Disease and Development DSE Winter School 2020, Lecture 1

Pascaline Dupas

December 14, 2020

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Introduction



Introduction

- Tropical regions tend to be poor
- Is there something about the tropics that makes it harder for countries to grow?
- One story: tropical diseases
 - malaria, yellow fever, dengue, ebola, helminths, sleeping sickness, lymphatic filariasis, schistosomiasis, ...

Correlations between Health and Income - Preston Curve





Source: Clio-Infra & UN Population Division ; Maddison Project Database (2018)

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Our Worl in Data

Correlations between Health and Income



Anemia and Income per Capita

source: Shastry and Weil (JEEA 2003): "How Much of Income Variation is Explained by Health?"

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Correlations between Health and Income



Also within-country: co-movement of health and income

 In the US, mortality hazard declines with income and with education, but hard to differentiate respective roles of income and education (Deaton and Paxson, 2001). Also within-country: co-movement of health and income

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- Also in the US, life expectancy gap between rich and poor is growing:
 - gap in life expectancy at age 65 between highest and lowest deciles grew from 0.3 years to 1.6 years between 1980 and 2000.
 - Recent work on this by Raj Chetty and team: https://healthinequality.org/

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 - Recent work on this by Raj Chetty and team: https://healthinequality.org/
- In lower income countries, the relationship between income and health is stronger
 - Under five mortality more than twice as high in bottom quintile as in top quintile.



Under-five mortality rate in urban areas By UN region and urban wealth quintile, 2005–2013

Source: UNICEF 2015

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Which way does the causality go?

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Which way does the causality go?

- Most likely, both ways
 - Health matters for productivity
 - Health is a normal good: rises with income

Historical Data on Health

- ► The 1000-yr perspective....
- Prior to the Industrial Revolution:
 - there was little long-term change in average health, though with considerable short-run variation (e.g. Black Plague)
 - cross-sectional differences (across countries) in health were small

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- In the 19th century, there was a takeoff of health in Europe and its offshoots, with little change elsewhere
- Starting in the middle of the 20th century, health improvements in trailing countries began to exceed those in leaders
 - Health convergence in last 50 years much stronger than income convergence

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 Timing above suggests important effect from income to health (with positive spillovers)

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- ▶ In high-income countries, these happened roughly in the order listed
- In catch-up countries, the order was different
 - benefited from medical discoveries in high-income countries, so arguably "exogenous" shock to health (shifting up of Preston Curve)

Preston Curve shifting up



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Health - Income Nexus

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Health - Income Nexus

- Likely, a two way relationship
- Such two-way relationships can give rise to multiple equilbria situations
 - possibility of poverty traps

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Health - Income Nexus

- Likely, a two way relationship
- Such two-way relationships can give rise to multiple equilbria situations
 - possibility of poverty traps
- Today's lecture: Focused on understanding the causal effect of health on development

(Do we really need a whole lecture on this?)

IMF Forecast Shows Slight Improvement for 2020

Global GDP growth estimates published by the IMF before and during the COVID-19 pandemic (in %)



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(Do we really need a whole lecture on this?)

Pre-COVID, many economists not convinced that disease burden could be a fundamental cause of lower economic growth....they may still tell you that COVID is different....so we'll go ahead with the lecture!

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Direct effect of disease on productivity

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- Direct effect of disease on productivity
 - Disease burden \Rightarrow Poor nutrition \Rightarrow Lower productivity
 - ► Disease burden ⇒ Many illness spells ⇒ Fewer days worked (because sick oneself or caring for sick relative)
 - ► Disease burden ⇒ Exposure in utero or childhood ⇒ Reduced endowments (physical, IQ) ⇒ Lower productivity

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- Indirect effect of disease on productivity (via *lower levels of* investments in education)
 - ► Disease burden ⇒ High health care costs ⇒ Reduces income available for investments in education, production, etc.
 - ► Disease burden ⇒ Shorter life expectancy ⇒Reduced returns to investing in education
 - ► Disease burden ⇒ High infant mortality ⇒ Higher fertility ⇒ quality-quantity tradeoff
 - Disease burden ⇒ Orphanhood / sick parents ⇒ Need to work as child to compensate (household work or labor market work) ⇒ no time for school

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 Disease burden reduces returns to business and infrastructure investments

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 - ► Disease burden ⇒ Less foreign direct investment⇒ Fewer resources in-country

