The effect of malaria on education: Evidence from the Ethiopian highlands

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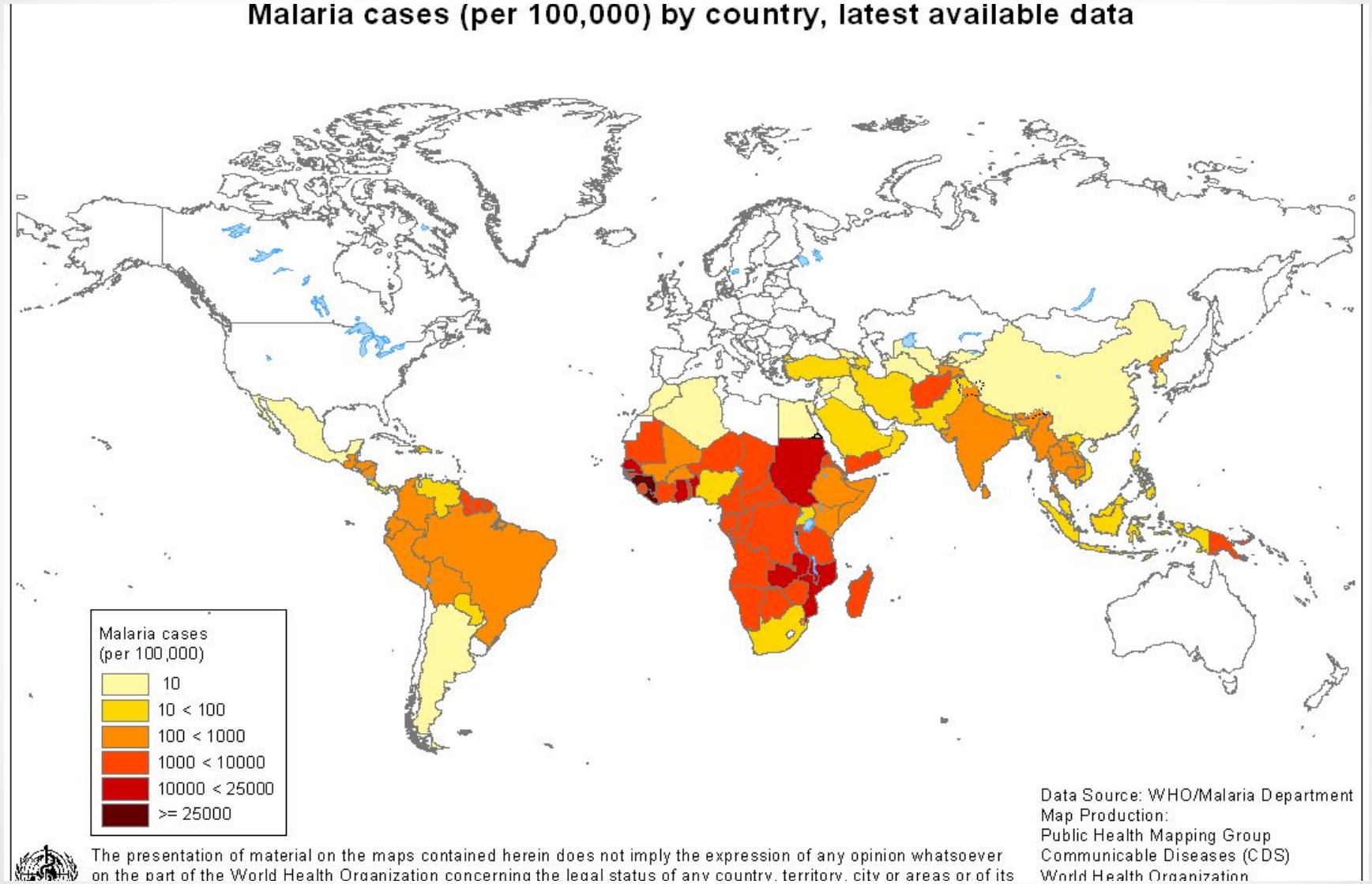
Objective and findings

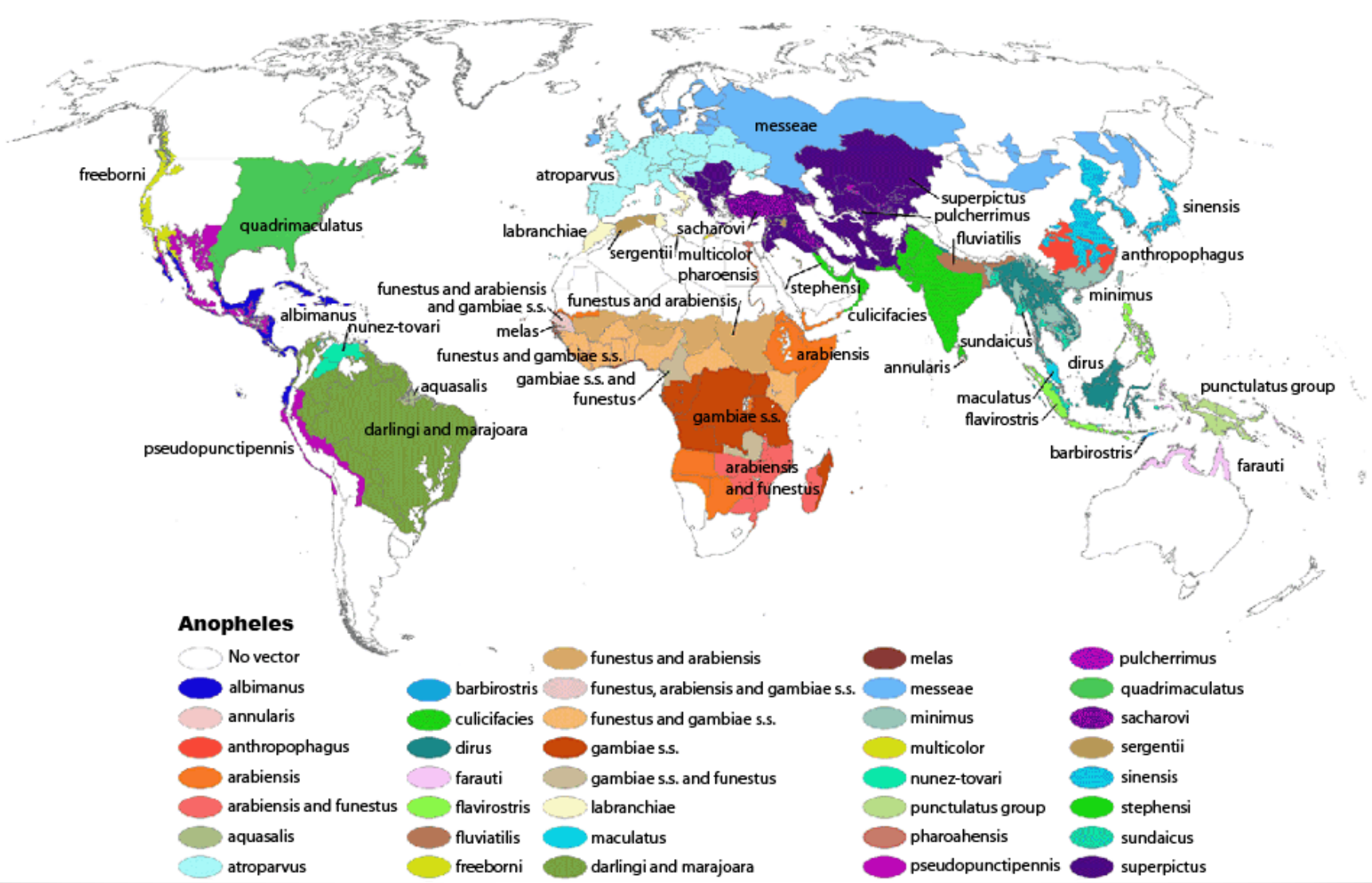
- This paper:
  - Measures the effect of a reduction in malaria exposure on schooling outcomes in Ethiopia
    - Years of schooling
    - Reading ability
  - Uses an exogenous variation in malaria prevalence rates across different villages

