

**Evaluating the Effects of Large Scale Health Interventions in
Developing Countries:
The Zambian Malaria Initiative**

Nava Ashraf, Harvard University and NBER

Günther Fink, Harvard University

David N. Weil, Brown University and NBER

December 2009

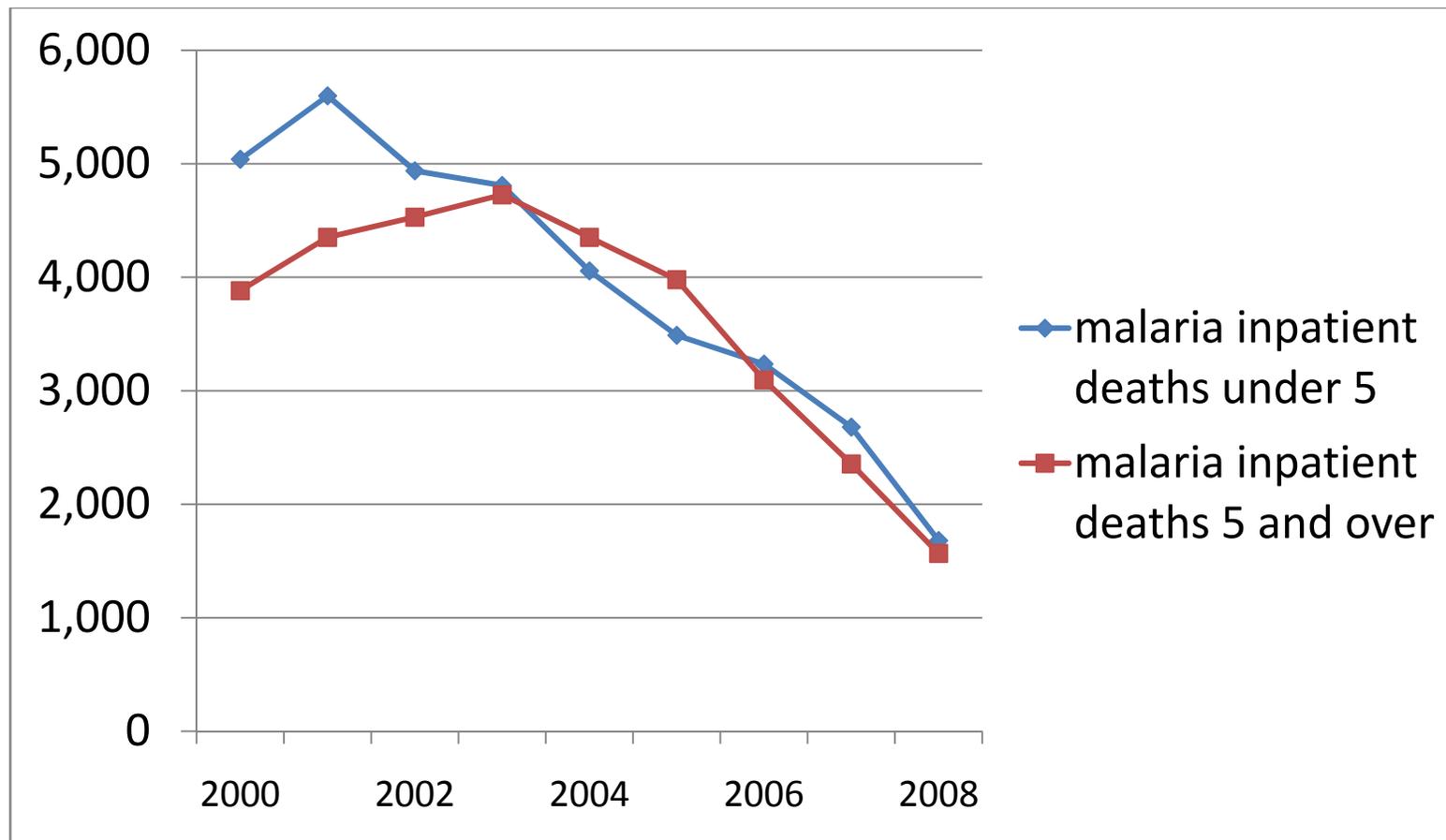
The Zambia Malaria Initiative

- Starting 2001, Zambia committed to large scale-up of malaria control and treatment
- Large commitment of domestic and donor resources
- Goal: 75% reduction in malaria incidence, 20% reduction in under-five mortality

Why Zambia, Why Now?

- History of malaria control: big successes in post-World War II period using DDT
- WHO etc. viewed Africa as too difficult
- Within Zambia: Success against malaria in post-independence, following by massive backsliding
- Maturation of new technologies (treated nets, ACT, RDT)
- Donor focus
- Desire for a big win as demonstration
- Institutional capacity, political commitment, favorable climate

Figure 1: Malaria Deaths



Source: HMIS

A Big Success

- Malaria deaths fell by half (2000-08) while population rose by 30%
- Similar decline for inpatient malaria visits
- DHS 2001-2007:
 - fever previous two weeks (under 5) fell from 45% to 18%
 - under five mortality fell from 168 to 119 (**not** all from malaria)
- **25,000 children's lives saved per year**
- HDI equivalent: 25% growth of income per capita

Our Paper

- Organize, clean, cross-check data
 - Apply our skills to help understand what is going on
- Study relation of inputs (nets distributed, houses sprayed, etc.) and outputs (health outcomes)
 - “bang for buck”
 - Need for caution in doing this!
- Use Zambian experiment to understand economic effects of malaria and its control

Data

- DHS 2001 and 2007. Standard data. Great timing!
- NMCC data on nets, spraying, anti-malarial drugs, etc.
 - NMCC takes strong hand in centralizing and coordinating NGO activities
- Health Management Information System (HMIS)

The HMIS

- 1995-2008, quarterly data
- Disease data (diagnosis, death, inpatient and outpatient), service delivery
- All MOH facilities from hospitals to health posts (except level 3 referral hospitals).
- Data passed from facility (1,554) → district (72) → province (9) → Lusaka
- Cleaned/checked at district and province levels
- Opportunities for error:
 - Varying quality of record keeping at facility level
 - Data entry (only once, no consistency checks)
 - Only most recent quarter appended to central data set; updates, corrections missed

Improvement of the HMIS

- Re-collect data that never made it into the national dataset
- systematically scanned for outliers and suspicious data points (duplicate figures, significant variance between quarters or years, reporting inconsistencies)
- District health officials were asked to find missing reports and justify all irregular data
- 9 provincial data workshops, total cost \$200,000; 250 total attendees
- Not only (or mostly) data improvement: also capacity building, analysis of impact of health interventions.

