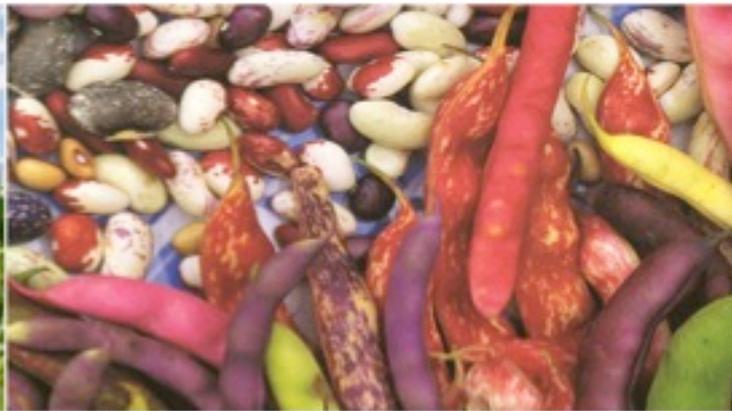


The Interconnection of Food



EARTH DAY 2015

Connecting the Dots: The Food, Energy, Water, and Climate Nexus

- **David Lobell**, Center on Food Security and the Environment, Environmental Earth System Science, Freeman Spogli Institute for International Studies, Stanford Woods Institute for the Environment
- **Marshall Burke**, Environmental Earth System Science, Center on Food Security and the Environment
- **Steve Luby**, Stanford Medicine, Stanford Woods Institute for the Environment, Freeman Spogli Institute for International Studies
- **Scott Rozelle**, Rural Education Action Program, Freeman Spogli Institute for International Studies, Stanford Institute for Economic Policy Research, Center on Food Security and the Environment

The food – conflict nexus

Marshall Burke

Dept. of Earth System Science, and
Center on Food Security and the Environment
Stanford University

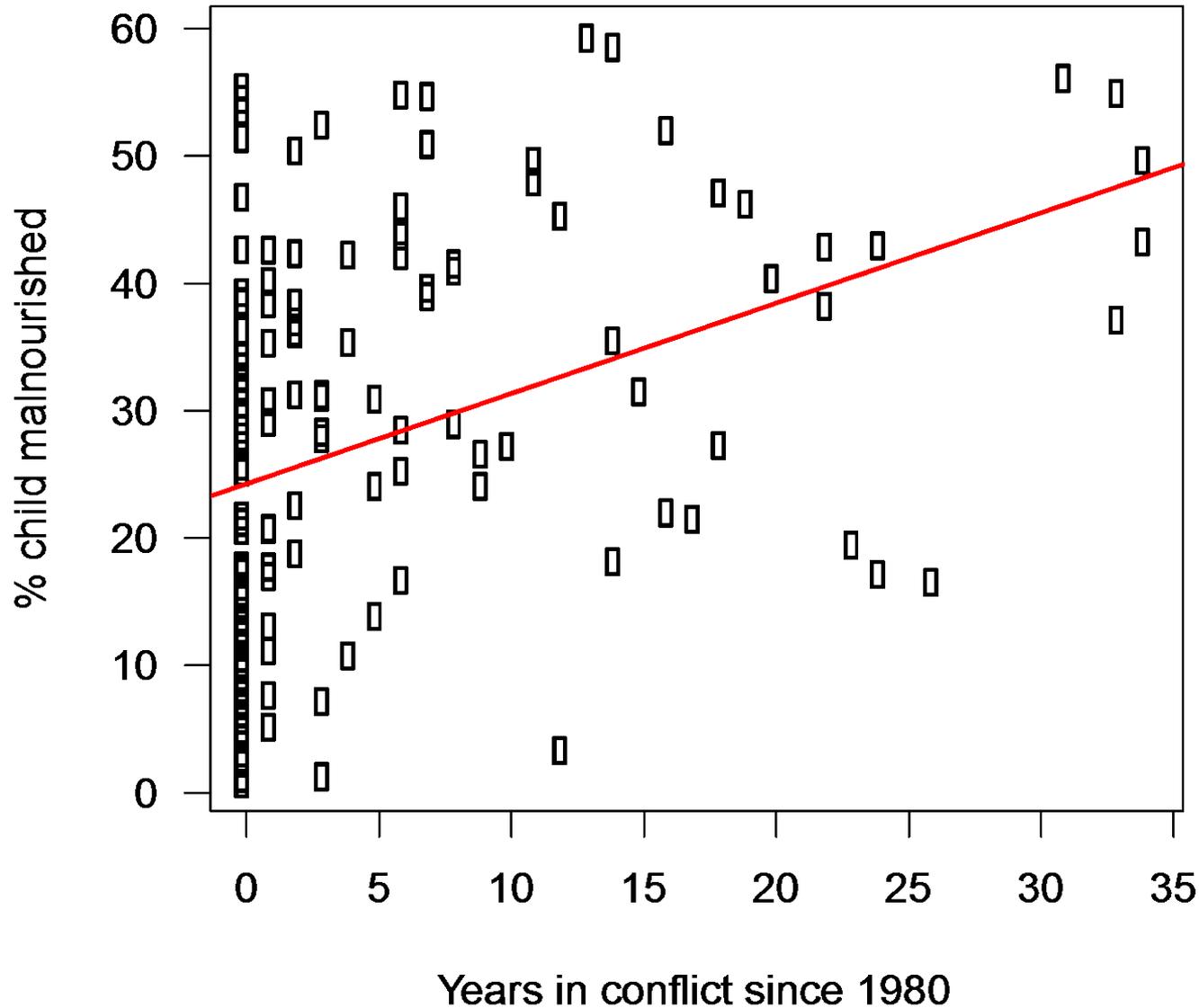


Conflict prone countries are more food insecure



Photo: UNHCR

Conflict prone countries are more food insecure



But which way does causal arrow go?

Food \rightarrow Conflict

Conflict \rightarrow Food

Conflict \leftrightarrow Food

Why does it matter?

And how can we figure it out?

Norway: food secure, peaceful

Nigeria: food insecure, conflict-prone

A world map with a dark background and light gray outlines of continents and countries. Norway is highlighted in yellow in the upper left, and Nigeria is highlighted in yellow in the lower left.

Conclude: *food insecurity* → *conflict* ?

Better research design:

Compare Nigeria to itself over time,
Norway to itself over time

Look for “natural experiments”

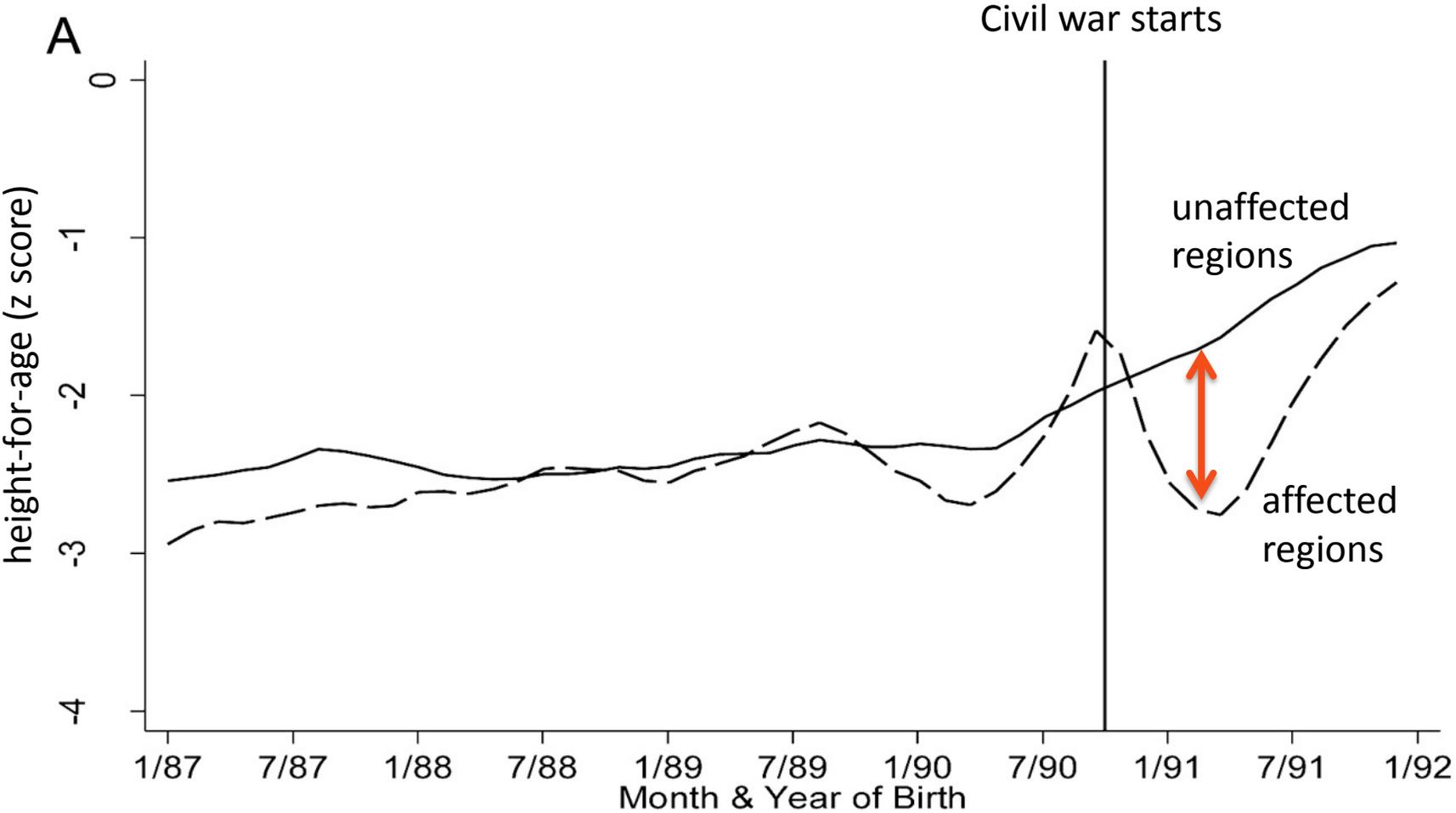
CONFLICT → FOOD INSECURITY

Conflict:

- Inhibits food production and trade
- Destroys productive assets
- Worsens access to health facilities



Rwandan civil war and child height



Broader economic effects also not good

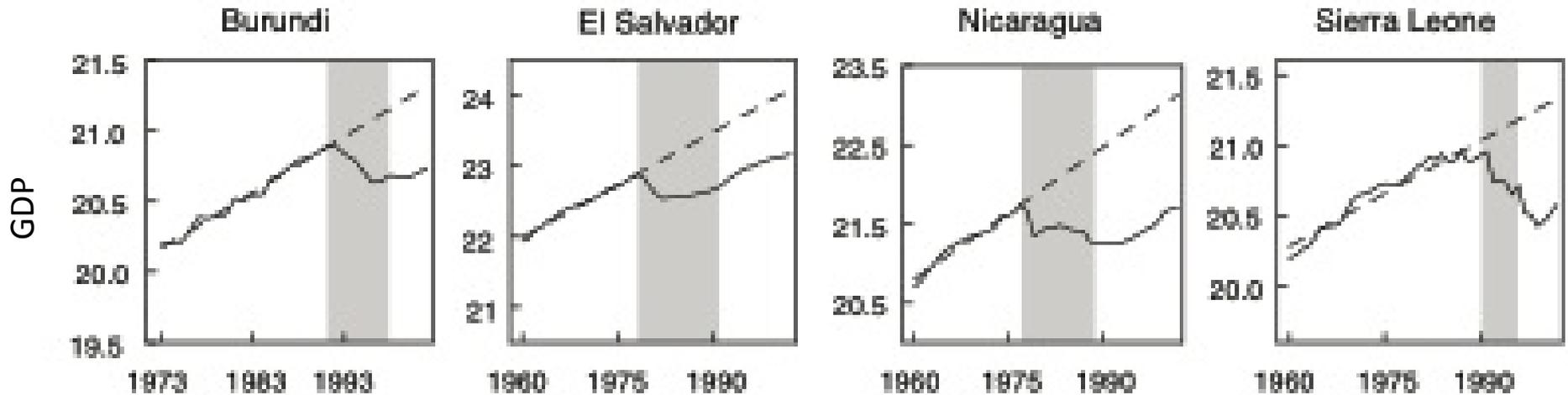
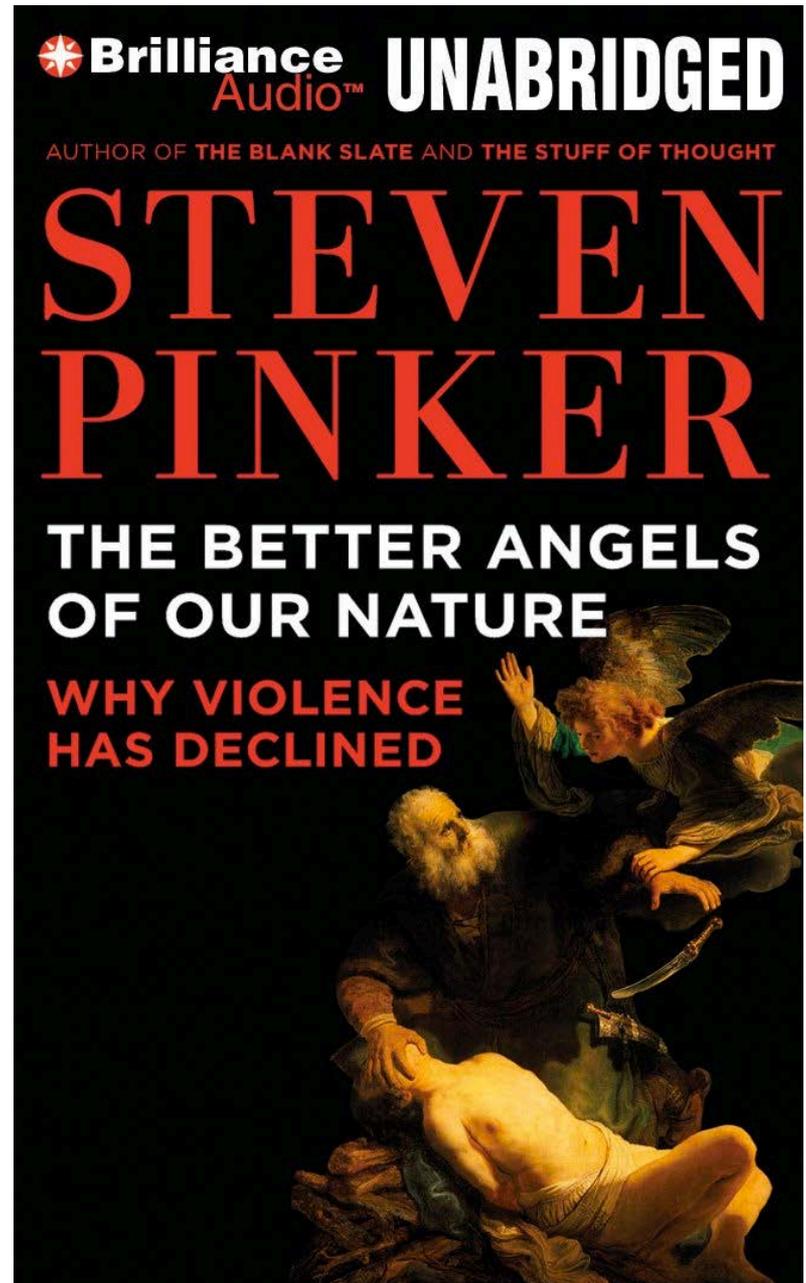


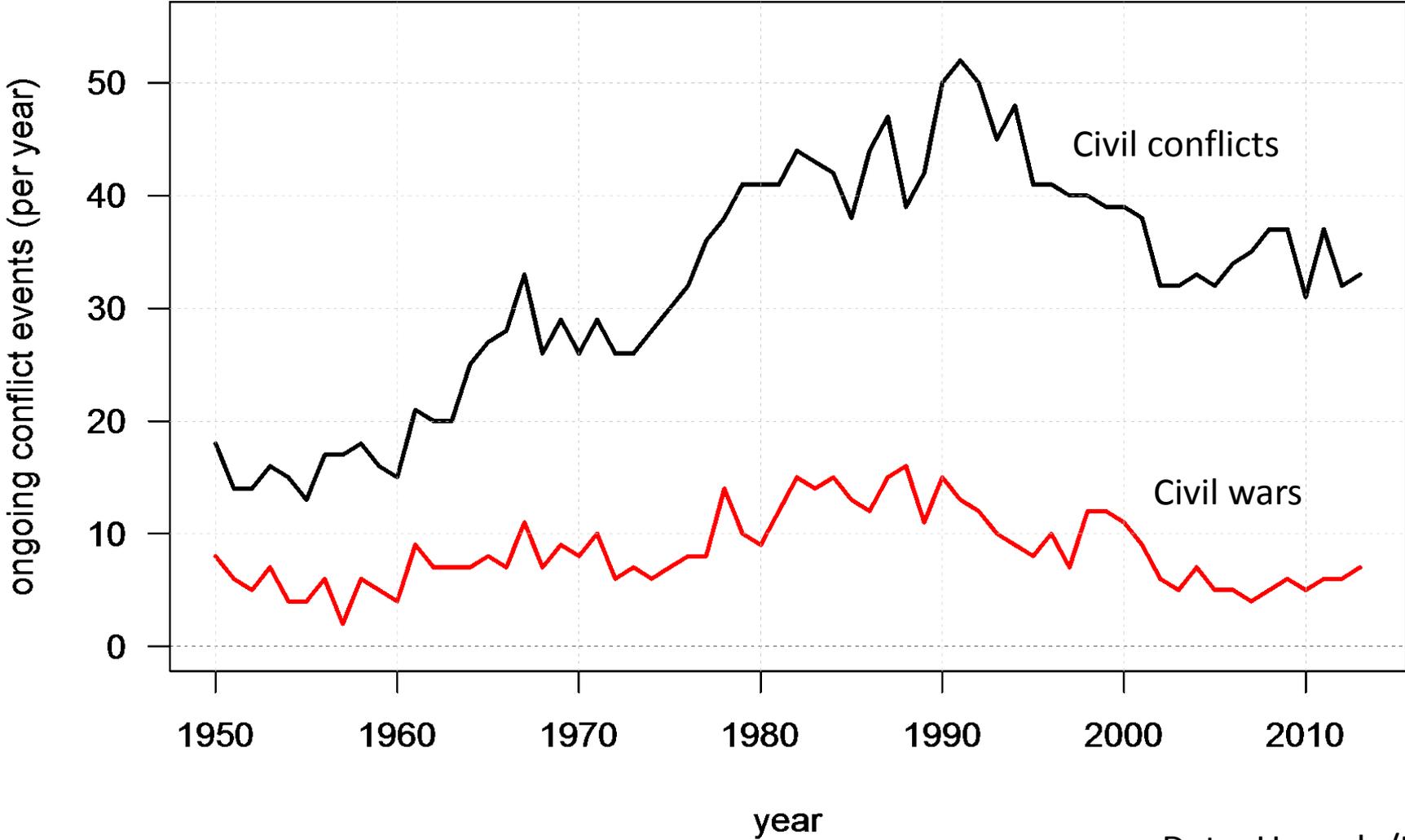
FIGURE 2. PROTRACTED CIVIL WARS

Maybe this is
good news?



