GMM Dengue Control in a Social and Cultural Context

Co-Authors: Tim Antonelli, Amanda Clayton*,
Molly Hartzog Storment, Sophia Webster, Gabriel Zilnik

PhD Student Fellows of the Genetic Engineering and Society Program**
North Carolina State University

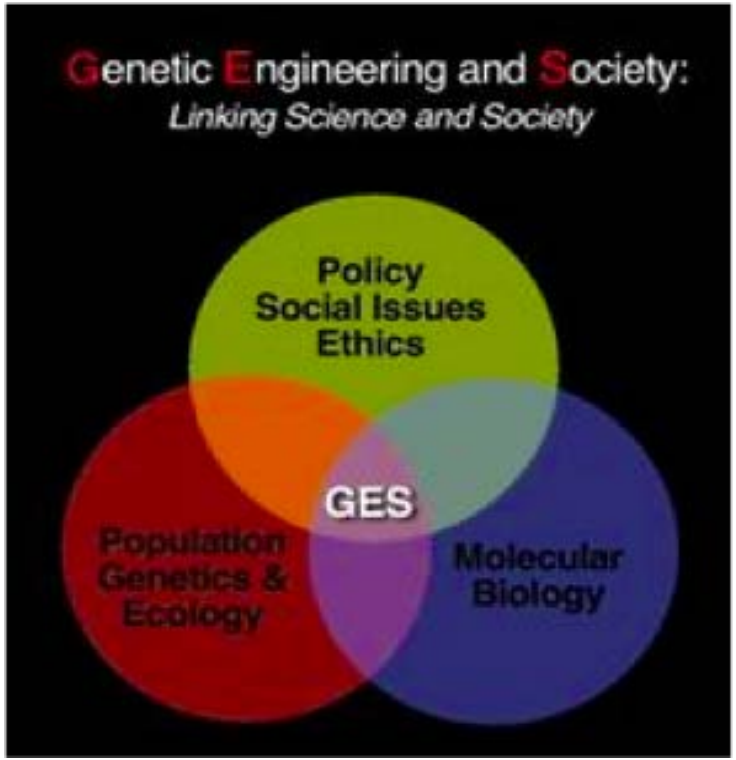
**Co-PI's: Fred Gould, Alun Lloyd, Nick Haddad, Nora Haenn, and William Kinsella

NC STATE UNIVERSITY
Center for
Genetic Engineering & Society

NSF

IGERT Grant #1068676

Genetic Engineering and Society
The Case of Transgenic Pests



- Interdisciplinary program at North Carolina State University
- Funded through NSF IGERT grant
- Represented Fields

  Biomathematics
  Biology
  Communication, Rhetoric, & Digital Media
  Economics
  Entomology
  Forestry & Environmental Resources
  Genetics
  History
  Public Administration
  Sociology & Anthropology

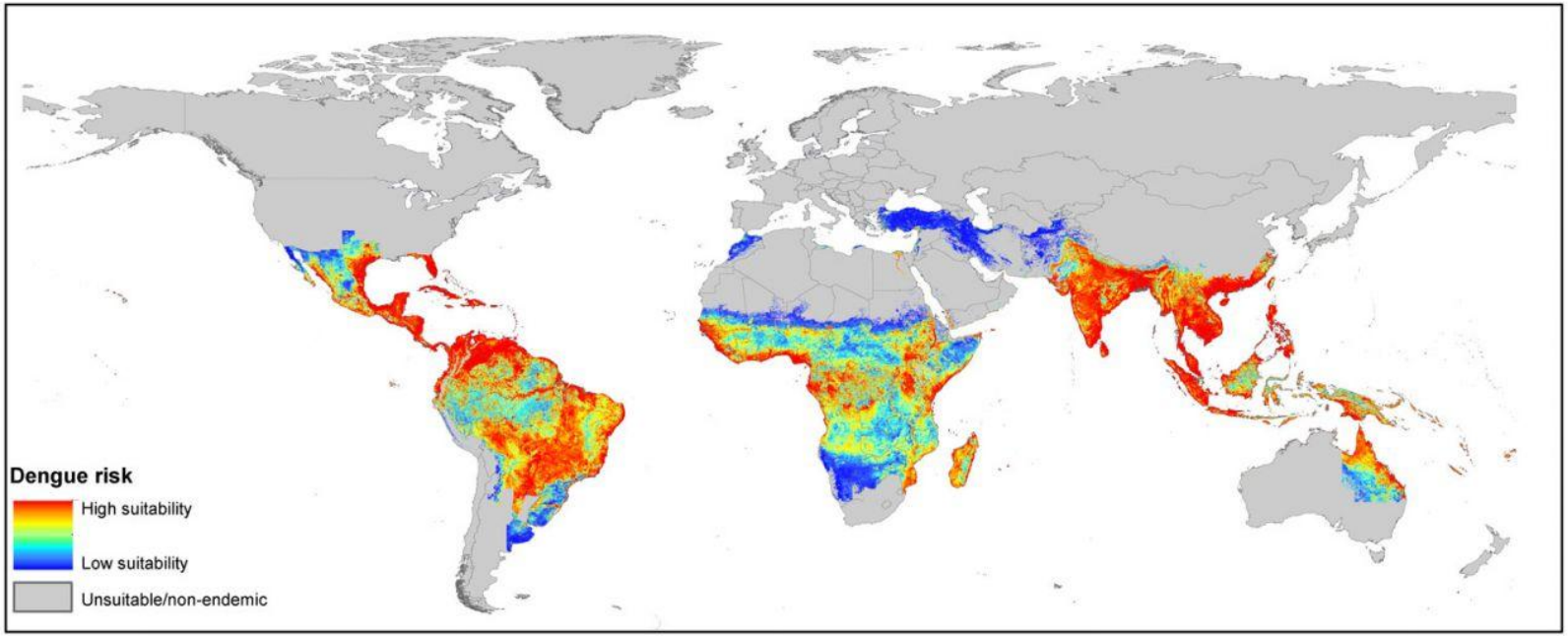
GMM for Dengue Control

- Question
  - Should we use GMM to control dengue fever?
- Students
  - Tim Antonelli: Biomathematics
  - Amanda Clayton: Economics
  - Molly Hartzog Storment: CRDM
  - Sophia Webster: Entomology
  - Gabriel Zilnik: Entomology