- Key findings:
  - People living in villages with higher likelihood of malaria attain lower education levels
    - Reducing malaria incidence unequivocally increases schooling
    - One st.dev. increase in malaria ➔0.4-0.8 fewer years of schooling
  - Not possible to disentangle the possible channels of transmission, but I exclude many co-factors

Malaria incidence



Anopheles Mosquitos Globally



Malaria in Ethiopia

- Malaria is leading cause of morbidity and mortality in Ethiopia
  - Millions of cases and thousands of deaths
- Very localized: spatially close villages have different malaria rates
  - Spatial autocorrelation in malaria incidence <10 Km (Yeshimondim et al, 2009)
- Highly affected by village elevation and slope
  - Transmission declines with temperature
    - Below 18.5 degrees Celsius, no malaria transmission is possible
    - Hyperendemic malaria in lowlands, hypoendemic in highlands
  - Less malaria in highly sloped villages
    - Larvae wash away during downpours
    - Less standing water for larval growth
  - Interaction of elevation and slope affects malaria
    - Lower declines in malaria incidence with elevation among steep-lands than flat-lands

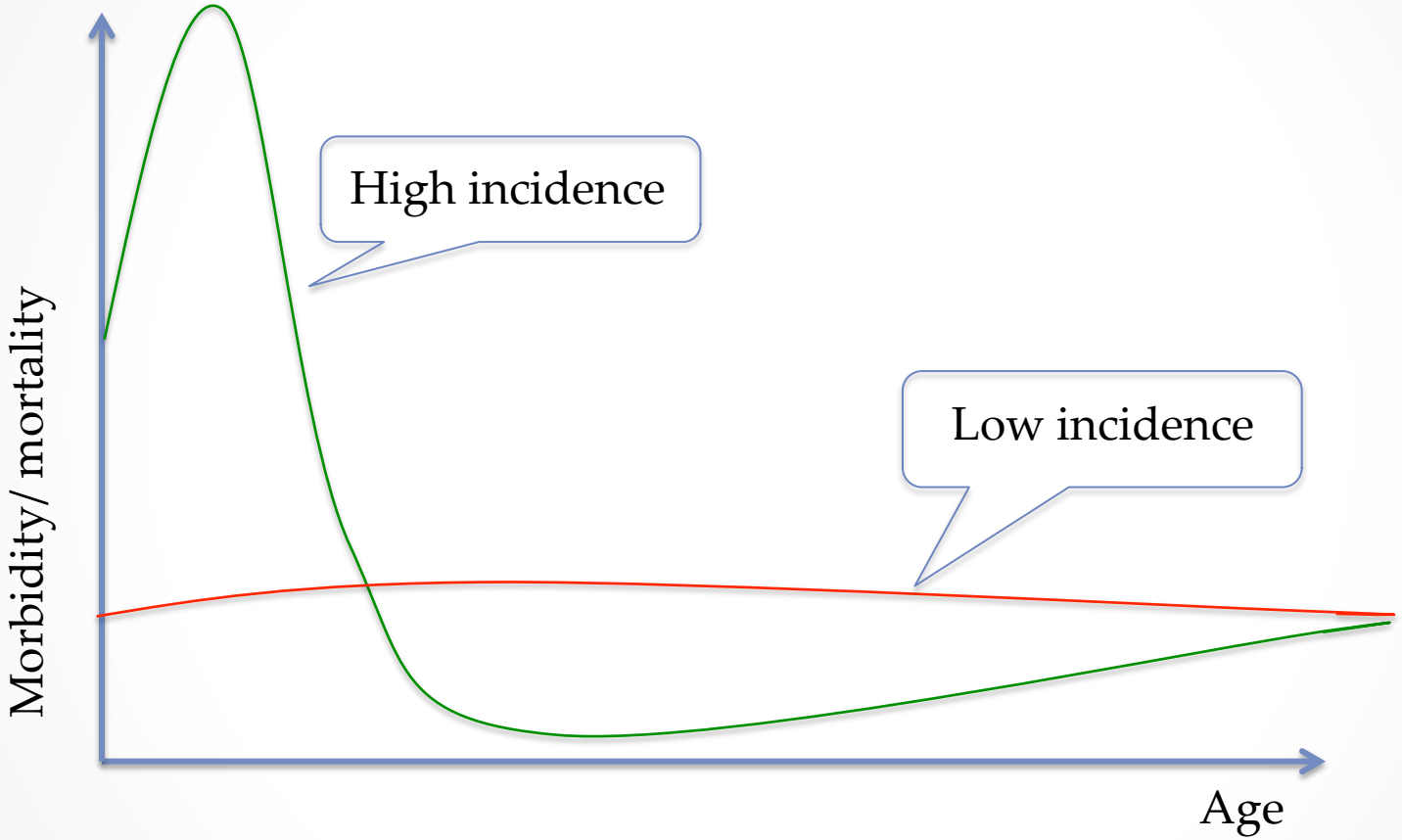
Malaria and education

- Impact on cognitive development
  - In utero exposure
  - Early childhood development

- Impact on school dropout