Problem: conflict hasn't fallen much (recently)

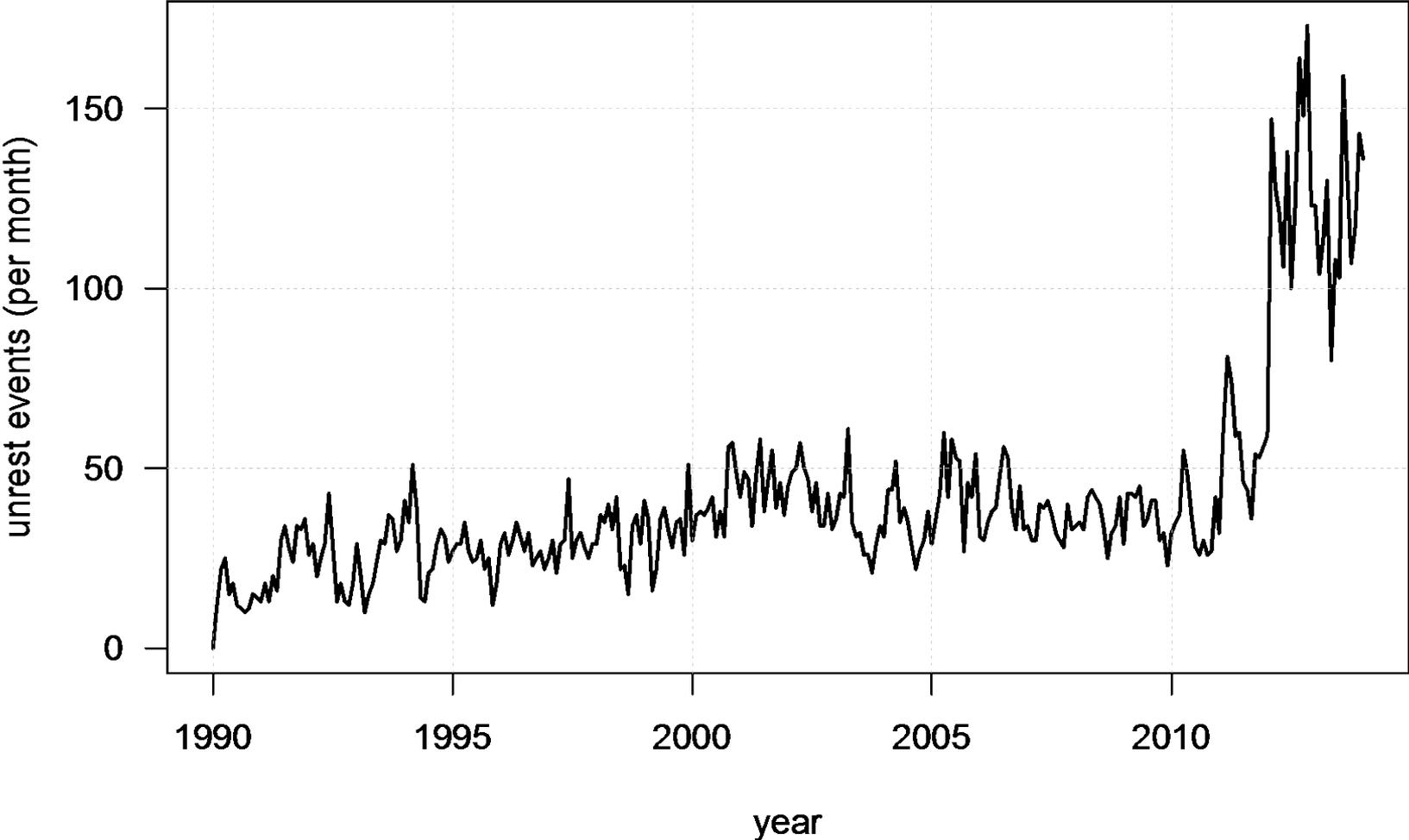
Civil conflict, all countries



Data: Uppsala/PRIO

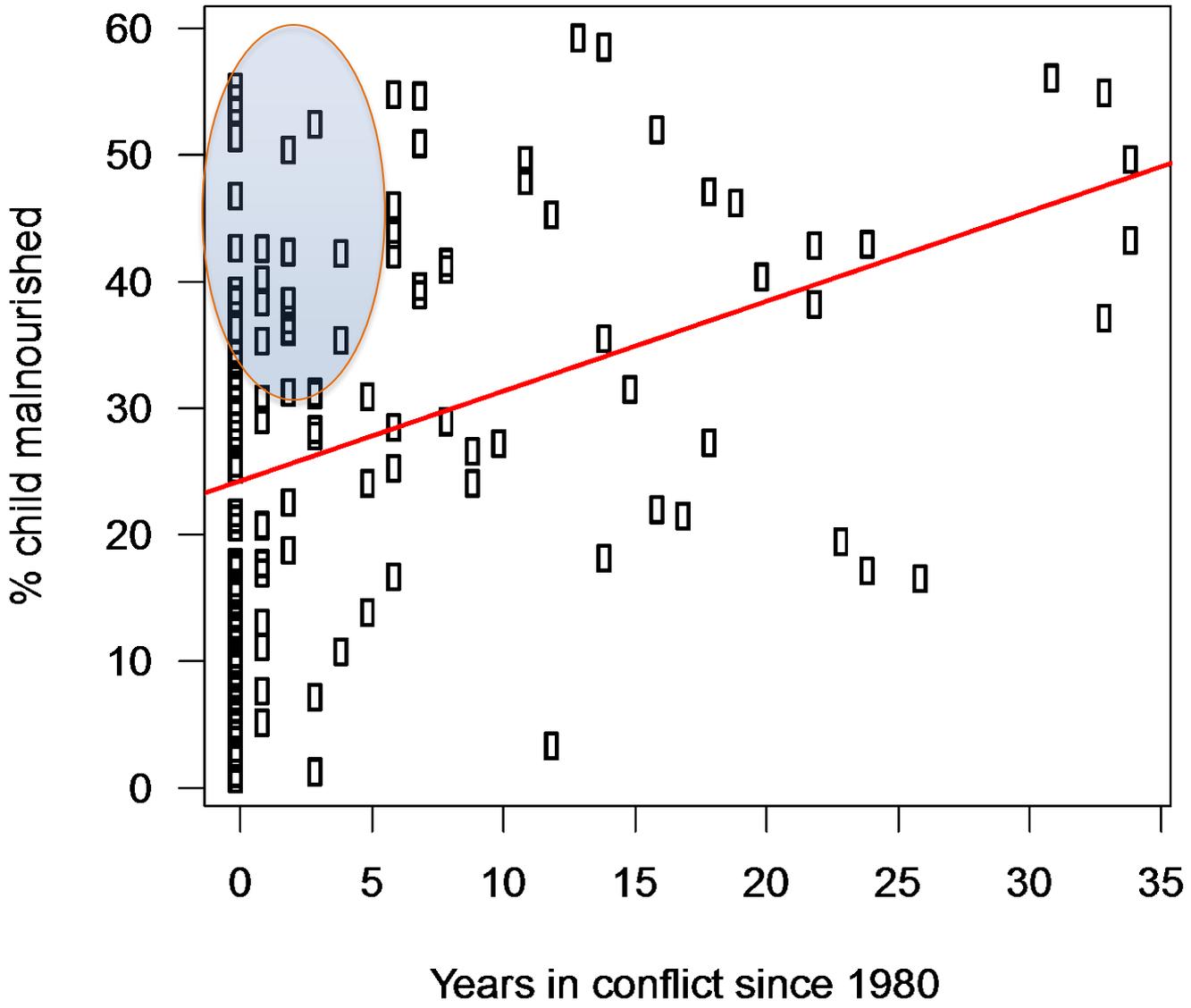
Problem: conflict hasn't fallen much (recently)

Civil unrest in Africa



Data: SCAD

Problem: conflict not the only factor



FOOD INSECURITY → CONFLICT

Economists view:

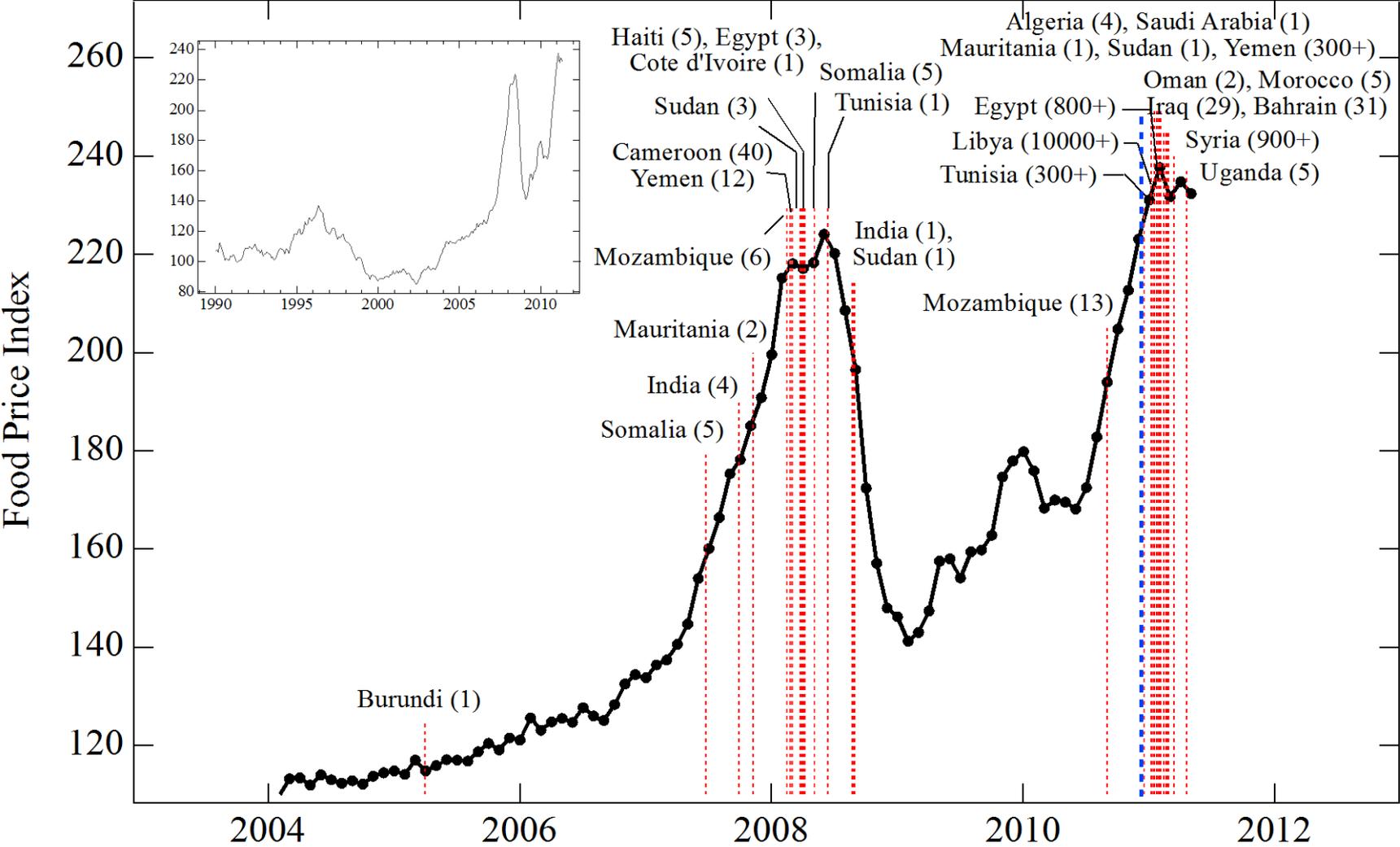
Joining a conflict is a cost/benefit calculation.

“Grievance” view:

Insecure access to food is breach of social contract.

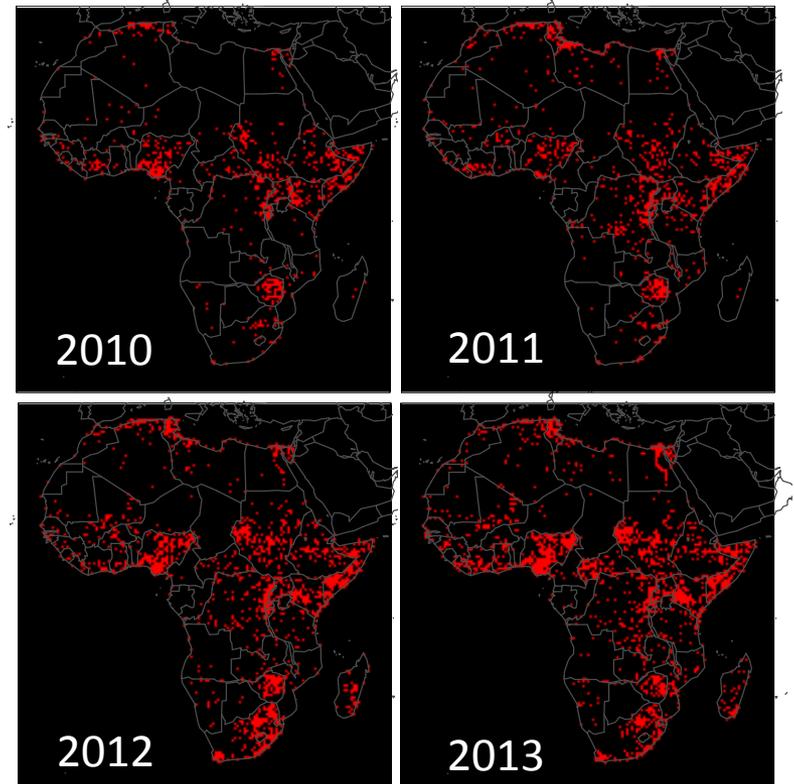
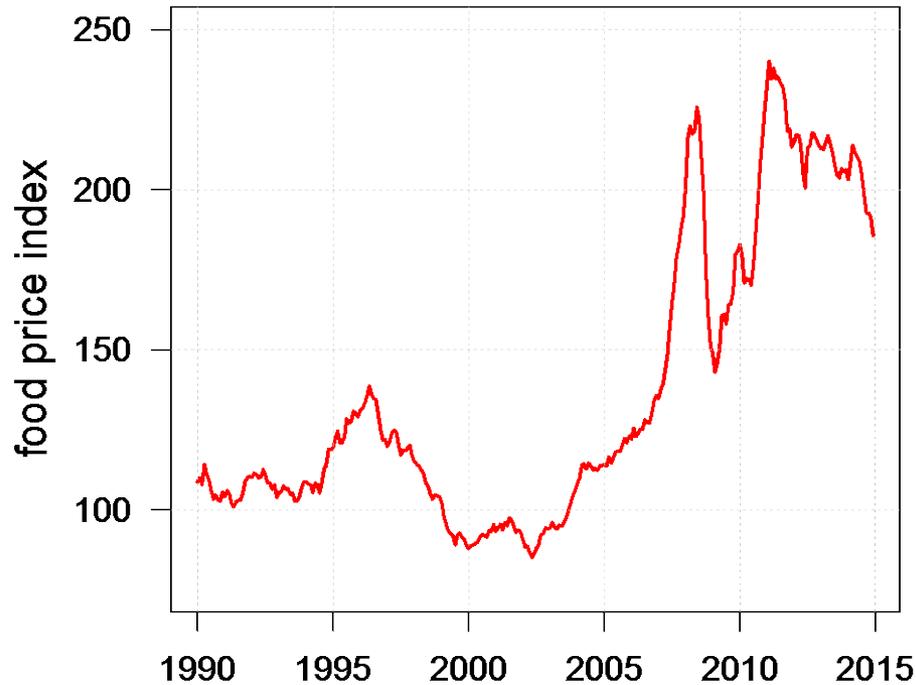
Grievances on display

Food price spikes and riots



An (unfortunate) natural experiment

External price spikes → less food security → local conflict (?)



An (unfortunate) natural experiment

External price spikes → less food security →
local conflict (?)