Changes in the HMIS

- Fill in of missing observations (about 4%)
- Corrections of errors (see table 1)
- Biggest example: change in under-five malaria deaths 2006-2007
 - Initial: rose by 13%
 - Corrected: fell by 18%

Remaining Issues in the HMIS Data: Diagnosis and Access

- Mis diagnosis due to
 - Treating all fevers as malaria
 - Fell with introduction of RDTs – bias in trend
 - Stigma leads to HIV deaths reported as malaria – bias in level or trend
- Abolition of user fees for adults in rural facilities: spike in outpatient visits that year
- To minimize all these biases: we look at inpatient cases, malaria deaths, total deaths

Remaining Issues in HMIS Data: Extent of HMIS Coverage

- Not all cases (or even all deaths) enter the government system
- What if this is non-representative or changes over time?
 - HMIS better in urban than rural? Miss much malaria mortality.
 - Program rolled out best near HMIS reporting facilities?

HMIS vs. DHS: Under 5 Deaths

	HMIS under-five deaths per 1,000	5 times column 1	DHS under-five mortality per 1,000	HMIS deaths as % of DHS deaths
2001	8.63	43.2	168	25.7%
2007	5.08	25.4	119	21.3%
% change	41%		29%	

- HMIS gets only 20-25% of total deaths!
- DHS mortality measured in 2007 is for 2003-2007: so too high for 2007
- HMIS decline in mortality 2001 to average 2003-07 is exactly 29%

Figure 3: Deaths by Province in DHS vs. HMIS

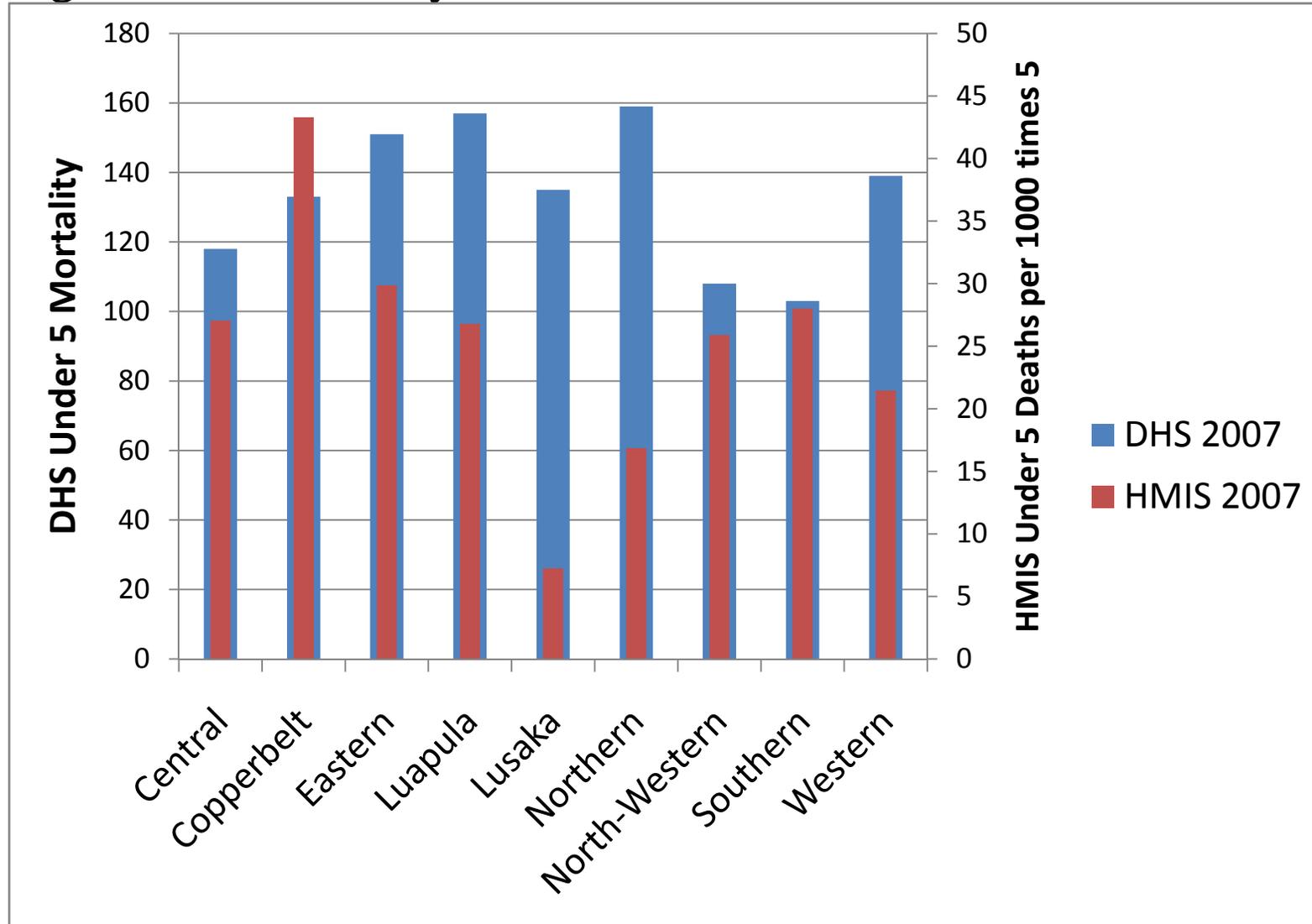
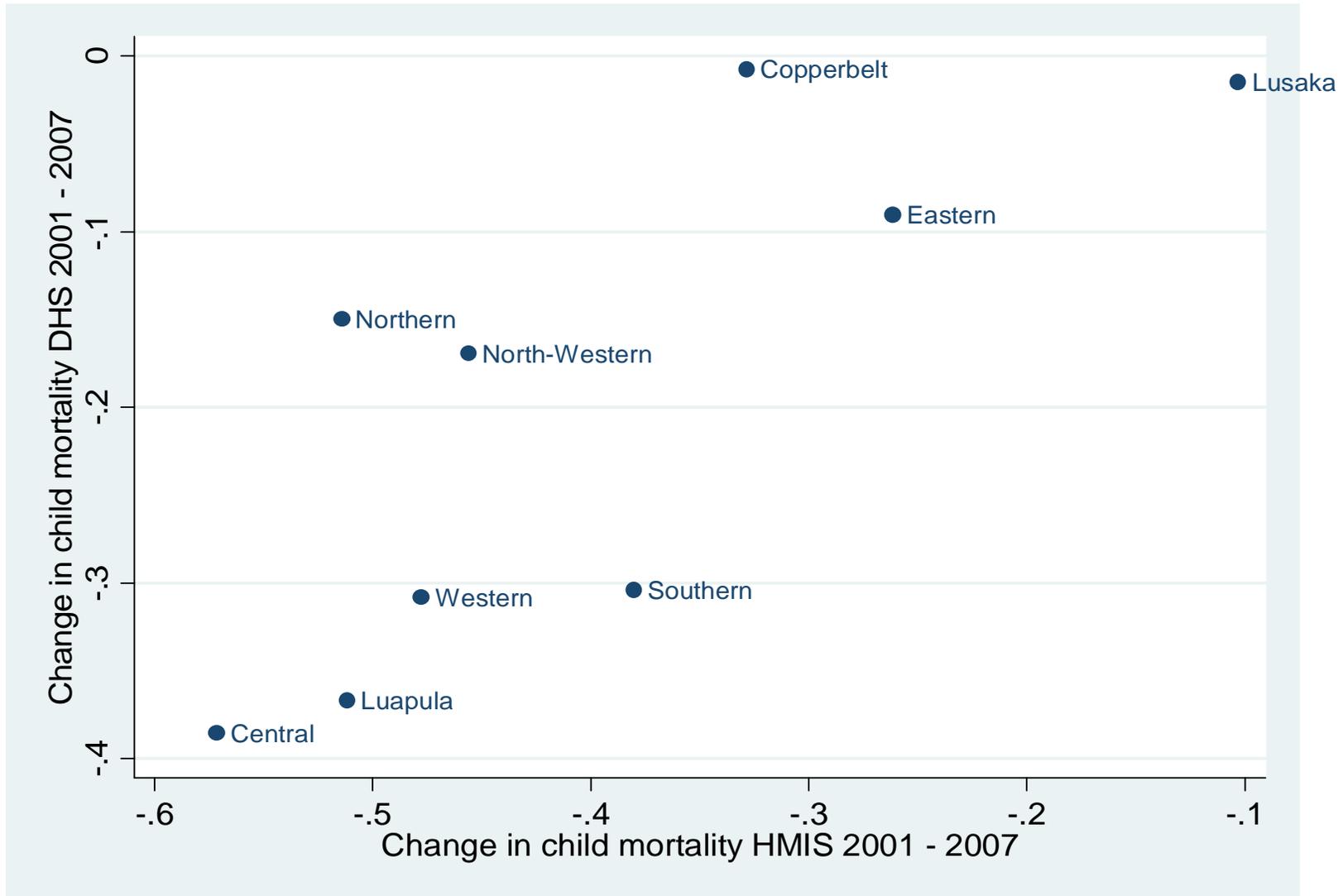