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- Other potential effects:
 - \blacktriangleright Disease burden \Rightarrow Outmigration of those who can afford to leave \Rightarrow Fewer resources in-country
 - Disease burden \Rightarrow Less income from tourism
 - Communicable Disease burden ⇒adoption of social structures that reduce disease transmission ⇒may inhibit the diffusion of new technologies and restrain economic development (Fogli and Veldkamp, 2016: "Germs, Social Networks and Growth")
COLLECTIVIST INDIVIDUALIST

Period 1:



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Period 3:



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Period 5:





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Period 7:



Period 8:



Period 9:



Period 10:



Germs and Social Networks



- Hofstede Individualism index: constructed by sociologists to measure dependency of individuals from the group (varies between 0 and 100).
- Pathogen prevalence of 9 of the deadliest communicable diseases: leishmanias, leprosy, trypanosomes, malaria, schistosomes, filariae, dengue, typhus and tuberculosis, from 1930 atlases of infectious diseases (on a 4 points scale).

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Impact of Animal Disease?

Tse-Tse fly

- Unique to the African continent
- Transmits a parasite harmful to humans and lethal to livestock
- Limits the use of domesticated animals in transport and agriculture and inhibits the adoption of animal-powered technologies
- So it's not only the human disease burden that may cause Africa's underdevelopment, possibly also animal disease burden

Animal Disease



Α. TseTse Suitability Index (1871)

Notes: Panel (A) shows the historical TseTse suitability index created using climate data from NOAA's 20th century reanalysis for the year 1871. Panel (B) shows the observed TseTse distribution in 1973 (Ford and Katondo, 1977).

Source: Alsan (2015). "The Effect of the TseTse Fly on African Development". American Economic Review.

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Areas of Africa with Tse-Tse are poorer....



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- Acemoglu, Johnson, Robinson (AER, 2001): "The Colonial Origins of Comparative Development: An Empirical Investigation."
 - Disease burden at the time of colonization determined where europeans settled en masse and where they only sent a few people
 - Determined which institutions were established

AJR (2001)

- If no or few European settlers in colonized country, no incentive to establish strong property rights and instead establishment of extractive rent-seeking institutions
- When there were significant settlements (e.g. US, Canada): Lower strata of European settlers demanded property rights; placed constraints on elites' ability to establish rent-seeking institutions
- Institutions persisted even after independence
- ► So: Disease burden ⇒ Potential mortality of European settlers ⇒ European settlements ⇒ Better early institutions ⇒ Better current institutions

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 At the macro-level, some have argued extremely high impact of health on GDP per capita (Sachs, Commission on macroeconomics and health)

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- At the macro-level, some have argued extremely high impact of health on GDP per capita (Sachs, Commission on macroeconomics and health)
 - Gallup and Sachs (2001) quantified the association between malaria and the level and growth of per capita income
 - period 1965-1995
 - cross-country regression framework controlling for historical, geographical, social, economic, and institutional country characteristics
 - malaria endemic countries had, ceteris paribus, per capita income levels 70% lower than those of nonendemic countries
 - a 10% reduction in the malaria exposure index was associated with a 0.26 percentage point increase in annual per capita growth rates.
 - Revisited by Sarma et al. (2019, Am J Trop Med Hyg):
 - period 2000-2017
 - exploiting Roll Back Malaria efforts to estimate country fixed-effects model
 - a 10% decrease in malaria incidence is associated with an increase in income per capita of nearly 0.3% on average and a 0.11 percentage point faster per capita growth per annum.

Sarma et al. (2019)



Association between malaria incidence and gross domestic product per capita (GDPpc) purchasing power parity (PPP) over the period 2000–2017. The figure on the left (N = 2,948) shows the simple binned correlation between GDPpc PPP and malaria case incidence. This relationship remains after both variables are purged of the effect of institutions, trade–GDP ratio, country, and time effects (right, N = 2,948). For visual clarity, the figures group observations into equally sized "bins" based on log malaria incidence and plot the mean log malaria incidence with the respective mean log GDPpc

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Potential problems with these estimates?

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- Potential problems with these estimates?
- Tropical disease is a consequence of poverty as well, so reverse causality. Hard to isolate effect of health on growth.