FINDING:

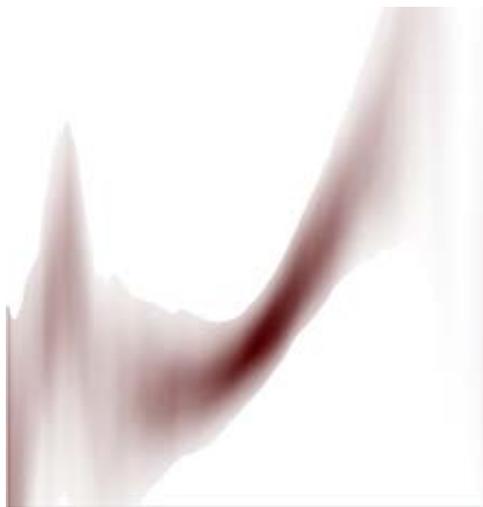
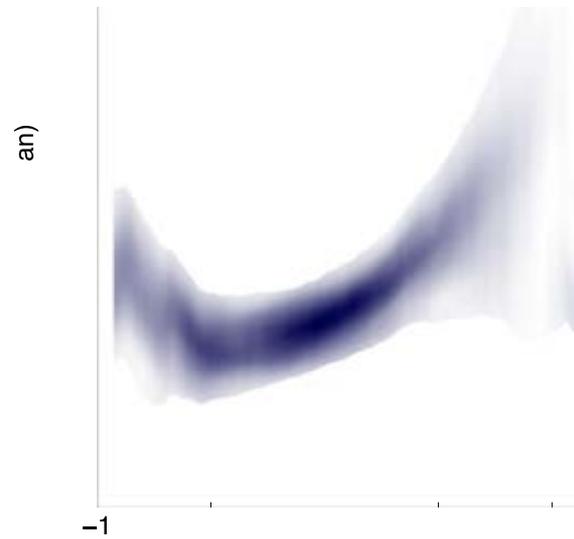
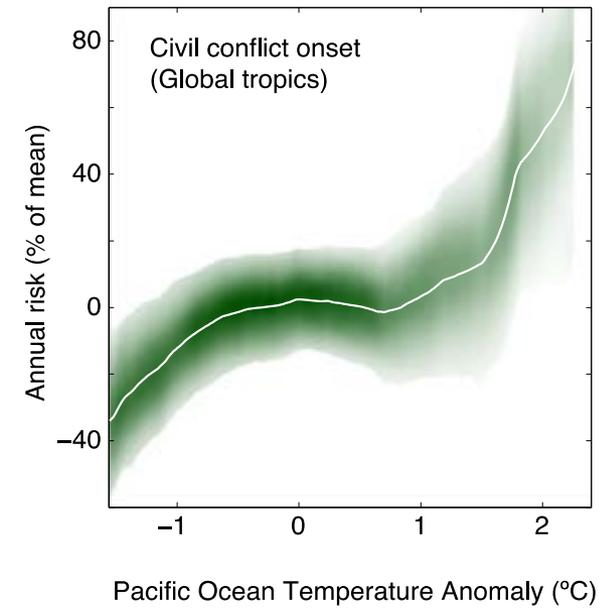
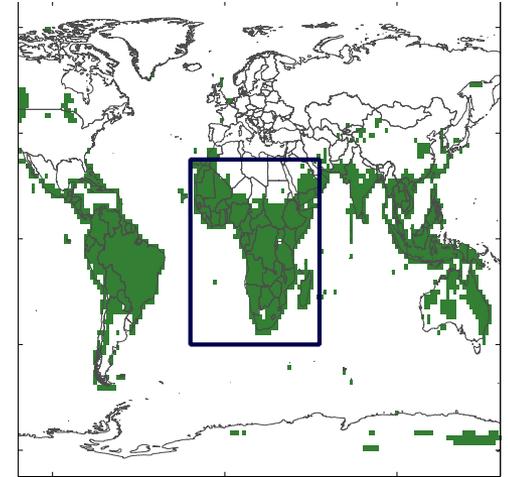
1 standard deviation increase in food prices

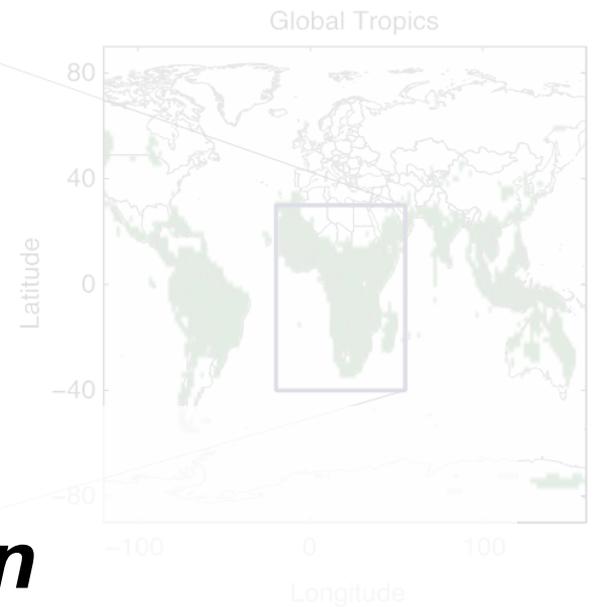
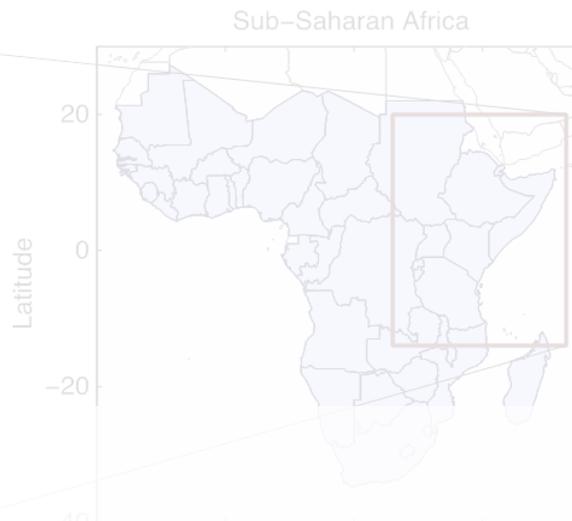
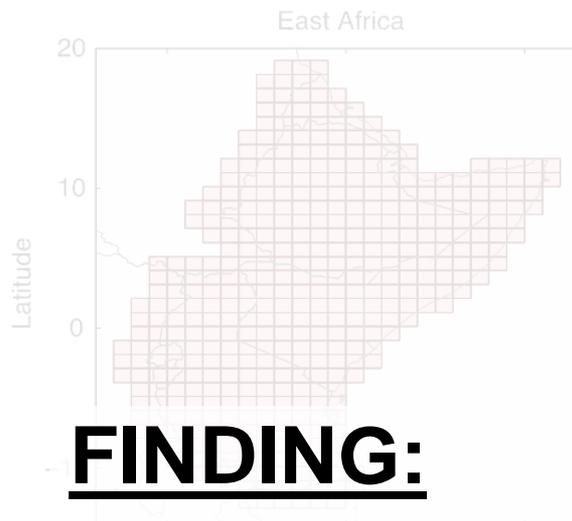
→ 10% increase in conflict events

Effect is twice as big in cities

Another natural experiment: the weather

Dry/hot year → lower agricultural production →
local conflict (?)

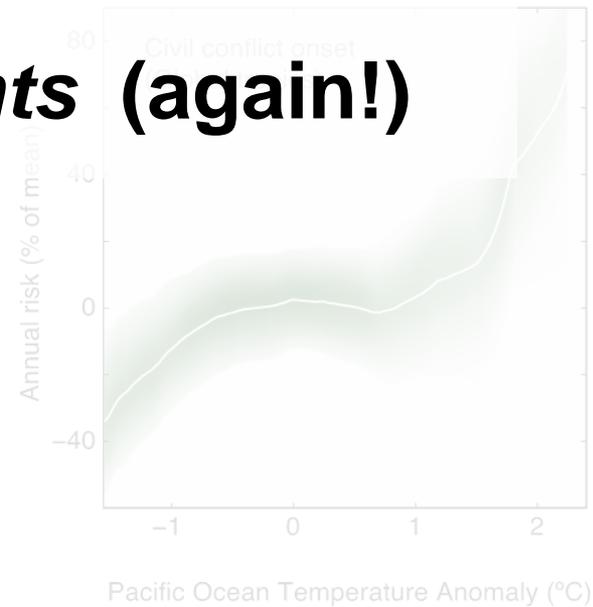
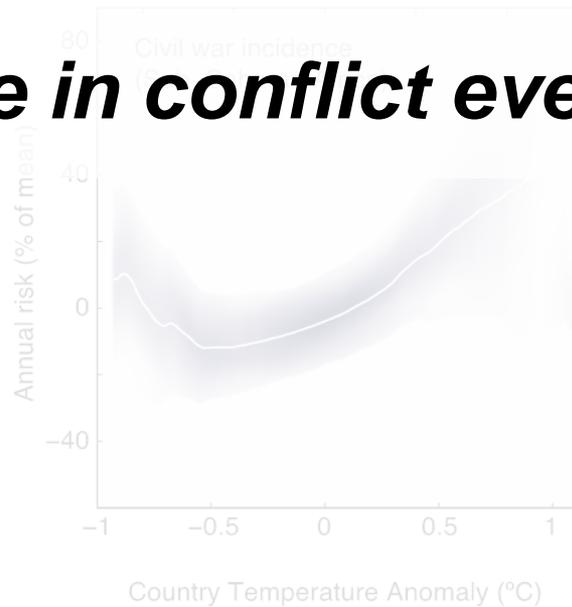
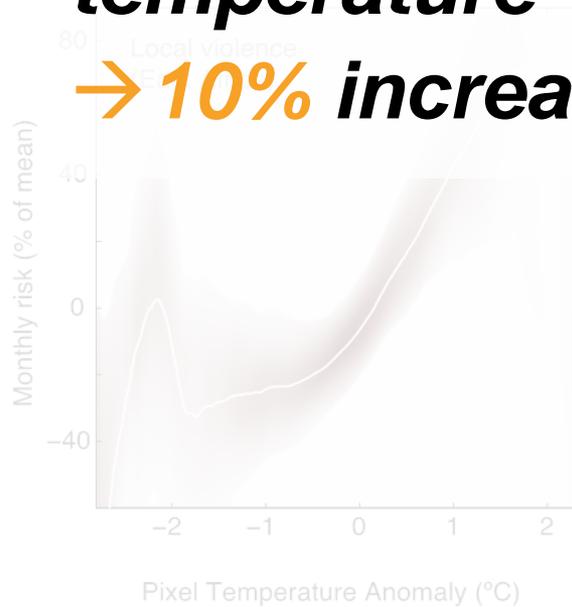




FINDING:

1 standard deviation increase in temperature

→ 10% increase in conflict events (again!)



The food \leftrightarrow conflict nexus

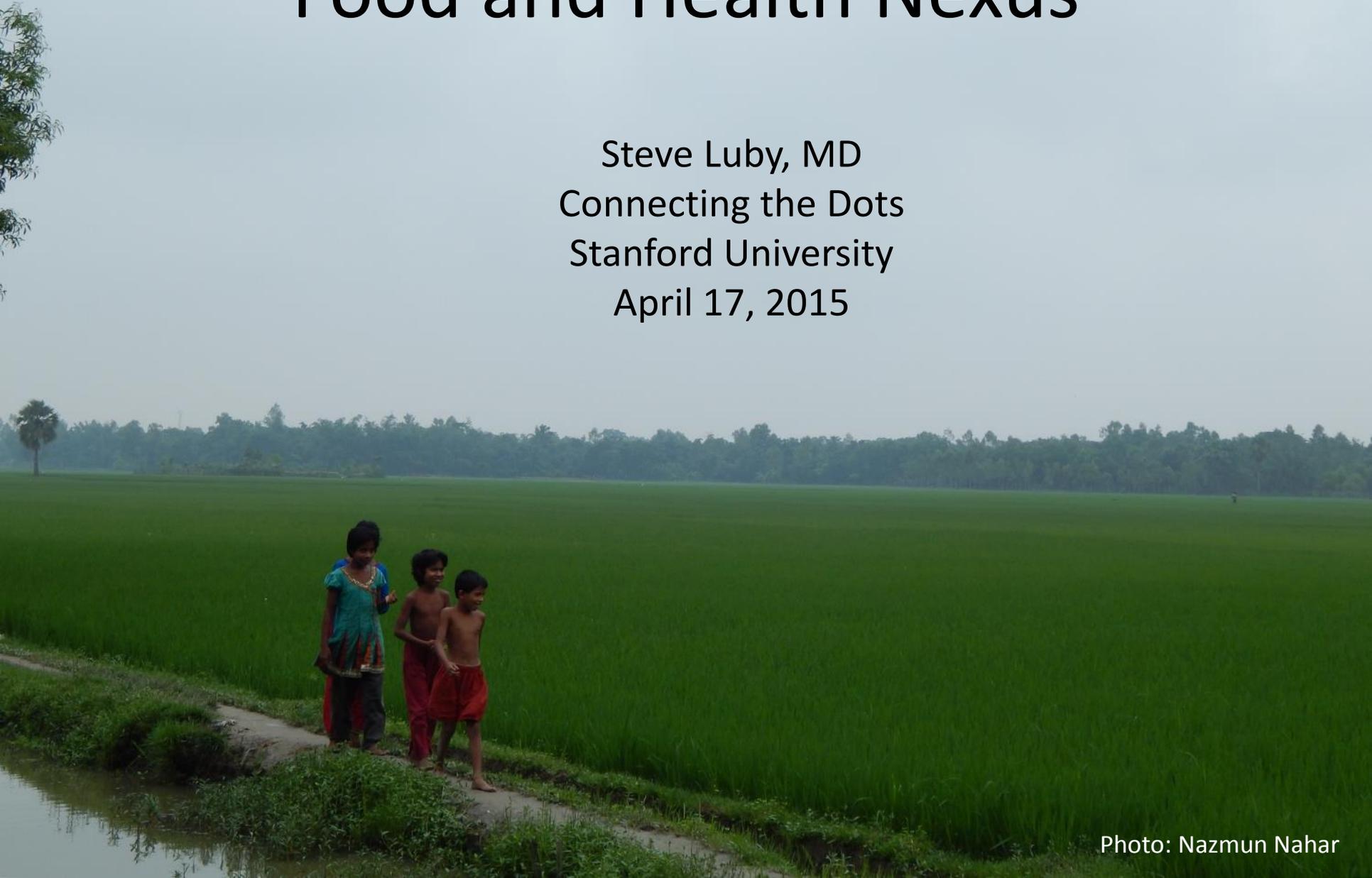
1. Conflict important, but probably not most important, factor in food insecurity
2. Food insecurity/ poverty is likely an underappreciated factor in conflict

Investments in food security could pay double.

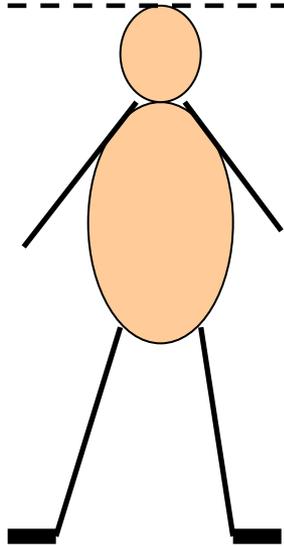


Food and Health Nexus

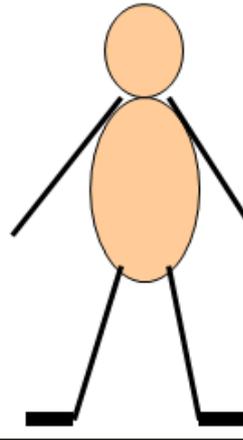
Steve Luby, MD
Connecting the Dots
Stanford University
April 17, 2015



