Health Costs and Benefits of DDT Use in Malaria Control and Prevention

Brian Blankespoor
Susmita Dasgupta
Abdelaziz Lagnaoui
Subhendu Roy

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Presentation Outline

- Background
  - Motivation
    - Objective of Research
  - Methodology
    - Data
    - Results
  - Conclusions
Prevalence of Malaria

- Malaria poses a risk to 3.3 billion people worldwide.
- Most malaria cases occur in Sub-Saharan Africa. Asia, Latin America, Middle East and parts of Europe are also affected.
- In 2010, malaria was present in 106 countries & territories.
- In 2010, there were 216 million cases of malaria and nearly 0.7 million deaths – mostly in Africa.
- Malaria can decrease GDP by as much as 1.3% in countries with high disease rates.
Targets of Global Malaria Action Plan

- **Achieve** universal coverage for all populations at risk with locally appropriate interventions for prevention and case management by 2010 and sustain universal coverage until risk of a generalized resurgence can be avoided;

- **Reduce** global malaria cases from 2000 levels by 50% in 2010 and by 75% in 2015 (In 2000, there were between 350 and 500 million cases of malaria);

- **Reduce** global malaria deaths from 2000 levels by 50% in 2010 and to near zero preventable deaths in 2015 (In 2000, there were at-least one million deaths from malaria worldwide);

- **Eliminate** malaria in 8-10 countries by 2015 and afterwards in all countries in the pre-elimination phase today; and

- In the long term, **eradicate** malaria world-wide by reducing the global incidence to zero through progressive elimination in countries.
Malaria Prevention

Malaria can be **prevented** with a combination of available tools:
- Long-lasting insecticidal nets
- Indoor Residual Spraying (IRS)
- Larvicidal & other Environmental Management

In 2006, the WHO issued a statement recommending **wider use** of **DDT** (dichloro-diphenyl-trichloro-ethane) through IRS to reduce the prevalence of malaria on the basis of high insecticidal activity, low acute mammalian toxicity, wide spectrum use, low price and long lasting effects of DDT.
Health Externalities of DDT

- DDT is a *Class II* “moderately hazardous” pesticide.
- Exposure of low to moderate levels of DDT may cause nausea, diarrhea, increased liver enzyme activity, irritation of the eyes, nose and/or throat.
- Exposure to high levels of DDT may cause tremors and convulsions.
- Other unintended health effects include: a poisoning hazard to children following acute ingestion, temporary damage to nervous system, possible carcinogenic effects (can cause cancer in liver, pancreas, testicles, breast, leukemia and lymphoma), development effects, adverse effects on the hormonal system and reproductive effects in both male and female.
Environmental Externalities of DDT

- DDT is persistent and bio-accumulative.
- DDT does not dissolve easily in water.
- Half of the residues of DDT break down in air within 2 days.
- Half of the residues of DDT break down in soil in 2-15 years.
- Externalities magnify through the food chain with the greater accumulation at the top of the food chain.
Motivation

Externalities of DDT are a serious concern, because of the persistent and bio-accumulative nature of DDT.

So far, little analysis has been done to quantify the externalities caused by DDT.
Objective of Research

- This paper quantifies externalities of DDT on human health based on area and population exposed to DDT, and the risks posed by the use of DDT.
- The analysis includes not only countries where DDT is currently being used, but also countries where the introduction of DDT may help in lowering the incidence of malaria.
- The externalities are quantified in economic terms, wherever feasible.
- A separate countrywide analysis of all countries with high incidence of malaria has been carried out.
Methodology

By Country:

1. Estimation of population in areas with low, medium, high transmission intensity ("endemicity") of malaria.
2. Estimation of likely exposure to DDT use under two alternative scenarios of DDT use: "restricted" and "widespread" depending on its potential application in high endemicity areas only versus all geographic locations prone to malaria.
3. Estimation of health externalities (likely incidence of unintended health effects) for "restricted" and "widespread" use of DDT.
4. Estimation of direct (treatment) cost of health externalities of DDT for "restricted" and "widespread" use.
5. Estimation of indirect cost of health externalities of DDT for "restricted" and "widespread" use: DALY of relevant Asthma, Cancers, Diabetes, Abortion, low birth weight.
6. Aggregation of direct and indirect cost for estimation of total cost of health externalities.
7. Estimation of direct (treatment) cost, indirect (DALY) cost and total cost of Malaria as a proxy of benefits of DDT use - for comparison.
Building Blocks

