Climate change and Vulnerability Assessment: Water-borne disease

AVEC Summer School
Peyresq
September 2003

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AIM OF LECTURE

Provide an overview of the methodological challenges in conducting vulnerability assessments for the health impacts of climate change

OUTLINE OF LECTURE

1. Climate change impacts on health
2. Vulnerability, and water-related disease
3. Global Burden of Disease – diarrhoeal disease
4. Vulnerability Assessment – some conclusions

Climate change impacts on health

WHAT IS PUBLIC HEALTH?

Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity. [WHO, 1946]

- focus on whole populations
- broad definition of health
- population health depends not only on the provision of good healthcare services but also on the physical, social, cultural and economic environment in which people live

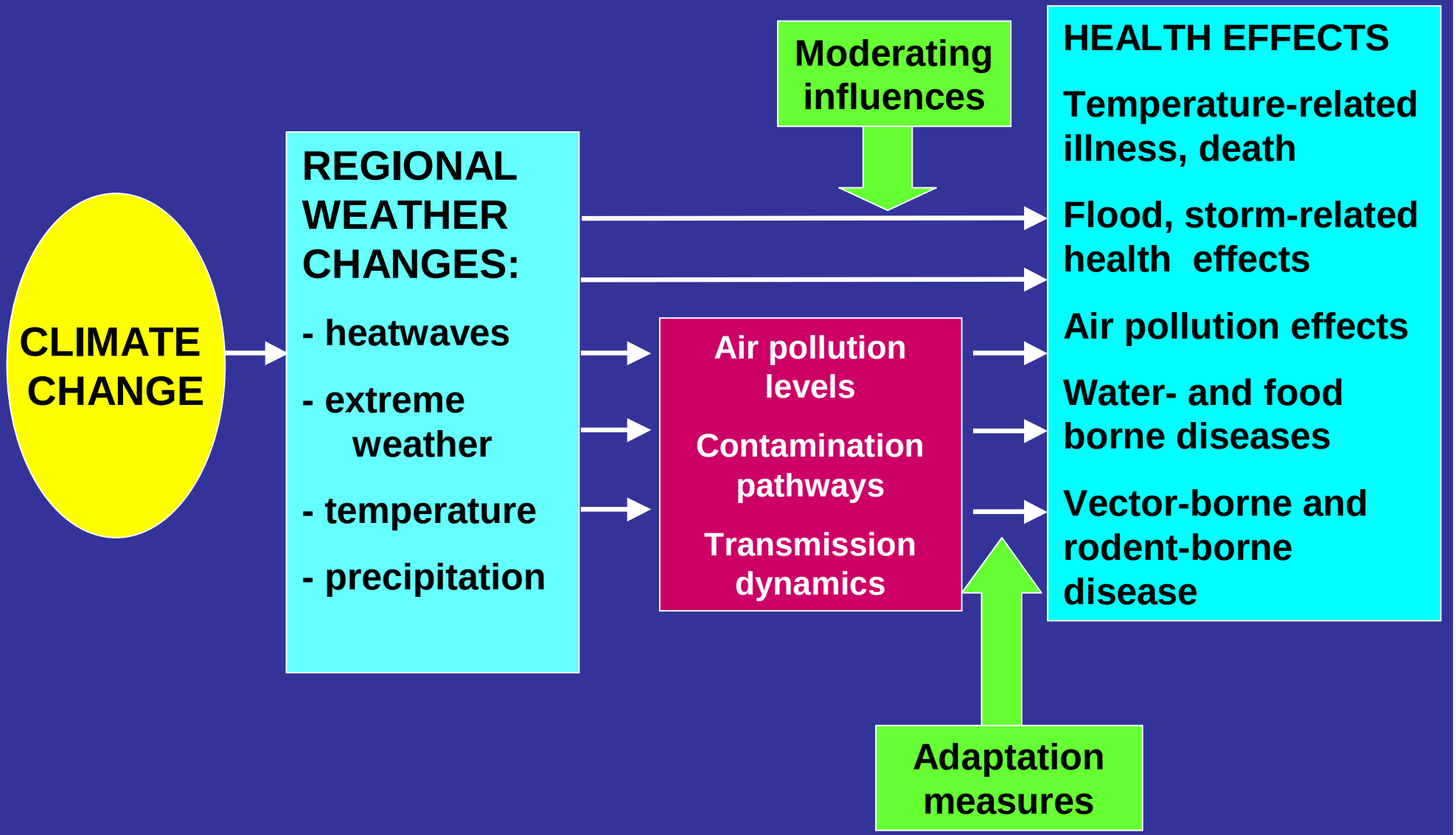
Health determinants

Bio-physical

Social

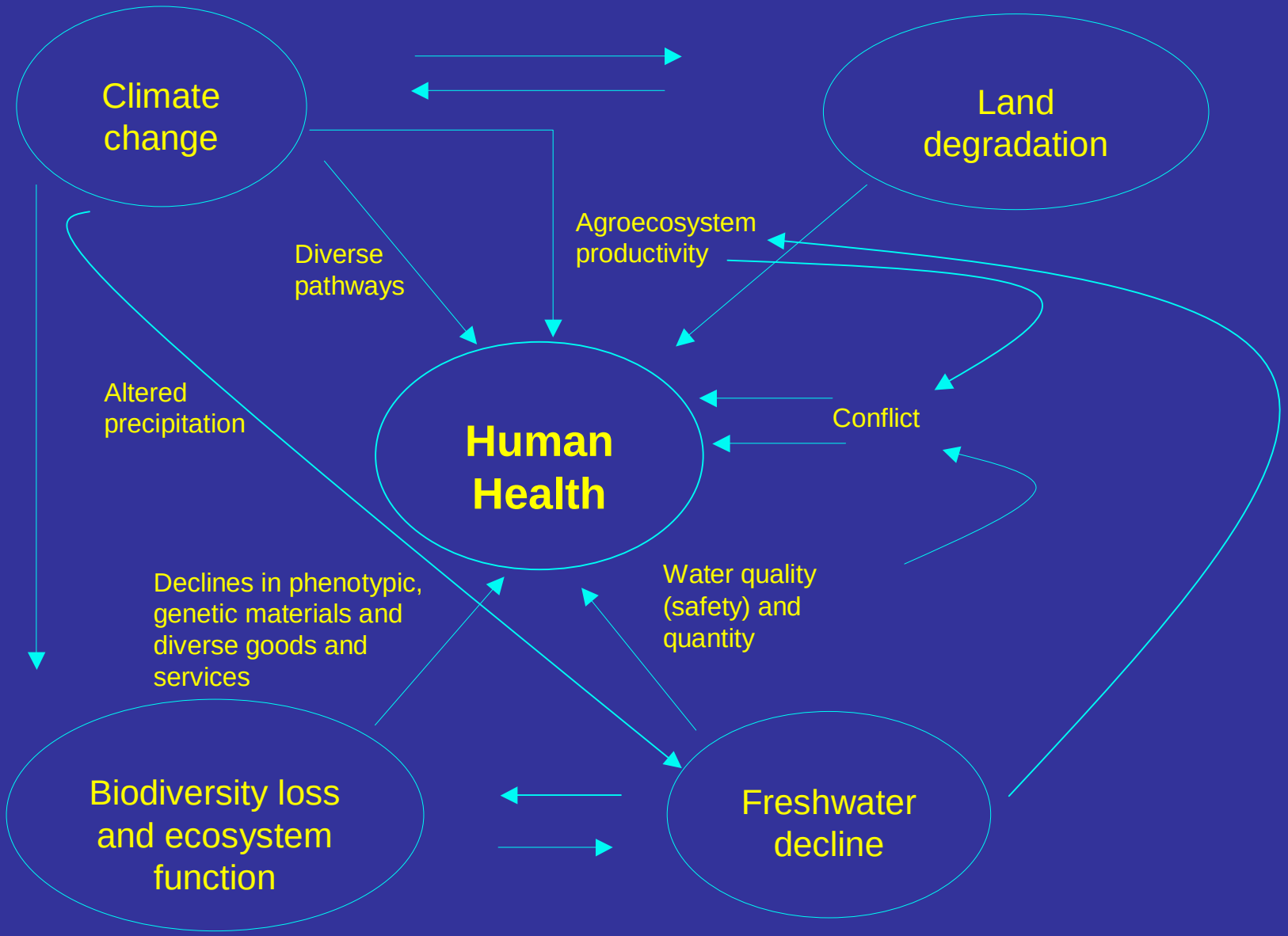
PATHWAYS BY WHICH CLIMATE CHANGE MAY AFFECT HEALTH

based on Patz et al. 2000



Complex interactions between, water, climate and health

Source: Adapted from Ahern, M.J. and McMichael, A.J. (2002)



Typology of water-related transmission route for infections *(Cairncross and Feachem, 1993)*

Transmission route	Examples of disease
Water-borne: humans become infected by drinking water containing infectious pathogen	Cholera, Typhoid
Water-washed (or water-scarce): infection influenced by quantity of water available	Scabies, Trachoma
Water-based: disease where pathogen spends part of its life-cycle in a water snail or other aquatic animal	Schistosomiasis
Water-related insect vector: pathogen spread via insects which breed in water or bite near water	Malaria, Yellow fever, Dengue

Water-borne disease 1

- Complex relationships between human health and problems of water quality, availability, sanitation, and hygiene
- Predicting potential impacts of climate change difficult because access to a clean safe water supply determined primarily by socioeconomic factors
- Water scarcity may necessitate use of poorer quality sources of freshwater, such as rivers, which often are contaminated