Normal height for age



Normal

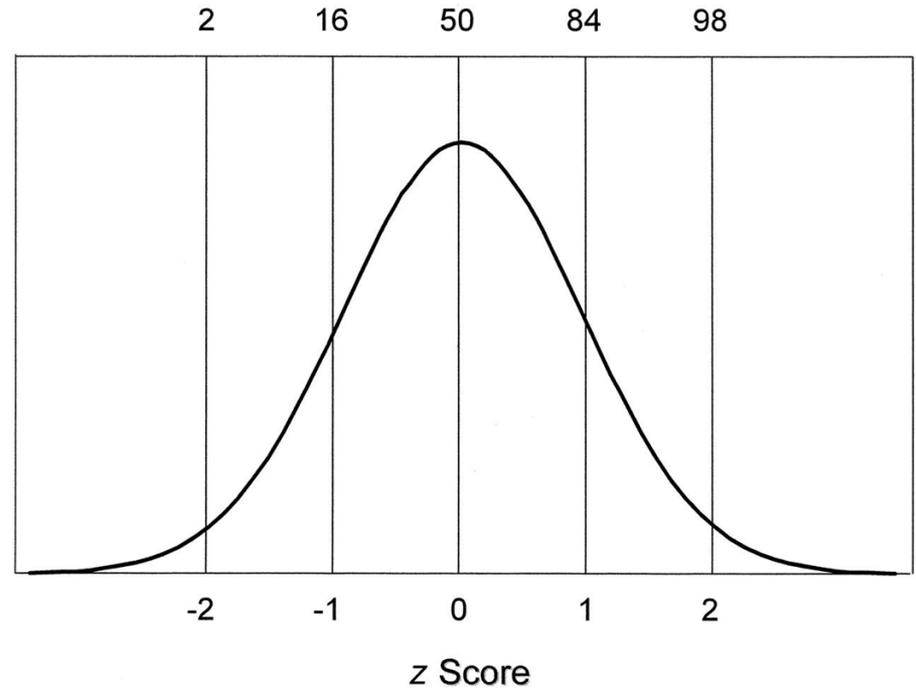


Stunted
Low height for age

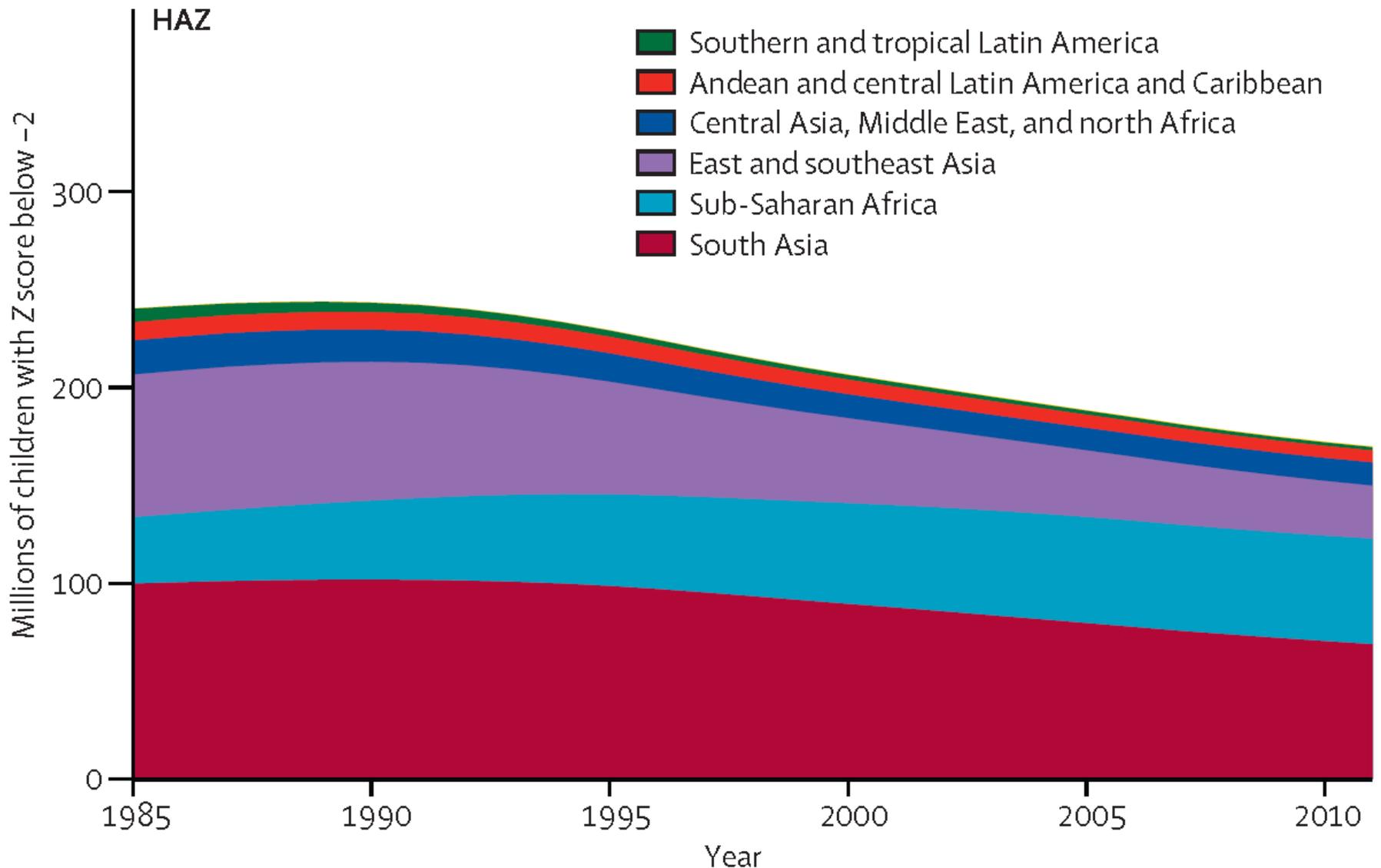
HAZ

Children

Percentile



Global trend in child under nutrition



WHO Multicentre Growth Reference Study

- Design
 - 8440 children from affluent families
 - Brazil, Ghana, India, Norway, Oman, US
 - 21 measurement visits from to age 24 months
- Results
 - Length of the children strikingly similar among the 6 sites
 - Variability
 - 3% due to inter-site differences
 - 70% due to individual differences by site

Why worry about stunting?



Mugsy Bogues

- 5' 3"
- Shortest player ever in the NBA
- Drafted 12th overall
- Played 14 seasons
- Blocked 39 shots
- 6726 assists

Shawn Bradley

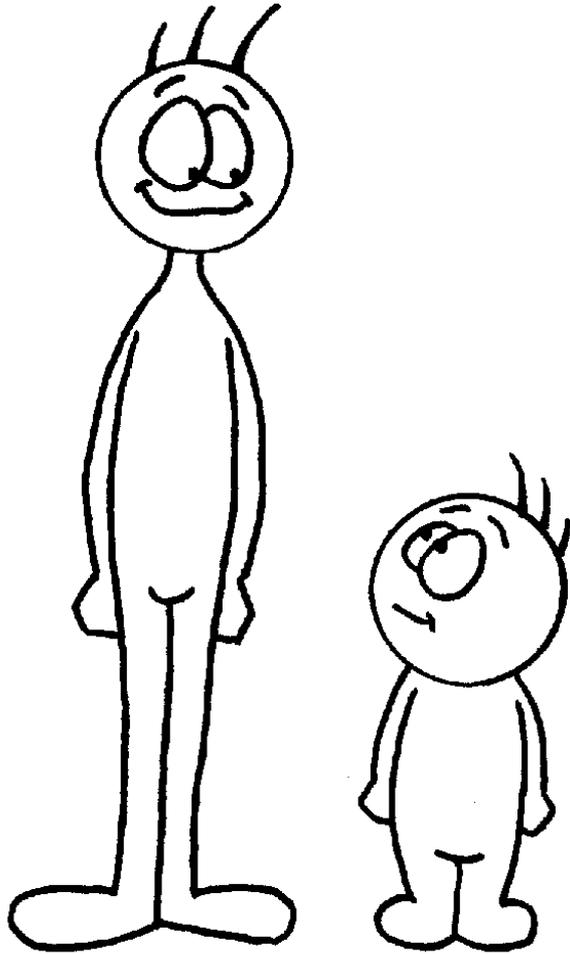
- 7' 6"
- Amongst the tallest players in the NBA
- Drafted 2nd overall
- Played 14 seasons
- Blocked 2110 shots
- 573 assists

Why worry about stunting?

When entire communities are short, this is a marker of chronic under-nutrition

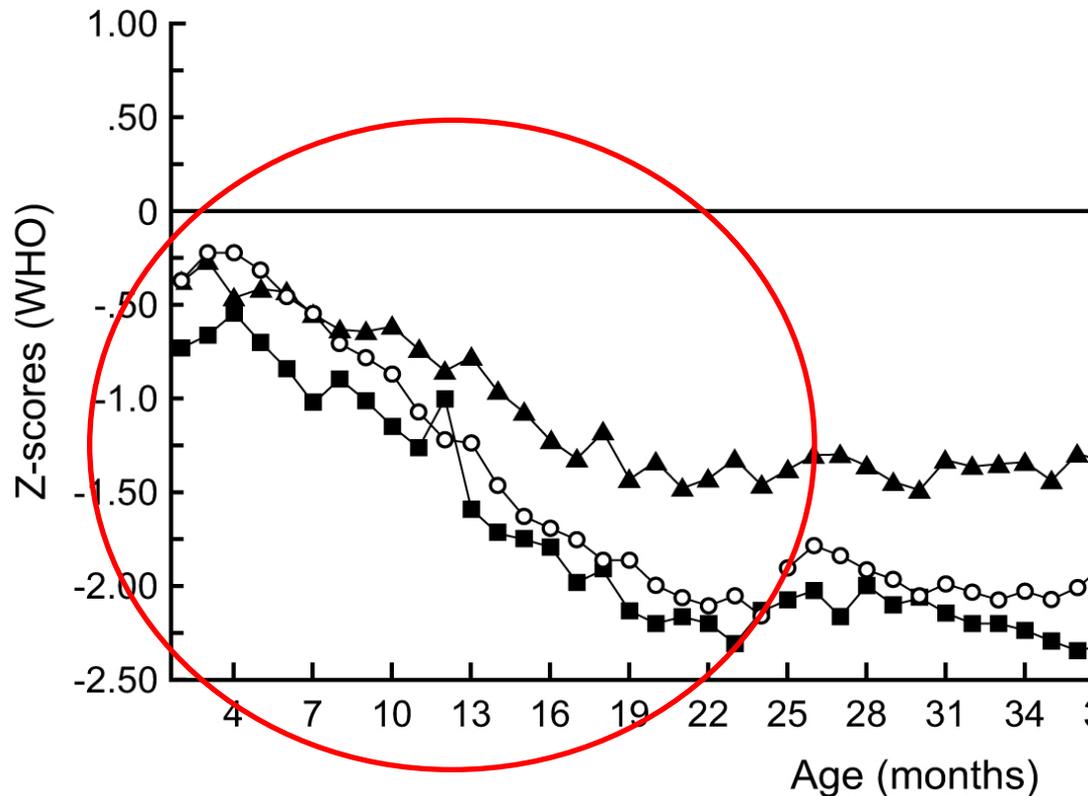
1.4 million child deaths annually attributable to undernutrition.

(Lancet 2012; 380: 2224–60)



- Malnourished children also face:
 - cognitive impairment
 - decreased wages
 - increased chronic diseases

Critical period for growth faltering



The first 1000 days

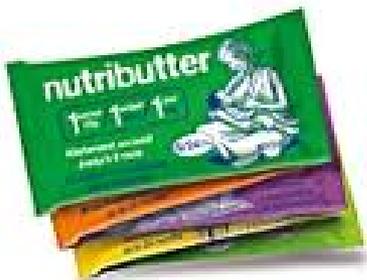
- Maternal nutrition
- Early child nutrition
- Key area for
 - Research
 - Interventions

If children are malnourished

- Feed them more
 - But more calories are insufficient
 - need nutrient dense food
- Supplement with nutrient dense foods
 - only correct 1/3 of growth faltering
(Dewey K. *Matern Child Nutr* 2008, 4 Suppl 1: 24--85)



Photo: Mubina Agboatwalla



- 118 Kcal
- 9.6 gm fat
- 2.6 gm protein
- $\geq 100\%$ RDA of 12 vitamins
- 9 minerals

If lack of food is not the sole common underlying sufficient cause of stunting, what else is driving this?

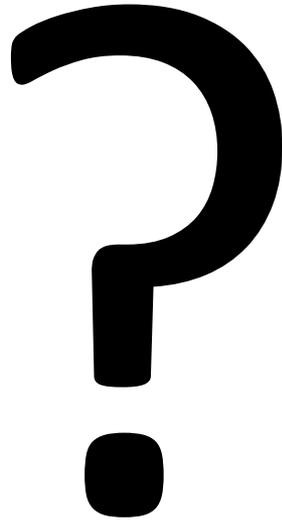




Photo : UNHCR / G. Akash



+



www.healthcosmic.com



Healthy
Thriving
Communities

+



www.priyo.com

www.precisionnutrition.com



Photo: Shovon Sazzad

- 98% of fecal sludge in Dhaka, Bangladesh is discharged untreated into the environment
- The poor have limited ability to secure
 - clean water
 - nutrient dense food
 - clean energy



George Orwell

Down and Out in Paris and London

“Hunger reduces one to an utterly spineless, brainless condition, more like the after-effects of influenza than anything else. It is as though one had been turned into a jellyfish, or as though all one's blood had been pumped out and luke-warm water substituted. Complete inertia is my chief memory of hunger.”

Impoverished households are risk averse



The Kathmandu post

- Non-cereal crops in Bangladesh
 - Provide better nutrition
 - Generate more earnings
- Bangladeshi farmers prefer to **grow rice** (Rahman S, *Asian J Ag Dev* 2008)
 - They are more familiar and know better what to expect with rice

Healthy
Thriving
Communities



www.precisionnutrition.com

+



www.healthcosmic.com

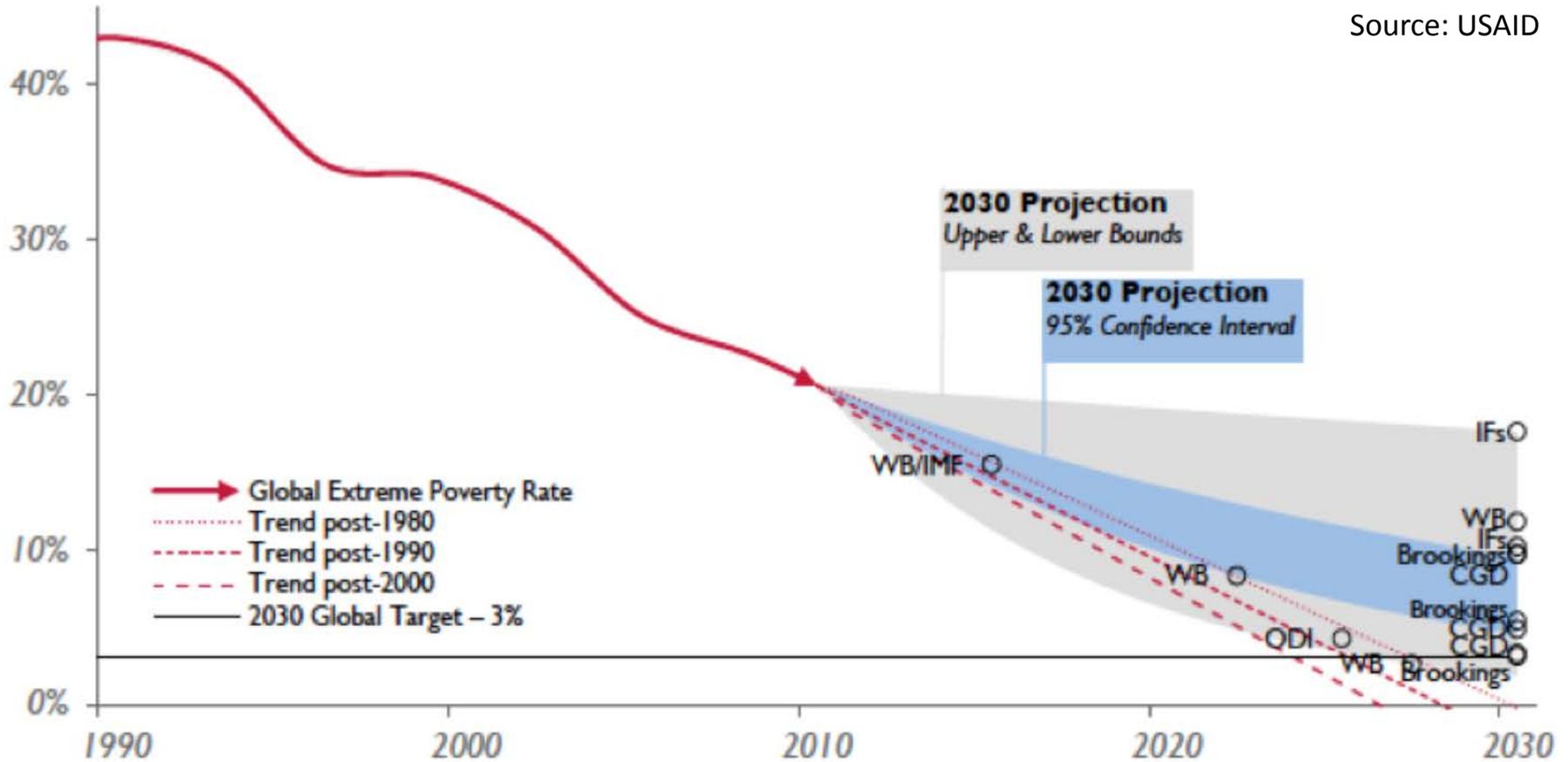
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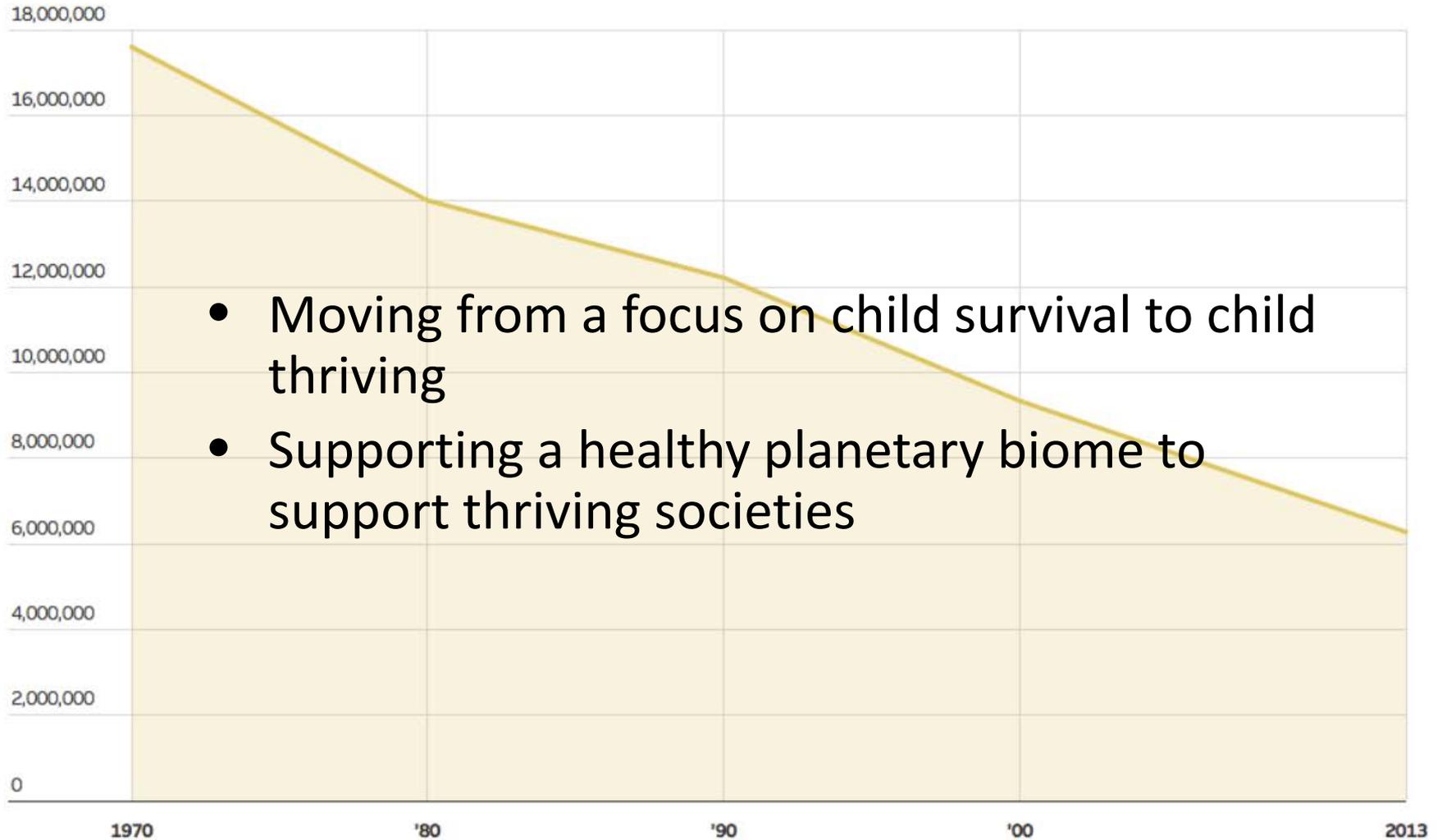
www.priyo.com