Photo Credit: Muhammad Mahdi Karim

Global Burden of Dengue

Distribution of global dengue risk (Simmons CP et al, 2012)



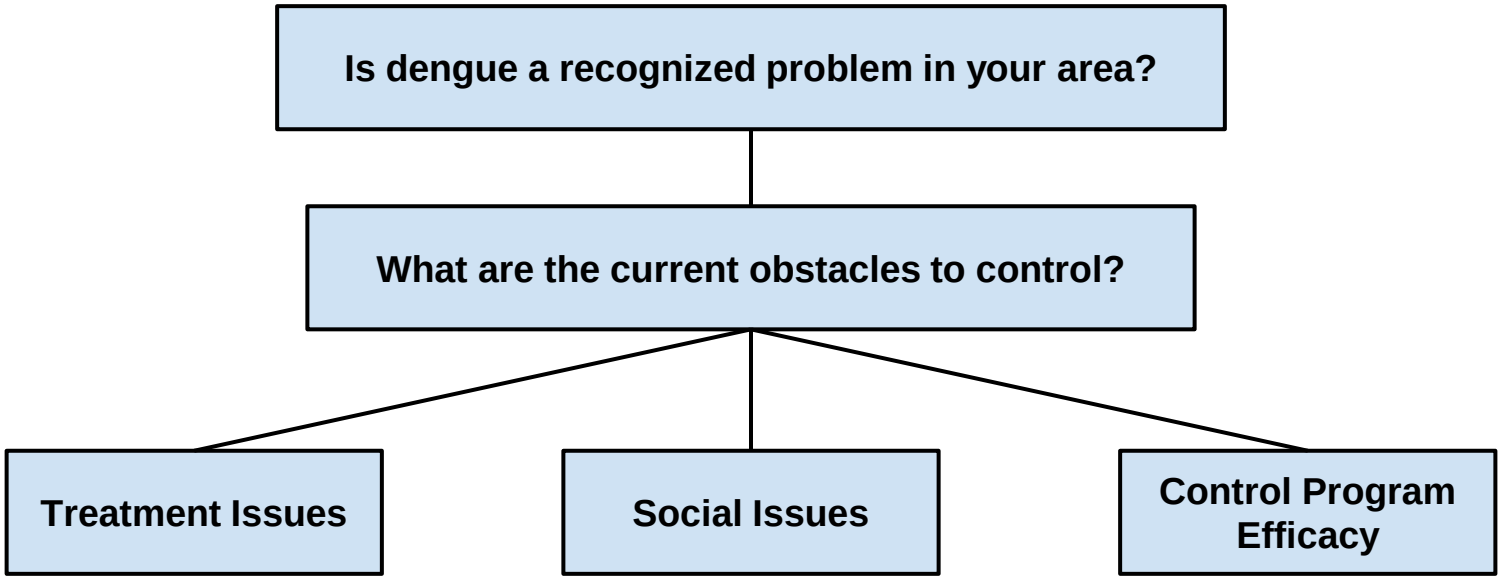
Global strategy for dengue prevention and control 2012-2020, World Health Organization, ISBN 978 92 4 150403 4, page 2, 2012