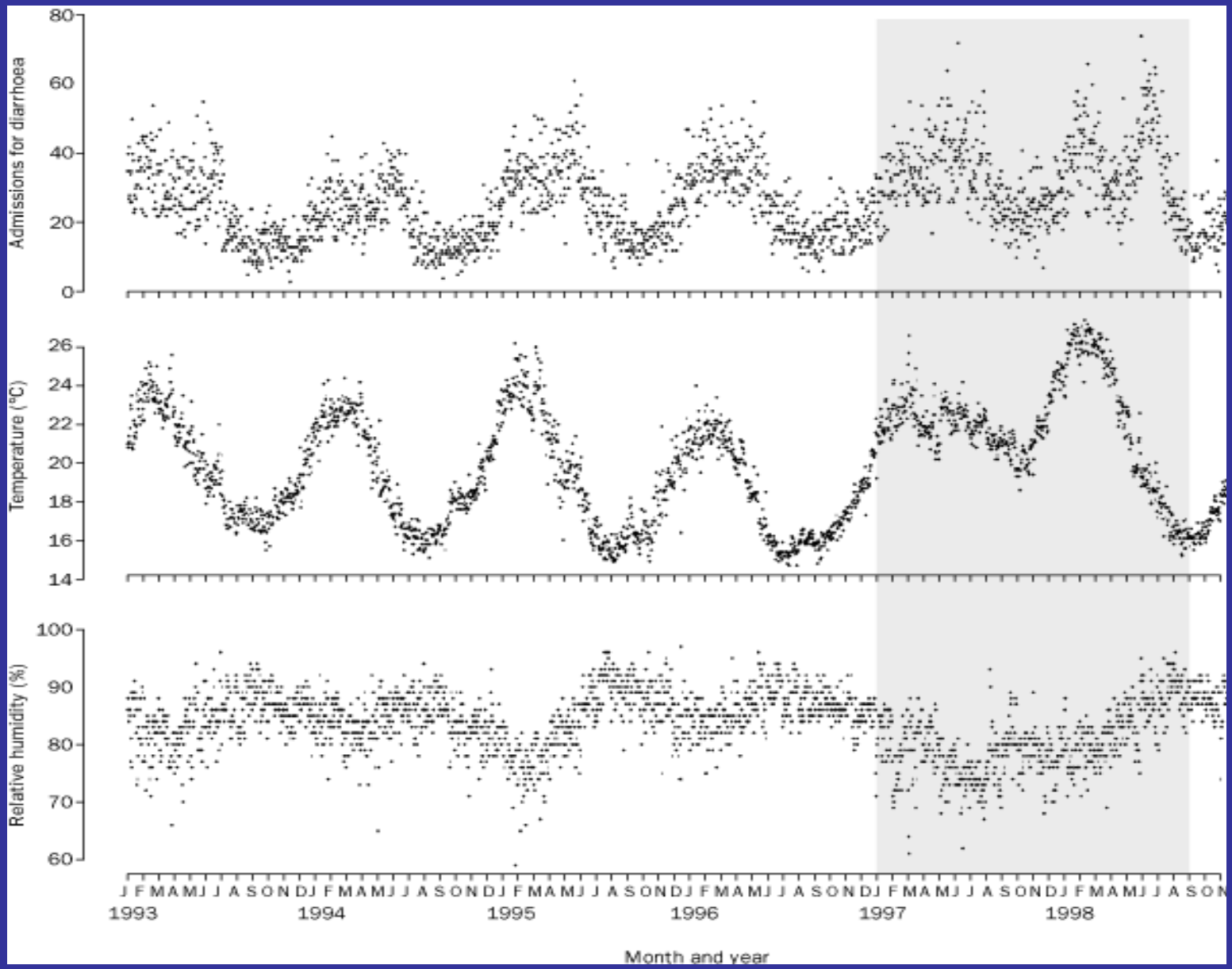
Water-borne disease 2

- Excessive precipitation can transport terrestrial microbiological agents into drinking-water sources
- Outbreaks of cryptosporidiosis, giardia, and other infections triggered by heavy rainfall events in UK and United States (Lisle and Rose, 1995; Atherholt *et al.*, 1998; Rose *et al.*, 2000; Curriero *et al*., 2001)
- Significant correlation between cumulative monthly distribution of cholera cases and monthly distribution of precipitation observed in Guam (Borroto and Haddock, 1998)

Water-borne disease 3

- Water-borne (and food-borne) diseases tend to show marked seasonality, peaks in early spring or summer
- Higher temperatures favour micro-organism proliferation and often are associated with an increase in gastrointestinal infections
- Above-average temperatures in Peru during the 1997–1998 El Niño associated with a doubling in the number of children admitted to hospital with diarrhoea (Checkley *et al.*, 2000)

Admissions for diarrhoea, mean ambient temperature, and relative humidity in Lima, Peru, 1 Jan 1993 to 15 Nov 1998.



Source: Checkley W, et al. Lancet 2000; ***355:*** *44250*

Vulnerability

Vulnerability 1

Vulnerability – degree to which individuals and systems are susceptible to or unable to cope with the adverse effects of climate change

And is a function of:

- The ***Exposure*** to the weather or climate-related hazard
- ***Sensitivity*** – extent to which health, or the natural or social systems on which health outcomes depend, are sensitive to changes in weather and climate (the **exposure-response** relationship)
- ***Adaptive capacity*** **–** measures and actions in place to reduce the burden of a particular adverse health outcome. The effectiveness of these interventions partially determines the exposure-response relationship (WHO, 2003)

Vulnerability 2

Individual factors – disease status (people with pre-existing poor health may be more vulnerable to direct effects); Socioeconomic factors (in general, the poor are more vulnerable; Demographic factors (infants are more vulnerable to diarrhoeal diseases)

Community factors- integrity of water and sanitation systems and their capacity to resist extreme events; access to information, including early warnings of extreme climate events

Geographical factors influence of f El Niño cycle or occurrence of extreme weather events; low-lying coastal populations more vulnerable to effects of sea-level rise

Global Burden of Disease

Global Burden of Disease (GBD) 1

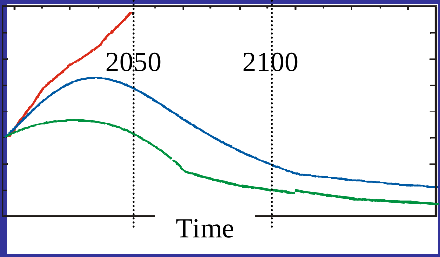
- What will be the **total** health impact caused by climate change, for the years 2000, 2001, 2005, 2010, 2020, 2030?

