe.
The table presents estimates of the linear trend in child mortality before (1995-2001) and after the start (2002-2011) of anti-malaria campaigns for different populations: the richest half and poorest half of households (according to durable goods ownership) in regions with high and low initial malaria prevalence ($\geq 50\%$ or $< 50\%$ of children aged 2 to 10 are infected by the parasite).
We kept only children born at most 10 years before the survey to perform the estimation.
The last line reports the p-value of a test of equality between linear trends before and after 2002.
S.e. in (). * p $\leq$ 0.1, ** p $\leq$ 0.05, *** p $\leq$ 0.01.

This paper

- Does malaria prevent parental investment in child health?
- Mechanism:
  - Competing mortality risks generate a complementarity between different health investments.
  - Malaria makes health investments unprofitable for the poor.
  - Subsidies for anti-malaria products generate incentives to fight other causes of deaths.
- Identification:
  - Exploit the introduction of high subsidies in 2009 in Senegal.
  - Examine changes in health-seeking behavior.
  - Diff-in-diff using variation in initial prevalence of malaria.

What we do

- Develop a simple model of investment in health.
  - Adapt Dow et al (1999) to contexts with one prevailing disease.
  - Predict private responses to anti-malaria subsidies.
- Use original data from Senegal.
  - Panel data on household expenditures on child health.
  - Repeated cross-sections on child health status and health-seeking behavior.
  - Geographical data on malaria prevalence.
- Preview of results
  - Households raised their expenses to fight malaria and other diseases.

Contribution

- Provide empirical support to an economic model of health-seeking behavior.
- First proper test of Dow et al (1999).
  - So far, evidence based on data on health outcomes.
  - Plagued with omitted variable issues.
  - Direct test requires data on private expenses.
- Fits in literature on human capital investments and mortality risks (Jayachandran and Llears-Muney 2009, Oster 2012).
- Conceptual framework useful to:
  - Explain why poor people in insalubrious environments invest little in child health.
  - Predict how people respond to health subsidies.

Policy implications

- Policy debate: to give or not to give health products to the poor?
- Academic debate: are public and private health expenses complements or substitutes in the least developed countries?
- Anti-malaria campaigns have not crowded out parental health investments, quite the opposite.
- Helps explaining *"one of the surprising results from large-scale trials of insecticide treated bednets is that the reduction in all-cause mortality is considerably greater than the reduction in malaria-attributed mortality"* (Sachs and Malaney, 2002).

Outline

Key theoretical insights

- Adapted from Dow, Philipson and Sala-i-Martin (AER, 1999).
- Trade-off between quantity and quality of life.
- Competing risks $\rightarrow$ Leontief function of production of survival $\rightarrow$ complementarity of disease-specific investments.
- Optimal allocation equalizes the lifetime across all causes of death.

Application to our context

- Predominance of malaria $\Rightarrow$ corner solutions.
- 3 optimal allocations depending on wealth:
  1. No investment.
  2. Positive investment in malaria only.
  3. Positive investment in malaria and other diseases.
- Dramatic decrease in the price of anti-malaria treatments is predicted to raise private investments to fight malaria and other diseases.

From theory to data

- Theory: private investments in malaria and other diseases.
- Data: total household expenditures on child health and disease-specific health-seeking behavior.
- Challenge: disentangle quantities/prices and free/costly treatments.
- Combine 3 predictions:
  - P1 Total expenditures on child health should increase.
  - P2 The proportion of households with no child health expenditures should decrease.
  - P3 Health-seeking behavior in case of other diseases should increase.

Outline

Data from Senegal

- Panel data on household expenditures on child health:
  - "Poverty and Family Structure" (PSF)
  - Nationally representative panel with 2 waves: 2006 and 2011.
  - Health and non-health expenditures at a disaggregated level ("cell").
  - Unit: all children in mother's cell.
  - Follow 1,594 cells in 1,118 households

- Repeated cross-sections on child health status:
  - Demographic and Health Surveys in 2005 and 2010.
  - Nationally representative.
  - Health-seeking behavior in case of diarrhea, cough and fever for children under 5.
  - 8,466 children.

- Geographical data on malaria prevalence:
  - Malaria Atlas.
  - Prevalence of the disease before Roll-Back Malaria.