  - Contracting malaria while in school could lead to higher dropout rates
    - Absences because sick at home
    - Substituting for sick adult labor

- Impact on school participation decision
  - High expected morbidity and mortality reduces benefit from investments in education

Effect of malaria reduction: morbidity/mortality



Effect of malaria reduction (without eradication)

- For Children:
  - Lower in utero malaria exposure
    - Higher average cognitive abilities and returns to education
  - Lower likelihood of contracting disease
    - Reduction in dropout rates

- For Adults:
  - Higher likelihood of severe morbidity and mortality
    - Lower ex-ante returns to education
    - Higher likelihood of dropping out, conditional on contracting the disease

- Ambiguous effect on schooling choice

Review of recent literature

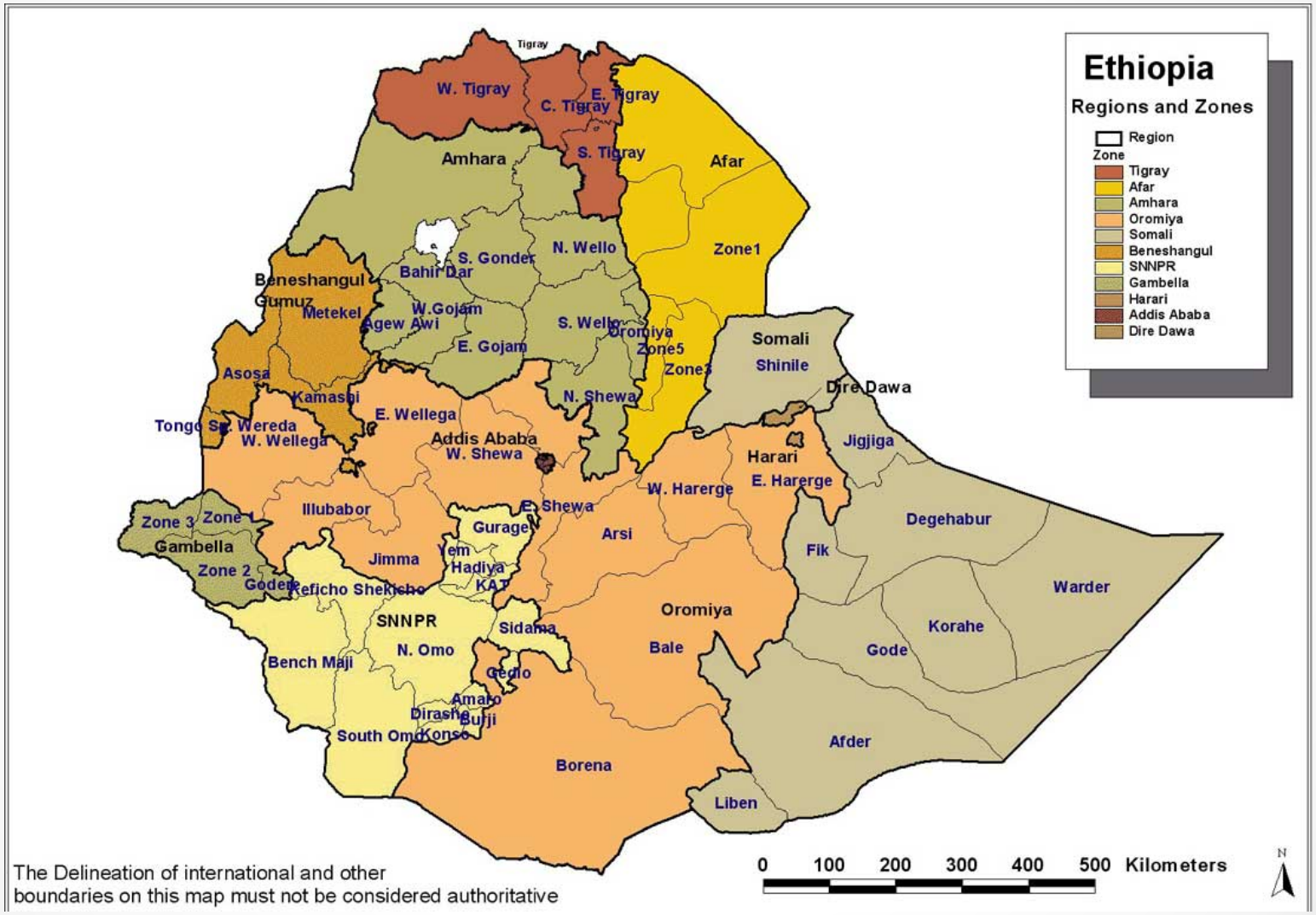
- Eradication literature: cohorts born post-eradication have better schooling and wage profiles
    - Lucas (2010): Paraguay, Sri Lanka
    - Bleakley (2010): USA, Brazil, Colombia
    - Percoco (2011): Southern Italy
- In utero exposure literature
    - Barreca (2010): USA

- Innovations over the above
    - In Africa
    - Benefits from malaria reduction rather than eradication
        - Eradication unlikely in Africa
    - Computes the overall effect of exposure rather than through a single channel
        - New methodology