Aedes aegypti & Genetic Modification

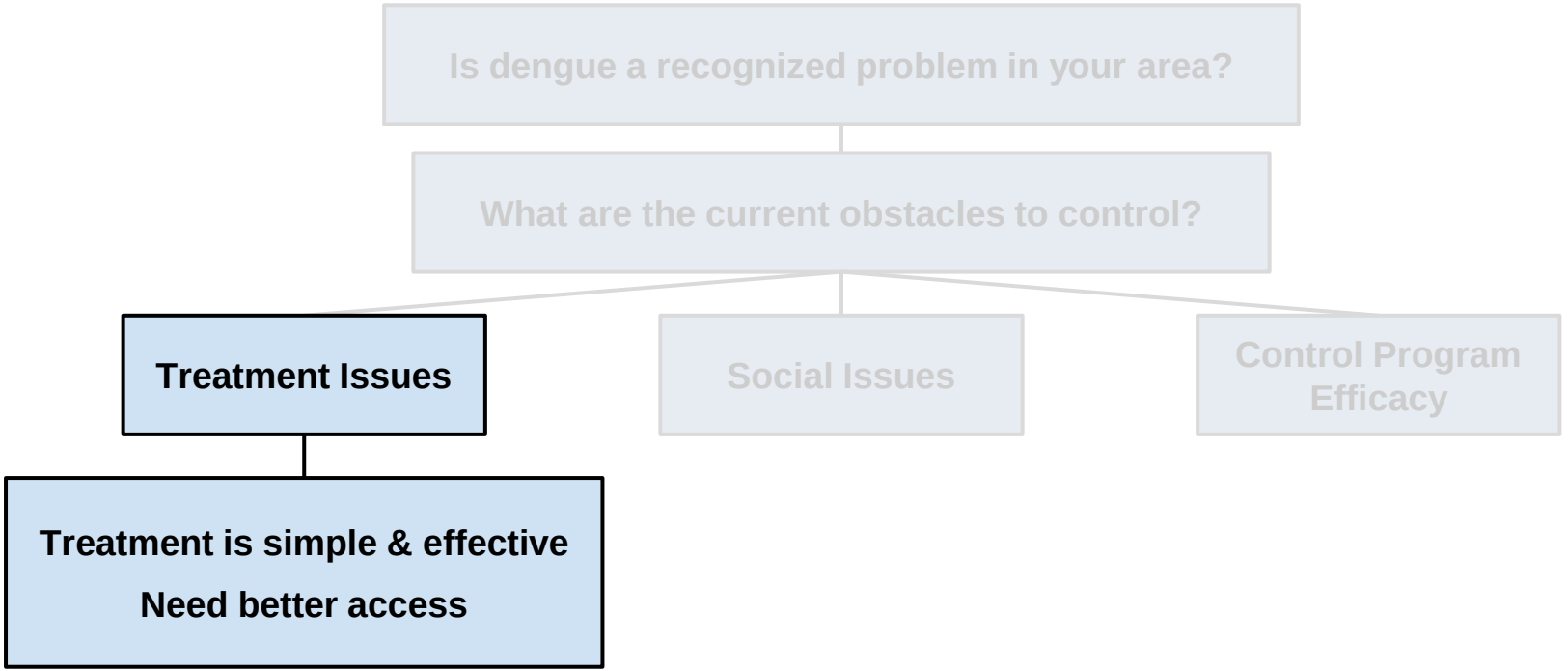
Photo Credit: James Gathany, Centers for Disease Control and Prevention

- Dengue is transmitted by the bite of an infected *Aedes aegypti* mosquito
  - Females bite during the day
  - Lay eggs in open water containers
  - Inhabit tropical urban areas
- GM Control Techniques
  - Population Suppression
  - Population Replacement

Should we use GMM to control dengue?

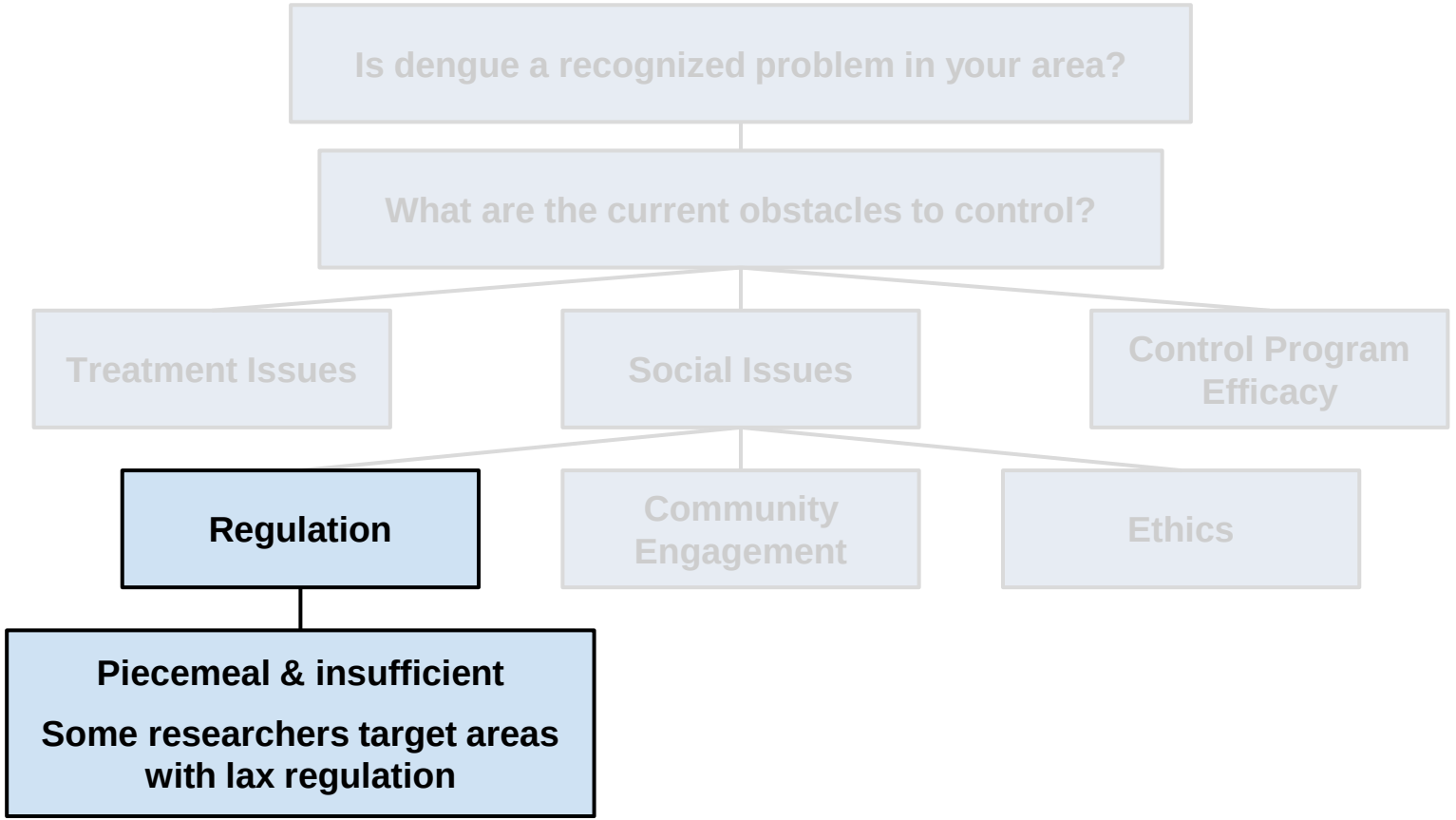


Should we use GMM to control dengue?