- How much of this impact could be avoided by reducing the risk factor (i.e. stabilizing greenhouse gas emissions)?

OVERVIEW OF GBD PROCESS FOR CLIMATE CHANGE

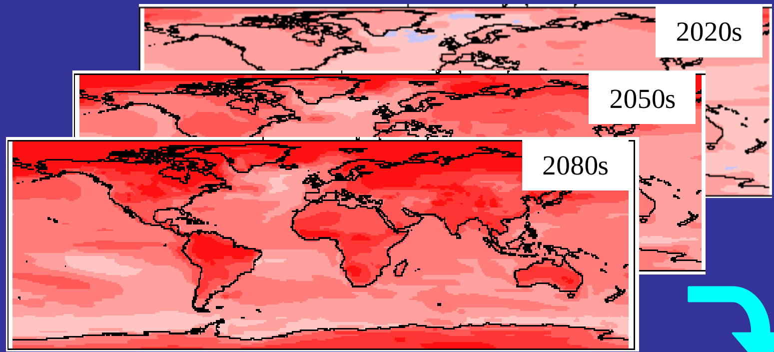
Greenhouse gas emissions scenarios

Defined by IPCC



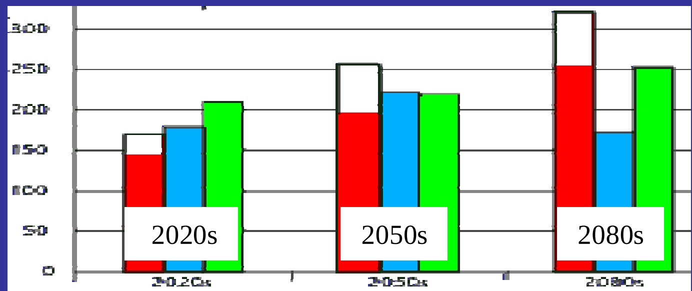
Global climate modelling:

Generates series of maps of predicted future distribution of climate variables



Health impact model

Generates comparative estimates of the regional impact of each climate scenario on specific health outcomes



Conversion to GBD endpoints (DALYs)

e.g. based on regression analysis

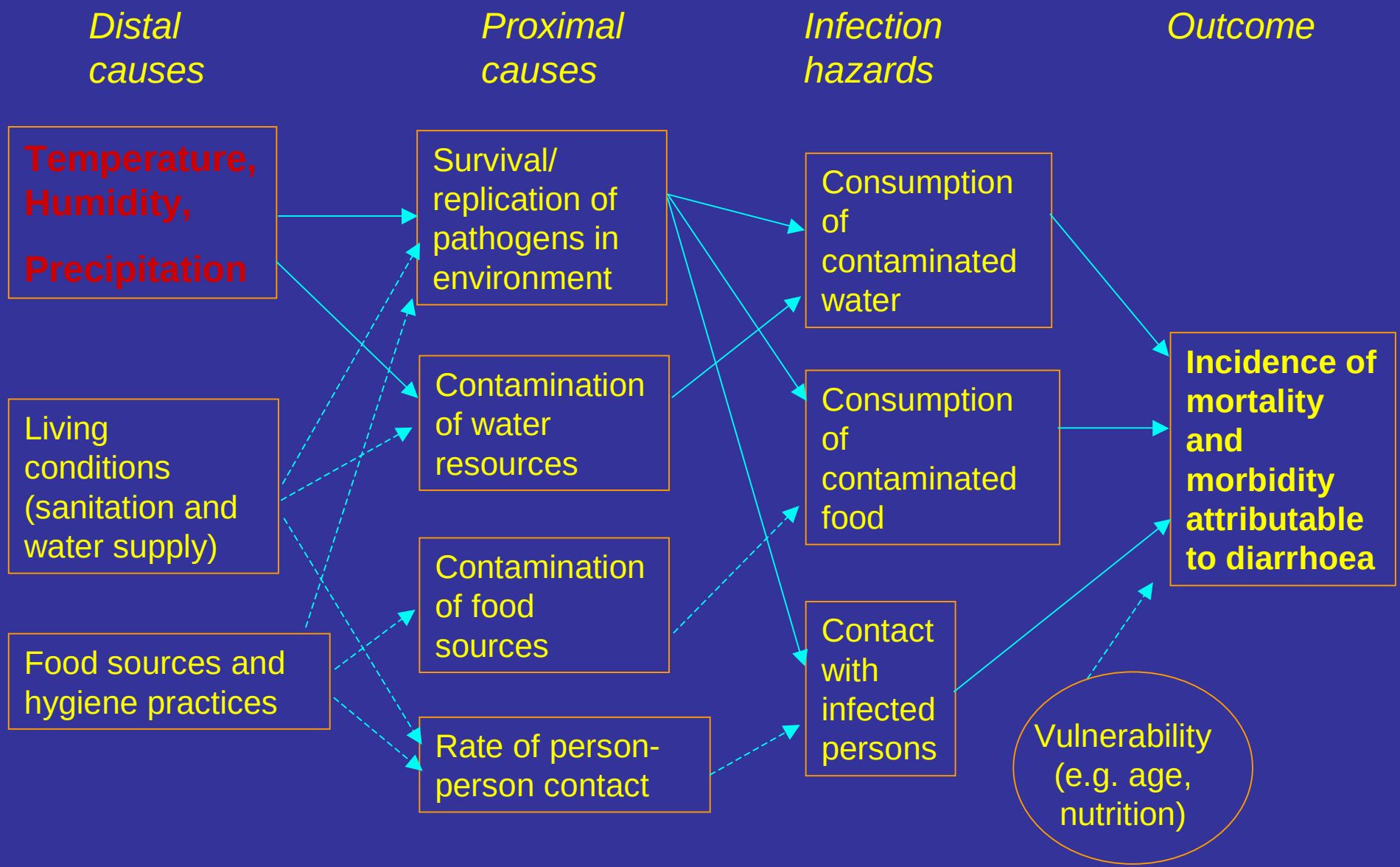
Level	Age group (years)						
	0-4	5-14	15-29	30-44	45-59	60-69	70+
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
3	1.7	1.7	1.7	1.7	1.7	1.7	1.7
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
3	1.7	1.7	1.7	1.7	1.7	1.7	1.7
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
3	1.7	1.7	1.7	1.7	1.7	1.7	1.7
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
3	1.7	1.7	1.7	1.7	1.7	1.7	1.7
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
3	1.7	1.7	1.7	1.7	1.7	1.7	1.7