Leveraging the nexus going forward: Ending extreme poverty

Source: USAID

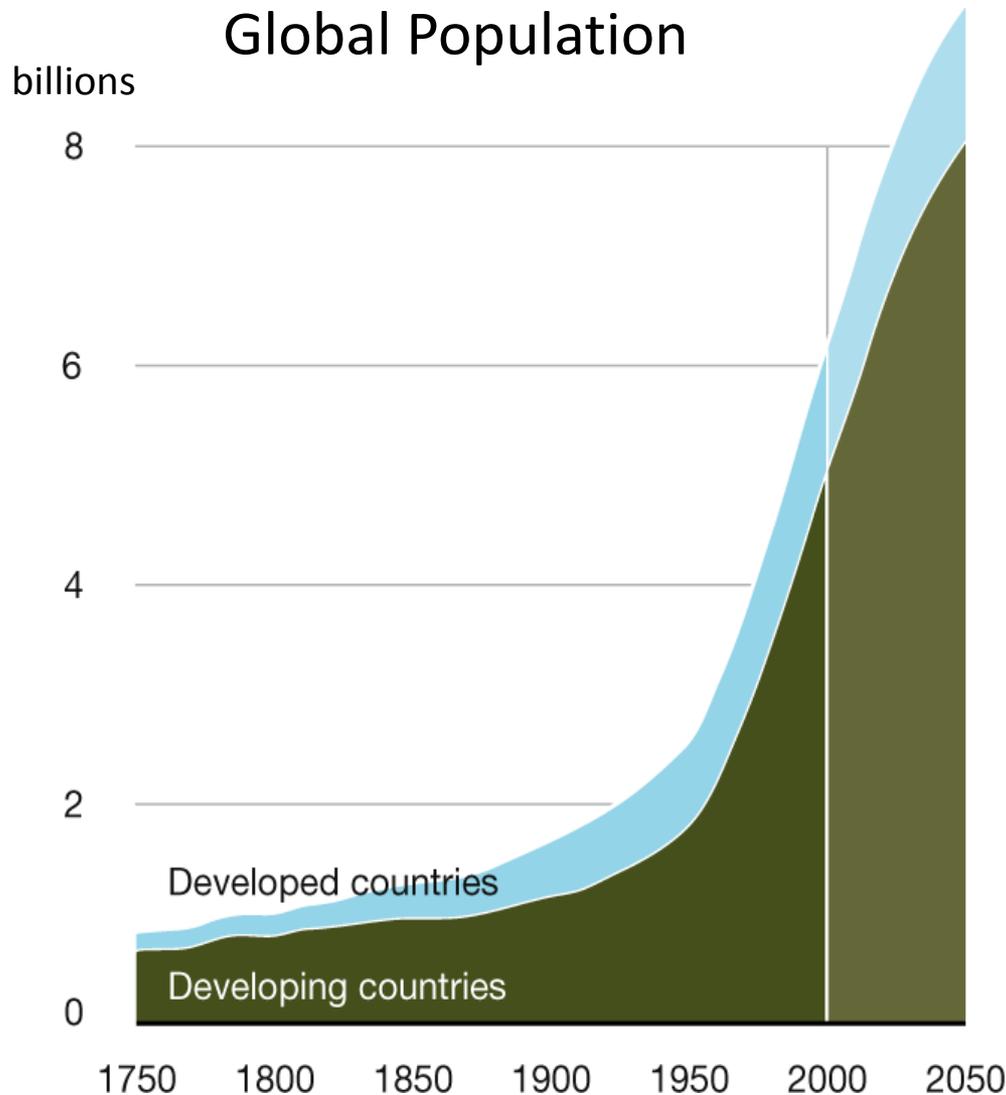


Global deaths for children under 5



- Moving from a focus on child survival to child thriving
- Supporting a healthy planetary biome to support thriving societies

Risks looking forward

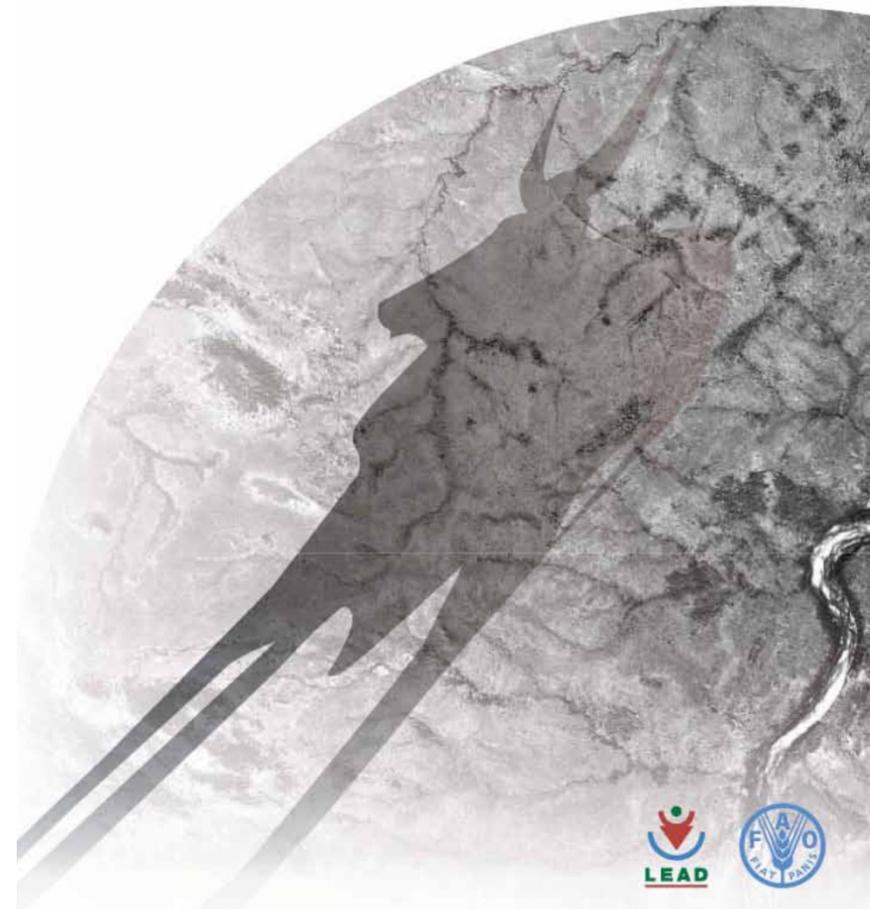


- Non-sustainable pressure on global resources
- Shocks
 - Volcanic eruption
 - Regional nuclear conflict
 - Pandemic

What can we do?

- Raising livestock accounts for
 - 30% of total human water use
 - 55% of erosion
 - Water pollution
 - 33% of nitrogen and phosphorus
 - 37% of pesticides
 - 37% of heavy metals
 - 50% of antibiotics

livestock's long shadow
environmental issues and options



The World's Second Food Security Challenge

or

The Food Security Roots of the
Middle Income Trap:

Scott Rozelle, Senior Fellow
Food Security and the Environment
Freeman Spogli Institute

The World's Second Food Security Challenge

Middle income trap

- When developing countries hit middle income (between US\$5,000 to US\$12,000 per capita), growth stagnates and in some cases economies collapse
 - Many different possible (theorized) sources (in past):
 - misdirected investment strategies;
 - interest groups that keep key infrastructure investments/policy changes from happening
 - One additional possible source (foreshadowing what we will examine in this presentation) is:
 - poor health and education due to systematic and chronic deficiencies in the foods that provide the nutrients needed for this stage of development → poor health and education → because jobs in a middle income country require health and educated individuals, many will be polarized out of the labor force → high cost to maintain the population / high crime / reduced investment → stagnation (yes: “caught in a trap”)

Goal

explore if there is a Second Food Security Challenge (when countries are in the Middle Income staged of Development) and try to understand how it occurs and what can be done to avoid it.

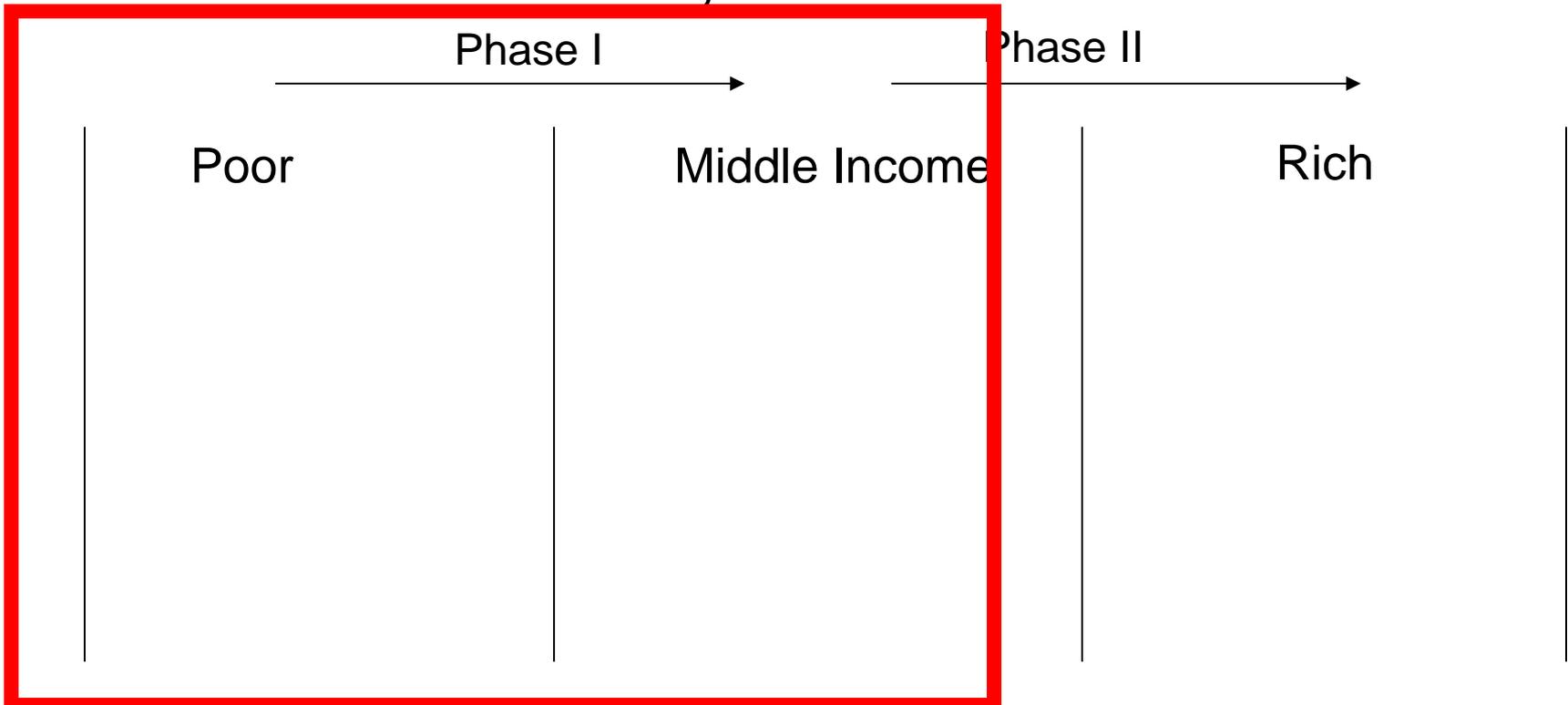
Plan

1. Background: Traditional Food Security Problem
 - Briefly review this in order to set up the contrasts and connections with the Second Food Security Challenge
2. Second Food Security Challenge
 - Economic Context
 - The Problem
 - The Reason
 - Policy Options
3. Summary and Conclusion

Will use some examples from China, a middle income country that I study, but, I believe this story is more generally true

2. Traditional Food Security: in Phase I of development

- The context: Countries at start of Phase I of Economic Development → poor, malnutrition, food deficit, high prices, access is difficult,



Definition: Traditional Food Security

- Food Security is:
 - having adequate supplies of affordable food (**calories/protein**);
 - for each household (a nation's population) throughout the year;
 - to ensure a healthy and productive life (economic growth path)

Food Security and Development Link: [In the case of Poor Countries]

- Insufficient calories / protein (macro-nutrients)
- Without enough calories →
 - Poor health
 - Increased morbidity
 - Stunting / wasting / chronic diseases
 - Negatively affects income → poverty/low income trap

Source of the problem for households

- The problem is one of “economic access”
- Economic access for the rural poor depends on income and food prices
- When prices are low, even those with low levels of income are typically able to access food in quantities enough to escape malnutrition (from the lack of calories)
- When prices are low and incomes are rising, food is even more affordable

Phase I: route to success (part a)

(this is how the Green Revolution jump starts economic growth when countries are poor)

- Increasing Incomes (in part with investment into Ag)
 - Rising Consumption
- Falling prices (in part with investment into Ag)
 - More Rising Consumption
- Falling Morbidity / Basic Education
- Stage I of Transformation of the Economy
 - Industrialization (phase I → low wage mfging)
 - Urbanization (phase I → temporary / permanent for some)
- Increasing Incomes [wages constant / more off-farm employment opportunities]
- Rising Consumption

[virtuous cycle begins → pushes economy to middle income]

Phase I: route to success (part b)

(Green Revolution is trigger / also need other policy efforts and economic transitions)

- Increasing Incomes (in part with investment into Ag)
 - Rising Consumption
- Falling prices (in part with investment into Ag)
 - More Rising Consumption

[virtuous cycle begins → pushes economy towards middle income]

- Falling Morbidity / Healthy Labor Force (*other policies: Basic Education*)
- Stage I of Transformation of the Economy (*also need good industrial and trade policies*)
 - Industrialization (phase I → low wage mfging)
 - Urbanization (phase I → temporary / permanent for some)
- Increasing Incomes [wages constant / more off-farm employment opportunities]
- Rising Consumption

Metric for success:

Traditional Food Security Policies

- Sufficient, low-priced calories / protein → macro nutrients is enough for most of the population
 - Those working in factories and constructions sites are healthy and strong
 - Those left working on the farm (larger farms) are healthy and strong

This is why producing lots of cheap calories and vegetable proteins is important ... Food Security with Phase I characteristics is an important part of development strategy when countries are just beginning their development push ... when they are poor people need sufficient macro nutrients

Food security success in Middle Income Countries (Kcal for 2009)

- Brazil: 3173
- China: 3036
- Mexico: 3146
- Thailand: 2862
- Turkey: 3666

FAOSTAT (2010)

2. World's Second Food Security Challenge

a. The Context: The Economic Setting of Middle Income Countries

[the context is important to understand as it explains how **malnutrition can coexist with rising incomes**

caution: the context can be complicated]

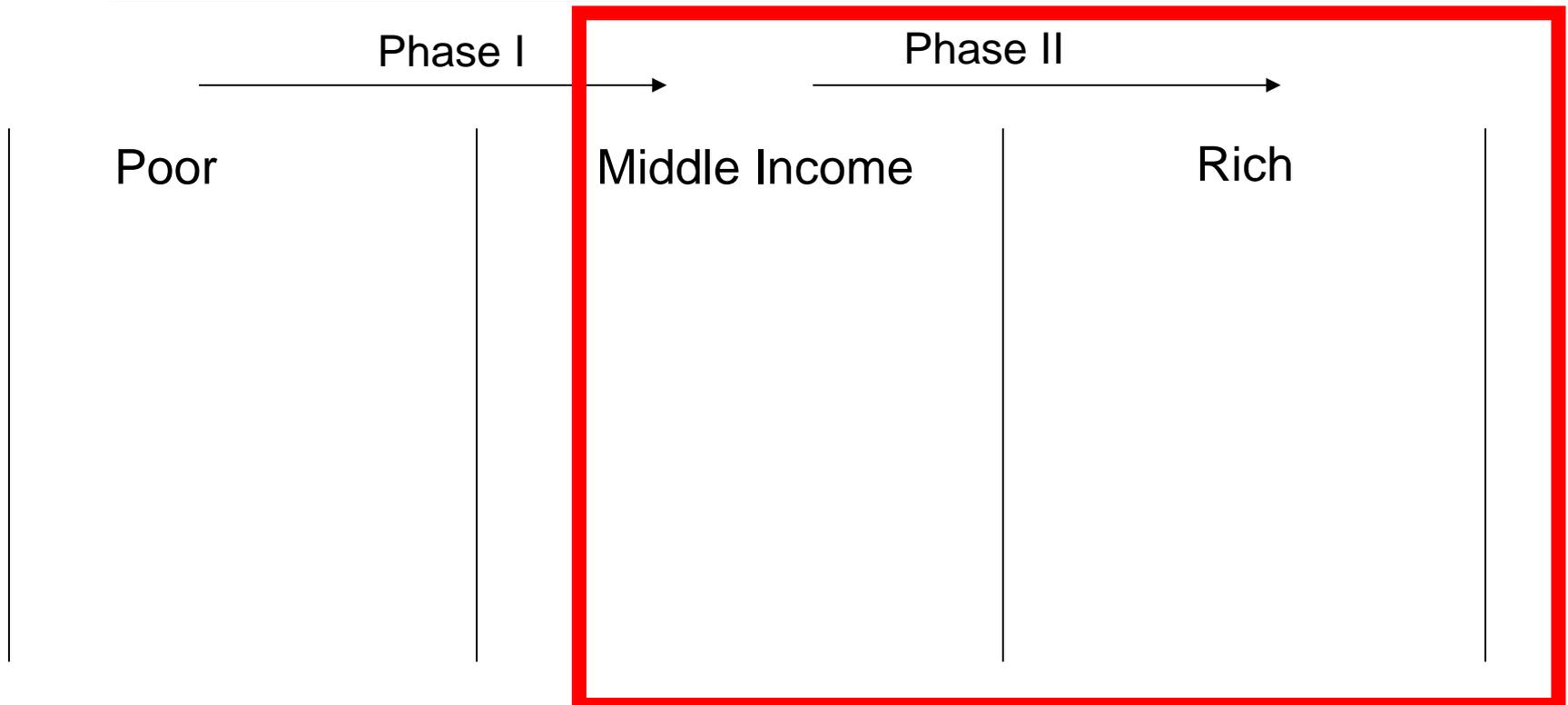
World's Second Food Security

Challenge is different

in (rapidly growing) middle income countries

- The context: Countries in Phase II of Economic Development

Economic Development is the process of transforming from poor to rich, but, in fact, it happens in TWO PHASES



Who is in Phase II?