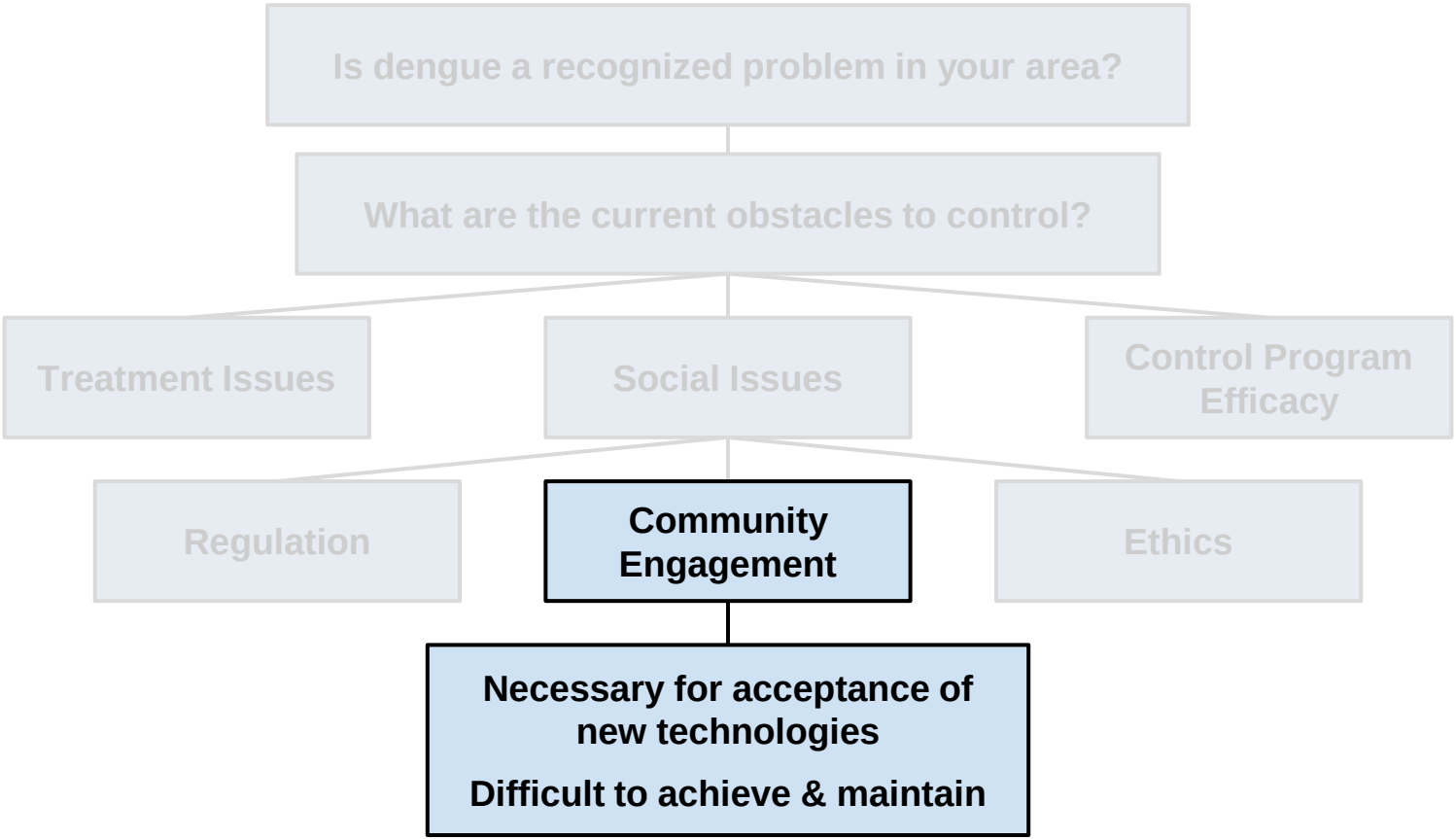


Should we use GMM to control dengue?