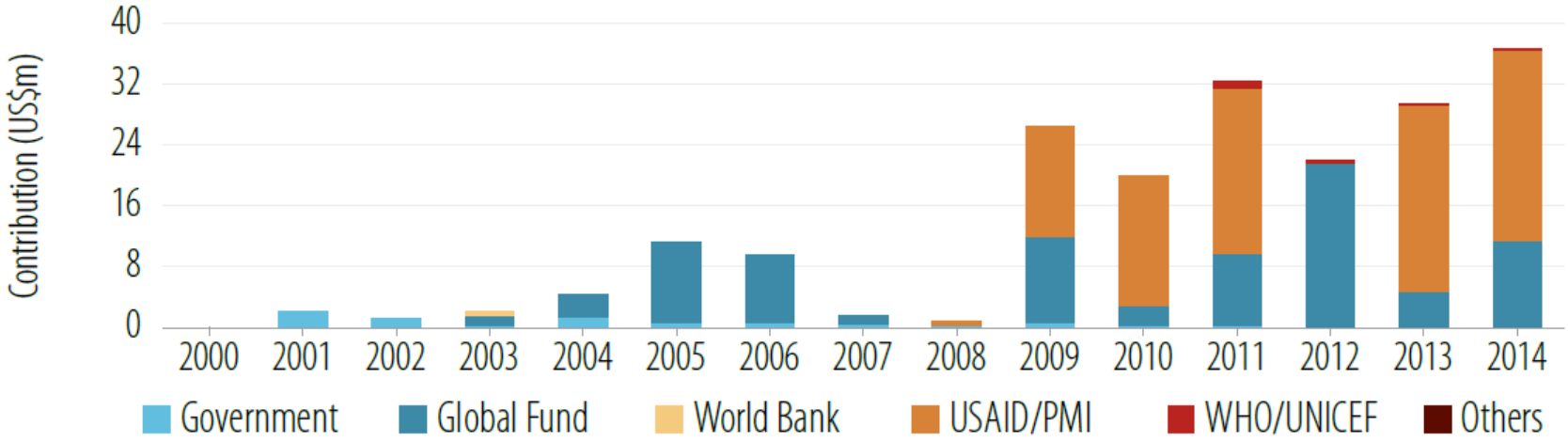
Outline

Difference-in-Difference

- Compare the evolution of child health expenditures:
  - Before and after the introduction of subsidies in 2009.
  - Between malarious and non-malarious regions.
- Similar strategy in Bleakley (AEJ: Applied, 2010).
- Identification assumption:
  - In the absence of *malaria*, the evolution of health expenditures would have been the same for all households.
  - Makes no sense to look at pre-trends. Cannot look at "post-trends" because no eradication.
  - Account for changes in composition with mother fixed effects.
  - Examine trends in other determinants of child health expenses: total income, access to health and child morbidity.

Temporal variation

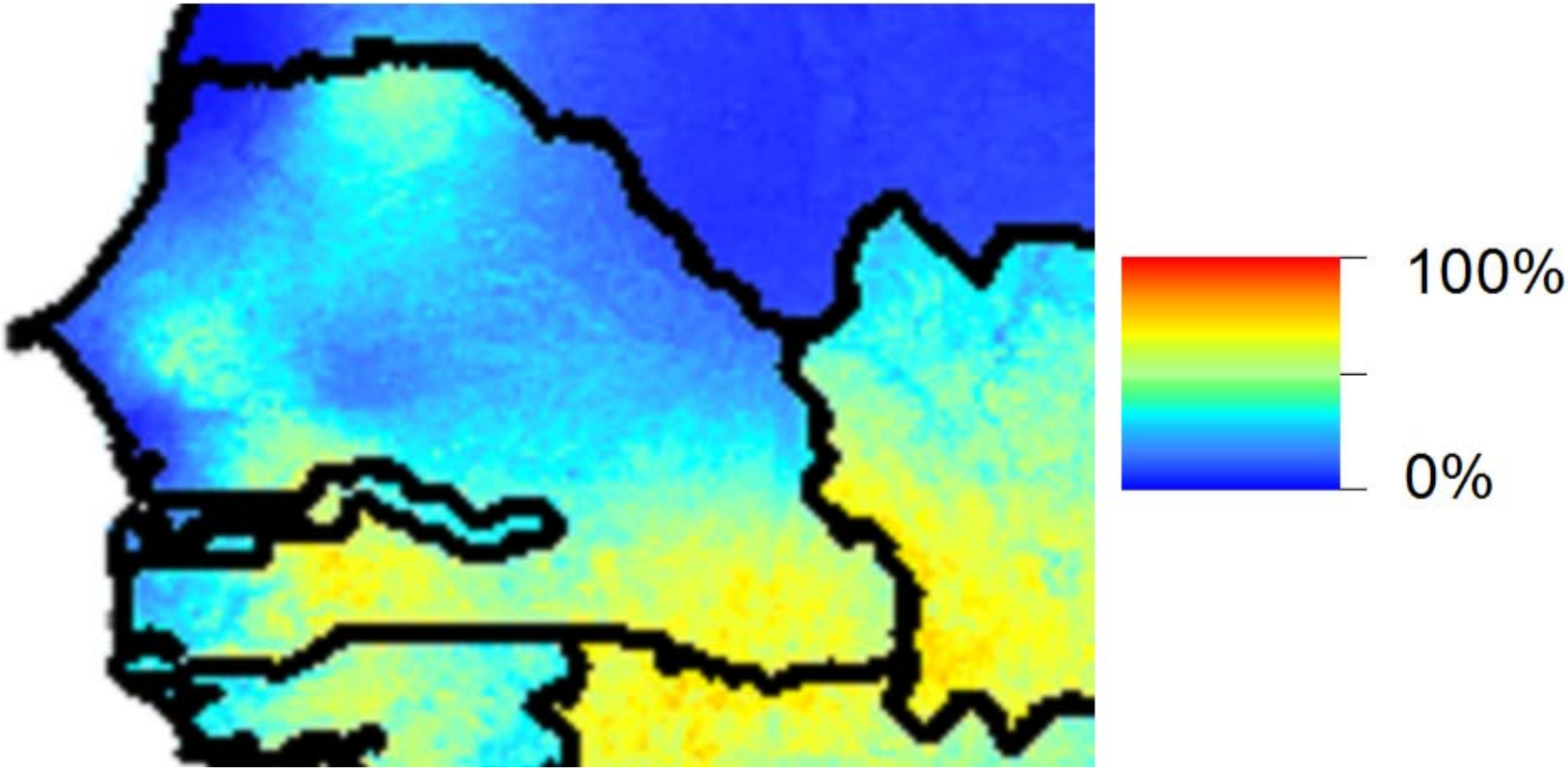
Amounts spent on anti-malaria programs (World Malaria Report, 2015).



- 2009: first nationwide distribution of ITNs:
  - 6 millions bednets.
  - Price decreased from 10-12 to 0-1 euro.
  - Coverage doubled from 20% in 2006 to 40% in 2010.
- 2010: ACT become free for all ages in public health facilities.