- Countries with income per capita levels between \$5,000 to \$12,000 US dollars / capita
 - And a lot of other similar characteristics

Middle Income Countries Aspirees for High Income Status

- Argentina
- Brazil
- Chile
- Costa Rica
- Malaysia
- Mexico
- Russia
- Thailand
- Tunisia
- Turkey
- Uruguay
- Venezuela

China

Who is in Phase II?

- Countries with income per capita levels between \$5,000 to \$12,000 US dollars / capita
- Countries that also share a lot of other characteristics

Phase II countries are in new stage of transition

- In phase II (especially for rapidly growing countries), economic dynamic of a country is different from those in phase I:
 - Wages rising
 - Rapid, permanent urbanization
 - Low wage manufacturing / subsistence agriculture disappearing
 - Re-industrialization → high-value, innovation-based industries and service sector
 - High premium on education/health (need to have skills in math / science / language / foreign language / etc. to get a job – at the high and rising wage rate)

Phase II countries are in new stage of transition

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What were the types of jobs that people had in South Korea during the 1990s?

Phase II countries are in new stage of transition

- In phase II (especially for rapidly growing countries), economic dynamic of a country is different from those in phase I:
 - Wages rising
 - Rapid, permanent urbanization
 - Low wage manufacturing / subsistence agriculture disappearing
 - Re-industrialization → high-value, innovation-based industries and service sector
 - High premium on education/health (need to have skills in math / science / language / foreign language / etc. to get a job – at the high and rising wage rate)

What are the types of jobs that people have in Mexico today?

All of this, of course, takes place in an environment that is NOT that of a fully developed country

- Characterized by underdeveloped (less than perfect) economic and social institutions:
 - Less than perfect credit markets (have to save for everything – housing / education / etc)
 - Less than perfect health insurance
 - Less than perfect social security
 - Less than perfect welfare systems

[that is these countries typically only have a low and permeable safety net]

YET: Another common characteristic:

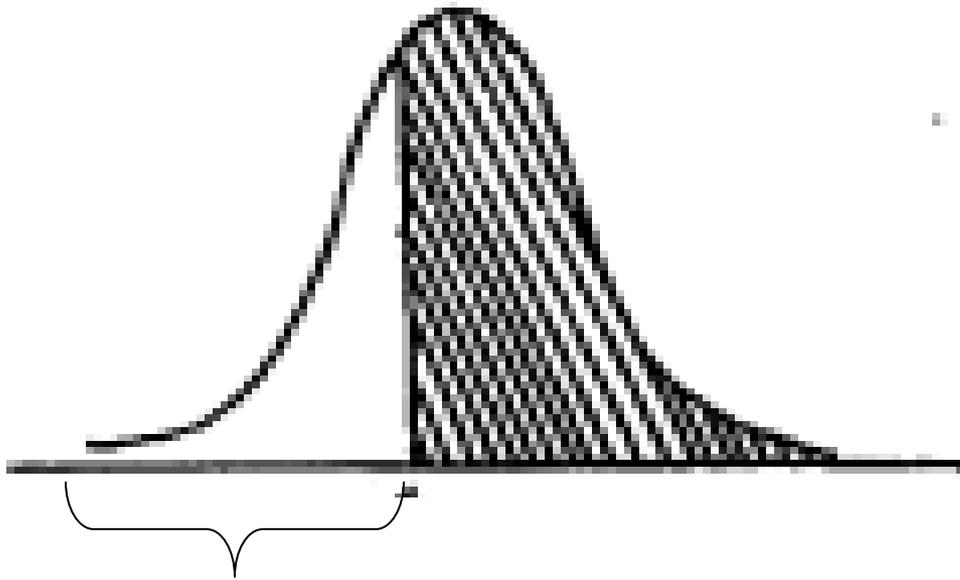
Aspirees (middle income countries) almost all middle income countries are countries with **high levels of Inequality** (gini ratios)

- Argentina (46)
- Brazil (54)
- Chile (52)
- Costa Rica (50)
- Malaysia (46)
- Mexico (52)
- Russia (42)
- Thailand (42)
- Tunisia (41)
- Turkey (43)
- Uruguay (42)
- Venezuela (44)

China: 50

Implications of high inequality:

Although average per capita income rising
& absolute grinding poverty is disappearing
→ still many “near-poor” people



China: 150 million people < \$2 / day

300 million people < \$3 / day

[although most billionaires in the world!]

Food security in the Middle Income World

- Not macro nutrient deficiency:
- Micro nutrient deficiency!
 - Hidden hunger:
 - Iron
 - Zinc
 - Vitamin B
 - More

As we have seen:

There are few calorie deficiencies
(Kcal for 2009)

- Brazil: 3173
- China: 3036
- Mexico: 3146
- Thailand: 2862
- Turkey: 3666

FAOSTAT (2010)

Food security in the Middle Income World

- Not macro nutrient deficiency:

- Micro nutrient deficiency!

- Hidden hunger:

- Iron
 - Zinc
 - Vitamin B
 - More

2b. What is evidence of micronutrient deficiencies in middle income countries?

- Whole World
- Case Study of China

Scope of problem (% with iron-deficient anemia)

Country	Pre-school	Pregnant Women	Reproductive-aged Women
Brazil	55	29	23
Mexico	30	26	21
Thailand	25	22	18
Turkey	33	40	26
China	20	29	20
US	3	5	7

And infants and school-aged
children (in China):

First: infants ...

What is the quality of China's youngest babies?

- Testing ≈2000 babies and their Mom's in Southern Shaanxi



(these areas are 2 to 3 hour drive from Xi'an – one of China's fastest growing cities)

Malnutrition during the first 1000 days

- Of the 1960 babies tested (in 2013)

➔ 862 of them are malnourished

*> 40 percent of infants are sick
with iron deficient anemia*

What are the Cognitive Consequence of Malnutrition?



All babies are being given an Infant IQ test (Bayles test)



Cognitive Consequence of Malnutrition

- Around 40 percent of infants also FAILED their baby infant IQ tests (highly correlated with anemia rates)
 - Malnutrition →
 - Sub-normal cognition
 - Sub-normal motor skills

We actually just did our fourth follow up survey (2015) and about 50% are failing the toddler IQ tests

Ultimate Consequences:

If the micronutrient deficiencies of infants / toddlers are not corrected before baby is 30 months old →

- **Life time** effects on:
 - IQ
 - Mental health
 - Height
 - Weight
 - Health

What does this mean?

In harshest terms:

Nearly 20 to 25 percent of China's future population (100s of millions of people) are in danger of becoming **PERMANENTLY** physically and mentally **HANDICAPPED**

... and school-aged children (in
China):

Between 2008 and 2013 we tested
nearly 60,000 students across
China for iron-deficiency anemia

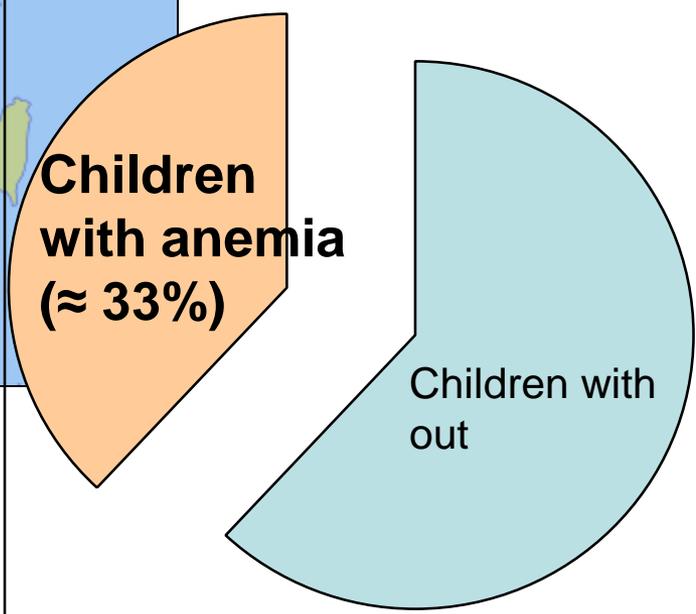
In fact, anemia is all over China

	Total
Total	33.7
Shaanxi—2008 (Dataset 1)	37.5
Shanxi—2009a (Dataset 2)	31.6
Gansu—2010 (Dataset 3)	31.2
Qinghai—2009 (Dataset 4)	51.1
Ningxia—2009 (Dataset 5)	25.4
Sichuan—2010 (Dataset 6)	24.8
Guizhou—2010 (Dataset 7)	33.1

Luo, R., X. Wang, C. Liu, et al. (2011) "Alarming High Anemia Prevalence in Western China." *Southeast Asian Journal of Tropical Medicine and Public Health* Vol. 42 No. 5



Poor areas of China



≈ 30 million school aged children are estimated to have anemia ...

Anemia → also can have severe effects on children populations



- Anemia affects:
 - School performance
 - Attendance
 - IQ
 - Health
 - Behavior

*Anemia → poor educational and cognitive performance / Stoltzfus et al. 2001 (in developing countries); **Bobonis et al. 2006 (in India)**; Halterman et al. 2001; Nokes et al. 1998 (US)*

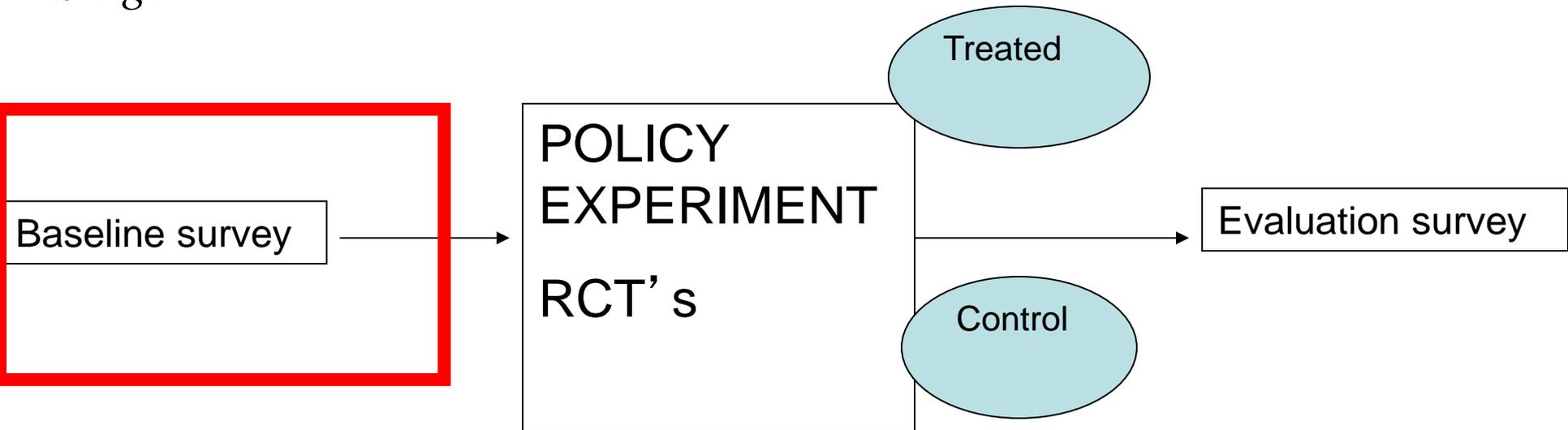
Does Addressing Anemia Really
Lead to Better Educational
Performance?

Our In-the-field Experiment

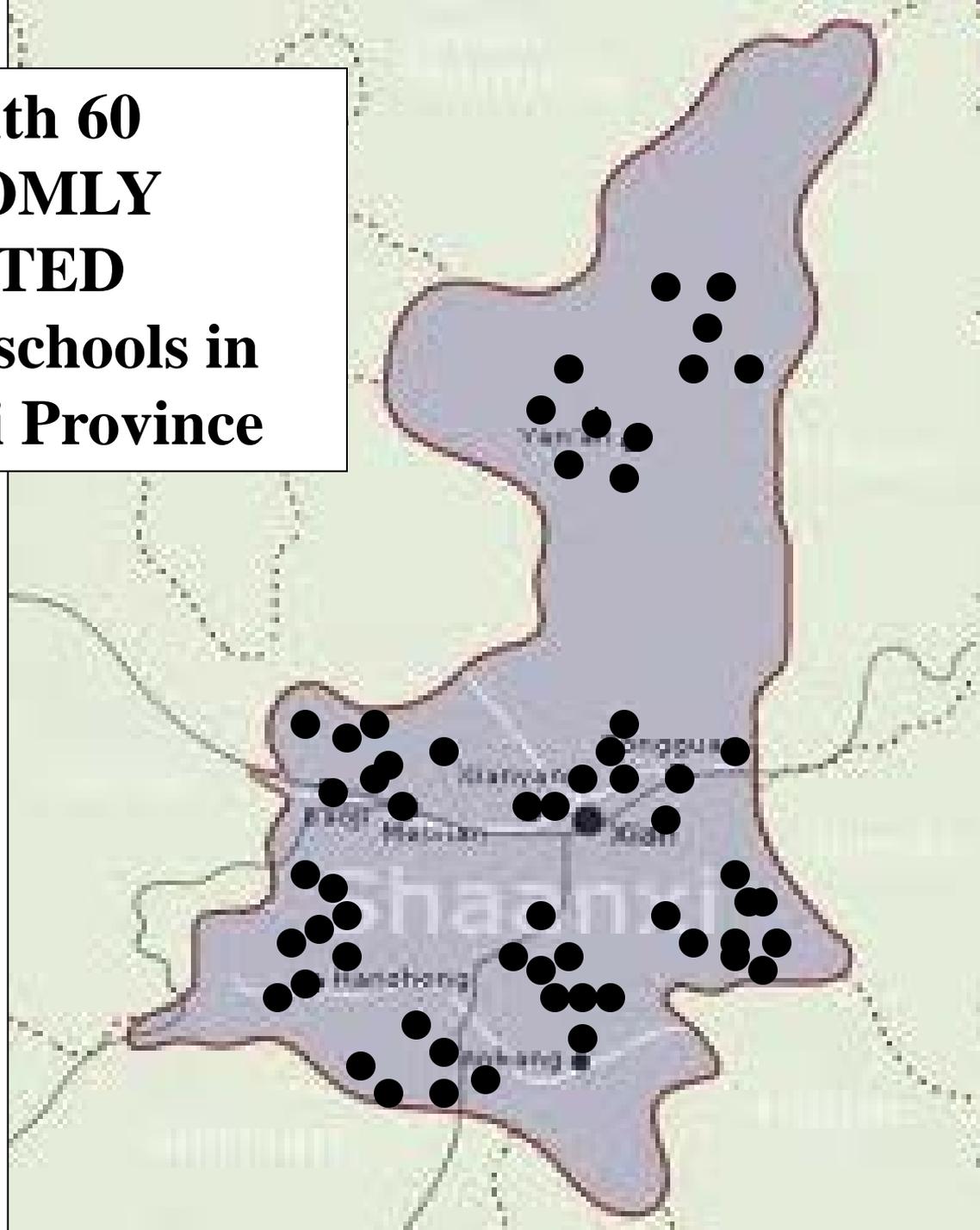
Will iron supplements → less anemia?

Lower anemia → Better school performance?

Stage 1



**Start with 60
RANDOMLY
SELECTED
sample schools in
Shaanxi Province**

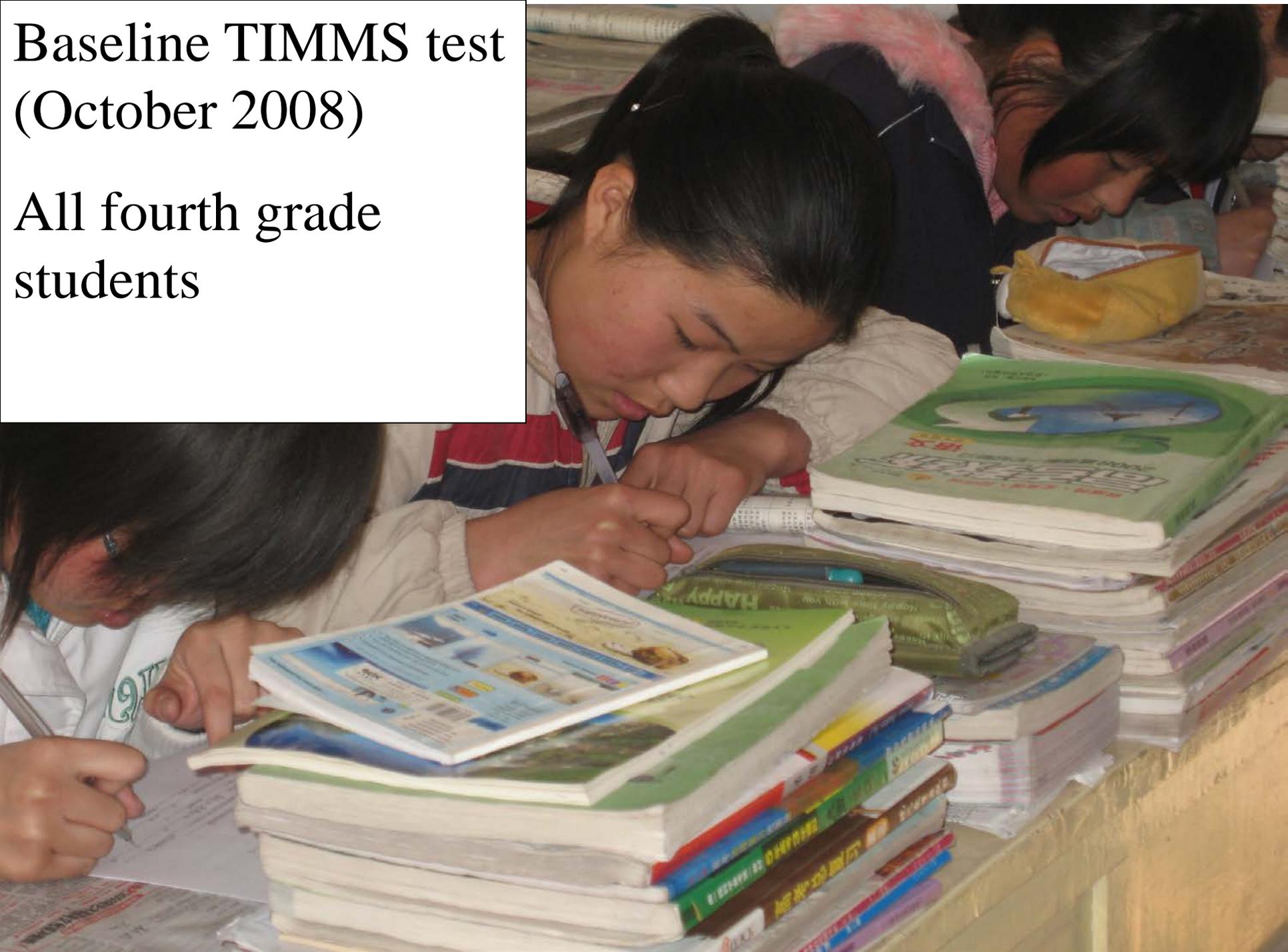


Using Hemocue 201+ technology → measures Hb levels (Oct. 2008)



Baseline TIMSS test
(October 2008)

All fourth grade
students



flipping a coin ...