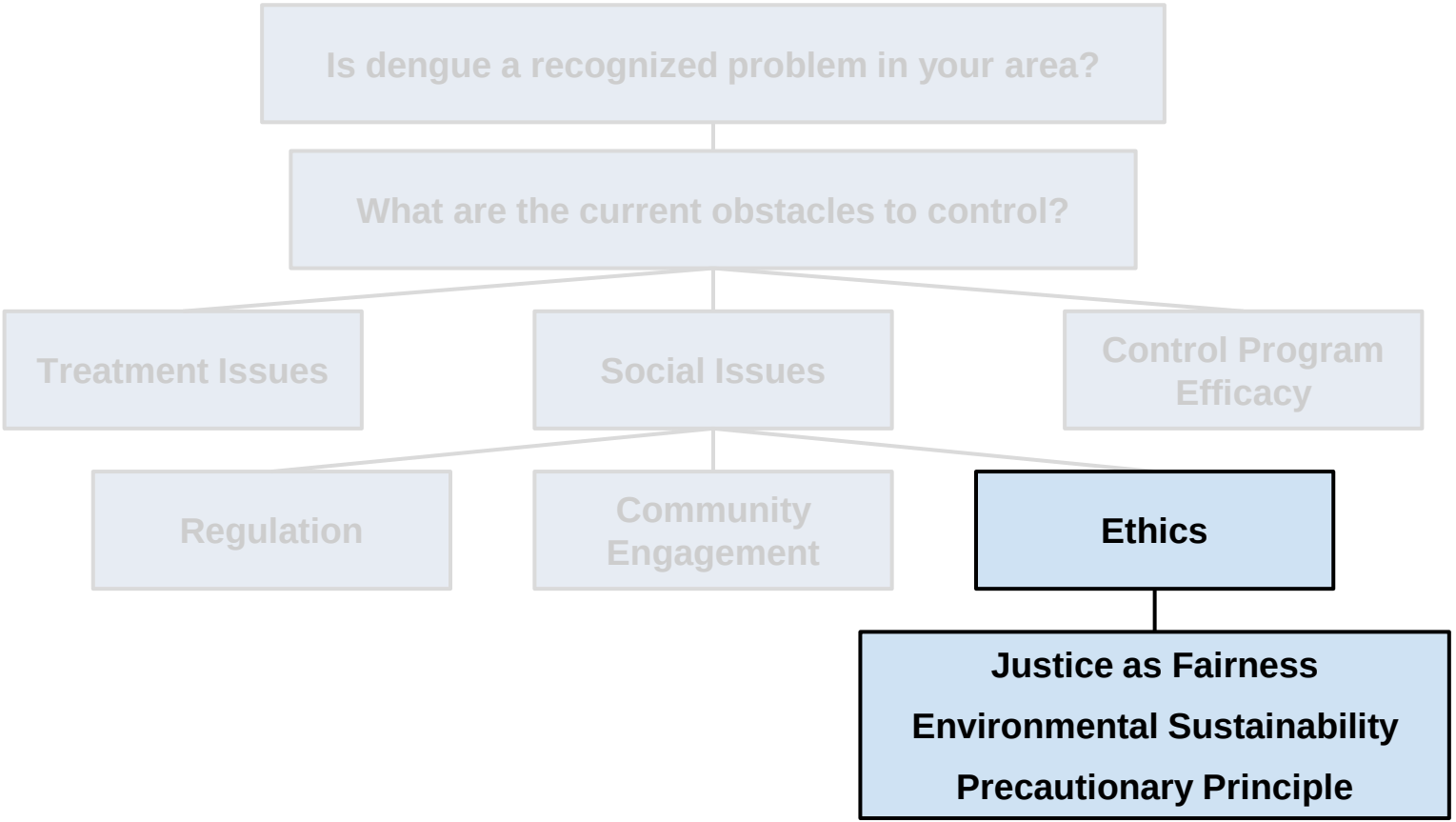
Should we use GMM to control dengue?



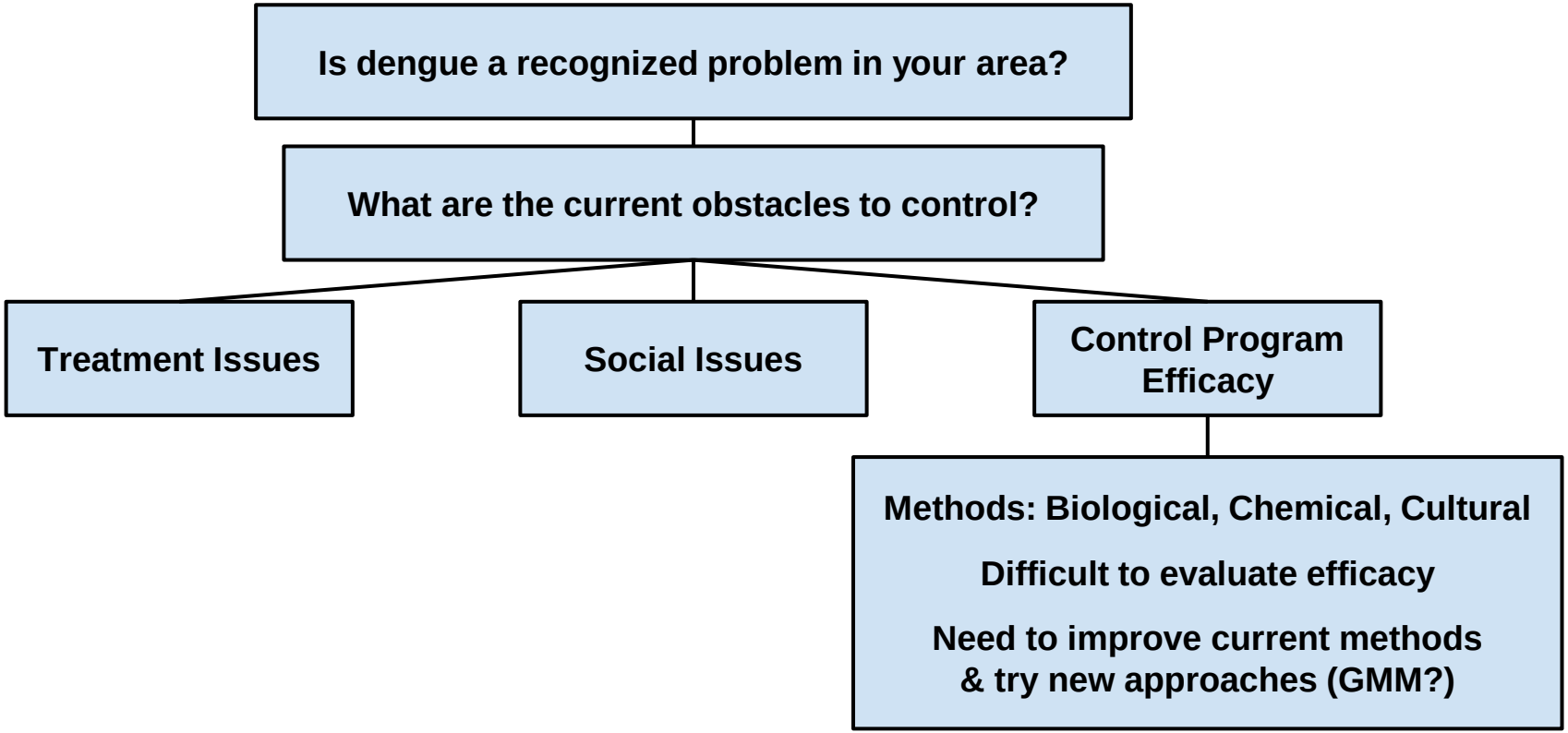
Should we use GMM to control dengue?