- Estimation of population in areas with low, medium, high endemicity of malaria: Malaria endemicity maps, Global population maps
- Estimation of health externalities for “restricted” and “widespread” use of DDT: Exposures of different populations, measured as total DDT or DDE concentrations, Number of Spray Operators, Population with direct exposure to IRS, Risk Ratios.
- Estimation of direct cost of health externalities of DDT for “restricted” and “widespread” use: Treatment Cost of Cancer, Treatment Cost of Diabetes
- Estimation of indirect cost of health externalities of DDT for “restricted” and “widespread” use: DALY of cancer and diabetes
- Estimation of direct (treatment) cost, indirect (DALY) cost and total cost of Malaria as a proxy of benefits of DDT use: Incidence of malaria by each country, Treatment Cost of Malaria, DALY of Malaria
<table>
<thead>
<tr>
<th>Data</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malaria endemicity maps</td>
<td>Oxford University - Malaria Atlas Project</td>
</tr>
<tr>
<td>Global population maps</td>
<td>Landscan 2005</td>
</tr>
<tr>
<td>Incidence of malaria by each country</td>
<td>World Malaria Report, 2011</td>
</tr>
<tr>
<td>Number of spray operators</td>
<td>USAID 2009. Indoor Residual Spraying (IRS) for Malaria Control Indefinite Quantity Contract (IQC) Task Order 1. IRS Training Guide for Spray Operations</td>
</tr>
<tr>
<td>Exposures of different populations, measured as total DDT or DDE concentrations</td>
<td>WHO 2011. Environmental Health Criteria 241 - DDT in Indoor Residual Spraying: Human Health Aspects</td>
</tr>
<tr>
<td>Risk ratio</td>
<td>Available Literature</td>
</tr>
<tr>
<td>Treatment Cost of Malaria</td>
<td>Microbiology Bytes, 2009</td>
</tr>
<tr>
<td>Treatment Cost of Diabetes</td>
<td>American Diabetes Association</td>
</tr>
<tr>
<td>PPP GDP data</td>
<td>IMF 2012. World Economic Outlook Database</td>
</tr>
</tbody>
</table>
Country-level Population Exposure to Malaria

Low endemicity

Percent Vulnerable Population

0 - 25
25 - 100

The data represent unified Sudan prior to the independence of South Sudan in July 2011.
Country-level Population Exposure to Malaria

Medium endemicity

Percent Vulnerable Population

0 - 25

25 - 100

The data represent unified Sudan prior to the independence of South Sudan in July 2011.
Country-level Population Exposure to Malaria

High endemicity

Percent Vulnerable Population

0 - 25

25 - 100

The data represent unified Sudan prior to the independence of South Sudan in July 2011.
## Top Five Countries with Vulnerable Population Estimates*

### Categories of Malaria Endemicity

<table>
<thead>
<tr>
<th>Rank</th>
<th>PfPR: &lt;5%</th>
<th>PfPR: 5 - 40%</th>
<th>PfPR: &gt;40%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>India (34,150) (3%)</td>
<td>India (348,899) (32%)</td>
<td>Nigeria (101,569) (79%)</td>
</tr>
<tr>
<td>2</td>
<td>Indonesia (24,230) (10%)</td>
<td>Indonesia (44,870) (19%)</td>
<td>Democratic Republic of Congo (37,828) (62%)</td>
</tr>
<tr>
<td>3</td>
<td>Pakistan (23,547) (15%)</td>
<td>Myanmar (35,857) (77%)</td>
<td>Ghana (17,369) (80%)</td>
</tr>
<tr>
<td>4</td>
<td>China (16,252) (1%)</td>
<td>Ethiopia (34,146) (47%)</td>
<td>Côte d'Ivoire (17,218) (100%)</td>
</tr>
<tr>
<td>5</td>
<td>Kenya (10,669) (31%)</td>
<td>Sudan (29,714) (74%)</td>
<td>Burkina Faso (13,405) (99%)</td>
</tr>
</tbody>
</table>

* Percentage of the total national population in parenthesis.
## Comparison of Aggregate Health Cost

### Health Externalities of DDT

<table>
<thead>
<tr>
<th>Region</th>
<th>DDT Use Widespread</th>
<th>DDT Use Restricted</th>
<th>Total Malaria Eradication</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Direct Cost $M</td>
<td>Indirect Cost $M</td>
<td>Total Cost $M</td>
</tr>
<tr>
<td>Central Asia</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>East Asia and Pacific</td>
<td>602</td>
<td>3,646</td>
<td>4,249</td>
</tr>
<tr>
<td>Middle East and North Africa</td>
<td>63</td>
<td>287</td>
<td>350</td>
</tr>
<tr>
<td>South Asia</td>
<td>1,273</td>
<td>12,805</td>
<td>14,078</td>
</tr>
<tr>
<td>Sub-Saharan Africa</td>
<td>1,094</td>
<td>8,183</td>
<td>9,276</td>
</tr>
<tr>
<td>Total</td>
<td>3,032</td>
<td>24,920</td>
<td>27,953</td>
</tr>
</tbody>
</table>
DDT externality and malaria cost as a percentage of GDP in Sub-Saharan Africa
Summary and Conclusions

- Current economic losses from malaria exceed $69 billion in 2010 U.S. dollar annually.
- A major part of the loss is in three regions: Sub-Saharan Africa (78%), South Asia (13%), and East Asia Pacific (8%).
- Globally, unintended health effects of DDT can cost more than US$ 28 billion annually.
- Sub-Saharan African countries are likely to see relatively larger net benefits.
- Net benefits of re-introduction of DDT calls for a careful country by country analysis of costs and benefits.