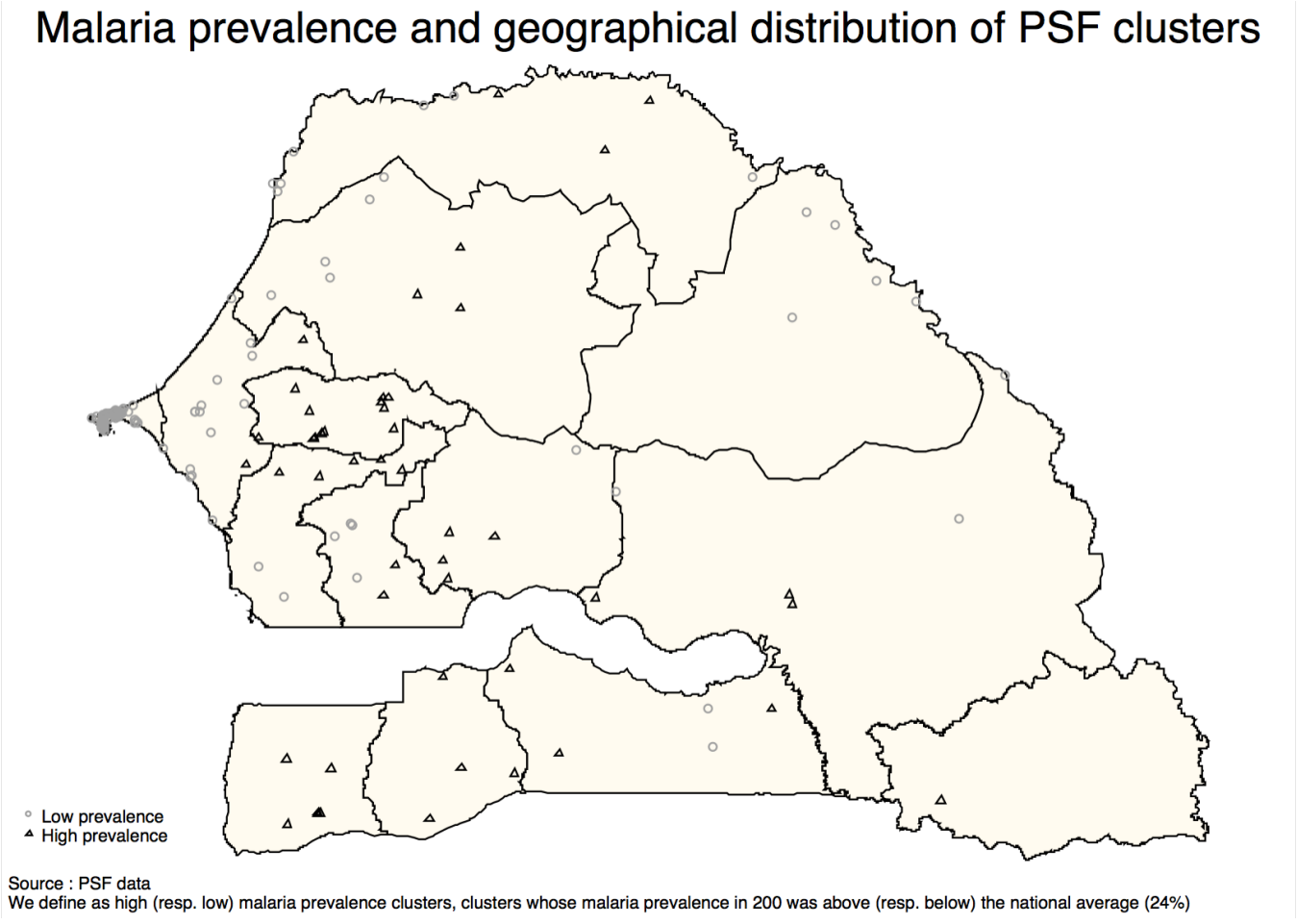
Spatial variation

Proportion of infected children in 2000 (Malaria Atlas)



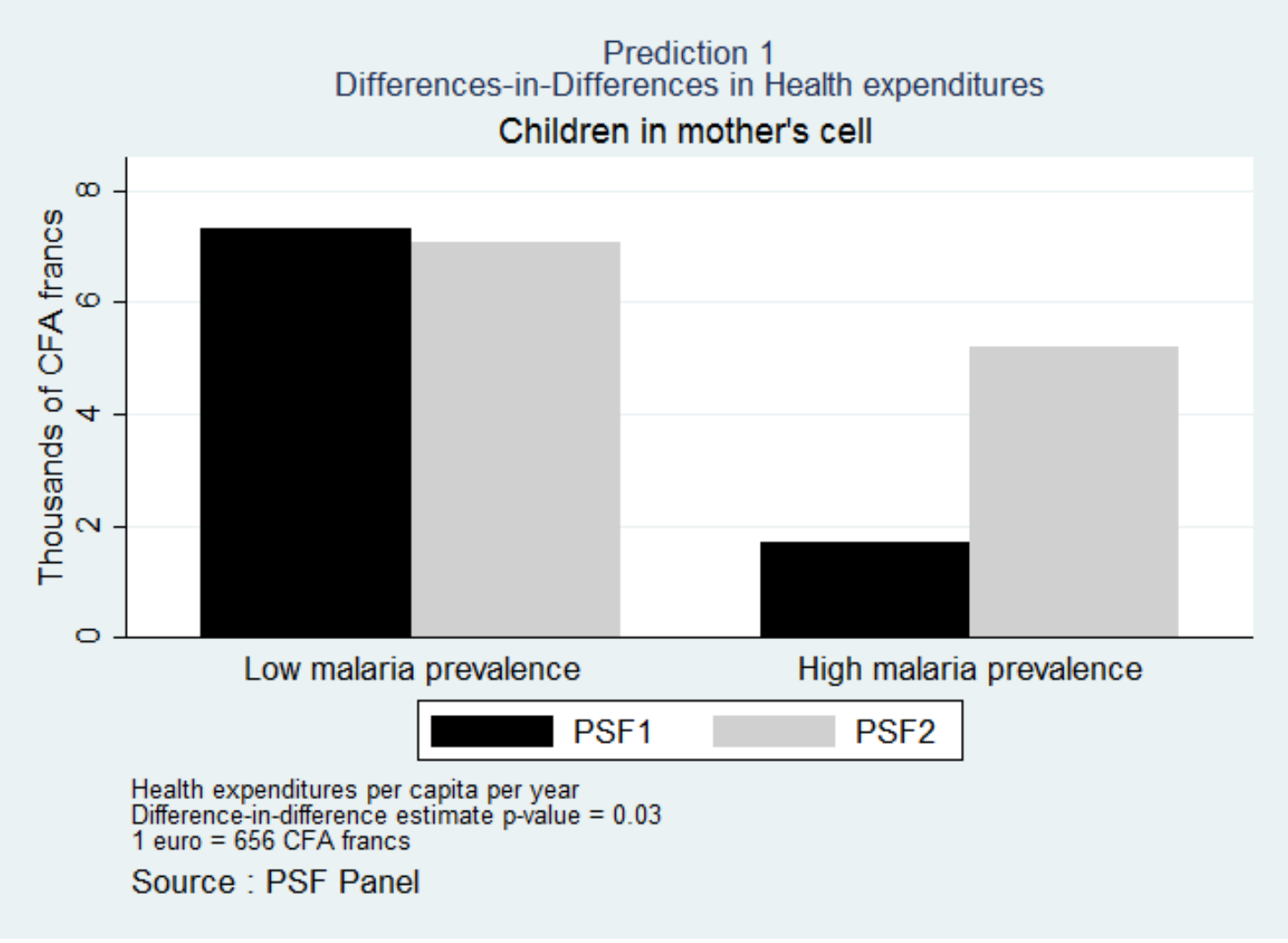
National average = 24% → High / Low malaria prevalence