Should we use GMM to control dengue?



Should we use GMM to control dengue?



So...should we use GMM to control dengue?

- Conclusion 1: Not right now...
  - Focus on treatment instead
  - GMM may not be better than current controls
  - Regulation & support not yet in place
  - Potential risks not fully explored

So...should we use GMM to control dengue?

- Conclusion 2: Yes BUT ONLY...
  - With caution
    - Need site-specific risk assessments
  - As part of a broader control strategy
    - Not a “silver bullet”
  - On a case-by-case basis
    - Need open community engagement

So...should we use GMM to control dengue?

- Research on GMM control techniques should continue regardless of its use for dengue control
  - Implications for malaria, chagas, west-nile, etc.

- Need to maintain an open dialogue with all interested publics throughout all processes
  - Research, policy, regulation, implementation, etc.

Thanks!

References

Alphey, N, Bonsall, MB & Alphey, L. 2011. Modeling Resistance to Genetic Control of Insects. *Journal of Theoretical Biology,* **270**(1) (February), 42–55.

Alvez, MJ et al. 2013. Clinical presentation and laboratory findings for the first autochthonous cases of dengue fever in Madeira island, Portugal, October 2012. *Eurosurveillance*, **18**(6), 2-5.

Armada Gessa, JA & Figueredo González R. 1986. Application of Environmental Management Principles in the Program for Eradication of Aedes (Stegomyia) aegypti (Linneus, 1762) in the Republic of Cuba, 1984. *Pan American Health Organization Bulletin* **20**(2), 86-193.

American Academy of Arts and Sciences. 2013. *The Heart of the Matter.* Cambridge: The American Academy of Arts and Sciences.

Angeli, E. L. 2012. Metaphors in the rhetoric of pandemic flu: Electronic media coverage of H1N1 and swine flu. *Journal of Technical Writing & Communication*, **42**(3), 203–222.

Baskaran, A, and R Boden. 2004. Science: a Controversial Commodity. *Science Technology & Society* **9**(1) (March 1): 1–26.

Bhatt, S. et al. 2013. The Global Distribution and Burden of Dengue. *Nature*, **496**(7446), 504-507.

Bleakley, H. 2007. Disease and development: evidence from hookworm eradication in the American South. *The Quarterly Journal of Economics*, **122**(1), 73-117.

Bleakley, Hoyt. 2010. Health, human capital, and development. *Annual Review of Economics* **2**(1) (09/04; 2012/09): 283-310.

Brossard, D, and J Shanahan. 2007. Perspectives and Communication About Agricultural Biotechnology. In *The Media, the Public and Agricultural Biotechnology*. Eds. D Brossard, J Shanahan, and T C Nesbitt. Wallingford, UK: CABI International. 3–20.

Brownstein, J S, E Hett, and S L O'Neill. 2003. The Potential of Virulent Wolbachia to Modulate Disease Transmission by Insects. *Journal of Invertebrate Pathology* **84**(1) (September): 24–29.

Bucchi, M. 2008. Of deficits, deviations, and dialog: Theories of public communication of science. In *Handbook of Public Communication of Science and Technology,* edited by Massimiano Bucchi and Brian Trench, 57-76. New York: Routledge, 2008.

Burke, K. 1966. *Language As Symbolic Action: Essays on Life, Literature and Method*. Berkeley: U of California P.

Burt, A. 2003. Site-Specific Selfish Genes as Tools for the Control and Genetic Engineering of Natural Populations. *Proceedings of the Royal Society B: Biological Sciences* **270**(1518): 921–928.

Burt, Austin, and Robert Trivers. 2009. *Genes in Conflict*. Harvard University Press.

Camilla, Shahnaz Murad, Alphey Luke, Nimmo Derric David, et al. 2013. Oral Ingestion of Transgenic RIDL Ae. Aegpyti Larvae Has No Negative Effect on Two Predator Toxorhynchites Species. *PLoS ONE*. **8**(3): e58805.

Carson, Rachel. 2002. *Silent Spring*. Boston: Houghton Mifflin Harcourt.

"Cartagena Protocol on Biosafety." 2000.

CDC. 2010. Locally acquired dengue – Key West, Florida, 2009-2010. *Morbidity and Mortality Weekly Report*, **29**: 577-81.

Chang, Shu-Fen. Huang, Jyh-Hsiung, and Shu, Pei-Yun. 2012. Characteristics of dengue epidemics in Taiwan. *Journal of the Formosan Medical Association*. **111**(6): 297-299.