Figure 4: Mortality Changes: HMIS vs. DHS



Remaining Issues in HMIS Data: Non-Reporting Facilities

- Many zero values may be non-reports
- Two ways to deal with this:
 - Sample of “always reporting facilities”
 - Construct chain-index

Figure 2: Deaths per 1,000 Children Under 5, HMIS

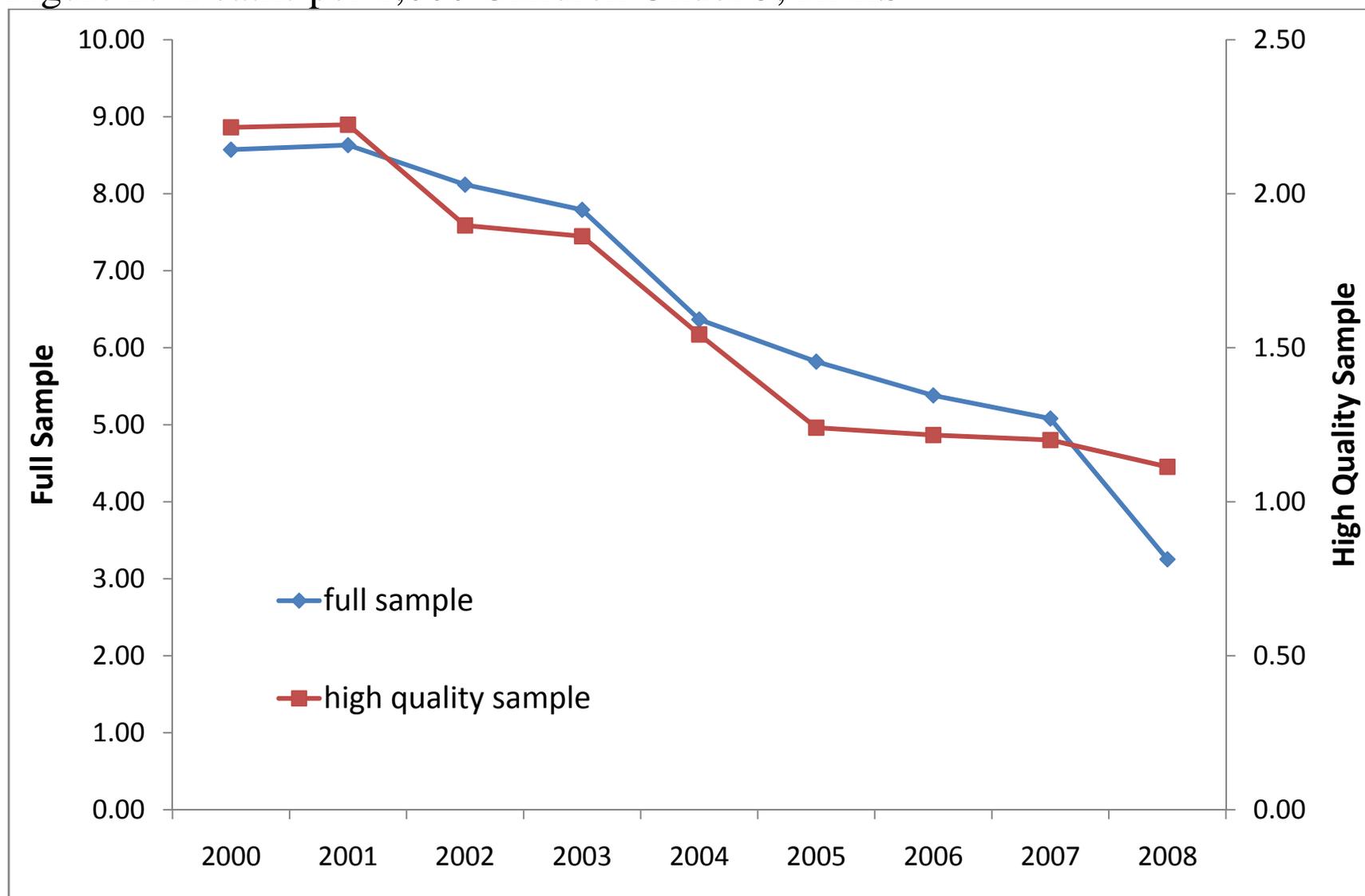