GBD

Outcome Class	Outcome
Direct impacts of heat and cold	Incidence of cardiovascular disease deaths
Food and water-borne disease	Incidence of diarrhoea episodes
Vector-borne disease	Incidence of malaria and dengue cases
Natural disasters	Incidence of deaths due to unintentional injuries
	Incidence of other unintentional injuries (non-fatal)
Risk of malnutrition	Prevalence of non-availability of recommended daily calorie intake

HEALTH IMPACT EXAMPLE: INCIDENCE OF DIARRHOEA CASES

Causal web for climate change effects on diarrhoeal disease (relative importance of pathways varies between pathogens). *Source:* McMichael, A.J. *et al* (2002)

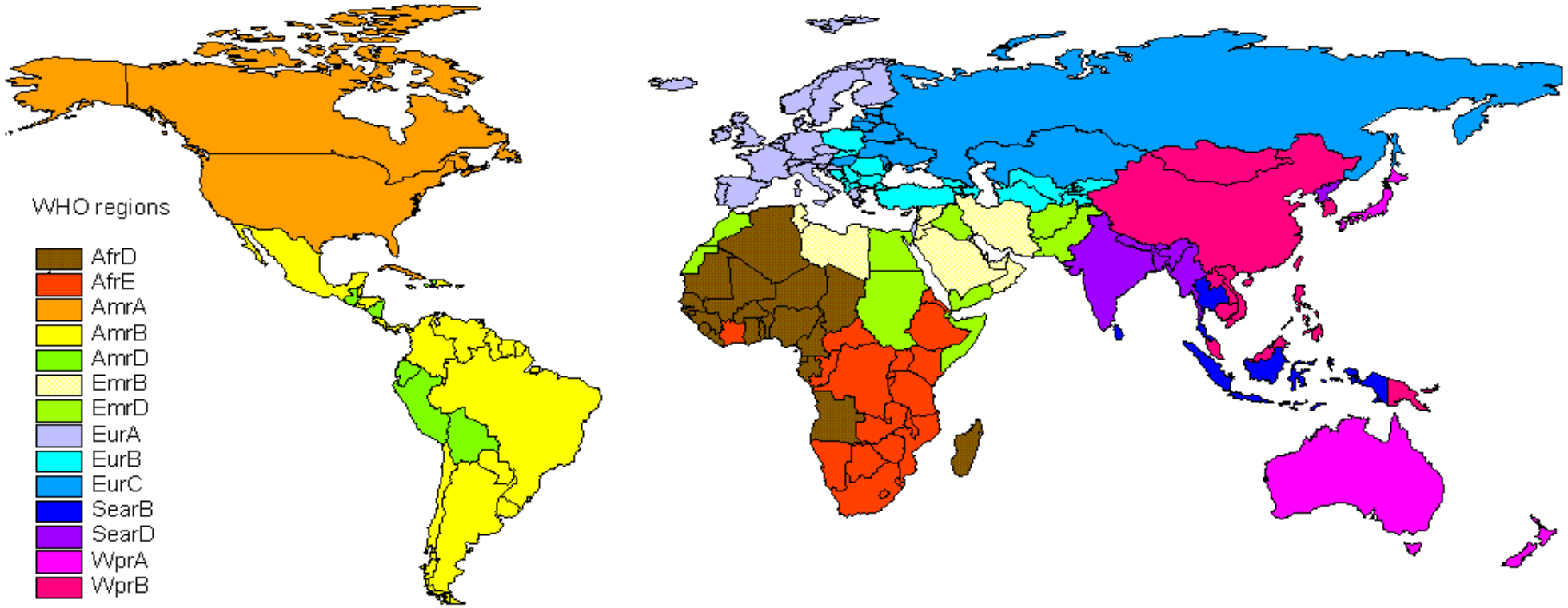


HOW MUCH WILL DIARRHOEA INCREASE WITH CLIMATE CHANGE ?