Charoensook O, Sethaputra S, Singklang K, et al. 1985. Prevalence of Aedes mosquitoes in big cement jars and rainwater tanks. *Communicable Disease Journal.* **11**: 247-263 (in Thai).

Core Working Group on Guidance for Contained Field Trials. 2008. Guidance for Contained Field Trials of Vector Mosquitoes Engineered to Contain a Gene Drive System: Recommendations of a Scientific Working Group. *Vector-Borne and Zoonotic Diseases*. **8**(2).

FDA. Genetically Engineered Animals: General Q&A [Internet] 2013 Apr 23 [cited 2014 Jan 6]. Available from: http://www.fda.gov/AnimalVeterinary/DevelopmentApprovalProcess/GeneticEngineering/GeneticallyEngineeredAnimals/ucm113605.htm

Flores, Adriana E, Gustavo Ponce, Brenda G Silva, Selene M Gutierrez, Cristina Bobadilla, Beatriz Lopez, Roberto Mercado, and William C Black IV. 2013. Wide Spread Cross Resistance to Pyrethroids in Aedes Aegypti (Diptera: Culicidae) From Veracruz State Mexico. *Journal of Economic Entomology* **106**(2): 959–969.

Fraser, Nancy. 1990. Rethinking the Public Sphere: A Contribution to the Critique of Actually Existing Democracy. *Social Text* (Duke University Press). **25**(26): 56–80,

French, Declan. 2012. Causation between health and income: A need to panic. *Empirical Economics.* **42**(2): 583-602.

García, Gustavo Ponce, Adriana E Flores, Ildefonso Fernández-Salas, Karla Saavedra-Rodríguez, Guadalupe Reyes-Solis, Saul Lozano-Fuentes, J Guillermo Bond, et al. 2009. Recent Rapid Rise of a Permethrin Knock Down Resistance Allele in Aedes Aegypti in México. Edited by Pattamaporn Kittayapong. *PLoS Neglected Tropical Diseases* **3**(10) (October 13): e531.

Getis A, Morrison AC, Gray K, Scott TW. 2003. Characteristics Of The Spatial Pattern Of The Dengue Vector, Aedes Aegypti, In Iquitos, Peru. *Am. J. Trop. Med. Hyg*. **69**(5): 494-505.

Graduate studies in genetic engineering and society. 2012 [cited 09/29 2012]. Available from http://geneticengsoc.ncsu.edu/.

G. T. Goodnight. 1982. The Personal, Technical, and Public Spheres of Argument. *Journal of the American Forensics Association*. **18**:214-227.

Gubler, Duane J, and Gary G Clark. 1996. Community Involvement in the Control of Aedes Aegypti. *Acta Tropica.* **61**(2): 169–179.

Gubler, Duane J. 2002. Epidemic dengue/dengue hemorrhagic fever as a public health, social and economic problem in the 21st century. *Trends in Microbiology.* **10**(2) (2/1): 100-103.

Guzman, MG, Alvarez, M & Halstead, SB. 2013. Secondary infection as a risk factor for dengue hemorrhagic fever/dengue shock syndrome: an historical perspective and role of antibody-dependent enhancement of infection. *Archives of virology*. **158**(7): 1445–59.

Habermas, Jürgen. 1989. *The Structural Transformation of the Public Sphere: An Inquiry into a Category of Bourgeois Society*. Thomas Burger (Trans.). Cambridge, Massachusetts: The MIT Press.

Hauser, Gerard. 1998. Vernacular Dialogue and the Rhetoricality of Public Opinion. *Communication Monographs.* **65**(2): 83–107.

Hoffmann, A A, B L Montgomery, J Popovici, et al. 2011. Successful Establishment of Wolbachia in Aedes Populations to Suppress Dengue Transmission. *Nature*. **476**(7361) (August 16): 454–457.

Hotez, P. J. 2009. How to Cure 1 Billion People?--Defeat Neglected Tropical Diseases: Scientific American. *Scientific American*. December 21.

Hotez, P. J., & Yamey, G. 2009. The Evolving Scope of PLoS Neglected Tropical Diseases. *PLoS Negl Trop Dis*. **3**(2): e379.

International Atomic Energy Agency. 2006. Status and Risk Assessment of the Use of Transgenic Arthropods in Plant Protection. International Atomic Energy Agency. 1–165.

Jansen, CC & Beebe, NW. 2010. The dengue vector Aedes aegypti: what comes next. *Microbes and Infection*. **12**: 272-279.

Jasanoff, S. 2007. *Designs on Nature: Science and Democracy in Europe and the United States*. Princeton University Press.

Katz, S. B. and C. R. Miller. 1996. The Low-Level Radioactive Waste Siting Controversy in North Carolina: Toward a Rhetorical Model of Risk Communication, In *Green Culture: Environmental Rhetoric in Contemporary America* edited by Carl G. Herndl and Stuart Brown, 111-140. Madison: U of Wisconsin P.

Krugman, Paul, Robin Wells, and Kathryn Graddy. 2010. *Essentials of Economics*. 2nd ed. New York, New York: Worth Publishers.

Kyle, JL. & Harris, E. 2008. Global Spread and Persistence of Dengue. *Annual Review of Microbiology,* **62**: 71-92.

La Ruche G, Souarès Y, Armengaud A, et al. 2010. First two autochthonous dengue virus infections in metropolitan France, September 2010. *Eurosurveillance*.

Legros M, Xu C, Okamoto K, Scott TW, Morrison AC, et al. 2012. Assessing the Feasibility of Controlling Aedes aegypti with Transgenic Methods: A Model-Based Evaluation. *PLoS ONE* **7**(12): e52235.

