Quantitative risk assessment of climate change on selected causes of death, 2030s and 2050s.

Report for the World Health Organization

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Outline

• WHO assessment – objectives
  – scenarios
• Summary results.
• Key models
  – Coastal flood risk
  – Undernutrition.
• Malaria
  – Multi-model intercomparison
• Conclusions
History of global modelling

  – Deaths and DALYs due to climate change in year 2000.
  – Malaria, Diarrhoeal disease, Coastal flood mortality, Malnutrition

• Inter-sectoral global modelling
  – E.g. Fast Track (UK Govt), QUEST, ICARUS (Japan), [more......]

• ISI MIP -Intersectoral Model Inter-comparison Project.
  – Malaria
A1b emissions trajectory
(for comparison, an optimistic mitigation scenario known as E1 is also shown)
Scenarios

Global level GDP per capita (as PPP) for three future worlds

World population projections out to the year to 2100 for the UN 2010 revision (medium variant) and IIASA A1
Mortality projections

Trends in mortality for communicable diseases, noncommunicable diseases and injuries, by age group, from 2008 to 2080
Diarrhoeal disease

Projections of diarrhoeal mortality: (a) deaths and (b) crude mortality rate
Estimated future annual mortality attributable to climate change under A1b emissions and for the base case socioeconomic scenario in 2030 (blue bars) and 2050 (orange bars), by world region and health outcome.
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Estimated future annual mortality attributable to climate change under A1b emissions and for the base case socioeconomic scenario in 2030 (blue bars) and 2050 (orange bars), by world region and health outcome.
## Adaptation assumptions

<table>
<thead>
<tr>
<th></th>
<th>Underlying trends</th>
<th>Adaptation assumptions included in model</th>
<th>Potential options not included in model</th>
<th>Foreseeable limits to adaptation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat-related mortality in elderly people</td>
<td>Population growth and ageing; improved health in elderly people due to economic development</td>
<td>Three levels of autonomous adaptation assumed – none, partial and full – based on shifts to optimum temperature</td>
<td>Improved heat health protection measures; early warning systems</td>
<td>Cost and feasibility of active and passive cooling measures in dwellings</td>
</tr>
<tr>
<td>Coastal flooding</td>
<td>Coastal population increase; increased vulnerability due to rapid urban development, which then declines</td>
<td>Evolving coastal protection measures</td>
<td>Population migration; hard seawalls; flood defences; early warning systems</td>
<td>Technical and cost barriers to coastal defences, particularly in atoll countries, deltas and low-lying areas in poor countries</td>
</tr>
<tr>
<td>Diarrhoeal disease</td>
<td>Improved mortality outcomes due to technology and economic development</td>
<td>None</td>
<td>None</td>
<td>Water supply failures, damage to infrastructure</td>
</tr>
<tr>
<td>Malaria and dengue</td>
<td>Assumed reductions in mortality rates resulting from socioeconomic development</td>
<td>Assumed reductions in mortality rates resulting from socioeconomic development</td>
<td>Specific novel interventions, e.g. vector control, vaccination, early warning systems</td>
<td>Insecticide or drug resistance</td>
</tr>
<tr>
<td>Undernutrition</td>
<td>Population growth; improved population health due to technology and economic development</td>
<td>Crop yield models include adaptation measures</td>
<td>Non-agricultural interventions, e.g. water and sanitation provision;</td>
<td>Limits of maximum productivity of agricultural systems</td>
</tr>
</tbody>
</table>
Heat-related mortality

Estimated annual counts of heat-related deaths in people aged 65 years and over, by 0.5° grid cell, for BCM2 in 2050, with no adaptation assumed.
Natural disasters..
Estimates of region-level annual average mortality ranges at baseline in 2030, 2050 and 2080, based on median exposure estimates.
Malaria atlas: (a) prevalence of children aged 2–10 years predicted to have malaria parasites in their blood; (b) malaria presence/absence map derived from the data in (a) by classifying all areas with percentages above 0% as malaria presence and all areas equal to 0% as malaria absence.
Malaria

Map of malaria predictions for baseline climate
Malaria

Map of predicted areas of malaria presence for 2050

The mean across the five A1B climate change datasets is shown.