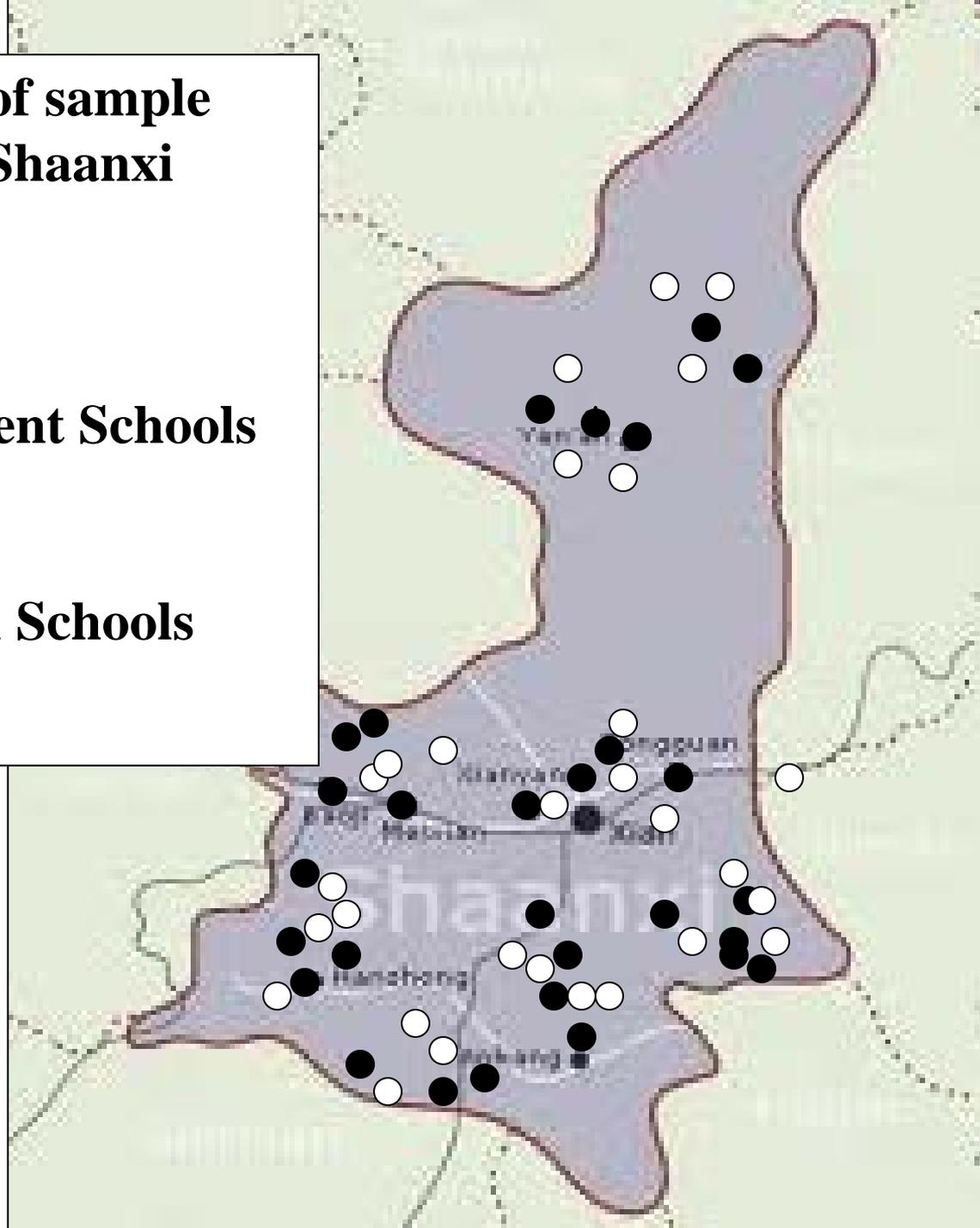
“heads” is treatment
school (●) ...

... “tails” → is control
class (○)

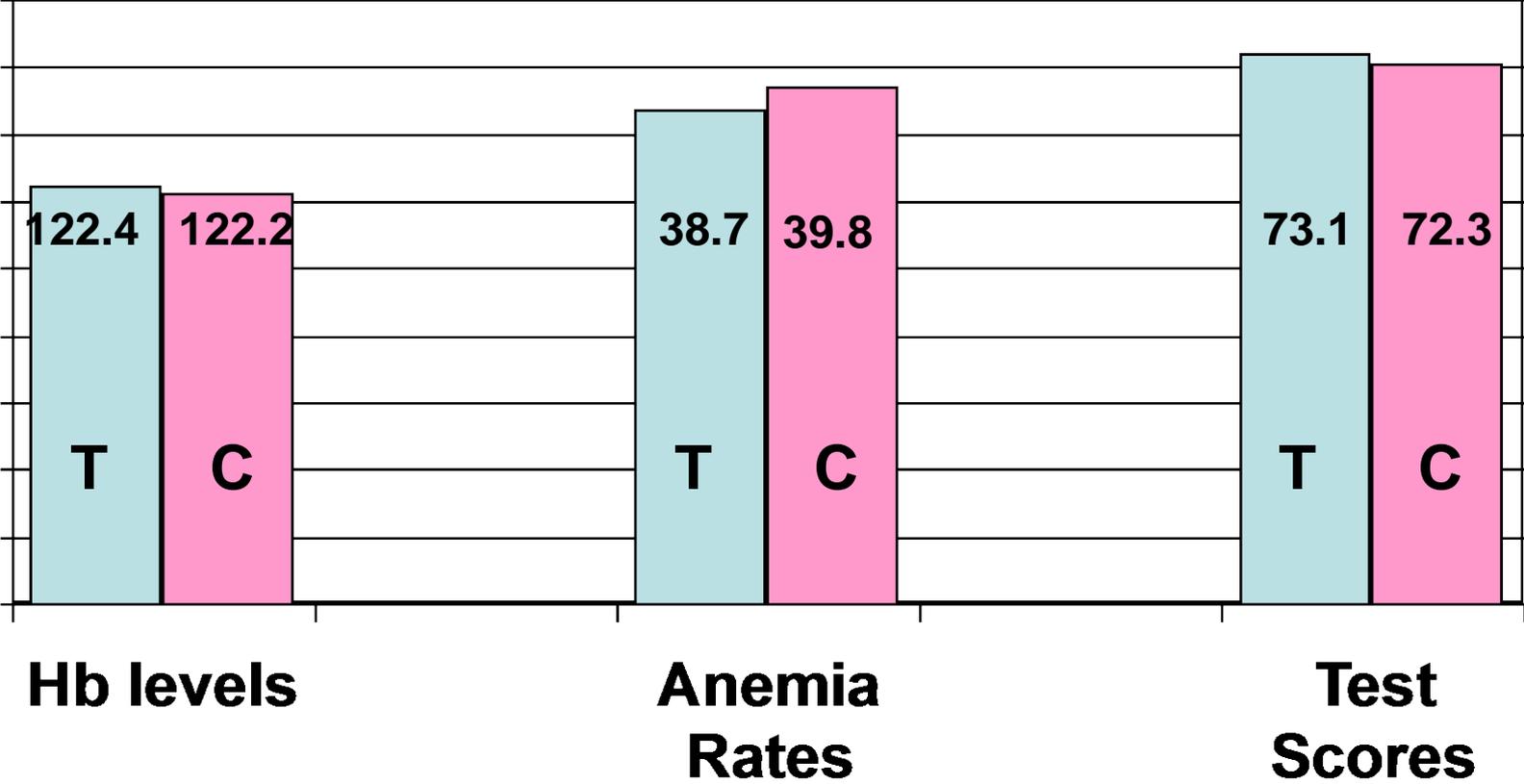
Locations of sample schools in Shaanxi Province

● Treatment Schools

○ Control Schools



Pre-balanced at the baseline between 30 Treatment (T) Schools and 30 Control (C) Schools



Prebalancing ensures that schools in treatment groups and schools in control groups are statistically identical prior to the intervention (like identical twins)

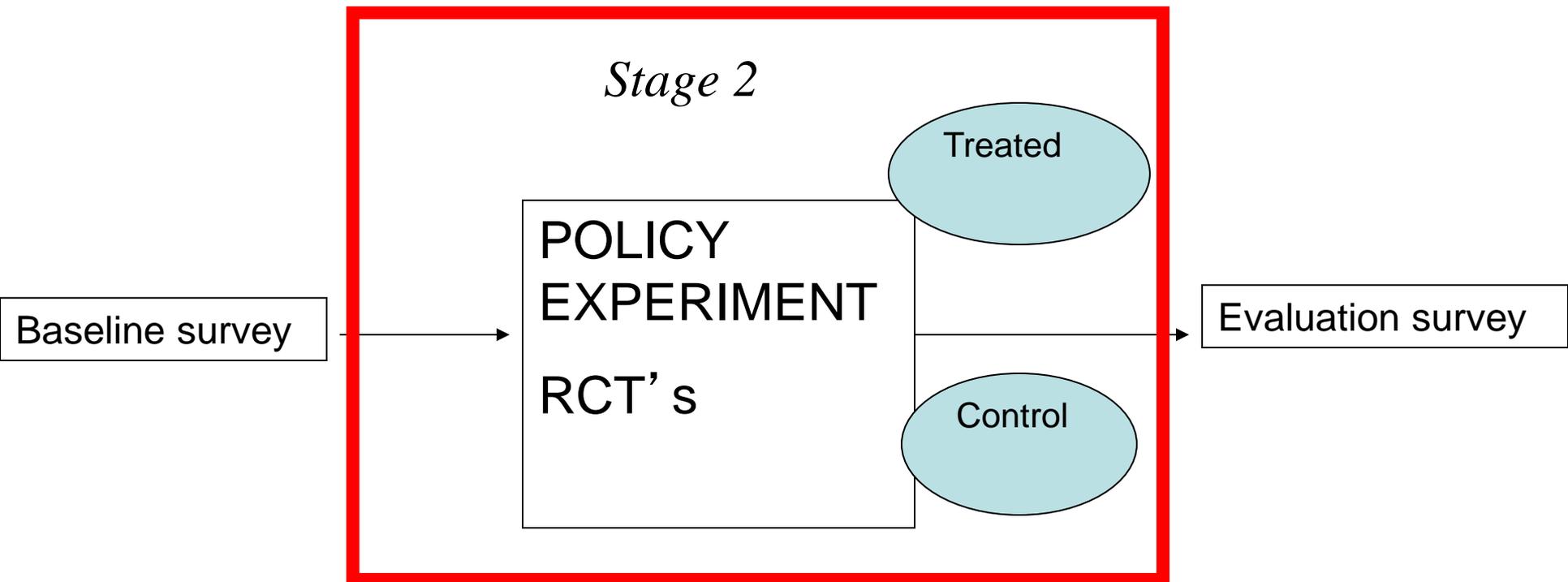


Therefore, after the intervention, we can interpret any differences to the outcome variables (Hb levels, anemia, test scores) to be due to the intervention

Stage 2 → The Intervention

Will iron supplements → less anemia?

Lower anemia → Better school performance?



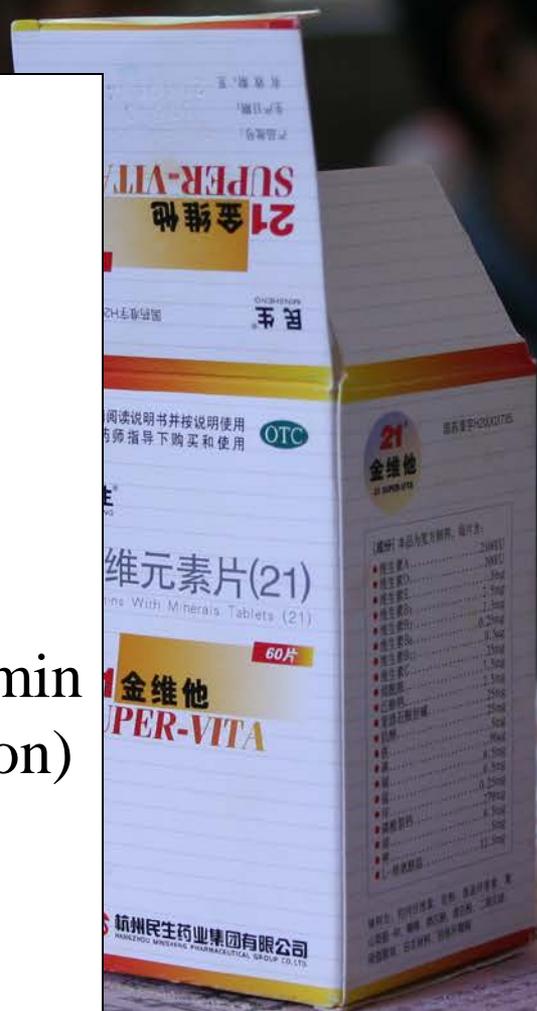
The Intervention

School Type A
(30 schools)

“Centrum / Day”

Give students one multi-vitamin
with iron per day (5 mg of iron)
... from November 2008 to
May 2009 (≈ 4 US cents/day)

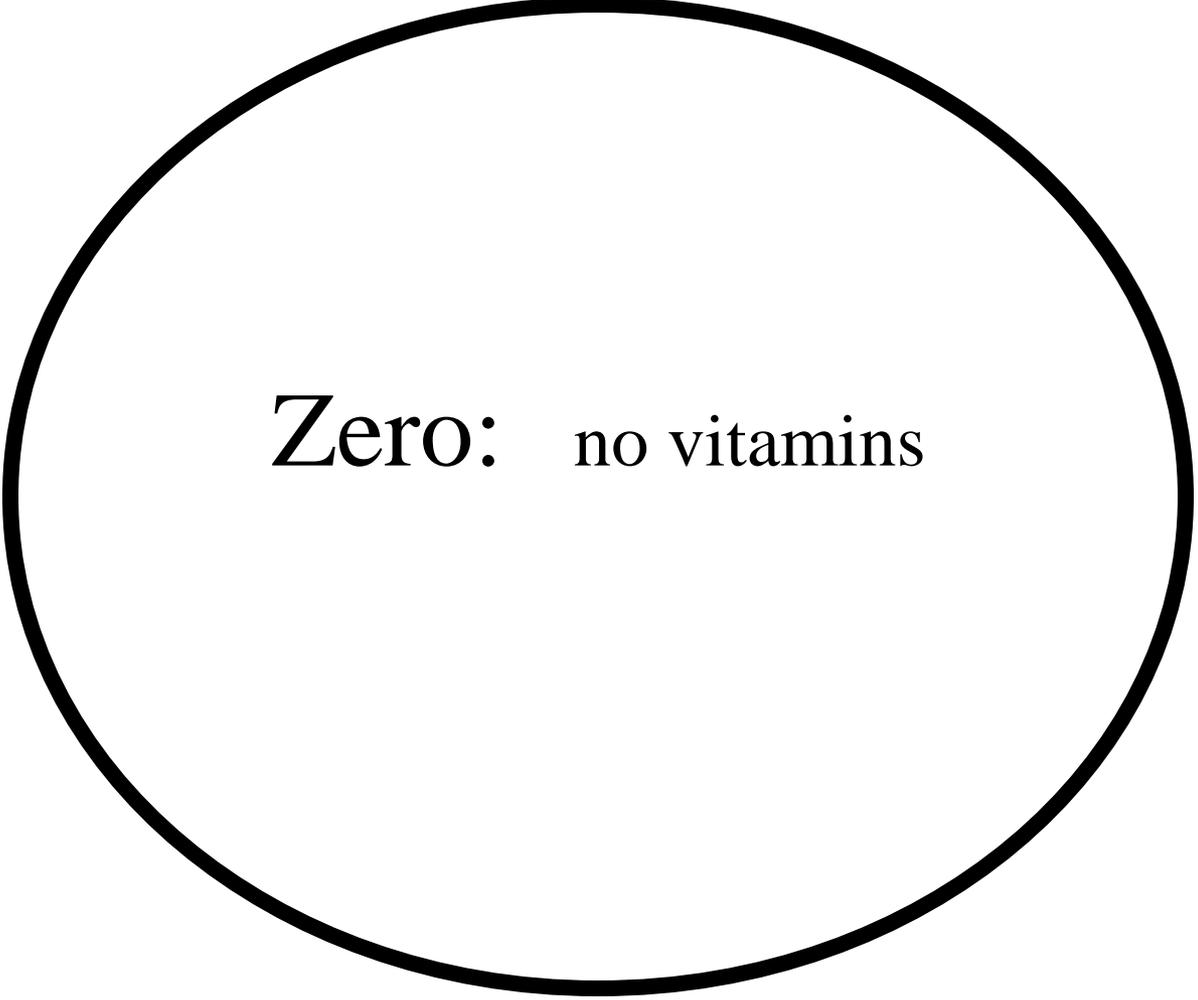
...







