Neglected Tropical Diseases

Infection, modelling and control

Robert Smith?

Department of Mathematics and Faculty of Medicine
The University of Ottawa
NTDs

• A group of bacterial and parasitic infections endemic in tropical climates
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• Some of the most common infections among the world’s poorest people
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  - poor standards of living
  - lack of hygiene.
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Neglect

- These diseases are neglected at the
Neglect

• These diseases are neglected at the community
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- These diseases are neglected at the
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The “big three”
Neglect

- These diseases are neglected at the community, national, international levels.
- Attention to disease in endemic areas usually focuses on HIV/AIDS, malaria, TB, and novel emerging infections.

The “big three”
Common features

• Ancient
Common features

• Ancient
• Chronic
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- Ancient
- Chronic
- Disfigurement and disability
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- Ancient
- Chronic
- Disfigurement and disability
- Impair growth and development in children
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- High disease burden, low mortality
Common features

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- Large socioeconomic effect
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- Stigmatising
- High disease burden, low mortality (530,000 per year).
Measuring the impact

- DALYs (Disability-Adjusted Life Years)
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  – measure the number of years of life lost from premature death/disability
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- These are likely underestimates, especially for NTDs.

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Proportion of DALYs

- Diarrhoeal diseases
- Childhood & vaccine preventable diseases
- Other infectious and parasitic diseases
- STDs excluding HIV
- HIV/AIDS
- TB
- Malaria
Proportion of DALYs

- Diarrhoeal diseases
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- Other infectious and parasitic diseases
Categories

- Core group of 13 tropical infections
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• Helminths
  – Soil-transmitted helminths, elephantitis, river blindness, Guinea worm disease, schistosomiasis
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- Core group of 13 tropical infections
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- Protozoan
Categories

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   blindness, Guinea worm disease, schistosomiasis
• Protozoan
  – Leishmaniasis, Chagas’ disease, sleeping
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Categories

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<td>Sandflies</td>
<td>Triatome bugs</td>
<td>Tsetse flies</td>
</tr>
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<td>Liver, spleen</td>
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</tr>
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<td></td>
<td>blood, bone</td>
<td></td>
<td>Blood, lymph,</td>
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<tr>
<td></td>
<td>marrow</td>
<td></td>
<td>spinal fluid,</td>
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</tr>
<tr>
<td><strong>Clinical</strong></td>
<td>Decreased</td>
<td>Chronic heart</td>
<td>Coma &amp; death</td>
</tr>
<tr>
<td><strong>manifestation/impairment</strong></td>
<td>red blood cell count, fever, weight loss</td>
<td>disease, megacolon, megaesophagus</td>
<td>Anemia, enlarged lymph nodes, personality change, gait</td>
</tr>
<tr>
<td></td>
<td>Disfigure-</td>
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<tr>
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<td>ment</td>
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<td></td>
<td></td>
<td></td>
<td>Death within a year</td>
</tr>
<tr>
<td><strong>Treatment</strong></td>
<td>Amphotericin B, Pentamidine, Mitefosine</td>
<td>Nifurtimox, Benznidazole, Pacemakers/transplant</td>
<td>Pentadmine, Suramine, Melarsoprol, Eflornithine</td>
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<tr>
<td><strong>Control</strong></td>
<td>Case detection &amp; management, vector control</td>
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# Bacterial Disease

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<td>Amputation</td>
<td>Multidrug treatment</td>
<td>facial hygiene, surgery</td>
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Management and control

• Prevention/treatment exists for most NTDs
Management and control

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  – cheap and effective chemical pharmaceuticals are available for some NTDs
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  – treatments may be toxic
• Inadequate funding.
What can help

• Availability and access to health care
What can help

• Availability and access to health care
• Clean living conditions
What can help

- Availability and access to health care
- Clean living conditions
- Clean drinking water
What can help

- Availability and access to health care
- Clean living conditions
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- Adequate nutrition
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- Gender equality
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- Non-discrimination
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- Pharmaceutical research and development
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- Overhaul of drug patent systems
What can help

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- Education
- Gender equality
- Non-discrimination
- Pharmaceutical research and development
- Overhaul of drug patent systems
- Identification/targeting of vulnerable groups.
Organisation

- Public-private partnerships have had considerable success
Organisation

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- Eg Guinea worm disease has been almost entirely eradicated, despite no biomedical intervention

Source: World Health Organization
Organisation

• Public-private partnerships have had considerable success
• Eg Guinea worm disease has been almost entirely eradicated, despite no biomedical intervention
• These relationships need to be strengthened.
Mathematical models

- Have contributed to many advances in disease control and management
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  – effects of climate change
Mathematical models

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• Eg
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  – polio eradication
  – vaccine design
  – mosquito management
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  – emergency preparedness.
Advantages of models

• Can assess theoretical intervention methods in the absence of data
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  - optimal drug administration schedule
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• Modellers need to be clear about limitations
Advantages of models

- Can assess theoretical intervention methods in the absence of data
- Eg
  - optimal drug administration schedule
  - optimal allocation of limited resources
  - vector control
- However, models depend critically on the assumptions used to construct them
- Modellers need to be clear about limitations
- Policy analysts need to be better educated about the power of models.
Modelling

- Provides greater understanding of existing control strategies without costly experiments
Modelling

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- Can find control/eradication thresholds
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Modelling

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  – a reliance on a model’s conclusion that does not consider its assumptions.
NTD modelling so far...

• Only sleeping sickness has received any substantial theoretical modelling
NTD modelling so far...

- Only sleeping sickness has received any substantial theoretical modelling
- No models for the Buruli ulcer
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NTD modelling so far...

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• Models that do exist are usually limited to one lab and its collaborators per NTD
• A diversity of voices is urgently needed.
A modelling success story

• The West African River Blindness Control Program was hailed as a success due to integrated modelling and control efforts
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• Modelling predicted that 14 years of vector control would reduce the risk to less than 1%.
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- Models were refined using subsequent data to include treatment.
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• Modelling retained a prominent role in subsequent policy discussions.
Future directions for modelling

• More mathematical models are urgently needed
Future directions for modelling

- More mathematical models are urgently needed
- Existing control efforts need to be optimised
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• Theoretical interventions need to be examined
  – eg potential vaccines
• Spatial effects are crucial
• Urban/rural models
• Fill in potential gaps in knowledge
  – eg routes of transmission.
Specific problems

- Adapting malaria pesticide models for vector control in Chagas’ Disease
Specific problems

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• Modelling access to resources across geographically difficult terrains
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  - eg distance to hospitals, swamps, mountains, road networks
- Categorise the cost to developing economies of disabling NTDs
- Model NTD research funding
- Co-infection models
  - with other NTDs and the big three.
Summary

• NTDs require immediate attention
Summary

• NTDs require immediate attention
• NTDs extract an enormous price in
Summary

• NTDs require immediate attention
• NTDs extract an enormous price in
  – suffering
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  - suffering
  - lack of economic development
  - promotion of poverty
Summary

• NTDs require immediate attention
• NTDs extract an enormous price in
  – suffering
  – lack of economic development
  – promotion of poverty
• Mathematical models can be used to inform policy at minimal cost.
Conclusions

• NTDs are the low-hanging fruit of disease modelling
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- A great many problems could be solved, relatively easily, by harnessing the power of mathematical modelling
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• NTDs are the low-hanging fruit of disease modelling

• A great many problems could be solved, relatively easily, by harnessing the power of mathematical modelling

• The price — political and otherwise — for such a huge improvement in the quality of life for 1/6 of the world’s population is tiny.
Key References


http://mysite.science.uottawa.ca/rsmith43