A Summary of the UCAR Google.org Weather and Meningitis Project

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Presented by: Mary Hayden, Tom Hopson, Jeff Lazo, Raj Pandya

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Influence Diagram of Vaccination Program

- Population Size
- Size of Outbreak
- Attack Rate
- Vaccine Effectiveness
- Meningitis Vaccination Program
  (type of vaccine, timing, scope, etc.)
- Carriage
- Population Immunity
- Active Serogroup
- % Vaccinated
- Population Movement
- Dry Season Weather
- Social Factors
- Respiratory Health
- Onset of Wet Season
- Morbidity (ST & LT)
- Morbidity Rate
- Vaccination Costs
- Research Costs
- Health Care Costs
- Fatality Rate
- Morbidity Rate
- Value

Symbols:

- □ = Decision
- ○ = Uncertainty/Data
- ▲ = Decision Value

- # of Early Cases
- Weather Forecast
- New Weather Research/Modeling

Influence Diagram Components:

- Epidemiology
- Decision Analysis
- Economics

Decision Components:

- Value
- Morbidity Rate
- Fatality Rate
- Vaccination Costs
- Research Costs
- Health Care Costs

Uncertainty/Data Components:

- # of Early Cases
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Decision Value Components:

- Value
- Morbidity Rate
- Fatality Rate
- Vaccination Costs
- Research Costs
- Health Care Costs
Applying Meteorology to Help Manage Meningitis

• Context:
  – Meningitis epidemiology, risk factors, and vaccination strategies
  – Ghana focus

• Project goal:
  – Minimize meningitis incidence by providing 1-14 day weather forecasts to target dissemination of scarce vaccine

• Project objectives:
  – Objective 1: Investigate utility of meteorological forecasts to inform vaccination campaigns
  – Objective 2: Identify and analyze myriad meningitis risk factors
Context: Managing Meningitis in the Sahel

- Meningitis is endemic in the Sahel in countries with a distinct wet-dry season
- Infectious disease due to bacterium – *Neisseria meningitidis*
- Epidemic in 1996-1997 resulted in 250,000 cases and 25,000 fatalities
- Person-to-person transmission through respiratory and throat secretions – between 10-25% of population may carry bacteria at any time; higher during epidemics
- A reactive vaccine strategy is currently used to manage epidemics
  - Doesn’t prevent transmission of the disease by the individual vaccinated
  - Only lasts one-to-two years
  - Doesn’t produce an immune response in children under two
Our Project Focuses on Ghana

• Available Epidemiological Data
  – Navrongo, in northern Ghana, has excellent meningitis surveillance data going back 10+ years

• Local Expertise
  – Drs. Abudulai Adams-Forgor and Abraham Hodgson, at the Navrongo Health Research Centre, have published on weather-meningitis links in Ghana
  – Former NCAR post-doc, Benjamin Lamptey, provides ties to the operational weather community in Ghana; this will help with data access and sustainability (ultimately, the goal is for the Ghana weather service will provide forecasts)
Weather Affects Meningitis Transmission

- *Nm. meningitidis* epidemics need three factors to happen
  - A population susceptible to the emerging serogroup
  - A hyperinvasive/hypervirulent strain
  - Risk factors (environmental factors/social factors)

- *Nm. meningitidis* epidemics are observed to occur in the dust season and end with the onset of the rainy season
  - Can humidity forecasts help identify regions where the epidemic will end naturally, so that scarce vaccines can be moved elsewhere?

- What other risk factors can we identify, to comparatively assess the value of the weather forecasts and offer other management strategies
Humidity and Meningococcal Concentration

Ghipponi et al. 1971

Slide from Sylwia Trzaska, IRI
Climatology of West Africa

January

July

World Survey of Climatology, 1972
There is a strong diurnal cycle in the monsoon flow.

The monsoon tends to advance northwards during the night (Parker et al., 2005)

*Slide from John Marsham, U. of Leeds*
Activities: Further Quantify the Weather-meningitis Link on 1-2 Week Time Scales

• Research Collaborators: Benjamin Lamptey (ACCRA), Fred Semazzi (NCSU) and Sylwia Trzaska (IRI)

• Previous studies focused on seasonal time scales over larger geographical regions -- Our focus:
  — medium-range time scale (1 to 2 weeks)
  — finer spatial resolution (Ghanaian district-level)

• Data Partners
  — Epidemiological data: archived 10 years Navrongo district epidemiological records
  — Weather analyses:
    • NCEP and ECMWF Re-analyses
    • NCAR’s African Initiative WRF analyses

• Quantifying the connection through
  — statistical models that incorporate impact of weather on meningitis
  — significance and uncertainties in the weather connection
Activities (cont.): Prediction of the End of the Dry Season

- Weather forecasts
  - WMO THORPEX TIGGE Weather Ensembles (focus: NCEP and ECMWF), 1 to 14 days
  - optimally-combine into probabilistic forecast for humidity, 1-15 days out, over Northern Ghana
  - verify forecast skill

- Dual probabilistic impact of both the weather variables on meningitis outbreaks and the probabilistic forecasting skill - how much utility we can provide?
Conceptual Representation and Quantification of Societal Impacts

• Approach – economics and decision analysis
  – decision model incorporating relevant aspects of the entire decision process
  – Google.org’s vision of Earth-gauging network that integrates environmental, social, and economic data to help communities respond to environmental influences
Influence Diagrams

- Graphical representation of the decision situation and the pathways of information
- Conceptually tying all the components together
- Helping everyone to speak the same language
- Identifying knowledge gaps
- Identifying and setting priorities for data collection
- Used for evaluating uncertainty
- Could be fully developed into a decision analysis model with sufficient quantitative data
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ECONOMICS / DECISION ANALYSIS

EPIDEMIOLOGY

METEOROLOGY
Valuing Health Outcomes

• Ultimate function of the model will be to develop estimates of the value of the improved forecast information and its use in health decision making

• Alternative health outcome measures will be explored based on both theoretical considerations and availability or collection of reliable applied measures including
  – disability adjusted life years (DALYs) – common in health literature
  – quality adjusted life years (QALYs) – relatively new in economics
  – willingness to pay (WTP) – preferred economic approach

• Joint field work to include data collection on economic/socio-behavioral components
  – exposure
  – risk behavior
  – household level impacts
  – benefits and values – WTP?
New Strategies to Engage Diverse and International Communities?

• In addition to people, this project brought together ideas and strategies from across the organization, including:
  – Community-based participatory research: Partnering with communities to develop a shared agenda integrating research, education, and capacity-building

  – Solutions-oriented research: Linking multiple disciplines and local expertise in an end-to-end process from basic understanding to socio-economic and human impact

  – Embedded atmospheric research: Working to contribute our expertise in broader contexts can open doors to new opportunities, including funding.

• Can this combination provide a strategy for further engagement with diverse and international communities?
• What organizational changes would facilitate this? (e.g., employee hiring and evaluation, grant administration, etc.)
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