Spatial variation in our sample

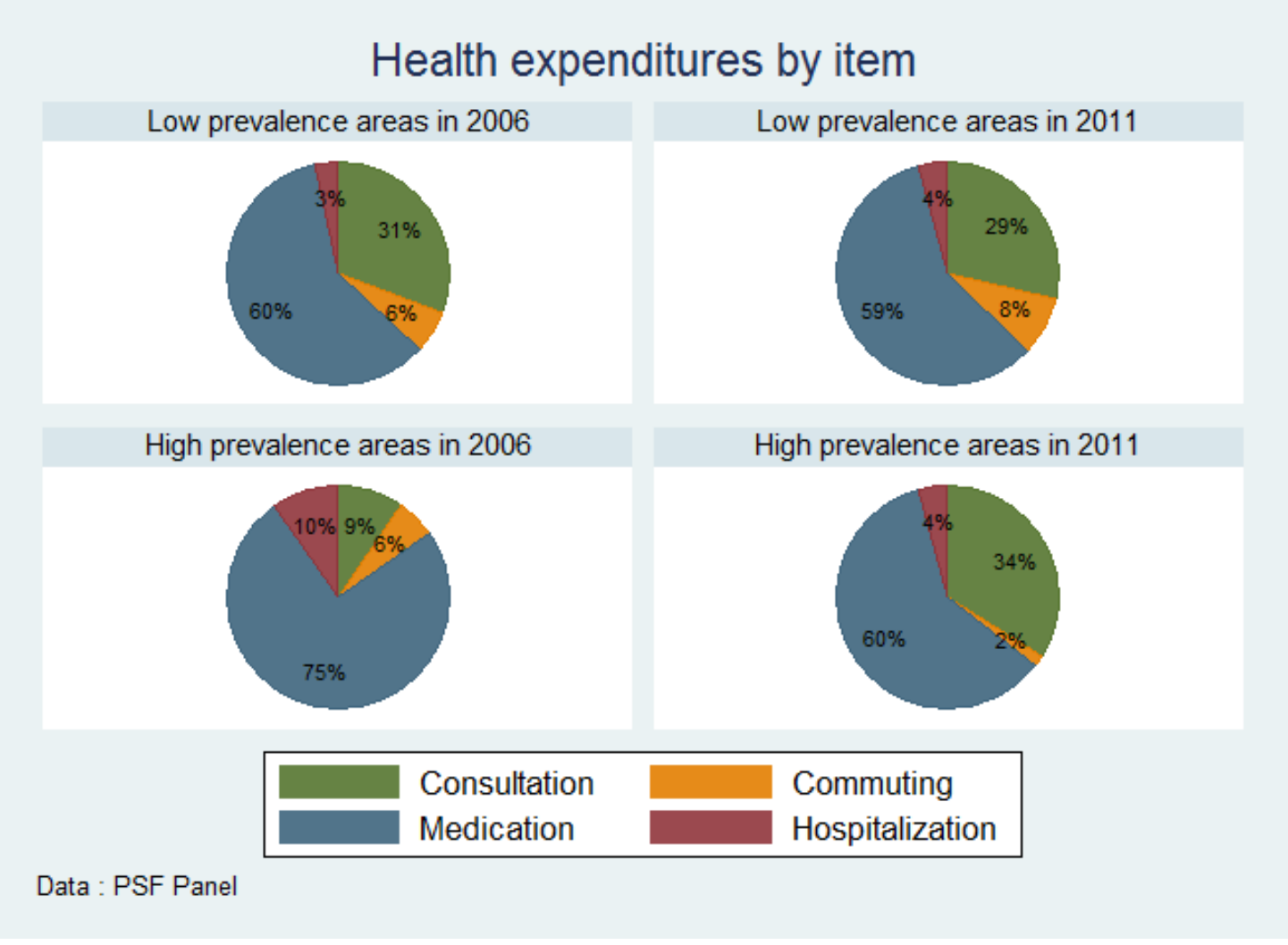


Outline

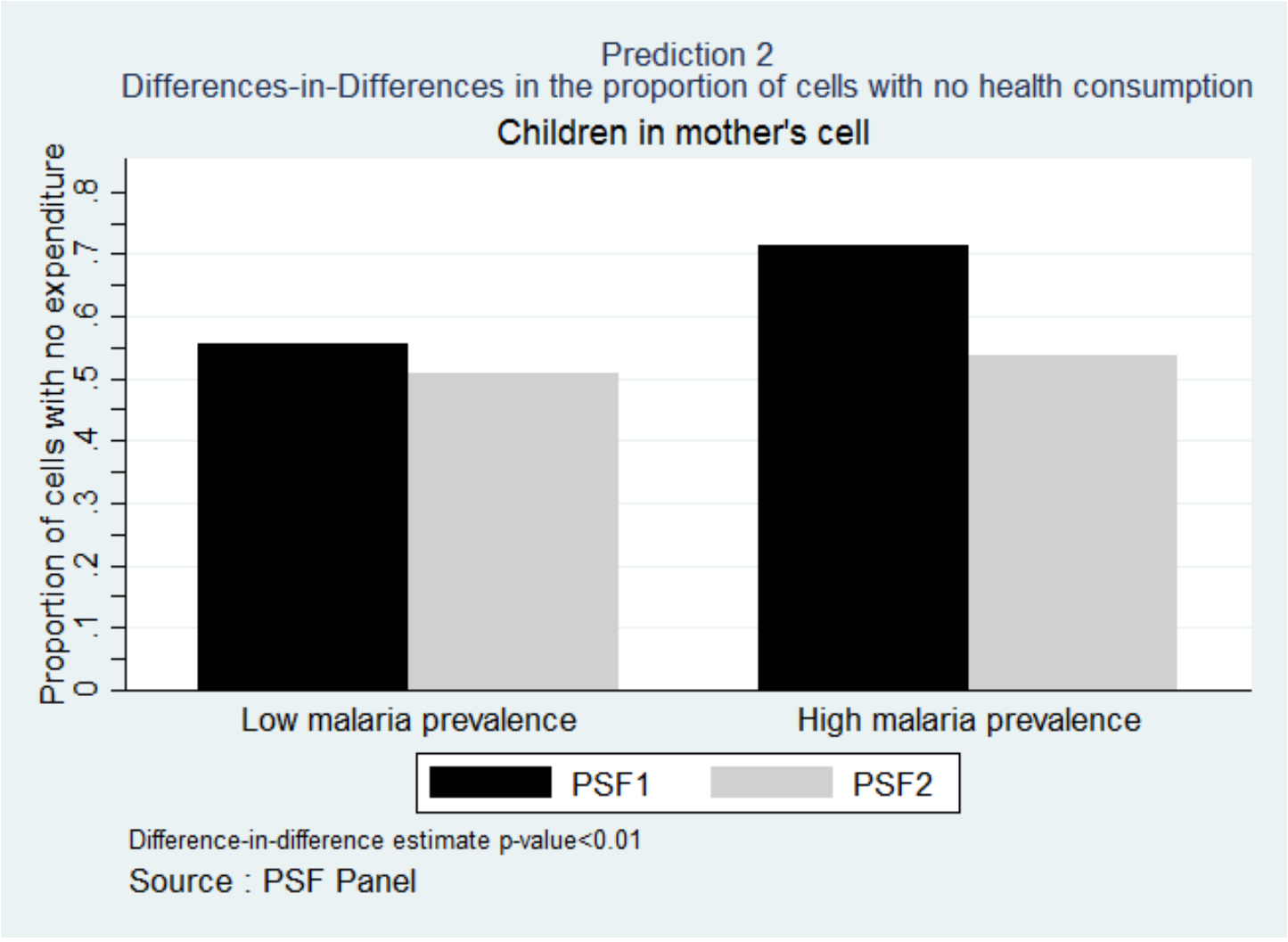
Prediction (1) : Per capita health expenditures



Breakdown of expenditures by item



Prediction (2) : Extensive margin



Regression with mother fixed effects

Table: Predictions 1 and 2: Differences in Differences in Health expenditures

	Per capita levels *(1)*	*Zero spending* *(2)*
Post	0.842	−0.041*
	(1.353)	(0.021)
High prevalence × Post	2.603	−0.115***
	(1.712)	(0.034)
Mother FE	*Yes*	*Yes*
N	4550	4550
Mean of dep. var. in low prevalence areas in 2006	7.33	0.56
Mean of dep. var. in high prevalence areas in 2006	1.72	0.71

Data : PSF Panel.
Differences-in-differences regression with mother fixed effects. Linear probability model.
Dep var : (1) Health expenditures per capita for children in mother's cell (thousands of CFA francs). (2) : Dummy for no health expenditures for any child in the mother's cell.
Standard errors, in (), are clustered at the mother level.
* p $\leq$ 0.1, ** p $\leq$ 0.05, *** p $\leq$ 0.01.

Prediction (3) : Health-seeking behavior

Table: Health decisions when child is sick : Medical advice or treatment sought

	All diseases (1)	*Diarrhea* (2)	*Fever and Cough* (3)
HMP	-0.075^{***}	-0.070^{***}	-0.065^{***}
	(0.016)	(0.020)	(0.018)
Post=1	0.017	0.135^{***}	-0.008
	(0.018)	(0.024)	(0.020)
HMP $\times$ Post=1	0.034	0.060^{**}	-0.002
	(0.023)	(0.030)	(0.026)
Constant	0.416^{***}	0.266^{***}	0.426^{***}
	(0.012)	(0.016)	(0.013)
N	8466	4188	6672

Data : DHS 2005 and DHS 2010. Children under 5 years of age.
LPM. Outcome : Did you seek any medical advice or medical treatment for your child she was sick?
Sample of children sick the last two weeks
S.e. in (). * p $\leq$ 0.1, ** p $\leq$ 0.05, *** p $\leq$ 0.01.