Figure 5: Malaria Cases and Deaths, Chained Index

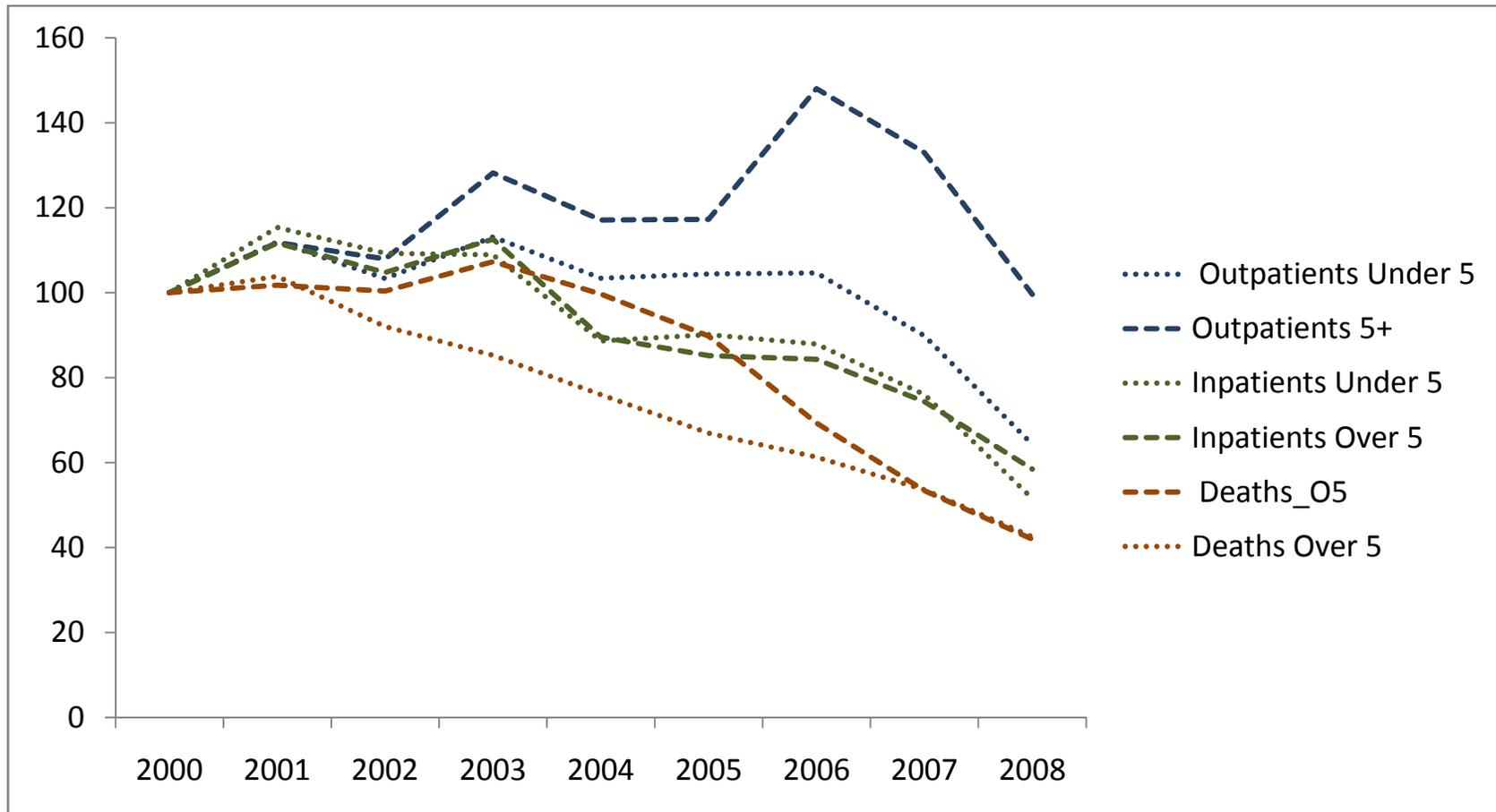
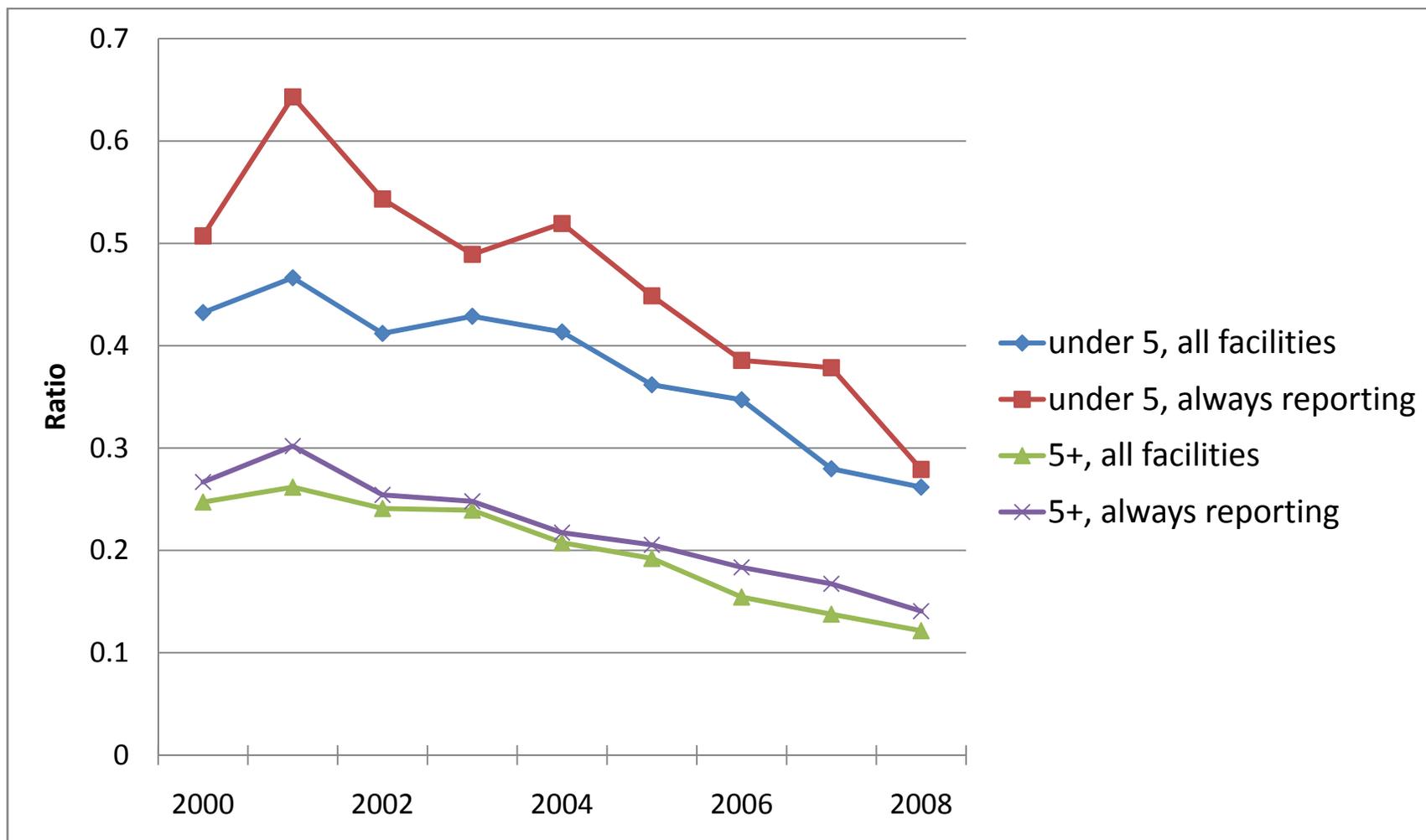
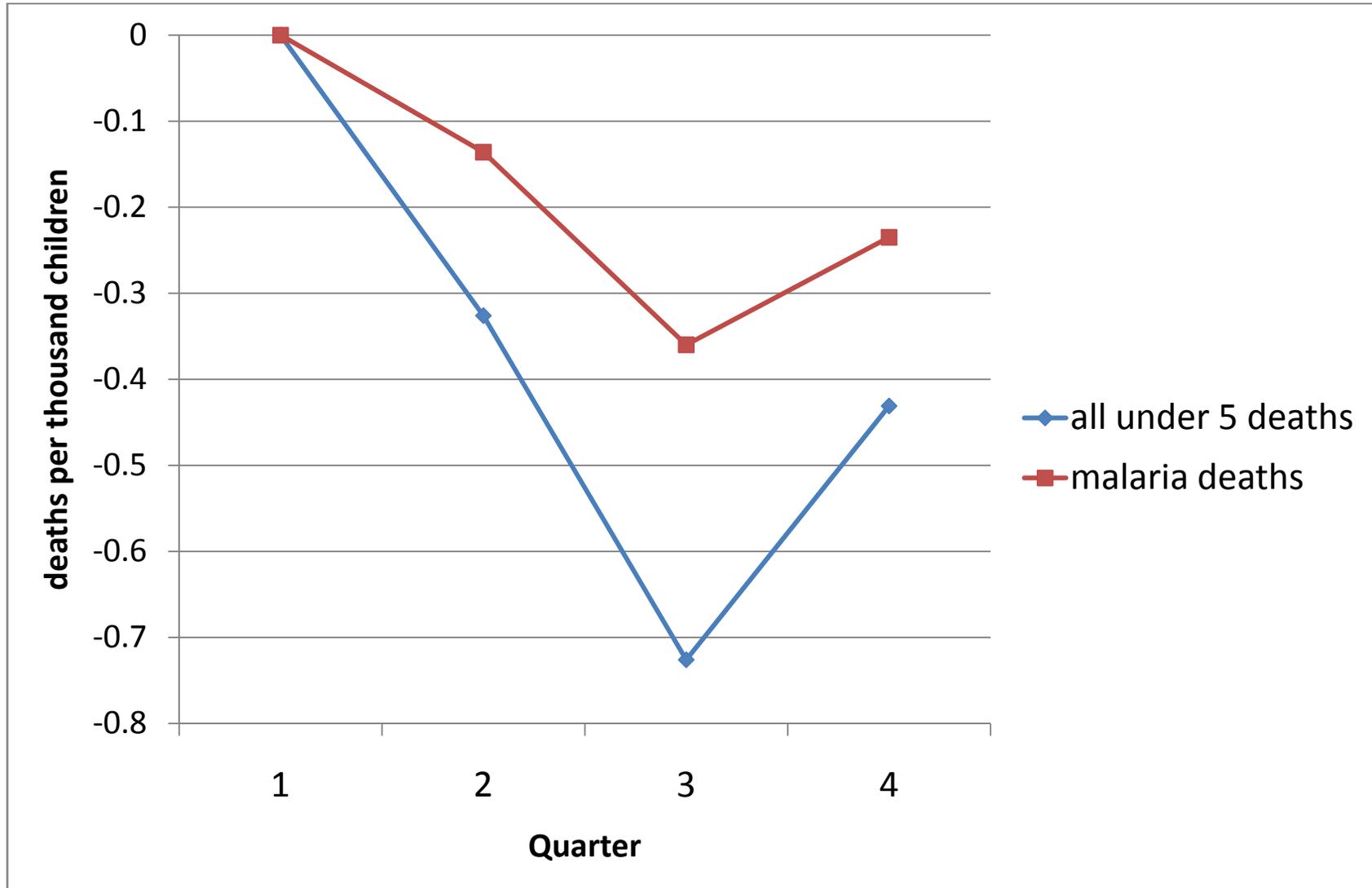