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 Look at studies trying to go around reverse causality and OVB problems (both micro and macro)

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- Typical approach: Look at large-scale, targeted campaigns

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- Look at studies trying to go around reverse causality and OVB problems (both micro and macro)
- Typical approach: Look at large-scale, targeted campaigns
- Let's start with Historical Efforts to Combat Malaria
 - US, circa 1920, result of new public-health knowledge
 - Latin America, circa 1955, DDT-based worldwide campaign

Example: Malaria Eradication in the Americas (Bleakley, 2010)

- Set-up:
 - Relatively swift malaria eradication campaigns
 - Intensity of treatment depends on whether there was malaria before or not
- This enables a "Diff-in-Diff" estimation strategy:
 - First difference: across birth cohorts
 - Second diffence: across regions

Swift Eradication campaigns



Notes: Panel A plots the estimated malaria mortality per capita for the Southern region and bordering states. Because the dealt neglestration system was being phased in over the period, a regression model with state fixed effects is used to control for sample changes, and the time series is constructed from the year dummiss in the regression, normalized to match the Panel B reports tation on otifice causes of malarine for (Colombia (SEM, 1977)).

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1st difference: across cohorts



- This graph displays the fraction of childhood that is exposed to a hypothetical (instantaneous) campaign as a function of the year of birth minus the start year of the campaign
- In paper, definition of "treated" cohorts: US: 1920 or later // Latin America: 1957 or later

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2nd difference: across regions

Figure B - 1: Malaria Intensity by State in the United States



Ratio of malaria mortality to total mortality by state circa 1890. Darker colors indicate more malaria.

Source: U.S. Bureau of the Census (1894).

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2nd difference: across regions

Figure B - 2: Malaria Intensity by State in Brazil



2nd difference: across regions



Notes: The y axis displays the estimated decrease in malaria mortality post-intervention. The x axis is the pre-campaign malaria mortality rate. The 45-degree line represents complete eradication. Both variables are expressed per 100,000 population.

 In both countries, highly infected areas saw greater declines in malaria
Data and Outcomes

- Census data limited number of outcomes
- ▶ US: Occupational income score (proxy for labor productivity)
- Brazil, Mexico: census has data on literacy, years of education, and income (both total and earned)
- Note: can only do analysis on males since females are harder to trace across censuses (they change their names!)

Results: US



- Each dot corresponds to a cohort
- Each dot displays the coefficient on state-of-birth 1890 malaria mortality for each year of birth.

For those born before 1900, more pre-eradication malaria in one's state of birth predicts lower adult income on average (coefficient is just below -1)

that's because they were exposed in utero/childhood

 For those born after 1920, more pre-eradication malaria in one's state of birth has no effect on adult income on average (coefficient is around 0)

that's because they were not exposed in utero/childhood

Results: Latin America



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Robustness

- Can perform "placebo" tests:
 - Old versus very Old
 - Young versus very Young
- If diverging pre-trends: then diff-in-diff doesn't pick up effect of malaria eradication campaign but some other thing
- Bleakley performs such placebo tests, results pass the test!

- Similar identification strategies are used by Cutler et al. (2010) in India and Lucas (2010) in Panama, Trinidad and Sri Lanka, also looking at the impact of malaria eradication campaigns after WWII on education and income
 - Results are quite comparable

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Recently: randomized trial with schoolchildren in Kenya

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- intermittent preventive treatment (IPT) = children aged 5-18 years received treatments every 4 month for a year
 - hypothesis: intermittent clearance of malaria parasitaemia would increase haemoglobin concentrations and, as a consequence, reduce anaemia and contribute to improved attention in class and educational performance

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Preventive Malaria Treatment of School Children

- Finds large effect
- Prevalence of anaemia at 12 months averaged 6.3% in the IPT group compared to 12.6% in the placebo group (p-value=0.028**) (so 50 percent decrease)



Presumptive Malaria Treatment of School Children

- Significant improvements were also seen in two class-based tests of sustained attention
- Interestingly: no effect on educational achievement test scores
 - This is only one of many programs that improve classroom attendance and/or attention but find no effect on test scores
 - Deworming program in Kenya found the same results...

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Exposure to malaria in childhood is bad

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- What about exposure to malaria in adulthood? does that affect productivity?