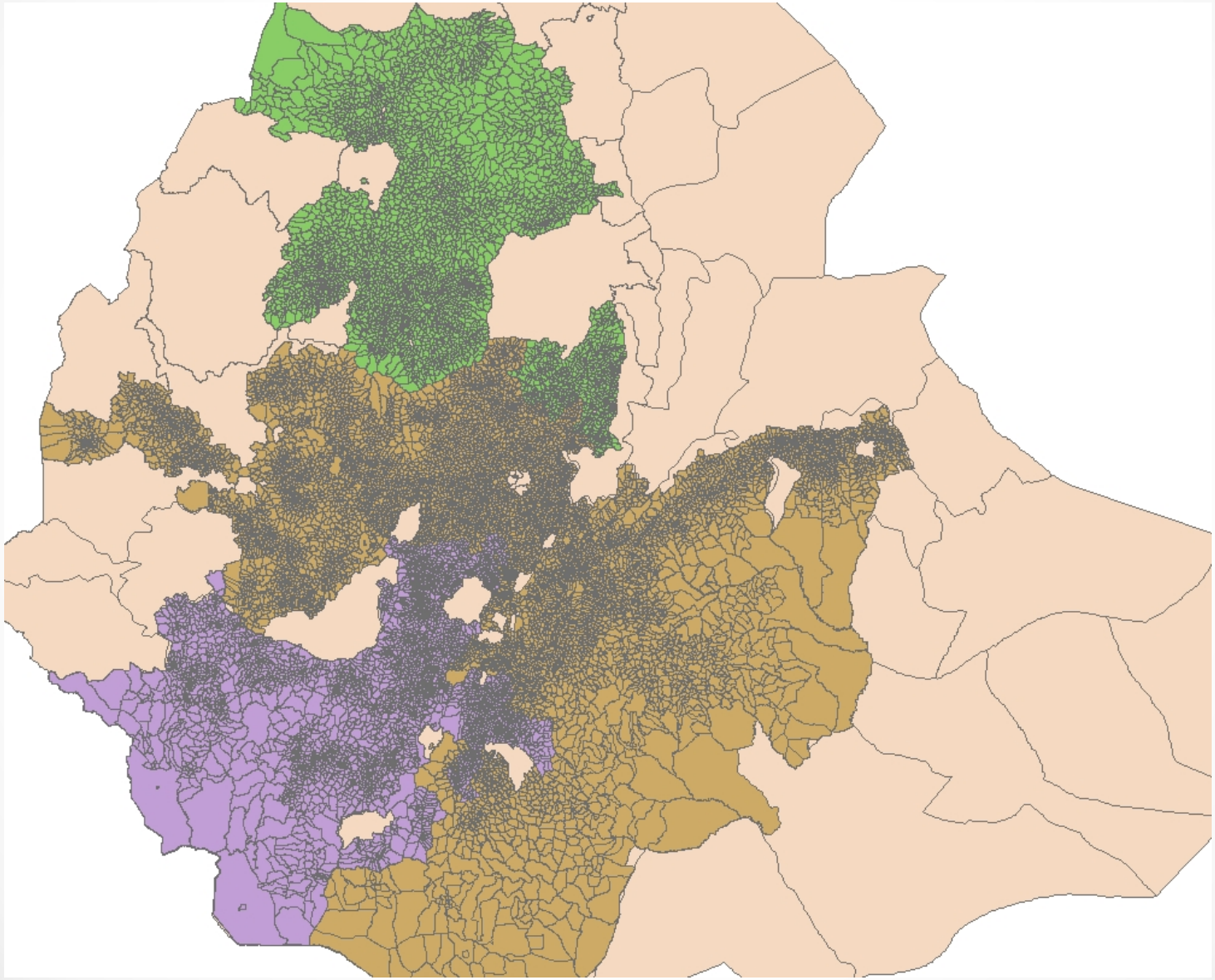
Data

- Information on disease, household characteristics and educational outcomes: 2004 Welfare Monitoring Survey
  - Covering over 2,000 villages in all Ethiopian regions
    - Focus on rural villages
  - Malaria: self-reported incident of malaria in household in the prior 3 months
    - Averaged at the village level➔ Measure of village level reported malaria
- Topography of Ethiopia
  - GIS maps from EDRI (Ethiopian Development Research Institute) obtained in 2004
- Elevation, slope, and temperature maps
  - Derived from NASA
- Matching done in 1,016 out of 1,500 villages from 3 regions
  - Not a random sample of WMS villages—non-matched villages less better off