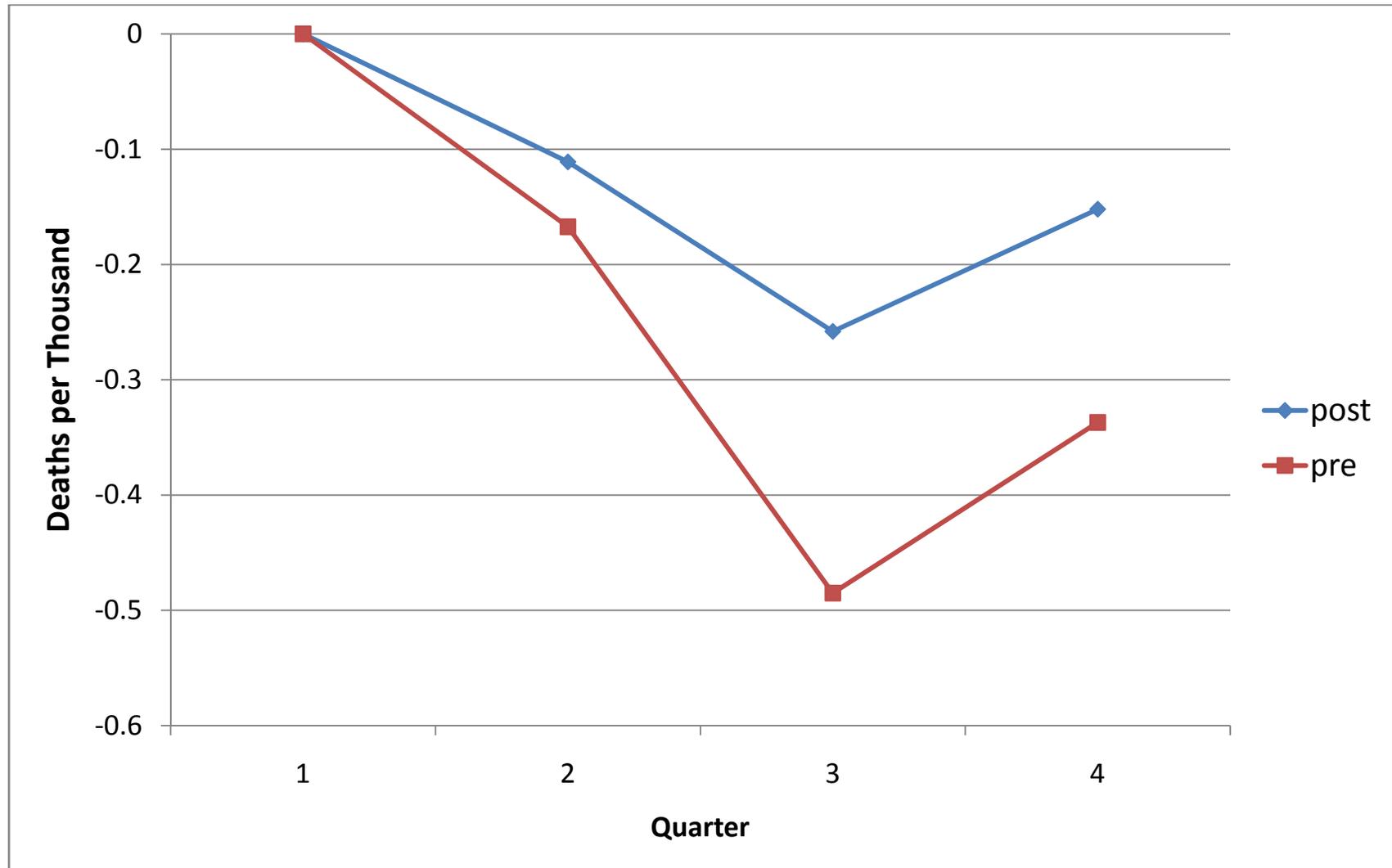
Figure 6: Ratio of Malaria to Non-Malaria Mortality