Outline

Alternative stories

Our results are not driven by differential trends in:

- Total income ▸ Test
- Health infrastructure ▸ Test
- Other child health campaigns ▸ Test
- Rainfall ▸ Test
- Child morbidity ▸ Test
- Between rural and urban areas ▸ Test

Robustness

Other robustness tests:

- Run the regression at the child level ▸ Test
- Heterogeneity by age ▸ Test
- Control for sibship structure and migration ▸ Test
- Exploit variation in campaigns intensity ▸ Test
- Account for attrition ▸ Test

Price or information?

Main mechanism is probably subsidies rather than information.

- Demand for bednets sensitive to price, not to framing (Dupas, 2009)
- Cross-disease effect hard to explain with imperfect information.
- Switchers are in the middle of the income distribution ▸ Table
- Response is not different for mothers targeted by information campaigns ▸ Table

Outline

Conclusion

- Parental investments in child health have increased in response to anti-malaria interventions in Senegal.
  - At the intensive and extensive margins.
  - Against malaria as well as other diseases.
- Patterns consistent with an economic model of health investments under competing mortality risks.
- Malaria has long prevented parental investment in child health and heavy subsidies proved to be necessary to alleviate this constraint.
- Further research is needed to investigate the implications for fertility choices.

Different trends in total income?

Table: Changes in cell total expenditures, by low/high prevalence region

	Total expenditures
Post=1	9.783
	(13.506)
HMP × Post=1	−5.367
	(16.034)
N	4550

Linear Probability Model.
Data :PSF Panel. Dependent variables : total expenditures for the whole cell in the last 12 months in thousands of CFA francs
Robust s.e. in (). * p ≤ 0.1, ** p ≤ 0.05, *** p ≤ 0.01.

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Different trends in health infrastructure?

Table: Mothers' Health seeking behavior and distance to health facilities as a main problem

	Distance *(1)*
HMP	0.106^{***}
	(0.010)
Post=1	-0.018^{*}
	(0.011)
HMP $\times$ Post=1	0.020
	(0.014)
Constant	0.336^{***}
	(0.008)
N	19098

Data : Mothers of children under 18 in DHS 2005 and DHS 2010.
Linear probability model. Outcome : When you are sick and want to get medical advice or treatment, is the distance to the nearest health facility a big problem or not?
Robust s.e. in (). * p $\leq$ 0.1, ** p $\leq$ 0.05, *** p $\leq$ 0.01.

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Different trends in campaigns against diarrhea?

Table: Controlling for interventions against diarrheal diseases

	Baseline results			*Controlling for distributed quantities of zinc*		
	All diseases	*Diarrhea*	*Fever and Cough*	*All diseases*	*Diarrhea*	*Fever and Cough*
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
High prevalence	-0.075^{***}	-0.070^{***}	-0.065^{***}	-0.075^{***}	-0.070^{***}	-0.065^{***}
	(0.016)	(0.020)	(0.018)	(0.016)	(0.020)	(0.018)
Post	0.017	0.135^{***}	-0.008	0.024	0.141^{***}	-0.002
	(0.018)	(0.024)	(0.020)	(0.018)	(0.025)	(0.020)
High prevalence × Post	0.034	0.060^{**}	-0.002	0.053^{**}	0.079^{**}	0.014
	(0.023)	(0.030)	(0.026)	(0.026)	(0.034)	(0.029)
Constant	0.416^{***}	0.266^{***}	0.426^{***}	0.416^{***}	0.266^{***}	0.426^{***}
	(0.012)	(0.016)	(0.013)	(0.012)	(0.016)	(0.013)
Mother FE	*No*	*No*	*No*	*No*	*No*	*No*
N	8466	4188	6672	8466	4188	6672

Data : DHS 2005 and DHS 2010.Sample: children under age 5 who have been sick in the last two weeks before the survey.
Differences-in-differences regression without mother fixed effects. Linear probability model.
Dep. var: dummy for seeking any medical advice or medical treatment when the child suffered from any disease (column 1), diarrhea (column 2), fever or cough (column 3).
Standard errors, in (), are clustered at the mother level.
* $p \leq 0.1$, ** $p \leq 0.05$, *** $p \leq 0.01$.

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Different trends in morbidity?

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Table: Morbidity trends for children under 5

	Sick child
Post=1	-0.082^{***}
	(0.012)
High malaria prevalence	-0.032^{***}
	(0.011)
Post=1 × High malaria prevalence	-0.017
	(0.015)
Constant	0.484^{***}
	(0.008)
N	20630

Data : DHS 2005 and DHS 2010. Children under 5 years of age.
Linear probability model. Outcome : Child had either fever, cough or diarrhea the last two weeks
Clustered s.e.at the mother level in (). * p $\leq$ 0.1, ** p $\leq$ 0.05, *** p $\leq$ 0.01.

Different trends in rainfall?