Data
Divisions of Ethiopia



Data
GIS maps



Data
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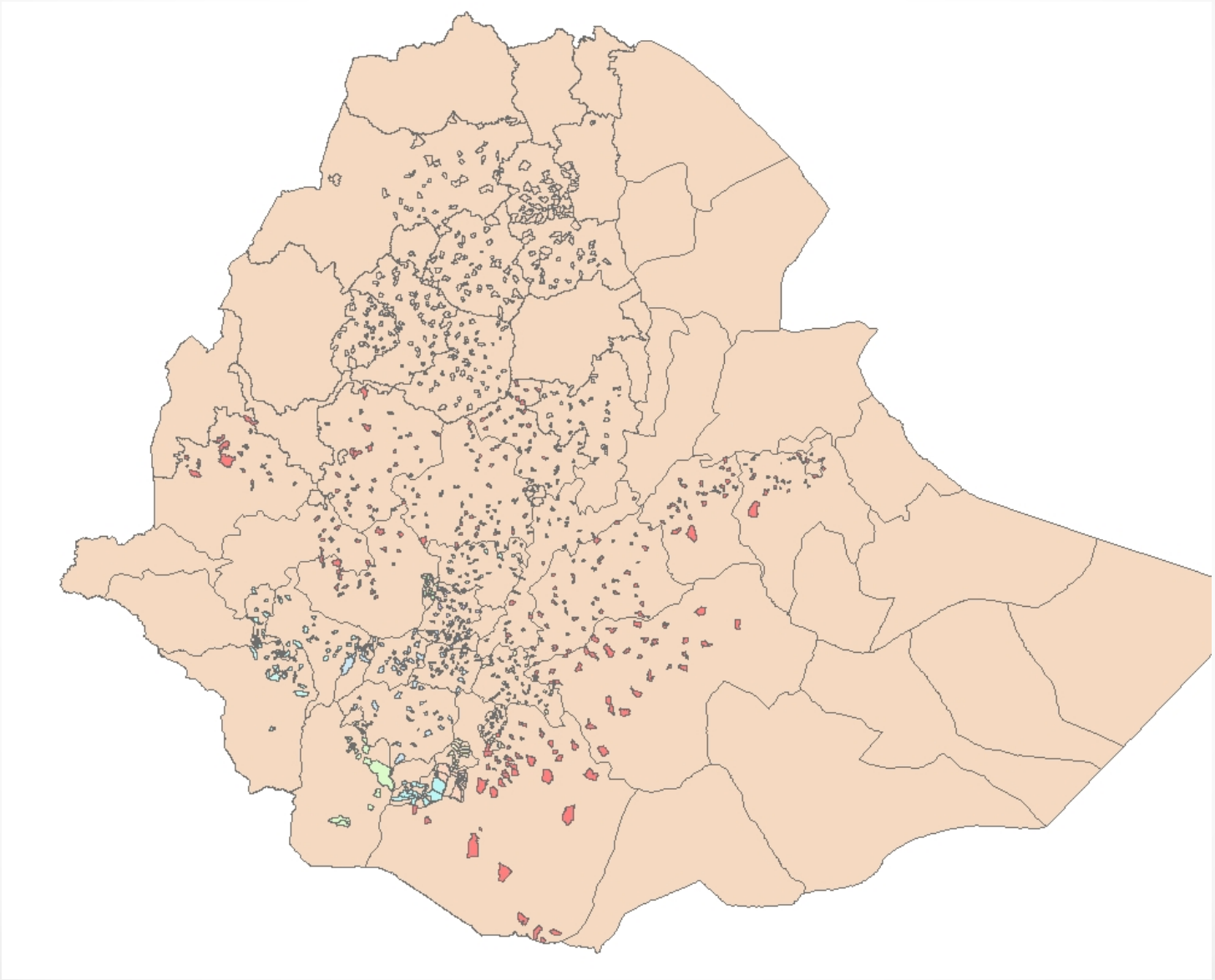


Econometric strategy

- Instrument malaria incidence using elevation, slope, and interactions
  - Method 1: elevation as instrument of malaria
    - Higher elevation villages have lower malaria incidence
  - Method 2: *Interaction* between village elevation and village slope
    - Controlling for the *direct* effect of elevation and slope
- Use province fixed effects: comparing villages with different topographical profiles in the same province
- Underlying assumption: spatial determinants do not impact education through other channels

Econometric strategy

- Malaria equation

$$M_v = \alpha Elevation_v + \delta Slope_v + X_v\beta + \rho_v + \varepsilon_v$$

$$M_v = \alpha Elevation_v + \sum_{j=1}^{5}\left[\delta_j Slopequintile_{vj} + \gamma_j Elevation_v \times Slopequintile_{vj}\right] + X_v\beta + \rho_v + \varepsilon_v$$

- Schooling equation

$$S_v^i = \alpha M_v + \delta Slope_v + X_v^i\beta^i + \rho_v + \omega_v$$

$$S_v^i = \alpha M_v + \theta Elevation_v + \sum_{j=1}^{5}\left[\delta_j Slopequintile_{vj}\right] + X_v^i\beta + \rho_v + \omega_v$$

M: Recent reported malaria

S^i: Average schooling (years of education) for group I

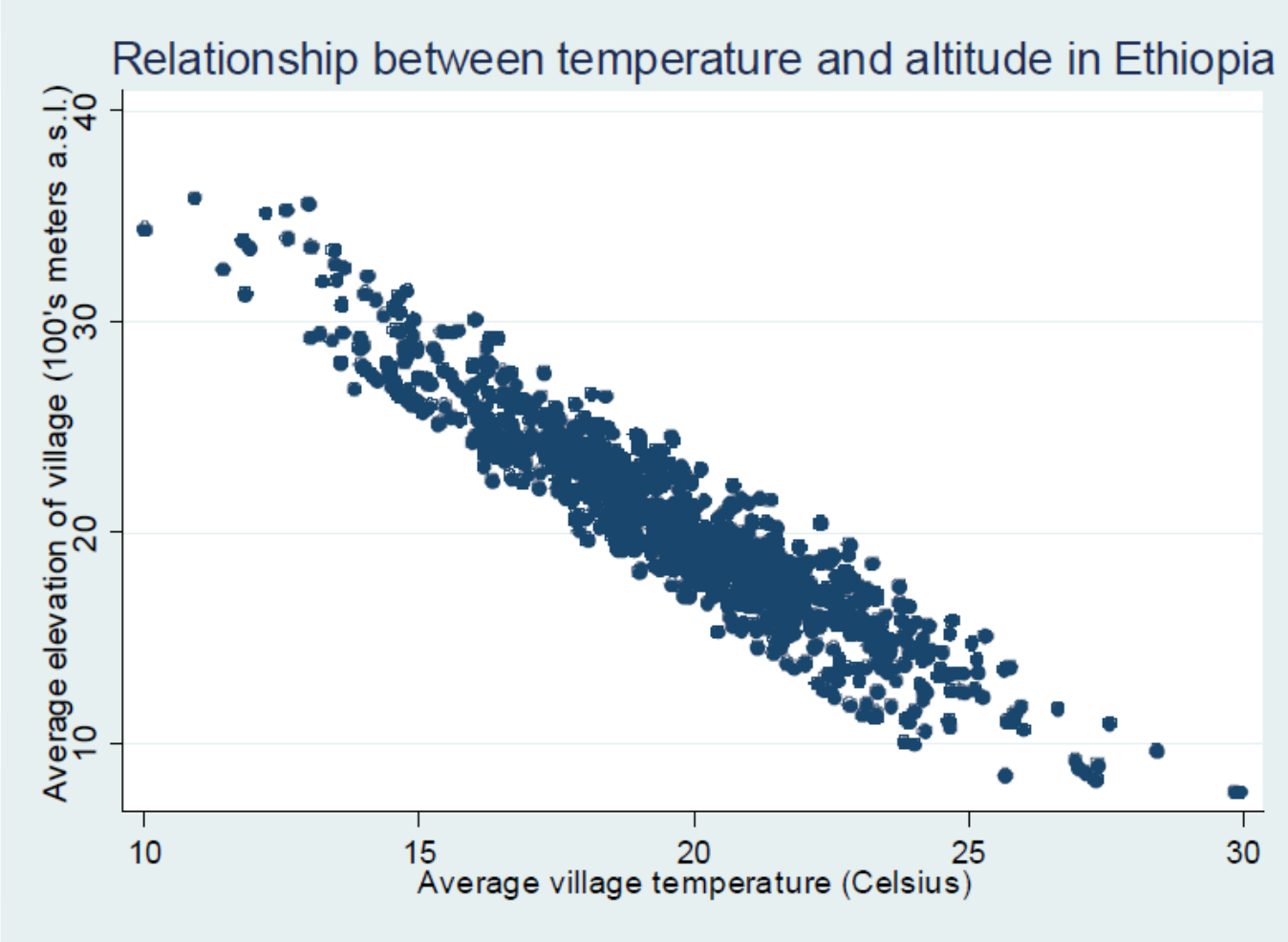
i: adults (age 20+) and children(age 7-19)