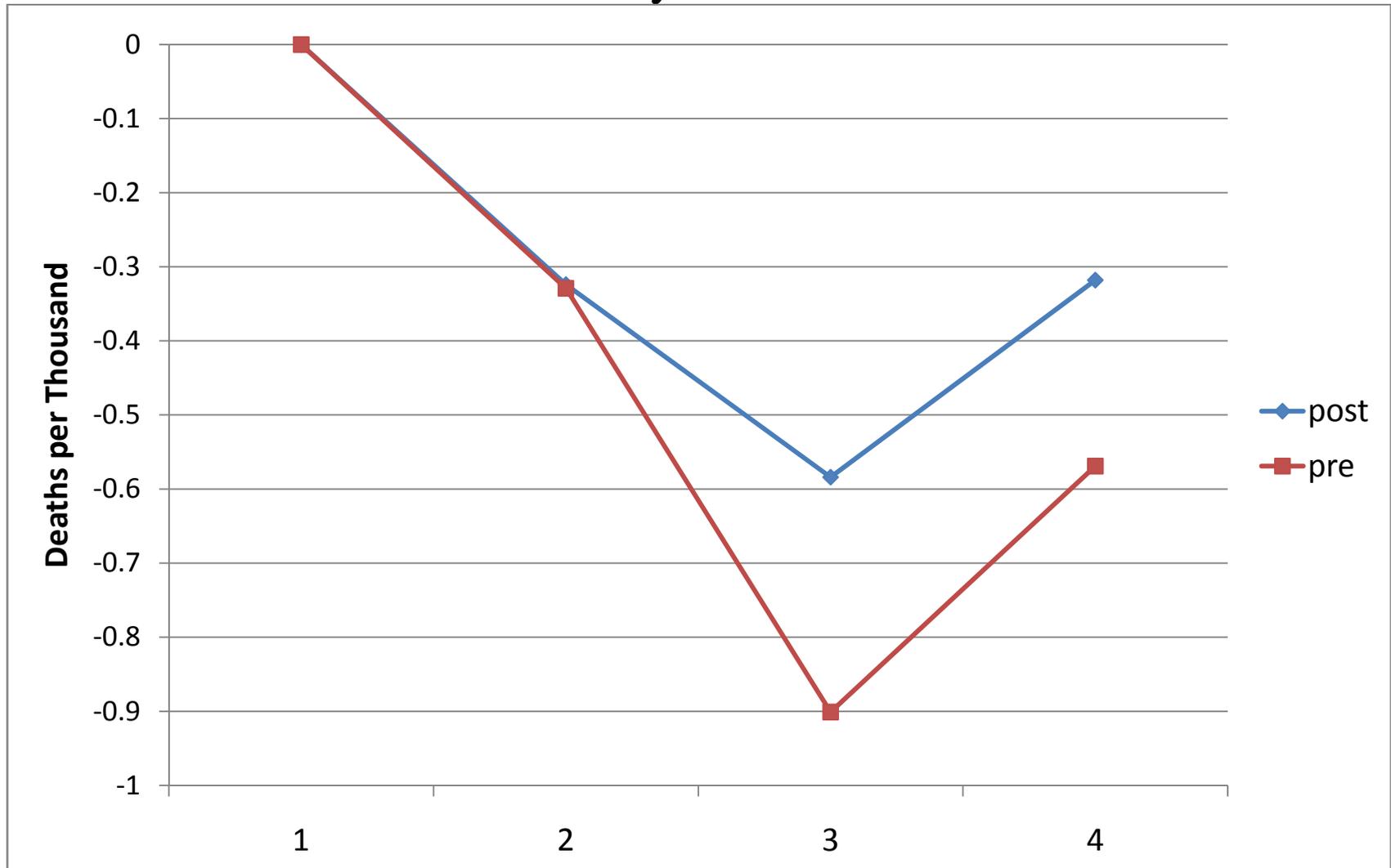
Seasonality in Deaths – full period



Seasonal Malaria Mortality



Seasonal in All-Cause Mortality



Elements of program

- Treated bednets (more than half of 2008 budget)
 - Indoor Residual Spraying
 - artemisinin-based combination therapy (ACT)
 - Rapid Diagnostic Testing
 - IPT in pregnancy
-
- Big contemporaneous push on HIV, tuberculosis, and child health!

	Number of bednets distributed	Population covered by spraying	RDT Distributed
2002	112,020	-	0
2003	557,071	324,137	0
2004	176,082	679,582	0
2005	516,999	1,163,802	172,257
2006	1,163,113	2,836,778	25,700
2007	2,446,102	3,286,514	243,600
2008	964,748	5,558,822	2,015,500

	Nets distributed per person between 2001 and 2007 DHS	Percentage of children in households owning at least one net 2007	Percentage of children sleeping under net 2007
Central	0.15	0.68	0.37
Copperbelt	0.12	0.74	0.43
Eastern	0.12	0.71	0.37
Luapula	0.43	0.86	0.74
Lusaka	0.16	0.68	0.30
Northern	0.15	0.57	0.41
North-Western	0.39	0.73	0.43
Southern	0.22	0.60	0.25
Western	0.64	0.87	0.55
Total	0.26	0.72	0.43

Province	Fraction of population officially covered by spraying in 2006	Percentage of children in 2007 DHS living in sprayed households	Urbanization (2000)
Central	0.12	0.12	.24
Copperbelt	0.63	0.41	.78
Eastern	0.00	0.02	.09
Luapula	0.00	0.01	.13
Lusaka	0.73	0.29	.82
Northern	0.00	0.04	.14
North-Western	0.09	0.14	.12
Southern	0.16	0.13	.21
Western	0.00	0.02	.12

Assessing the Link from Rollout to Incidence

- Want to learn the structural effect of inputs (nets, spraying, etc.) on outputs (disease, death)
- Treatment is not randomly applied
 - Resources pushed to areas in need (or forecast need)
 - modalities chosen in optimizing fashion
 - Efficacy of local staff important omitted variable (field works says)
- Can we sign the biases? (current conditions, health staff efficacy, forecast conditions)
- Identifying variation comes from
 - Deviation from optimal plan, random events
 - Discontinuities in response function (e.g. IRS rollout; ACT stockouts; bednets in 2008?)

Table 7: Bednets, child fever and child diarrhea, DHS

Dependent variable	Child had fever over last two weeks			
	(1)	(2)	(3)	(4)
HH owns bednet	-0.0213* (0.0111)			-0.921*** (0.267)
slept under net		-0.0106 (0.0110)		
Bednet distribution pc			-0.209*** (0.0487)	
Observations	11193	11027	11193	11193
R-squared	0.129	0.128	0.131	-0.513

- **Placebo test with diarrhea**

Table 9: Control for baseline level in micro-level regression, DHS

Dependent variable	Child had fever over last two weeks			
	(1)	(2)	(3)	(4)
HH owns bednet	-0.0141 (0.0105)			-0.695 (0.496)
Child slept under net		-0.00428 (0.00895)		
Bednet distribution			-0.104*** (0.0364)	
Baseline fever prevalence	0.867*** (0.0944)	0.888*** (0.0933)	0.806*** (0.0973)	0.393 (0.400)
Observations	11193	11027	11193	11193
R-squared	0.136	0.135	0.136	-0.229

Table 11: Bednets and Death of Child in last 5 years

	(1)	(2)	(3)
HH owns bednet	-0.00968 (0.00690)		
Kids in HH slept with ITN district coverage		-0.0486*** (0.00608)	-0.0443* (0.0255)
Female	-0.0199*** (0.00538)	-0.0199*** (0.00535)	-0.0199*** (0.00539)
Observations	13201	13201	13201
R-squared	0.032	0.036	0.032

- **Full coverage reduces deaths by 4.4 percentage points**

Table 13 B: ITN Distribution and Malaria Relative to Population

	Malaria inpatients per 1000 children under 5	Malaria deaths per 1000 children under 5	Other deaths per 1000 children under 5	Malaria inpatients per 1000 children under 5	Malaria deaths per 1000 children under 5	Other deaths per 1000 children under 5
	(1)	(2)	(3)	(4)	(5)	(6)
Nets per capita				6.088 (9.872)	-0.121 (0.309)	-1.543 (1.102)
L1 nets per capita	-26.25*** (9.279)	-0.778*** (0.271)	-0.709 (0.769)	-30.14** (12.74)	-0.852** (0.382)	-1.797* (1.077)
L2 nets per capita				-33.50 (36.40)	-0.0370 (0.817)	-3.839** (1.557)
Observations	573	573	573	501	501	501
R-squared	0.811	0.634	0.744	0.824	0.637	0.771

Table 14: IRS Results, DHS

Dependent variable	Child had fever over last two weeks			
	(1)	(2)	(3)	(4)
Percentage of district population sprayed	0.102*** (0.0192)			
Household sprayed (self-report)		0.0482** (0.0195)	-0.0162 (0.0199)	
Fraction of households sprayed in Cluster				-0.00778 (0.0394)
2 nd wave dummy	-0.283*** (0.0122)	-0.257*** (0.0108)		
Observations	11524	11523	5671	5672
R-squared	0.123	0.121	0.047	0.046