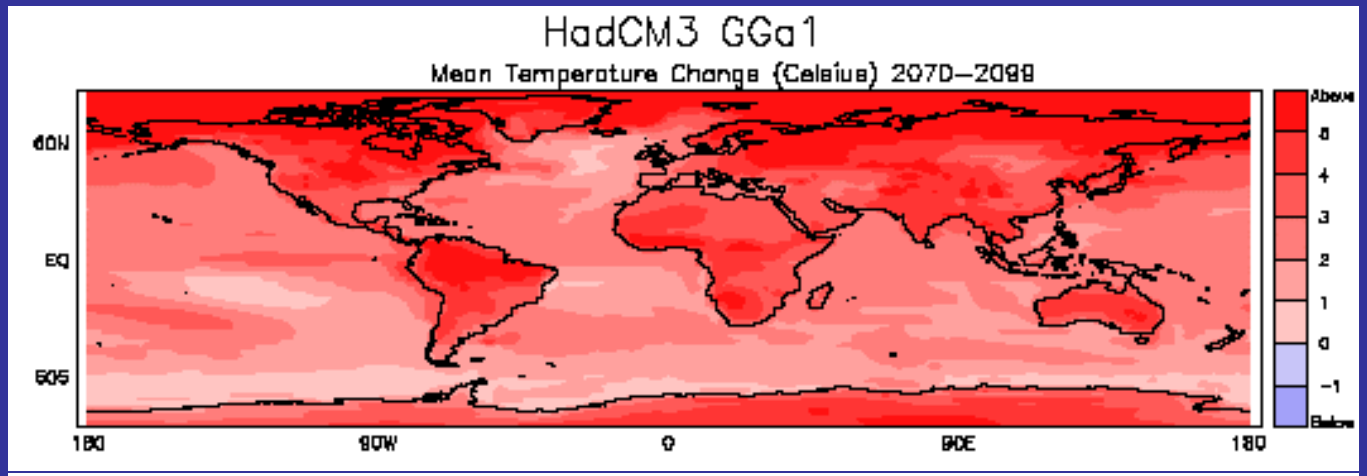
1) Overlay maps of projected temperature change on country maps, using a Geographic Information System

2) For each country with GDPpc < US $6000, multiply temperature increase by 1.05 (=5% increase per C^0 increase in temperature)

3) Calculate average increase in incidence for each WHO region


WHO regions
AfrD
AfrE
AmrA
AmrB
AmrD
EmrB
EmrD
EurA
EurB
EurC
SearB
SearD
WprA
WprB

PREDICTED MEAN TEMPERATURE CHANGE



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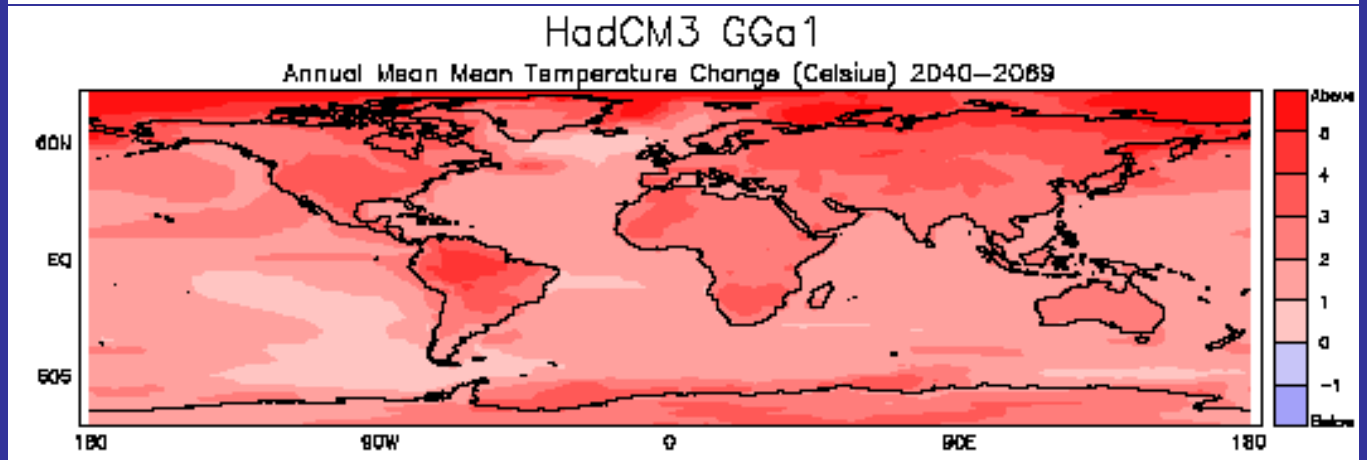

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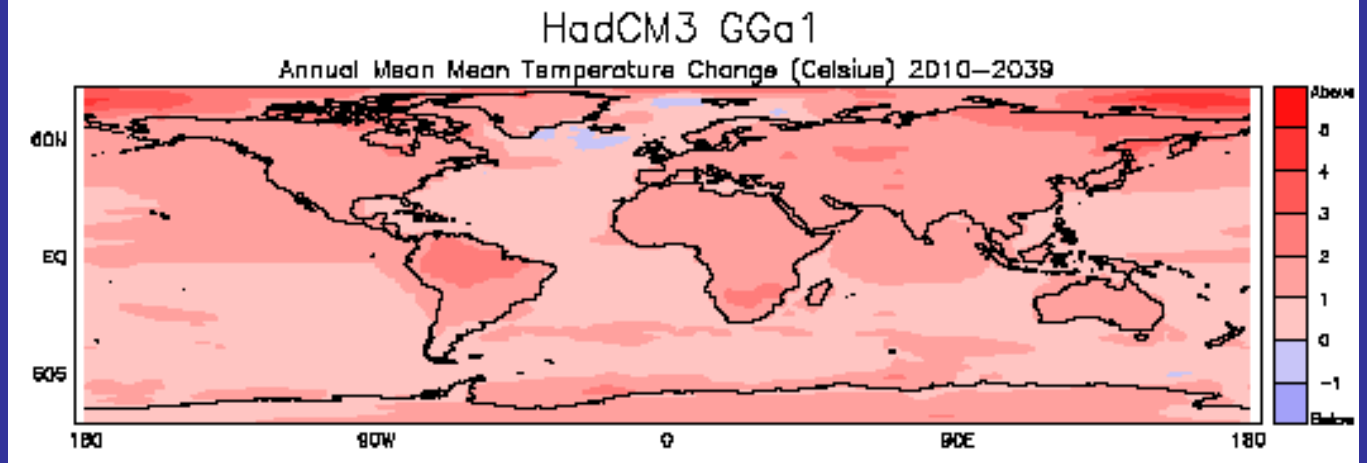
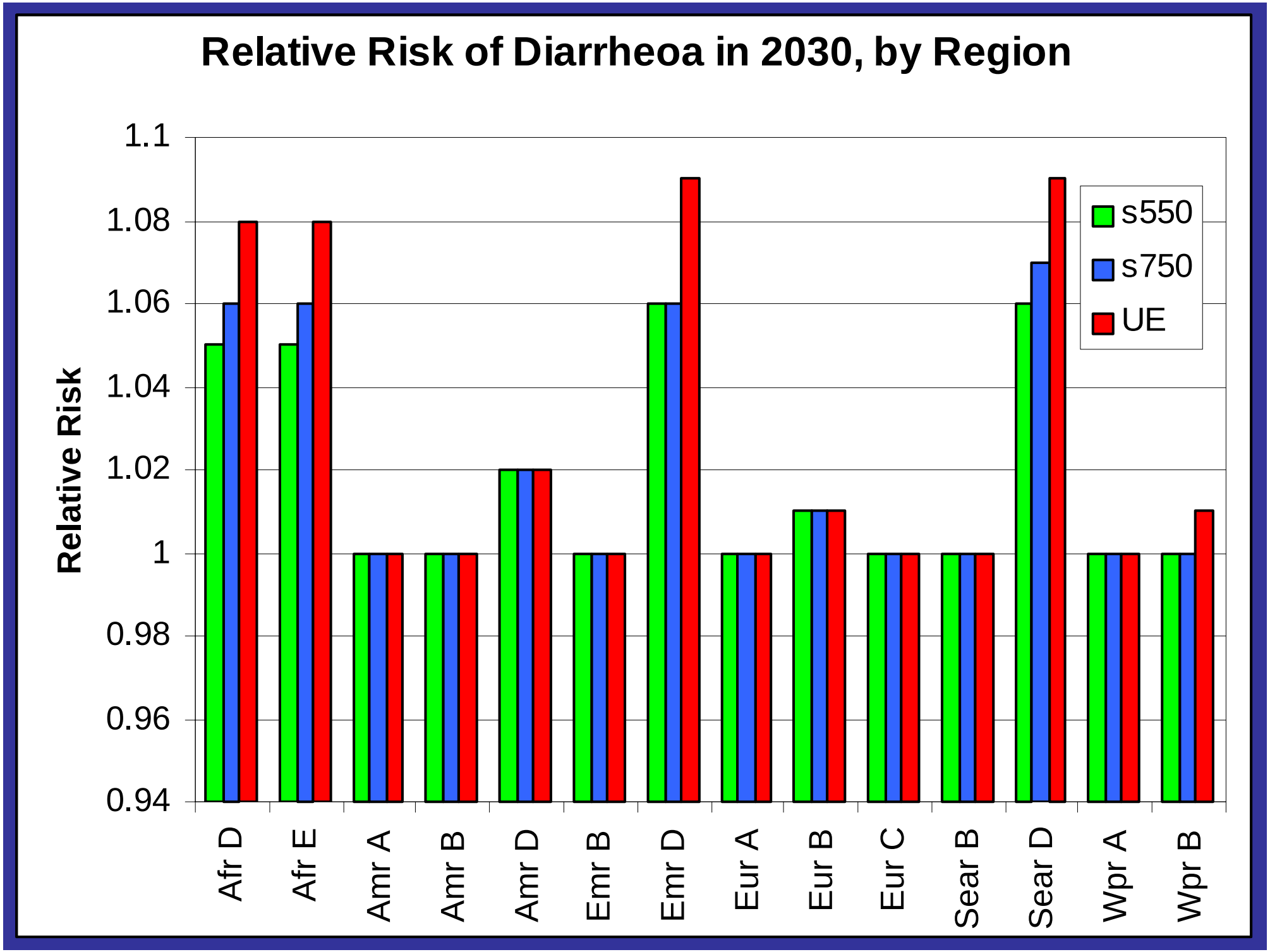


S550

ESTIMATED DEATH RATE FROM DIARRHOEA (2000)

	Total Deaths	Death rate/1000 pop.
Afr D	271798	0.949
Afr E	433011	1.312
Amr A	1695	0.005
Amr B	49295	0.116
Amr D	26880	0.385
Emr B	23600	0.173
Emr D	261536	0.751
Eur A	1965	0.005
Eur B	27023	0.126
Eur C	3544	0.014
Sear B	30113	0.104
Sear D	921135	0.755
Wpr A	1182	0.008
Wpr B	71257	0.047

WHO World Health Report 2001


Relative Risk of Diarrheoa in 2030, by Region
Relative Risk
1.1
1.08
1.06
1.04
1.02
1
0.98
0.96
0.94
s550
s750
UE
Afr D
Afr E
Amr A
Amr B
Amr D
Emr B
Emr D
Eur A
Eur B
Eur C
Sear B
Sear D
Wpr A
Wpr B

GBD

Diarrhoeal diseases

- Relative risk for 2030 in developing regions estimated to be 1.0-1.1 under unmitigated emissions compared to baseline climate
- Richer countries (GDP > $6000/year) will suffer little
- Uncertainties due to poor characterisation of variations in relationship between climate and diarrhoea in more or less developed regions, which have different balances between pathogens preferring higher or lower temperatures

GBD

- Considerable uncertainties around these estimates.
- Climate change obscured by natural climate variability, and effects health through complex causal pathways
- Coupled with poor health surveillance in most vulnerable populations = inherently difficult to directly measure health losses or gains attributable to climate change

Uncertainties could be reduced by

1. Applying projections from several climate models
2. Relating climate and disease data from a wider range of climatic and socioeconomic environments
3. More careful validation against patterns in the present or recent past

GBD

- Long-term climate change effects are slow and difficult to measure with confidence
- Lack of good long term data series >20 years
- Analyses are affected by the confounding effects of long-term changes in other [non-climate] causative factors
- Although, it simpler and quicker to measure the health effects of climatic variation either over short time periods (seasonal or inter-annual), or with geography, the attribution to climate change is indirect...

Europe

Water-borne disease

- Impacts in European Region not as great as other regions, e.g. Sub-Saharan Africa, South Asia
- Some populations in eastern Europe with restricted access to water in the home would be vulnerable to any climate related decreases in freshwater availability
- The most significant water-borne disease associated with the public water supply in western Europe is cryptosporidiosis
- Increases in the frequency or intensity of extreme precipitation events can increase the risk of outbreaks of this disease

Evidence of Health Impacts of Climate Change

- Little evidence that recent trends in regional climates have affected health outcomes in human populations
- Could reflect a lack of such effects to date or difficulty in detecting them against a noisy background containing other more potent influences on health
- Causation of most human health disorders is multi-factorial and the socioeconomic, demographic, and environmental context varies constantly
- Infectious diseases – no single epidemiological study has clearly related recent climate trends to a particular disease
- Various studies of the correlation between interannual fluctuations in climatic conditions and occurrence of malaria, dengue, cholera, and other infectious diseases have been reported

Vulnerability Assessment 1

- One way of integrating various stresses on populations and regions arising from climate change (IPCC, 2001)
- Methods and tools for evaluating vulnerability are in formative stages of development
- Further development of methods and tools for vulnerability assessment warranted, especially for the human dimensions of vulnerability, integration of biophysical and socioeconomic impacts, and comparison of regional vulnerability.

Vulnerability Assessment 2

- Uncertainties regarding the sensitivity of many health outcomes to climate or climate-induced environmental changes
- Little quantitative research, with estimation of exposure-response relationships, for outcomes other than death rates associated with thermal stress and changes in the transmission potential of several vector-borne infectious diseases
- Increased effort to map current distribution of vectors and diseases, e.g. malaria using climate and other environmental data (including satellite data).

Vulnerability Assessment 2

- Not yet clear what criteria are most appropriate for assessment of climatic influences on changes in infectious disease patterns

- Inherent difficulty in detecting small climate-induced shifts in population health outcomes and in attributing the shift to a change in climate

Vulnerability Assessment 4

- Formal methods of choosing indicators and combining them into meaningful composite indices must be tested
- Combining qualitative insight and quantitative information is difficult but essential to full assessments
- Finally, improved methods and tools should facilitate comparison of vulnerability profiles between at-risk regions and populations and highlight potential reductions in vulnerability, through policy measures or the beneficial effects of climate change

Acknowledgements

Diarmid Campbell-Lendrum, WHO

Paul Wilkinson and Sari Kovats, LSHTM

THANK YOU