Vector Borne Diseases: The Ecologic Interface of Global Health, One Health, and Travelers' Health

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ACME: American Committee of Medical Entomology

• ACME is organized under the auspices of the American Society of Tropical Medicine and Hygiene (ASTMH) and exists to work toward the following objectives:
  – To promote medical entomology
  – To organize symposia or workshops annually that emphasize the contributions of medical entomology to tropical medicine
  – To encourage participation of medical entomologists in the ASTMH
  – To recognize outstanding contributions by medical entomologists

ACME Awards

Hoogstraal Award
The Harry Hoogstraal Medal for Outstanding Achievement in Medical Entomology. Nominations for the Harry Hoogstraal Medal for outstanding achievement in Medical Entomology may be submitted online during the Call for Nominations.

ACME Breakthroughs in Medical Entomology Award
Awards seeks to award funding of $1,000 to outstanding recent contributions (within the past 5 years) to the study and/or practice of Medical Entomology that ultimately will contribute to reducing the burden of human disease transmitted by arthropods.

ACME Future Leaders Fellowship in International Medical Entomology
The Future Leaders Fellowship is a competitive award that will be offered to an outstanding junior medical entomology researcher (must be in the undergraduate to post-doctoral level) to showcase individuals that have matched interests to ACME's objectives of promoting medical entomology and reducing the burden of human disease transmitted by arthropods globally.

ACME Travel Awards for Young Investigators
ACME now offers three Young Investigator Travel Awards: Masters, Doctoral and Post-doctoral and International. All research must involve arthropods of medical importance. Recap recipients will receive a complimentary registration to the Annual Meeting and up to $900 to support travel and accommodations costs.

Award application and nomination instructions can be found on the ACME website: https://www.astmh.org/subgroups/acme

Outline

Relevance of the interface between humans, pathogens and environment

Vector-borne diseases: a ‘complex’ transmission system

Social/environmental drivers: two case studies
- Anthropogenic change and West Nile virus transmission
- Human movement and dengue transmission

Conclusions

Planetary Health
Global Health
One health
Eco-Health
Travelers health

Humanity’s health and future global prosperity depend on blurring boundaries:

Local - global
Human - animal
Environmental degradation – health/development
Urban - rural issues

Planetary Health

World Population (billions)

Data: United Nations population Division

"Global ecological change is a normal process in the geological and biotic evolution of the Earth. What makes it a concern today is the unprecedented speed and scale of declines in ecological functioning that are attributable to human activity over the past century, and especially over the last 50 years."


https://healthforanimals.org/general/one-health.html
Emerging Infectious Diseases: more common and lethal

EID: original case or cluster of cases of an infectious disease occurring for the first time.

Increasing number, and of animal origin. Relevance of the human-wildlife interface

Discovery of enzootic Zika virus transmission focus, 1947-48

Historic and Recent History of Zika Virus Spread and Epidemics

Vector borne diseases

Caused by pathogens transmitted through the bite of another organism, such as fleas, ticks or mosquitoes

Requisites for VBD transmission

- Vector presence and survival
- Presence of suitable hosts
- Pathogen introduction/amplification
- Opportunities for human exposure
What happens when we oversimplify? Warmer = buggier

Do we know enough about climate (or even weather) *per se* and VBZD?

Climate, weather and VBD: a complex association

- Temperature
- Rainfall
- Humidity
- Variability
- Extreme Events
- Vector survival
- Presence of reservoir hosts
- Pathogen transmission
- Opportunities for human exposure

Infection of reservoir hosts
Disease of human hosts

Multiple sources of uncertainty:
- scale of change is variable
- Multi-factorial process:
- coupled heterogeneities
- human influence can impact predictions with higher effect-size
- Complex vector ecology and behavior

Figure 3. Overlapping global distribution of nine major vector-borne diseases for which integration of vector control programmes may be beneficial, 2016. Reflects all locations where the population is at risk of at least one of the following vectors: *Anopheles*, *Aedes*, *Culex*, *Haemagogus*, *Aedes* spp., *Babesia*, *Chagas disease*, human African trypanosomiasis or *Onchocerca*.
Multiple scales of movement lead to different aspects of VBD transmission.