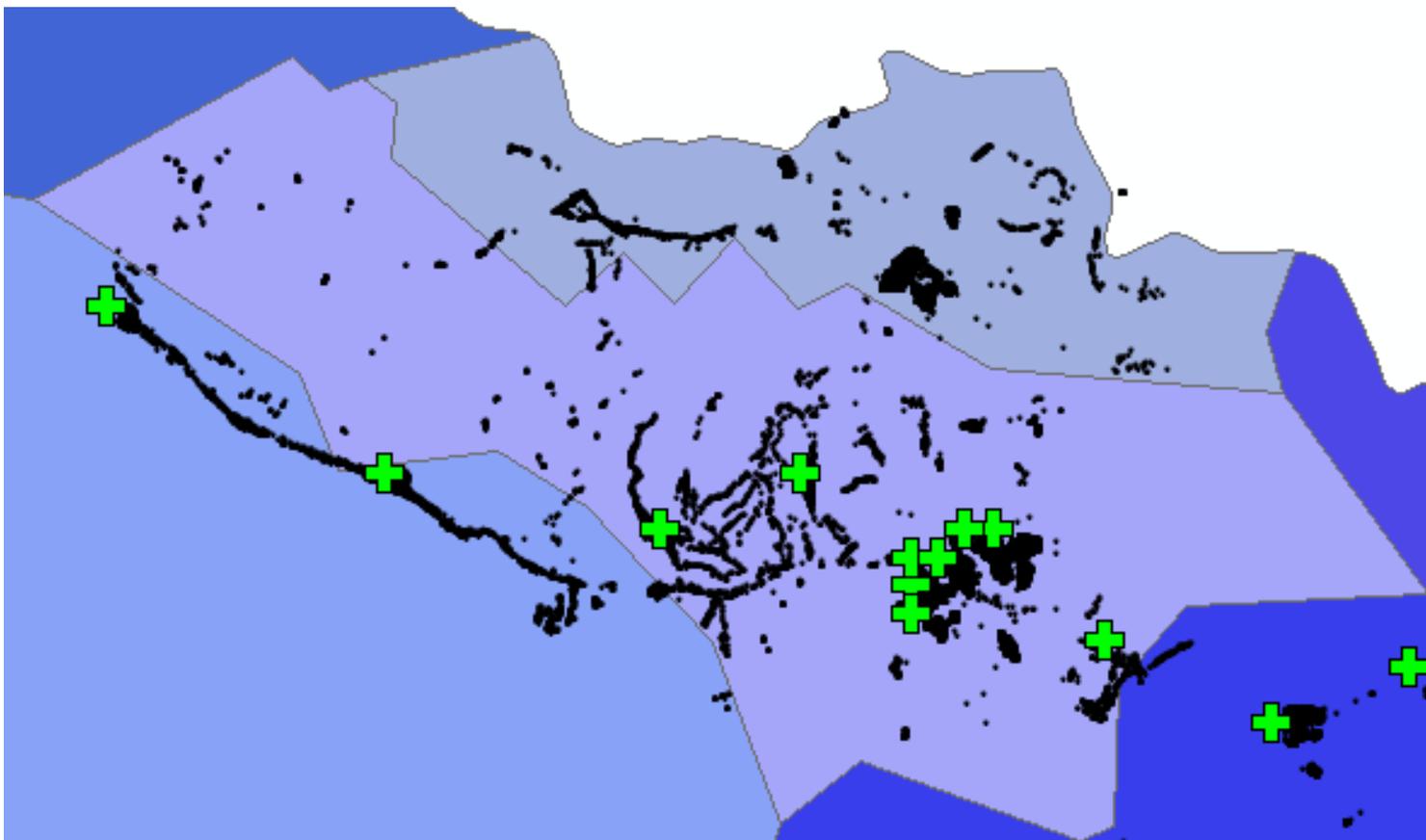
IRS in the HMIS (Table 15A)

	Malaria inpatient s under 5	Malaria deaths under 5	Other deaths under 5	Malaria inpatients under 5	Malaria deaths under 5	Other deaths under 5
	(1)	(2)	(3)	(4)	(5)	(6)
Spraying target Dummy	-241.5 (189.1)	-22.57* (12.15)	0.539 (17.62)	-308.9* (176.4)	-24.72** (12.12)	-0.278 (17.28)
Lag 1 Bed nets in thousands				-9.351*** (2.324)	-0.298*** (0.0702)	-0.113 (0.147)
Observations	573	573	573	573	573	573
R-squared	0.866	0.760	0.905	0.873	0.766	0.905

Table 15 B (Nets and Spraying Adjusted by Population)

	Malaria inpatients per 1000 children under 5	Malaria deaths per 1000 children under 5	Other deaths per 1000 children under 5	Malaria inpatients per 1000 children under 5	Malaria deaths per 1000 children under 5	Other deaths per 1000 children under 5
	(1)	(2)	(3)	(4)	(5)	(6)
Fraction Sprayed	6.199 (9.660)	-0.416 (0.370)	0.792 (0.559)	2.526 (9.760)	-0.558 (0.372)	0.722 (0.543)
Nets per capita				-25.38*** (9.548)	-0.984*** (0.257)	-0.484 (0.704)
Observations	573	573	573	573	573	573
R-squared	0.809	0.656	0.787	0.811	0.661	0.787

Figure 8: Health Facilities and Spraying in the Chingola District 2008



Green crosses represent health facilities, black dots sprayed structures. Grey lines are district boundaries.

Conclusions

- Anti-malaria campaign has been a huge success
- Other dimensions of health push also huge success
- Cleaned up HMIS useful tool for tracking rollout and impact
- Input->outcome results: *very* tentative evidence that we see nets working better than spraying

Future direction for research

- How does malaria (or health more generally) affect economic outcomes?
 - Macarthur and Sachs
 - Acemoglu and Johnson
 - Ashraf, Lester, and Weil
- Zambia provides good identifying variation because
 - Impetus for campaign was (largely) exogenous
 - Regional variations in rollout partly random
 - Possible to identify other random shocks
- Issues to study
 - Fertility (rural TFR rose from 6.9 to 7.5, urban flat at 4.0)
 - Labor productivity
 - education

Sustainability and Further Progress

- This is not eradication (yet?)
- Maintaining 75% reduction much harder than maintaining 100%
- Resource demands will remain high
- Always danger of relapse