v: village

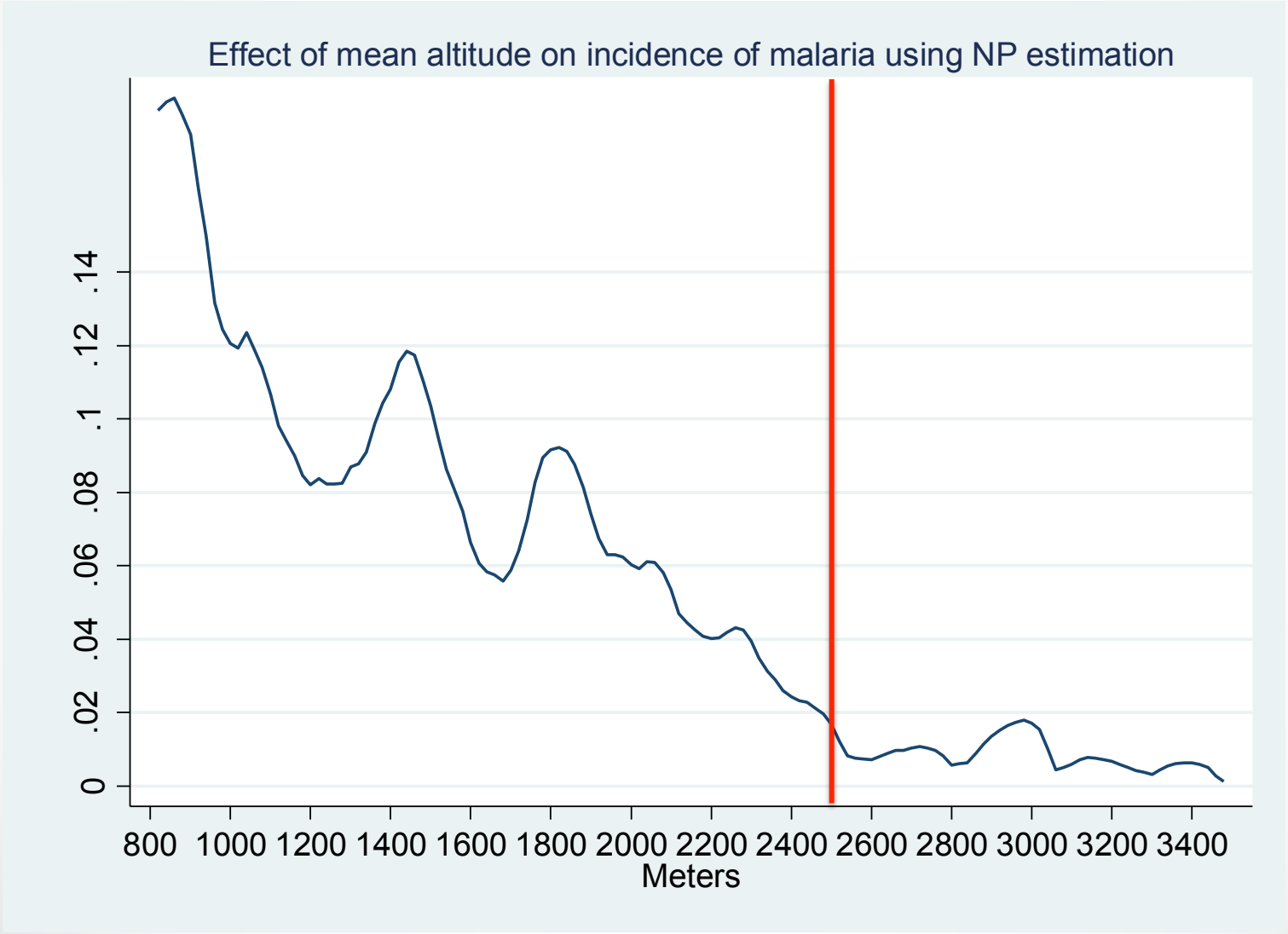
X^i: average village controls

p_v: province fixed effect

Temperature and elevation



Recent reported malaria and topography



Recent reported malaria and topography

Table 1a: Relationship between elevation and reported health incidents

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	malaria		other sickness		all sickness types		death	
Elevation	-0.005***	-0.005***	-0.003	-0.003	-0.008***	-0.008***	-0.004	-0.004
	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)
Elevation x 2,500 m		0.009***		0.000		0.009*		0.010**
		(0.002)		(0.005)		(0.005)		(0.004)
Slope	-0.003***	-0.003***	0.001	0.001	-0.002	-0.002	-0.000	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Observations	844	1,000	844	1,000	844	1,000	844	1,000
R-squared	0.133	0.139	0.022	0.020	0.056	0.051	0.048	0.043
Number of provinces	276	295	276	295	276	295	276	295
Average outcome var:	0.057		0.186		0.244		0.287	