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- What about exposure to malaria in adulthood? does that affect productivity?
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 - But historical accounts suggest yes: Panama canal story...
 - Also household surveys show many days of work lost to illness



Other diseases matter for productivity:

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- ▶ TB in childhood (Norway Butikofer and Kjell Salvanes, *Restud* 2020)

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- TB in childhood (Norway Butikofer and Kjell Salvanes, Restud 2020)
- Worm infections in children (Kenya Miguel and Kremer, ECMA 2004; US – Bleakley, QJE 2007)

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- Bleakley estimate: childhood infection decreases adult income by 50%
- So if malarious countries have childhood infection rates about 60%, and assuming no general equilibrium effect, implies a GDP effect of 0.6*(50%)=30%
 - malaria would account for 10%-15% of the gap betwen Brazil/ Mexico and the US
 - Lower than the gap measured in Gallup and Sachs (2001) (70%)

- What are the macro-economic implications of all this?
- Bleakley estimate: childhood infection decreases adult income by 50%
- So if malarious countries have childhood infection rates about 60%, and assuming no general equilibrium effect, implies a GDP effect of 0.6*(50%)=30%
 - malaria would account for 10%-15% of the gap betwen Brazil/ Mexico and the US
 - Lower than the gap measured in Gallup and Sachs (2001) (70%)
 - Reason for difference:
 - OVB, reverse causality in Gallup and Sachs estimate
 - Difference between Vivax and Falsiparum (Vivax in the Americas vs. Falsiparum (much higher morbidity and mortality) in Africa)

- Galasso et al. (2016). "The Economic Costs of Stunting and How to Reduce Them". World Bank Policy paper.
 - "If those in the current workforce who were stunted in childhood had not been [...] their income today would have been higher by a percentage that reflects the education penalty associated with childhood stunting, the returns to education, the adult height penalty to childhood stunting, and the returns to height."
 - "Reviewing studies quantifying these penalties and returns, and by finding out the age distribution of current workers so we can find out what fraction of current workers were stunted in childhood, we can quantify – using the method of 'development accounting' – the per capita income penalty a country incurs for not having eliminated stunting when today's workers were children."
 - Result: on average, per capita income penalty is around 7%
 - Africa and South Asia incur larger penalties around 9-10% of GDP per capita.

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- So ideally we would want to look at macro-estimate (that takes into account eq. effects across generations and diseases)
- But what's hard there is to find plausible source of variation (identification)
 - if countries that eradicate malaria are those with better institutions, then comparing them with countries not eradicating malaria would not be very helpful in estimating impacts of malaria eradication

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- Pre-campaign morbidity from turberculosis, pneumonia, malaria ==> use that to "predict" the change in mortality generated by the eradication campaigns
- Find clear correlation between predicted change in mortality and realized change in life expectancy
 - so as in Bleakley, treatment intensity is a function of pre-campaign morbidity

Considerable gains in life expectancy



Considerable gains in population



Change in log of population and change in predicted mortality, 1940-80, base sample.

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▶ ... but no gains in TOTAL GDP



.... so on balance a *los*s in GDP per capita!

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- so on balance a loss in GDP per capita!
- Their interpretation of their finding: Big reductions in mortality triggered rapid population growth, which reduced income per capita via Solow/Malthus channel

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- so on balance a loss in GDP per capita!
- Their interpretation of their finding: Big reductions in mortality triggered rapid population growth, which reduced income per capita via Solow/Malthus channel
- Note: This does not mean that epidemiological transition was a bad thing! Big welfare gain from lives saved, lots of suffering avoided.

- Critic by Bloom, Canning and Fink ("Disease and Development Revisited"), JPE 2014
 - Argue that malaria mortality in 1940 was endogenous, with richer countries in 1940 being better able to afford vector control of mosquitoes, such as swamp clearance.
 - so countries that got a big "treatment" were systematically different from those that didn't

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Another critic by Cervellati and Sunde (Economics Letters 2011)

Argue that the negative overall effect of AJ 2007 masks substantial heterogeneity in the effect across two sub-samples – countries that had not entered the fertility transition by 1940 ('pre-transitional' countries) and countries where fertility had already begun to drop ('post-transitional countries')



Cervellati, M, and U Sunde (2011), "Disease and Development: The Role of Life Expectancy Reconsidered", *Economics Letters*, 113(3):269-272.

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 - But for countries past the demographic transition the growth effect of life expectancy is significantly positive.
- Also: Increasing life expectancy could be indirectly beneficial for growth by increasing the likelihood of a country undergoing the fertility transition.

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 - but better late than never!

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Dupas Lec 1: Disease and Development

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- Insecticide of choice for combating malaria is DDT (dichloro-diphenyl-trichloroethane)
- That's what was used to eradicate malaria in Southern Europe, and during the post-WW2 WHO campaign
- but today donors rarely pay to use it....
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 - Best-seller by Rachel Carson (1962) Silent Spring
 - DDT use eventually banned in the US and other countries

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- Too bad because DDT is a highly effective and inexpensive (patent expired) means of eradicating malaria, and its use for that is not harmful (indoor spraying – no environmental damage and no known damage to humans)

Malaria Eradication efforts

- Not all hope is lost
- Ongoing effort: "Malaria Elimination Initiative" by UC San Francisco
 - Provides intellectual and practical support to countries around the world that are pursuing a goal of malaria elimination.
- Two primary areas: Southern Africa (Bostwana, Namibia, South Africa and Swaziland) and Asia Pacific (14 countries)

If not eradication, at least control?