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Table: Controlling for rainfall deviation

	Baseline results		*Controlling for rainfall deviation*	
	Per capita levels	*Zero spending*	*Per capita levels*	*Zero spending*
	(1)	*(2)*	*(3)*	*(4)*
Post	0.842	-0.041^{*}	1.125	-0.050^{**}
	(1.353)	(0.021)	(1.375)	(0.022)
High prevalence × Post	2.603	-0.115^{***}	3.131^{*}	-0.131^{***}
	(1.712)	(0.034)	(1.886)	(0.036)
Mother FE	*Yes*	*Yes*	*Yes*	*Yes*
N	4550	4550	4548	4548
Mean of dep. variable in low prevalence areas in 2006	7.33	0.56	7.33	0.56
Mean of dep. variable in high prevalence areas in 2006	1.72	0.71	1.72	0.71

Data : PSF Panel.
Differences-in-differences regression with mother fixed effects. Linear probability model.
Dep var : (1) and (3) :Health expenditures per capita for children in mother's cell (thousands of CFA francs). (2) an (4) : Dummy for no health expenditures for any child in the mother's cell.
Rainfall deviation is defined as ...
Standard errors, in (), are clustered at the mother level.
* $p \leq 0.1$, ** $p \leq 0.05$, *** $p \leq 0.01$.

Different trends between rural and urban areas?

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Table: Results by sub-sample, rural and urban

	Rural		Urban	
	Per capita levels	*Zero spending*	*Per capita levels*	*Zero spending*
	(1)	*(2)*	*(3)*	*(4)*
Post	1.820^{*}	-0.093^{***}	0.284	-0.011
	(1.048)	(0.035)	(2.039)	(0.026)
High prevalence × Post	1.791	-0.054	2.350	-0.189^{***}
	(1.631)	(0.046)	(2.242)	(0.072)
Mother FE	*Yes*	*Yes*	*Yes*	*Yes*
N	2339	2339	2211	2211
Mean of dep. var. in low prevalence areas in 2006	2.26	0.70	9.74	0.49
Mean of dep. var. in high prevalence areas in 2006	1.87	0.70	1.05	0.76
Number of clusters	64	64	86	86
% of high prevalence clusters	60%	60%	12%	12%

Data : PSF Panel.
Differences-in-differences regression with mother fixed effects. Linear probability model.
Dep var : (1) Health expenditures per capita for children in mother's cell (thousands of CFA francs). (2) : Dummy for no health expenditures for any child in the mother's cell.
Standard errors, in (), are clustered at the mother level.
* p $\leq$ 0.1, ** p $\leq$ 0.05, *** p $\leq$ 0.01.

Regression at the child level

Table: Differences in Differences in Health expenditures at the child level

	Full sample	Children younger than 5 in 2009	Children older than 5 in 2009
	(1)	*(2)*	*(3)*
Post	0.392	−1.558	1.338
	(1.043)	(1.948)	(1.227)
High prevalence × Post	2.411**	4.810**	1.249
	(1.207)	(2.289)	(1.408)
Child FE	*Yes*	*Yes*	*Yes*
N	8824	2867	5957
Mean of dep. var. in low prevalence areas in 2006	6.12	7.02	5.69
Mean of dep. var. in high prevalence areas in 2006	1.32	1.06	1.44

Data : PSF Panel. Sample of children living with their mother in PSF1.
Differences-in-differences regression with child fixed effects. Linear probability model.
Dep var : individual health expenditures (thousands of CFA francs).
Standard errors, in (), are clustered at the child level.
* p $\leq$ 0.1, ** p $\leq$ 0.05, *** p $\leq$ 0.01.

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Controlling for sibship structure and excluding migrants

Table: Robustess tests

	Baseline results		Controlling for sibship structure		Excluding migrants	
	Per capita levels	*Zero spending*	*Per capita levels*	*Zero spending*	*Per capita levels*	*Zero spending*
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
Post	0.842	-0.041^{*}	1.854	-0.055^{**}	0.966	-0.049^{**}
	(1.353)	(0.021)	(1.512)	(0.026)	(1.442)	(0.022)
High prevalence × Post	2.603	-0.115^{***}	2.421	-0.108^{***}	2.812	-0.102^{***}
	(1.712)	(0.034)	(1.684)	(0.034)	(1.794)	(0.036)
Mother FE	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
N	4550	4550	4550	4550	2974	2974
Mean of dep. var. in low prevalence areas in 2006	7.33	0.56	7.33	0.56	6.07	0.57
Mean of dep. var. in high prevalence areas in 2006	1.72	0.71	1.72	0.71	1.18	0.69

Data : PSF Panel. Sample in (5) & (6) : Mothers residing in the same geographical district in both waves.
Differences-in-differences regression with mother fixed-effects. Linear probability model.
Dep var in (1), (3) & (5) : Health expenditures per capita for children in mother's cell (thousands of CFA francs). Dep var in (2), (4) & (6): Dummy for no health expenditures for any child in the mother's cell.
Controls included in (3) & (4) : average age of children, number of children and share of children under 5
Standard errors, in (), are clustered at the mother level.
* p $\leq$ 0.1, ** p $\leq$ 0.05, *** p $\leq$ 0.01.

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Selective attrition?

Table: Attrition: characteristics of mothers not found in the second PSF wave

	High prevalence		Low prevalence	
	Non-attrited	Attrited	Non-attrited	Attrited
Mother's age in PSF1	34.71	30.60	35.49	33.77
Cell total consumption (thousands of CFA francs) in PSF1	182.88	198.34	362.21	485.41
Average age of children in cell in PSF1	7.54	5.22	7.61	6.46
Health exp. for children per capita in PSF1	1.76	0.97	6.58	12.90
# of cells	767	42	1195	163

Data : PSF Panel.

The Table shows the average characteristics reported in the first wave for women who were found (non-attrited) and were not found (attrited) in the second wave.