30 control schools

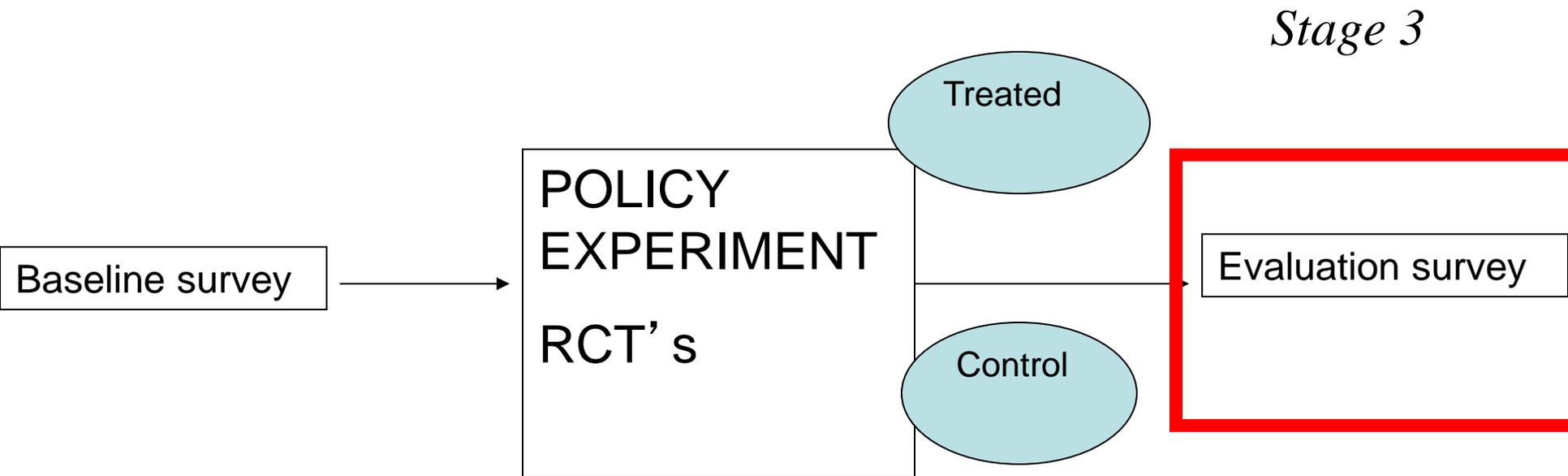


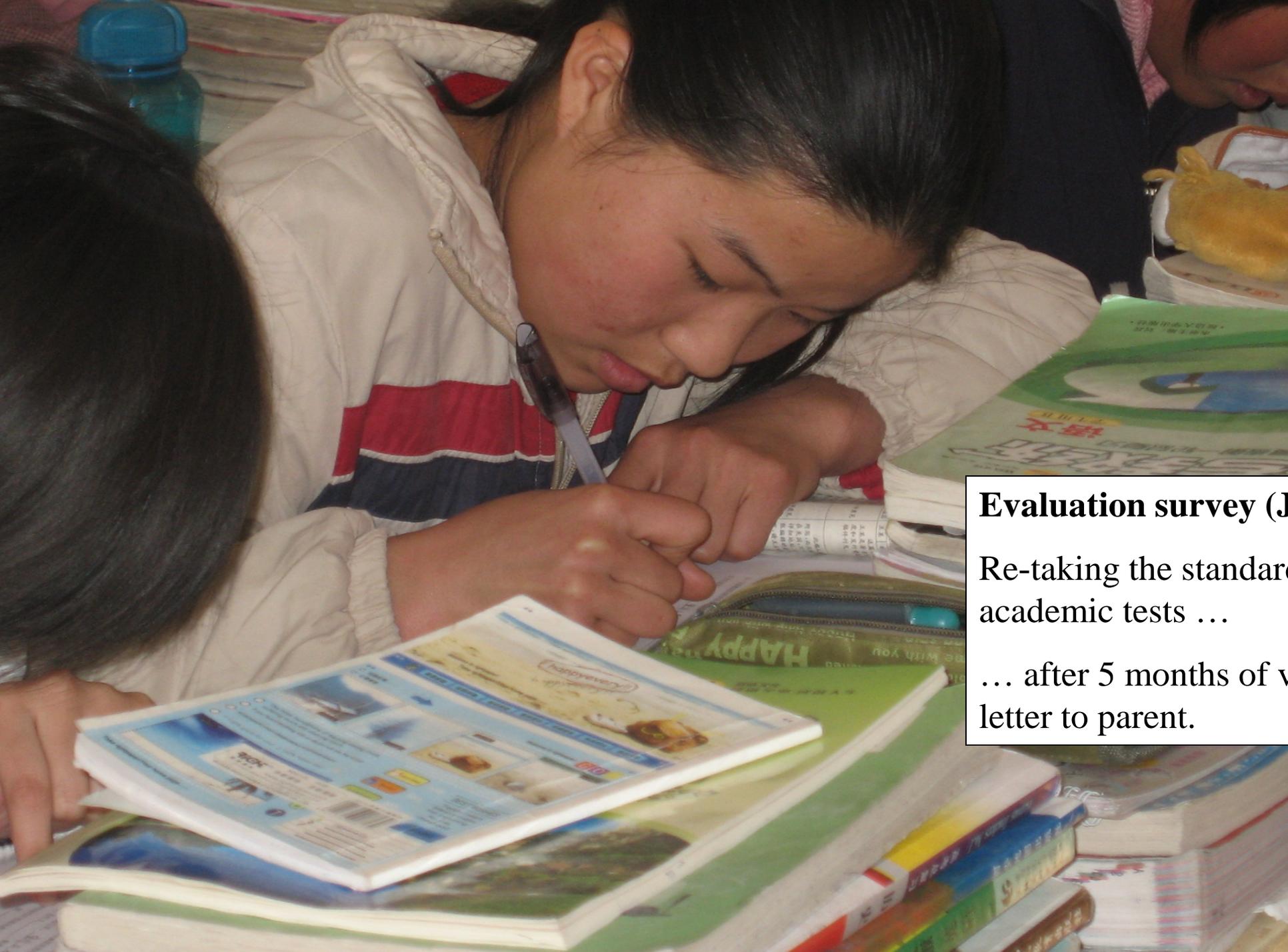
Zero: no vitamins

Our In-the-field Experiment

Will iron supplements → less anemia?

Lower anemia → Better school performance?





Evaluation survey (J

Re-taking the standard
academic tests ...

... after 5 months of v
letter to parent.

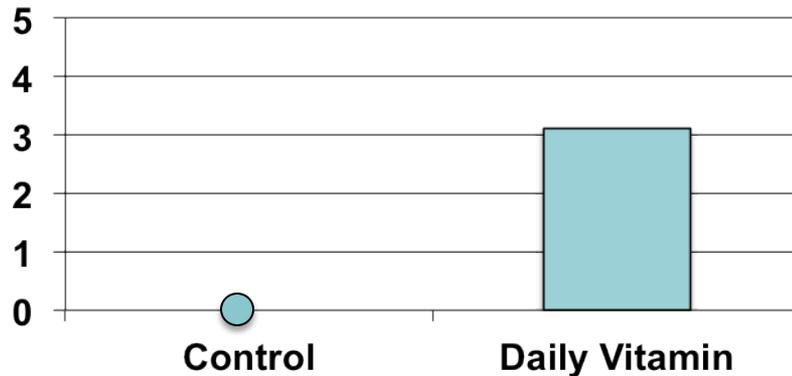
Re-taking the Hb Test (June 2009) Still anemic or not?



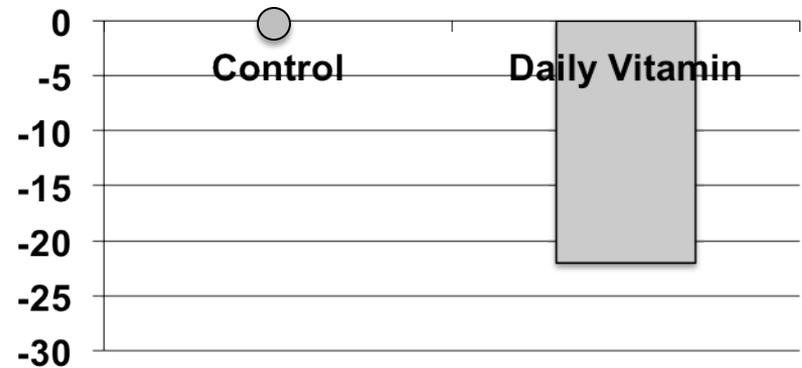
Results

Impact of daily vitamin on students:

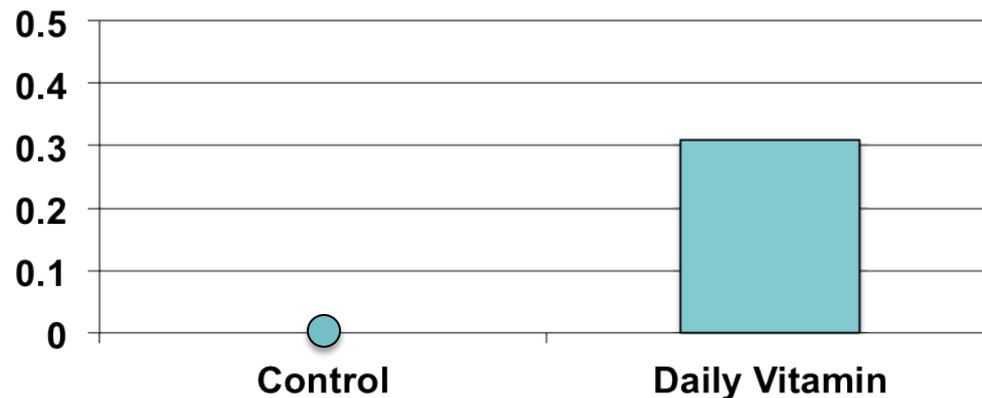
Hemoglobin



Anemia (%)



Math Test Scores (std. dev.)



Other interventions

Intervention Two: 1 egg/day + vitamin



Intervention Three

Chewable Vitamin per Day



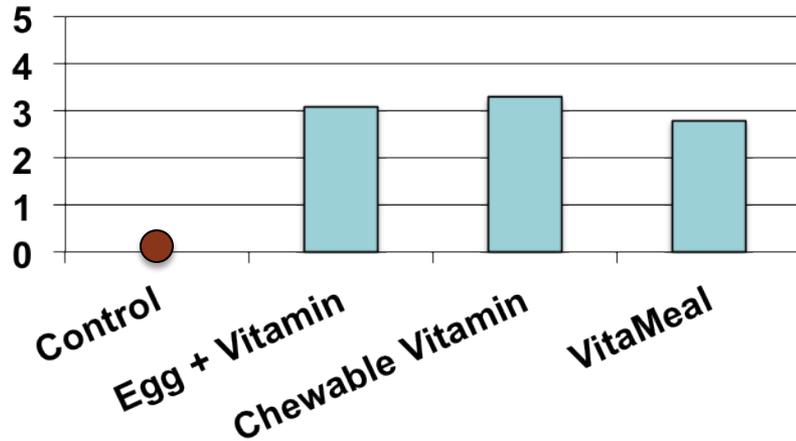
Intervention Four

Vita Meal (vitamin fortified porridge)

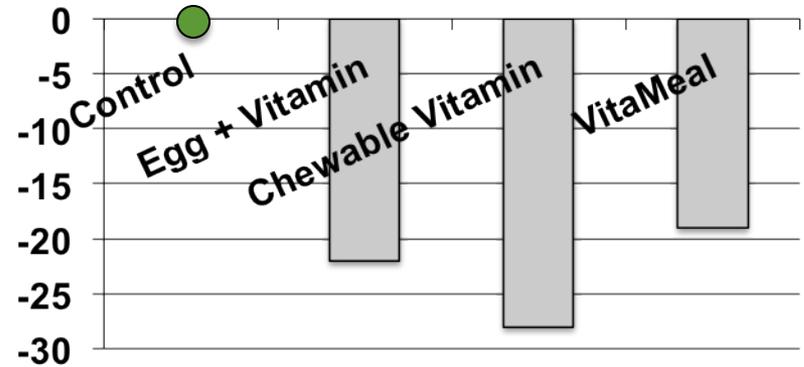


Impact of vitamin supplementation on students

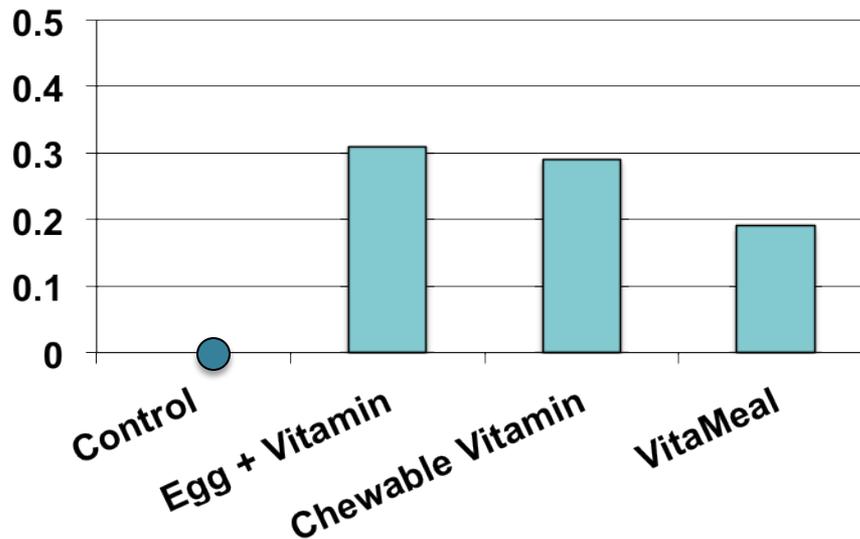
Hemoglobin



Anemia (%)



Win
Win
Win



Math Test
Scores
(std. dev.)

Does Addressing Anemia Really
Lead to Better Educational
Performance?

Answer: Yes ...

&

Implications: if anemia rates are
high, students are underperforming

Summary: Longer-run Implications for Economy / Society

- 100s of million of children are cognitively impaired
- They are not competitive in school system
- Do not learn / Drop out
 - It is ok at first ... wages are rising ... still low wage, unskilled jobs [this actually exacerbates the drop out problem ... victim of own success]
- Low wage jobs disappear ... only high wage jobs left ... employers will not hire someone for a high wage if they can barely read and write (no math / no science / no language skills → no formal job)
- Polarization of the labor market:
 - Half in high wage sector (rich get richer)
 - Half in informal sector ... or drop out all together (gangs / organized crime)
- Society has to spend more and more on police / crime / security ... large part of labor force is unproductive (or counter-productive ... investment falls as uncertainty rises) →
VICIOUS CYCLE and STAGNATION

c. Explanation for the causes of the
Second Food Security Challenge

Real Question: What is going on?

- Countries are growing and growing fast
- Wages are rising
- There are a lot of poor people, but, not extreme poverty
- ➔ So, why don't families invest in their:
 - Babies?
 - Children?

Two reasons

REASON ONE:

The Price of Food:

- Victim of their success in Phase I ...
- Investments in agriculture / open door policies → are behind growth ...
 - contributed to alleviation of worst poverty
 - and: made price of food low ...
- Cheap calories (from staples) raise demand for staples by those in the lower end of the income distribution (even though they could afford more)

Many reasons for not spending more on diversified diet

- i. Real cost of meat and fruits and vegetables is not only relatively expensive, they are absolutely expensive (in real terms)
 - Need refrigeration
 - Need markets close by
 - Need time if markets not close by
 - More expensive to prepare

ii. Many competing uses for extra income

- There is extra income ...
- But, as DuFlo and Banerjee point out:
 - There are many competing uses for the income of families in developing countries (especially in countries with underdeveloped economic and social institutions – which as we see characterizes middle income countries)
 - Saving for marriage
 - Saving for housing
 - Saving for retirement
 - Saving for catastrophic illnesses/injuries
 - Temples; celebrations; and more
 - Etc / etc / etc
 - Why spend additional money on higher-priced, more varied diet

ii. Many competing uses for extra income

- There is extra income ...
- But, as DuFlo and Banerjee point out:
 - There are many competing uses for the income of families in developing countries (especially in countries with underdeveloped economic and social institutions, which come with characteristics of middle income countries)
 - In short, this is often called:
 - “the battle for the wallet”
 - Saving for retirement
 - Saving for catastrophic illnesses/injuries
 - Temples; celebrations; and more
 - Etc / etc / etc
 - Why spend additional money on higher-priced, more varied diet

REASON TWO: absence of knowledge

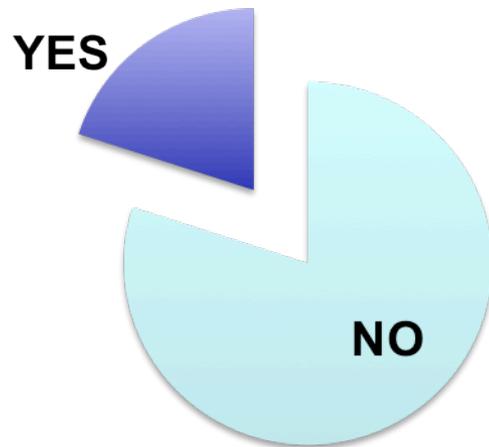
- Hidden hunger: no outside symptoms
- Slow and imperfect correlation between nutrition intervention and anemia status and behavior/performance/physical status
- With high rates of migration, caregiving is being done by Grandma: “I never ate meat, and aren’t I ok?” ...
- Time inconsistency between demand for skills and need to invest in skills: Current health and cognitive skills are fine for now; but, not sufficient for 10 to 20 years from now
- Lack of any formal nutrition education/training.

Empirical evidence

- The most educated person in a rural community is often the **principal of the school**:
 - But: only 1 out of 20 even know what “anemia” is
 - Principals believed that only 3% of their students were nutritionally deprived (actual number is more than 33%)
- Only 2 out of 100 caregivers have had any formal education/training in nutrition ...
- MORE (from our study on infants) →

Survey of 2000 caregivers (Moms and Grandmas in rural China, 2012

Percent of women that know that human babies require micronutrients:



Percent of women that know that baby pigs require micronutrients:

