Can epidemiological studies improve estimates of health damages due to climate change in the Integrated Assessment Models (IAMs)?

KRISTEN DOWNS

University of North Carolina at Chapel Hill

Camp Resources XXI

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Motivation

- Recent call for a new generation of Integrated Assessment Models (IAMs) to estimate the economic impacts of climate change (Stern, 2013; Pindyck, 2013)
  - Partially due to the arbitrary nature of existing damage functions
- Health impacts are likely to be an important component of these damages, but are not well represented in the IAMs.
- High level of temporal (annual) and spatial aggregation (global or regional) in the IAMs is problematic when estimating local, heterogeneous climate change impacts
  - Preliminary results comparing the effects of using regional- and country-level data for the FUND diarrheal disease models indicate that the level of spatial aggregation is important (Hanemann et al. 2014)

Research Questions

- I am exploring alternative ways to model the impacts of climate change and weather variability on health (specifically diarrheal disease) at the global and regional levels using epidemiological studies and meta-analyses.

- I attempt to answer 3 main questions:

1. How do the estimates and model specifications between disease and climatological variables vary across studies in the epidemiological literature?

2. How does aggregation affect the estimates of temperature and precipitation elasticities for disease outcomes at different temporal and spatial scales?

3. How can this information then be incorporated into the IAMs?

Methods

1. Literature review of epidemiological studies on diarrheal disease and seasonality and/or climate change

2. Reanalyze existing meta-analyses of the relationship between climatological factors and diarrheal disease to explore the importance of …
   - Pathogen-specificity of diarrheal disease
   - Seasonality and temporal aggregation
   - Spatial heterogeneity and aggregation

How are Epi Models Different? Time, Space and Specification

Epidemiological Models

1. Time series models with short time steps (day, week, month) that consider seasonality of infectious diseases
2. Small spatial units
3. Models are diverse and disease-specific; some account for non-linearities and threshold effects

IAMs

Ex: diarrheal disease model in FUND

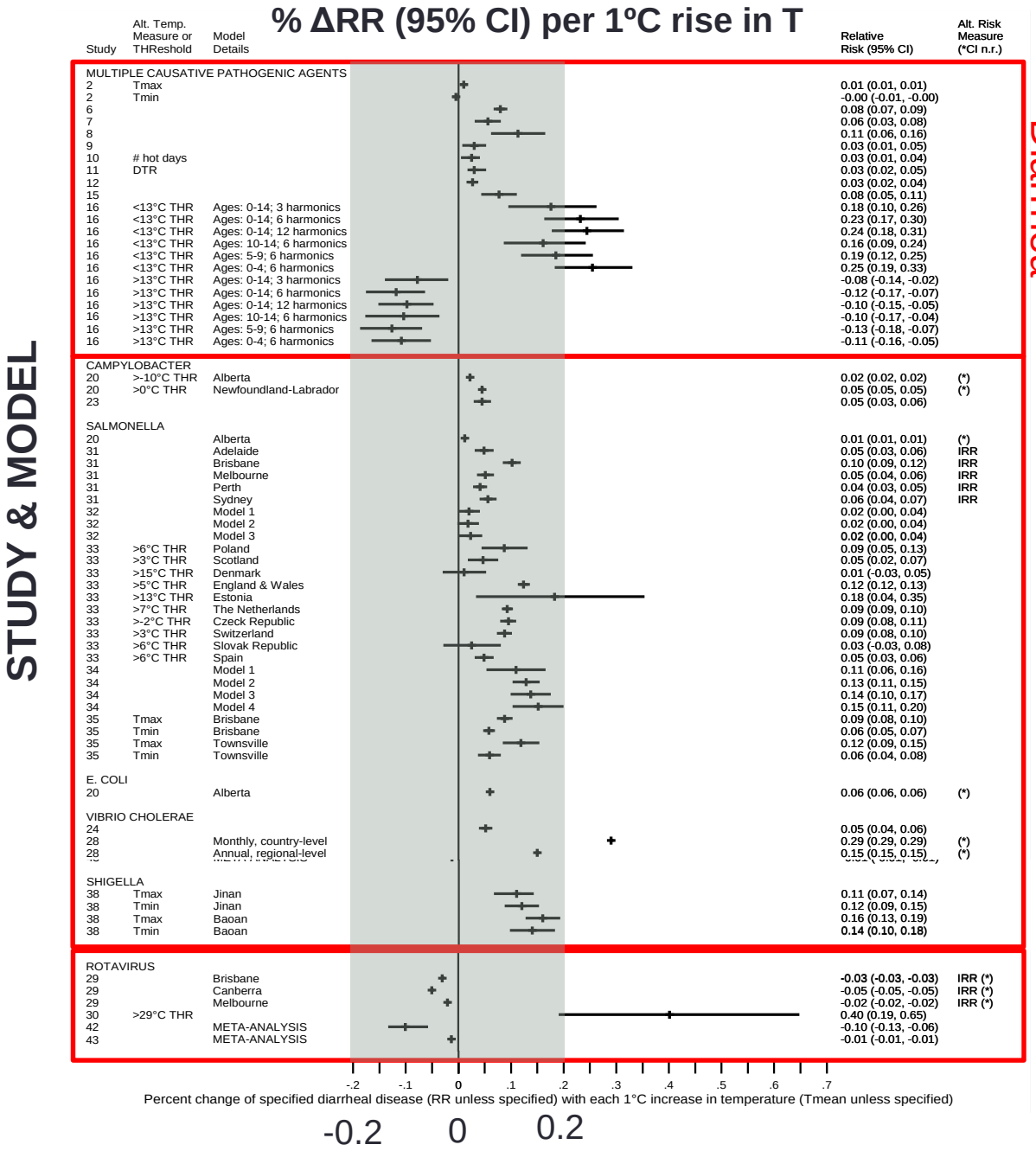
1. Cross-sectional analyses of annual data (diarrheal disease)
2. Global or regional (multi-country) zones
3. Log-linear functions

Preliminary Results:
Literature Review on Diarrhea Seasonality

Percent change in relative risk of diarrheal disease with each 1°C rise in temperature

Sources of variation:

- Etiology
  - all-cause diarrhea
  - pathogen-specific
- Geographic
  - b/t regions
  - w/in countries
- Model specification
  - non-linearities
- Climatological variables (mean or extreme?)
- Population



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Data

- 4 pathogen-specific diarrheal disease meta-analyses
  1. Cases of monthly diarrheal disease from time series surveillance epidemiological studies
     - **Rotavirus**: (1) 26 studies, tropics (1974-2003)[1]; (2) 63 studies, South Asia (1976-2009)[2]
     - **Pathogenic E. coli:** (3) 28 studies, global (1975-2010) [3]
     - **Cryptosporidiosis:** (4) 61 studies, global (1982-2005) [4]
  2. Mean monthly temperature (ºC) and monthly precipitation (cm)
     - Hadley Centre CRUTEM4[3]
     - National Climatic Data Center[1,2,4]
     - Global Historical Climatology Network-Monthly (GHCN-M) [1,2,3,4]
     - Original paper[1]

[1]Levy et al. (2009). *International Journal of Epidemiology*, 38(6).
[2]Jagai et al. (2012). *PLoS ONE,* 7(5).
[3]Phillipsborn et al. (2014, Submitted). *Lancet Infectious Disease.*
[4]Jagai et al. (2009). *Environmental Research,* 109(4).

Next Steps

1. Reanalyze and harmonize existing meta-analysis models
   - Compare between pathogens (rotavirus, cryptosporidium, E. coli) with same model specification (Phillipsborn et al., 2014):
     - GEE models with poisson distribution and AR(1) correlation structure, clustered by study
     - Exposure variables: (1) T, (2) Ppt, (3) T and Ppt
     - Fixed effects: developed vs. developing
   - Temporal aggregation: monthly (original) vs. annual (IAM) scales
   - Spatial variation: study site vs. regional vs. global
2. Test additional climatological data, covariates (e.g. GDP), and model specifications
3. Monte Carlo simulations to extend time series and generate range of potential damages

Thank you!

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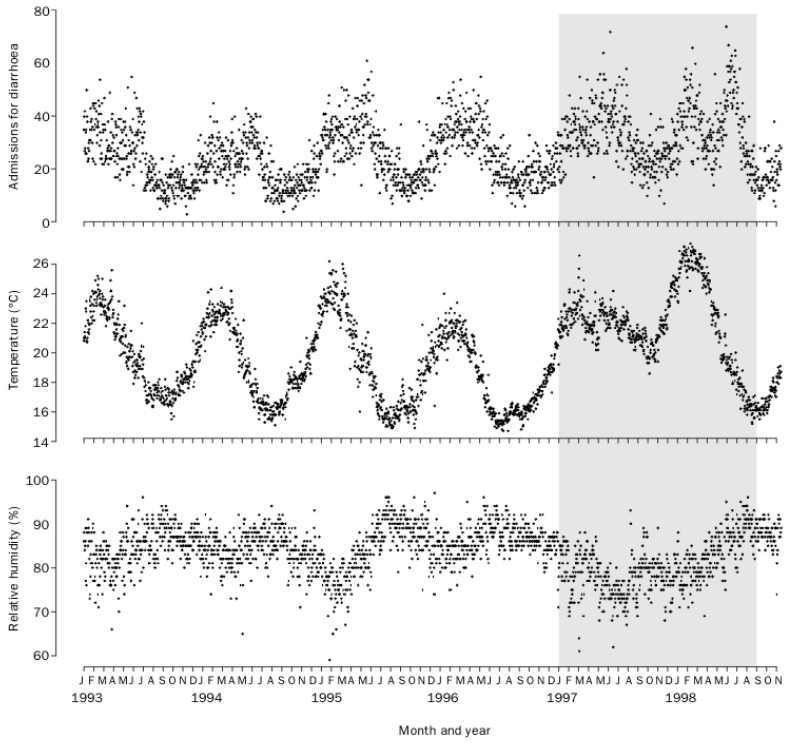
- **Whittington group**



Checkley et al, 2000, Figure 1

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Request for Feedback

- Potential confounders
  - GDP per capita
  - Geographic
  - Water and sanitation
  - Baseline disease rates
- Alternative modeling methods
- Handling different study time periods and lengths
- Distinguish between weather variability and climate change