Pascaline Dupas (Stanford)

Dupas Lec 1: Disease and Development

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If not eradication, at least control?

Why not yet a malaria vaccine?

If not eradication, at least control?

- Why not yet a malaria vaccine?
- Why aren't all households in poor countries covered with antimalaria bednets and antimalarial curtains?
- More on these topics over the next two days

Climate change and Disease Burden

- Climate change is changing the pattern of diseases
- Example: Malaria and Dengue. Transmitted by two different mosquitoes:
 - nighttime-biting Anopheles gambiae mosquito transmits malaria
 - day-time biting Aedes aegypti mosquito transmits a range of other devastating diseases, such as Rift Valley Fever, yellow fever, Zika, chikungunya and dengue.
- Malaria is most likely to spread at 25 degrees Celsius (78 degrees Fahrenheit) while the risk of dengue is highest at 29 degrees Celsius (84 degrees Fahrenheit).
- As a result, a warming world has meant more dengue 2019 was the worst year on record for the disease, with cases in every region, including some countries that had never seen dengue, according to the World Health Organization.
- Recent Lancet Planetary Heatlh paper by Stanford team led by Erin Mordecai projects impacts of climate change on shifting disease burden: Link

Climate change and Disease Burden



Graphic showing possible scenarios of temperature-driven changes in disease risk across Sub-Saharan Africa under a "business as usual" climate scenario. Red circles denote disease risk hotspots. Color scale indicates the intensity of human exposure risk, based on temperature.

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APPENDIX SLIDES

Dupas Lec 1: Disease and Development

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(Disappointing) Malaria Productivity RCTs

Fink and Masiye (2015): randomized access to bednets among cotton-growing households in rural area of Zambia with highly endemic malaria.

- control vs. free bednets vs. subsidized bednets on credit.
- ▶ 90% of farmers used their nets at follow-up in both intervention arms
- large drop in self-reported all-cause morbidity (by 40–42%) and the odds of self-reported confirmed malaria by 53–60%
- \blacktriangleright self-reported yields: free nets \uparrow total farm output by 14.7%
- Pb: gains are obtained conditional on the baseline yield, but that was quite imbalanced across arms
 - could suggest differential trends over time? or differences in how susceptible the households are to rainfall shocks.
 - reported yield data over only a single season is also potentially problematic
- Overall: positive results but not clear we can believe them

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(Disappointing) Malaria Productivity RCTs

Dillon, Friedman and Serneels (2014) with sugar cane cutters in Nigeria.

Easy mesurement this time: piece rate for every measured "rod" of cane cut, where a "rod" (approximately two meters in length) is a physical standard measured by supervisor and kept in records by plantation = high-quality and objective measure of productivity

▶ Pb here: type of health intervention that could feasibly be carried out.

- Randomizing access to malaria prevention over the entire period across workers was not possible (ethically difficult?)
- Instead, workers hired for a 6-week harvest season were called in for a "medical visit" at some point over the 6-week period, with the exact date on which the visit happened randomized across workers
- At visit, tested for malaria and treated if positive (prevalence: 30%)
- Pb: we don't know who was malaria positive in control group (no visit that week, so not tested)

(Disappointing) Malaria Productivity RCTs

Dillon, Friedman and Serneels (2014) with sugar cane cutters in Nigeria (cont'ed)

- Instead, researchers compare workers who were tested early on in the study period to those tested later on
 - Find a large intention-to-treat (ITT) effect: those sampled for an early test are 15% more productive on the plantation during the three weeks following the medical visit compared to those tested later on.
 - Really large effect, almost too big to be true?
 - Surprisingly, productivity effects are as large (even larger) for those who test malaria negative as for those who test malaria positive...Authors discuss somewhat far-fetch explanation: if I think I may have malaria, I may have low expectations about my likely productivity and hence choose the lower-paying "scrabbling" task for a few days, to spare my strength; or I may choose to do cane cutting but take it slow in the morning to not exhaust myself too quickly. But if get tested and receive a negative diagnostic, then I get higher expectations and may find it optimal to choose a higher effort level.



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