Village level regressions on self-reported recent incidence of sickness
Full set of village controls and province fixed effects.
Errors clustered at the province level reported in parentheses

Recent reported malaria and topography

Table 1b: Relationship between slope, elevation, and reported sickness

VARIABLES	(1) Malaria	(2) Other sickness	(3) All sickness	(4) Deaths
Elevation	-0.009**	0.001	-0.008	-0.027**
	(0.004)	(0.004)	(0.005)	(0.013)
Elevation x quantile:				
Slope 2	0.001	0.001	0.001	0.016
	(0.004)	(0.004)	(0.005)	(0.014)
Slope 3	0.001	-0.002	-0.002	0.000
	(0.003)	(0.004)	(0.005)	(0.011)
Slope 4	0.004	-0.004	0.000	0.020
	(0.004)	(0.004)	(0.005)	(0.020)
Slope 5	0.008**	-0.007	0.001	0.026
	(0.004)	(0.004)	(0.006)	(0.016)
Observations	844	844	844	844
R-squared	0.151	0.035	0.064	0.028
Number of waid	276	276	276	276

Village level regressions on self-reported recent incidence of sickness reported by individuals in the prior three months. Deaths measured as the average number of instances suffered by household in past 5 years.
Full set of village controls and province fixed effects.
Errors clustered at the province level reported in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Main results—OLS of malaria on education

Table 2a: OLS of reported malaria on education–Children

Outcome: years of schooling	(1) Children	(2) Boys	(3) Girls
Recent reported village malaria	-0.058	0.357	-0.240
	(0.294)	(0.451)	(0.358)
Land size	-0.013	0.013	-0.021
	(0.031)	(0.039)	(0.038)
Rainfall	0.042	0.088**	0.018
	(0.043)	(0.038)	(0.058)
Slope	-0.016**	-0.016	-0.007
	(0.008)	(0.011)	(0.009)
Distance to primary school	-0.159***	-0.173***	-0.138***
	(0.036)	(0.043)	(0.050)
Distance to health post	-0.001	0.003	-0.005
	(0.004)	(0.006)	(0.005)
Age	0.123***	0.246***	0.100***
	(0.021)	(0.024)	(0.021)
Wealth	0.435***	0.396***	0.481***
	(0.058)	(0.069)	(0.071)
Father's education	0.086**	0.137***	0.055
	(0.038)	(0.047)	(0.041)
Mother's education	0.229***	0.144**	0.346***
	(0.060)	(0.072)	(0.081)
Female hhld head	0.924***	0.961***	0.618***
	(0.180)	(0.244)	(0.229)
Livestock	0.029***	0.020	0.023*
	(0.010)	(0.013)	(0.013)
Oxen	0.075	-0.039	0.159**
	(0.056)	(0.083)	(0.065)
Constant	-0.944	-2.734***	-0.543
	(0.627)	(0.576)	(0.837)
Observations	844	843	844
R-squared	0.403	0.371	0.357
Number of waid	276	276	276

Main results—RF estimates of effect of topography on education

Table 3: Reduced form effects of village topography on schooling

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dep var:	Villages <2,500m		All villages		Villages < 2,500m		
Average yrs schooling	Children	Adults	Children	Adults	Children	Adults	All
Elevation	0.031**	0.046**	0.031**	0.036*	0.095***	0.078*	0.075***
	(0.013)	(0.022)	(0.012)	(0.021)	(0.023)	(0.040)	(0.027)
Elevation × quantile:							
Slope 2					-0.048**	0.001	-0.020
					(0.021)	(0.032)	(0.023)
Slope 3					-0.066***	0.005	-0.017
					(0.021)	(0.034)	(0.024)
Slope 4					-0.056**	-0.056	-0.046*
					(0.024)	(0.038)	(0.026)
Slope 5					-0.089***	-0.054	-0.059**
					(0.025)	(0.038)	(0.027)
Elevation × over 2,500m			-0.051**	-0.022			
			(0.025)	(0.027)			
Constant	-0.737	3.084***	-0.526	2.811***	-1.868***	2.709***	1.197
	(0.607)	(0.839)	(0.584)	(0.616)	(0.651)	(0.998)	(0.738)
Observations	844	844	1,000	1,000	844	844	844
R-squared	0.408	0.105	0.412	0.120	0.418	0.130	0.127
Number of waid	276	276	295	295	276	276	276

All regressions at the village level. Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Main results-IV estimates of effects of malaria on education

Table 4: IV of reported malaria on schooling

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	IV: elevation		IV: elevation + interaction above 2,500 meters		IV: interaction slope quintiles only (control: elev, slope)		
Dep Var:	Villages <2,500m		All villages		Villages <2,500m		
Yrs of schooling	Children	Adults	Children	Adults	Children	Adults	All
village malaria	-5.076**	-9.409	-4.490**	-4.850	-4.679*	-8.445**	-6.211*
	(2.425)	(6.107)	(1.903)	(3.391)	(2.417)	(4.160)	(3.238)
Observations	844	844	1,000	1,000	844	844	844
R-squared	0.530	0.301	0.530	0.519	0.552	0.363	0.282

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Main results—IV estimates of the effects of malaria on education

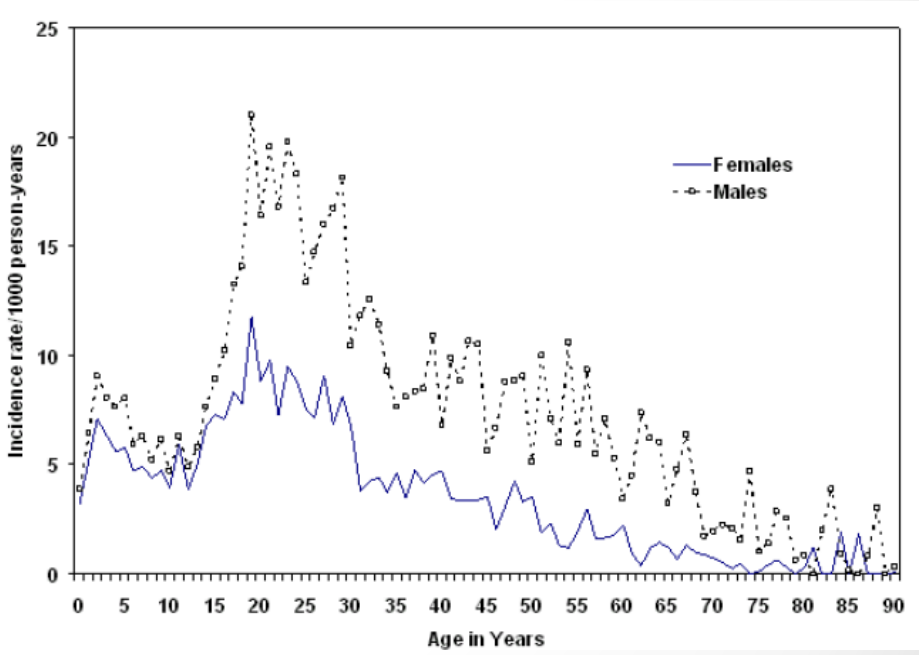
IV results by gender

Table 5: IV of reported malaria on schooling by gender and age group

Dep Var:	(1)	(2)	(3)	(4)
Years of schooling	Children		Adults	
	Boys	Girls	Men	Women
village malaria	-6.896*	-2.808	-13.546**	-4.606
	(3.752)	(2.622)	(6.417)	(3.031)
Observations	843	844	844	844
Controls	Yes	Yes	Yes	Yes
Province f.e.	Yes	Yes	Yes	Yes
R-squared	0.466	0.614	0.353	0.376

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Yeshimondim et al (2009)



Identification

- Many things could be correlated with elevation
  - Farm productivity/wealth
  - Supply of education
  - Village exposure to other shocks (droughts, floods)
  - Migration

  - Preferences
  - Market returns to education

- More difficult to make the case that these things are correlated with elevation in flat areas but not in steep areas

Identification—potential correlates

Table 6: Wealth, employment structure, migration

	(1)	(2)	(3)	(4)
Dep vars:	Wealth	Nonfarm employment	Tenure	School distance
Panel A: elevation only				
Elevation	0.005	0.001	-0.071	-0.033**
	(0.009)	(0.004)	(0.110)	(0.017)
Observations	844	844	844	844
R-squared	0.375	0.186	0.104	0.138
Controls	YES	YES	YES	YES
Province f.e.	YES	YES	YES	YES
Panel B: Interaction with slope				
Elevation	-0.005	-0.004	0.026	-0.023
	(0.018)	(0.007)	(0.183)	(0.020)
Elevation × quantile:				
Slope 2	0.009	0.006	0.005	0.019
	(0.018)	(0.006)	(0.183)	(0.019)
Slope 3	0.002	0.003	-0.054	0.018
	(0.017)	(0.007)	(0.162)	(0.017)
Slope 4	0.023	0.005	-0.135	-0.036
	(0.018)	(0.008)	(0.187)	(0.032)
Slope 5	0.005	0.008	-0.180	-0.025
	(0.019)	(0.009)	(0.190)	(0.030)
Observations	844	844	844	844
R-squared	0.378	0.193	0.113	0.143
Controls	YES	YES	YES	YES
Province f.e.	YES	YES	YES	YES

Wealth is average of household wealth index.
Nonfarm employment is the percentage working in nonfarm sectors. Tenure is the number of years household existed.
Robust standard errors in parentheses

Identification—Likelihood of agricultural shocks

Table 6: Exposure to shocks

Dep Var: Type of shock suffered past 5 years	(1) Floods	(2) Droughts	(3) Loss of livestock	(4) Other shocks
Panel A: Elevation only				
Elevation	-0.010	-0.023	0.009	0.000
	(0.011)	(0.022)	(0.016)	(0.004)
Observations	844	844	844	844
R-squared	0.016	0.045	0.038	0.023
Controls	YES	YES	YES	YES
Province f.e.	YES	YES	YES	YES
Panel B: interaction with slope				
Elevation	-0.014	-0.081**	-0.003	-0.001
	(0.014)	(0.033)	(0.030)	(0.014)
Elevation × quantile:				
Slope 2	0.003	0.059**	0.044*	0.007
	(0.013)	(0.029)	(0.026)	(0.017)
Slope 3	0.005	0.054*	0.019	0.001
	(0.015)	(0.030)	(0.029)	(0.012)
Slope 4	0.016	0.071**	0.038	0.007
	(0.015)	(0.034)	(0.031)	(0.014)
Slope 5	-0.000	0.062*	-0.029	-0.008
	(0.017)	(0.033)	(0.038)	(0.013)
Controls	YES	YES	YES	YES
Province f.e.	YES	YES	YES	YES
Observations	844	844	844	844
R-squared	0.018	0.057	0.060	0.033
Number of waid	276	276	276	276

Conclusion

- This paper uses topographic differences across villages in the same province to create an instrument for malaria incidence
  - Malaria more responsive to changes in village elevation in flat areas than in steep areas
- Finds that an increase in predicted malaria exposure reduces educational attainment by 0.4-0.8 years
  - COMPARISON
- Similar effects found for basic schooling (reading and writing ability)
- Implications
    - Campaigns against malaria have possibly large spillover effects on health and education sectors
    - Possibly large spillover effects from the expansion of the malarial environment due to global warming

History of failed eradication in Africa

- Past attempts
  - Part of global eradication campaign in the 1950s-1960s
    - Eradication succeeded in America and Europe, partial success in Asia
  - Inside the continent: all attempts failed (James Webb, 2010)

- Current attempts
  - Gates Foundation Funding
    - Technological solutions
  - Roll Back Malaria/ Global Fund
    - All same, exact tools used in the 1950s:
    - PLUS long-lasting, insecticide-treated mosquito nets
    - MINUS indoor residual spraying with DDT (but less toxic substitutes)
    - MINUS more heavy-handed government tactics
  - Vaccines
    - Short-term, limited success, expected for tourists only