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Heterogeneity by campaign intensity

Table: Heterogeneity analysis by variation in ITN use

	Per capita levels (1)	*Zero spending* (2)
Post	1.215^{*}	-0.106
	(0.627)	(0.071)
High Δ in ITN use $\times$ Post	2.631^{*}	-0.058
	(1.383)	(0.077)
Mother FE	*Yes*	*Yes*
N	1717	1717
Mean of dep. var. in low Δ in ITN use areas in 2006	2.62	0.73
Mean of dep. var. in high Δ in ITN use areas in 2006	1.55	0.71

Data :PSF Panel. Sample restricted to high malaria prevalence areas.
Difference-in-difference regression with mother fixed effects. Linear probability model.
Dep var : (1) Health expenditures per capita for children in mother's cell (thousands of CFA francs).
(2) : Dummy for no health expenditures for any child in the mother's cell.
High Δ in ITN use: dummy equal to one if the average ITN use variation between 2006 and 2011 within the cluster of observation was higher than the national average (+20pp).
Standard errors, in (), are clustered at the mother level.
* p $\leq$ 0.1, ** p $\leq$ 0.05, *** p $\leq$ 0.01.

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Who changed behavior?

Table: Who started to invest between the two waves?

	Never Invest (1)	Switchers (2)	Always Invest (3)
Consumption level in PSF1	261.51	276.02	347.28
s.e	12.73	17.50	22.34
Observations	541	424	340

Data: PSF Panel. Table constructed on the balanced sample of mothers.
Mean of total cell consumption level in the last 12 months, in thousands of CFA Francs.
"Never invest" (resp. "Always Invest") are cells with zero spending (resp. some spending) on child health in both waves. "Switchers" are cells with zero spending in the first wave and some spending in the second wave: they started to invest in child health between the two waves.
P-values of the difference in means : (1)-(2) : p-value $= 0.49$; (2)-(3) : p-value $=0.01$; (1)-(3) : p-value < 0.01.

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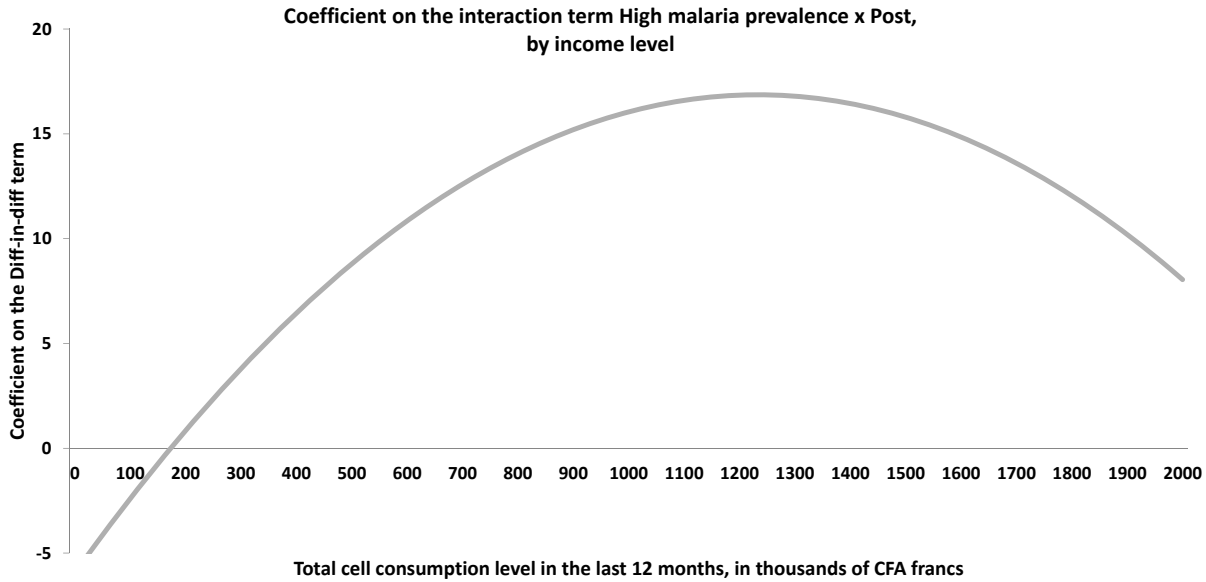
Heterogeneity by income



The figure shows the estimated difference-in-difference by income level. Specifically, the graph plots the following equation: $y = -5,951 + 0,037x - 0,000015x^2$ where x ranges from the minimum to the maximum values of total annual consumption levels observed in PSF1 (excluding top 1% outliers). The coefficients are obtained by interacting $Post$ and $Post \times High\ Prevalence$ with $Income$ and $Income^2$.

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Separating mothers targeted by information campaigns

Table: What is the role of information?

	Mothers targeted specifically by information campaigns		Other mothers	
	Per capita levels	Zero spending	Per capita levels	Zero spending
	(1)	*(2)*	*(3)*	*(4)*
Post	1.083	−0.092***	0.384	0.056
	(1.148)	(0.025)	(3.260)	(0.037)
High prevalence × Post	2.406	−0.111***	2.960	−0.104*
	(1.771)	(0.041)	(3.607)	(0.063)
Mother FE	*Yes*	*Yes*	*Yes*	*Yes*
N	2749	2749	1228	1228
Mean of dep. var. in low prevalence areas in 2006	5.99	0.54	6.42	0.59
Mean of dep. var. in high prevalence areas in 2006	1.74	0.69	0.84	0.67

Data : PSF Panel. Sample restricted to mothers residing in the same geographical district in both waves.
Columns (1) & (2): Sample of mothers of children under 5 or pregnant women, at time of the 2009 campaign. These mothers were targeted specifically by information campaigns. Columns (3) & (4) : Sample of other mothers.
Differences-in-differences regression with mother fixed effects. Linear probability model.
Dep var : (1) & (3) Health expenditures per capita for children in mother's cell (thousands of CFA francs). (2) & (4) : Dummy for no health expenditures for any child in the mother's cell.
Standard errors, in (), are clustered at the mother level.
* p $\leq$ 0.1, ** p $\leq$ 0.05, *** p $\leq$ 0.01.

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