(a) Climate and GDP changes; (b) only climate changes.
Dengue

Maps showing the difference between current modelled dengue distribution in 2050

(a) climate and socioeconomic change

(b) climate change

(c) socioeconomic change
Schematic illustration of the modelled pathway from climate change to child undernutrition and its consequences
Undernutrition

FAO method for estimating the proportion of a population that is undernourished.
Additional number of children aged under 5 years stunted due to climate change in 2030 and 2050 in the 12 study regions under low growth (L), base case (B) and high growth (H) socioeconomic scenarios.
Number of children with severe stunting, with and without climate change, in 2030 and 2050 in four African regions.
Estimated additional deaths in children aged under 5 years attributable to climate change in 2030 and 2050, in the 12 study regions, under low growth (L), base case (B) and high growth (H) scenarios.
Histograms proportional to probability density functions for the proportion of children estimated to be stunted in 2050 under the base case scenario

- Not/mild stunting
- Moderate stunting
- Severe stunting

<table>
<thead>
<tr>
<th>Area</th>
<th>Not/mild stunting</th>
<th>Moderate stunting</th>
<th>Severe stunting</th>
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<tbody>
<tr>
<td>As, S</td>
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<tr>
<td>LA, M</td>
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<td>SSA, E</td>
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Climate change and malaria

Kovats RS, Rocklov J, Caminade C, Tompkins AM, Morse AP, Jesús Colón-González F, Stenlund H, Martens P, Lloyd SJ
## 5 malaria models

<table>
<thead>
<tr>
<th>Model</th>
<th>Reference</th>
<th>Type</th>
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<tbody>
<tr>
<td>LMM</td>
<td>Liverpool Malaria Model</td>
<td>Hoshen and Morse 2004 biological - vector transmission potential model</td>
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<tr>
<td>MARA</td>
<td>Mapping Malaria Risk in Africa project</td>
<td>Craig et al. 1999 biological - seasonality model</td>
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<tr>
<td>VECTRI</td>
<td>International Centre for Theoretical Physics</td>
<td>Tompkins and Ermert 2012 biological – full dynamical model</td>
</tr>
<tr>
<td>MIASMA</td>
<td>University of Maastricht</td>
<td>Van Lieshout et al. 2004 biological - transmission potential model</td>
</tr>
<tr>
<td>UMU</td>
<td>University of Umea</td>
<td>Beguin et al. 2011 statistical model</td>
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</table>
The different hues represent change in the length of the transmission season between 1980–2010 and 2069–2099 for the mean of CMIP5 sub-ensemble.

The different saturations represent signal-to-noise ($\mu$/Sigma) across the super ensemble (the noise is defined as one standard deviation within the multi-GCM and multi-malaria ensemble, n=20).

Stippled area = multi-malaria multi-GCM agreement (60% of the models agree on the sign of changes if the simulated absolute changes are above one month of malaria transmission).
Additional population at risk due to climate change in African regions

<table>
<thead>
<tr>
<th>Region</th>
<th>2020s</th>
<th>2050s</th>
<th>2080s</th>
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<tbody>
<tr>
<td>Central Africa</td>
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<td>Southern Africa</td>
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<tr>
<td>Western Africa</td>
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<tr>
<td>Eastern Africa</td>
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</table>
Sources of uncertainty. Relative contribution of malaria impact model (MIM), climate model (GCM), and emissions scenario (RCP) to estimated future malaria distribution under climate change.
Conclusions

- Modelling climate change impacts on health is complex.
- Limited number of outcomes.
- Negative impacts even under high economic growth and including adaptation.
- Regional impacts
  - Sub-Saharan Africa
  - South Asia.
- Uncertainties are large.
  - Better methods for quantifying uncertainty.
- Relationship with economic growth and rate of warming varies by outcomes.