But understanding exposure is essential to knowing how VBDs emerge and are maintained.

Understanding Exposure: Examples

- Environmental change: urban infrastructure and West Nile Virus transmission.
- Human behavior and response to disease: human movement and dengue transmission.

Environmental change and VBD transmission: urban infrastructure and West Nile Virus transmission.

Collaborators:
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Thomas Burkot - CDC
Danny Mead - UGA
Rosmarie Kelly - GA-DPH

Combined Sewer Systems and Mosquitoes

Combined Sewer Overflows (CSO) Are Major Urban Breeding Sites for Culex quinquefasciatus in Atlanta, Georgia

Collaborators:
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Combined Sewer Overflow Systems

Designed to carry both sewage and storm water.
When flow exceeds the maximum capacity of the sewer systems, it overflows directly into bodies of water with minor treatment.

Atlanta: 7 CSO facilities located in close proximity to residential, commercial and recreational sites.

WNV infection in mosquitoes, birds and humans clustered in close proximity to CSO streams.
Risk factors of WNV infection

Mosquitoes: Distance to CSO, followed by Tree cover range

New CSO and wastewater management: 2009 - present

• New tunnels to divert water to treatment facilities
• Large reservoirs for temporary water storage
• Goals:
  – Separate CSO from runoff waters
  – Delay CSO events.

Impacts on Cx. quinquefasciatus population dynamics?

Urban infrastructure and WNV

• CSO:
  – Reduces stream diversity (less predators)
  – Increases bacterial counts
  – Increases Culex sp. mosquito abundance.
  – Abundant bird populations in riparian forests.
• Perfect for WNV amplification & spillover.

Where is WNV now amplifying?

• Solutions to environmental and public health problems are achievable!

Dengue

Most important mosquito-borne viral disease in the world

Annually:
390 million (95% credible interval 284–528) infections per year, 96 million (67–136) as apparent disease.

- Preferentially (>90%) a human biter.
- Hungry for our blood (~1.5 days).
- "Lazy" flier: ~30-100m.
- Daytime biter.
Considering human behavior when estimating dengue transmission risk

**Revisiting the Common Assumption:**
Infection occurs in the home

If other locations are important, then:
Human movement needs to be considered when determining exposure and probability of key encounters

**Challenges in the estimation movement and exposure**

- Traditional methods: direct observations, diaries and interviews
- Issues of recall, reliability, reproducibility, compliance, behavioral change, and privacy
- Alternative: use of GPS technology
  - Used in the past
  - Costly and technology challenging

What data do we obtain from GPS?

- Latitude, longitude, date, time, elevation

**Human movement influences dengue exposure**

Sampled Activity Spaces:
- DENV-positive
- DENV-negative

**But transmission may be driven by asymptomatics**

Stochastic simulation model that couples:
Within-host sub-model to simulate human infectiousness to DENV infection with any of the 4 serotypes. Disease severity with different contributors (asymptomatic, inapparent symptomatic, symptomatic and pre-symptomatic infections) Human movement.

88% of contribution to transmission from asymptomatic carriers (pre-symptoms or no symptoms).

Implication for control and virus introduction

**Conclusions/Discussion points**

In a continually shrinking world, VBDs are interdependent on environmental, biological and human components. Need for deeper understanding of the ecological processes underlying VBD transmission.

Climate change may enhance (or disrupt) transmission of VBDs, but other (mostly anthropogenic) factors impact transmission & disease (in synergy or antagonistically), rendering the “warmer=buggier” approach highly simplistic.

Global agenda for VBD mitigation will require working at the interface of global health, one health and eco-health.
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