Levins, Richard, and Richard C Lewontin. 1985. *The Dialectical Biologist*. Cambridge, Massachusetts: Harvard University Press.

Longnecker, Matthew P, Walter J Rogan, and George Lucier. 1997. The Human Health Effects of Ddt (Dichlorodiphenyltrichloroethane) and PCBs (Polychlorinated Biphenyls) and an Overview of Organochlorines in Public Health. *Annual Review of Public Health*. **18**(1): 211–244.

Martins, Ademir Jesus, Diogo Fernandes Bellinato, Alexandre Afranio Peixoto, et al. 2012. Effect of Insecticide Resistance on Development, Longevity and Reproduction of Field or Laboratory Selected Aedes Aegypti Populations. *PLoS ONE* **7**(3): e31889.

Medlock, Jan. Luz, Paula M., Struchiner, Claudio J., et al. 2009. The Impact of Transgenic Mosquitoes on Dengue Virulence to Humans and Mosquitoes. *NIH Author Manuscript Am Nat*. **174**(4): 565-577.

Melo-Santos, M A V, J J M Varjal-Melo, A P Araújo, et al. 2010. Resistance to the Organophosphate Temephos: Mechanisms, Evolution and Reversion in an Aedes Aegypti Laboratory Strain From Brazil. *Acta Tropica*. **113**(2) (February): 180–189.

Merton, Robert K. 1973. *The Sociology of Science*. University of Chicago Press.

Morris, Jane E. 2011. Open field release of a self-limiting transgenic Aedes aegypti mosquito strain to combat dengue- a structured risk-benefit analysis. *AsPac J. Molecular Biology Biotechnology*. **19**(3): 107-110.

Morrison, Amy C., Sharon L. Minnick, Claudio Rocha, et al. 2010. Epidemiology of dengue virus in iquitos, peru 1999 to 2005: Interepidemic and epidemic patterns of transmission. *Public Library of Science*. **4**(5).

Morrison Amy C, Zielinski-Gutierrez Emily, Scott Thomas. W, Rosenburg Ronald. 2008. Defining Challenges and Proposing Solutions for Control of the Virus Vector Aedes aegypti. *PLoS Med.* **5**(3):e68.

Mumford, John D. 2012. Science, Regulation, and Precedent for Genetically Modified Insects. *PLoS Neglected Tropical Diseases*. **6**(1): e1504.

Nam, Vu Sinh, Nguyen Thi Yen, Maria Holynska, et al. 2000. National Progress in Dengue Vector Control in Vietnam: Survey for Mesocyclops (Copepoda), Micronecta (Corixidae), and Fish as Biological Control Agents. *The American Journal of Tropical Medicine and Hygiene*. **62**(1): 5–10.

NC State Newsroom. Shipman, Matt. 2012. First-Ever National Survey on Genetically Engineered Mosquitoes Shows Mixed Support [Press release]. http://news.ncsu.edu/releases/wms-cobb-mosquitoes.

Oreenaiza Nordin, Donald Wesley, Ming Wong Hong, et al. 2003. Wolbachia-Induced Mortality as a Mechanism to Modulate Pathogen Transmission by Vector Arthropods. *Journal of Medical Entomology.* **40**(2): 125–132.

Pacey, A. 1999. *Meaning in Technology*. MIT Press.

Phuanukoonnon, Suparat. Brough, Mark. Bryan, Joan H. 2006. Folk knowledge about dengue mosquitoes and contributions of health belief model in dengue control promotion in Northeast Thailand. *Acta Tropica*. **99**(1): 6-14.

Pretty, Jules. 2008. Agricultural Sustainability: Concepts, Principles and Evidence. *Philosophical Transactions of the Royal Society B: Biological Sciences.* **363**(1491) (February 12): 447–465.

Pretty, Jules, and Hermann Waibel. 2005. Paying the Price: the Full Costs of Pesticides. In *The Pesticide Detox*. Ed. Jules Pretty. London: Earthscan. 39–54.

Reeves, R Guy, Jai A Denton, Fiammetta Santucci, et al. 2012. Scientific Standards and the Regulation of Genetically Modified Insects. Edited by Michael J Lehane. *PLoS Neglected Tropical Diseases*. **6**(1) (January 31): e1502.

Reiter, Paul, et al., 2003. Texas Lifestyle Limits Transmission of Dengue Virus. *Emerging Infectious Diseases*. **9**(1): 86-89.

Resnik, David B. 2003. Is the precautionary principle unscientific? *Studies in the History and Philosophy of Biology and the Biomedical Sciences*. **34**: 329-44.

Resnik, David B. 2012. *Environmental Health Ethics*. New York, Cambridge: Cambridge University Press.

Scott, Thomas W., Morrison, Amy C. 2010. Vector dynamics and transmission of dengue virus: Implications for dengue surveillance and prevention strategies. In *Dengue virus*. Ed. Alan L. Rothman. Berlin Heidelberg: Springer. 115-128.

Scott, Thomas W., Morrison, Amy C. 2003. Aedes aegypti density and the risk of dengue-virus transmission. In *Ecological aspects for application of genetically modified mosquitoes*. Eds. W. Takken, T. W. Scott. Google eBook: Springer. 187-206.

Schuldt, J. P., Konrath, S. H., & Schwarz, N. 2011. “Global warming” or “climate change”? Whether the planet is warming depends on question wording. *Public Opinion Quarterly*. ***75***(1), 115–124.

Siller, Quetzaly, Gustavo Ponce, Saul Lozano, et al. 2011. Update on the Frequency of Ile1016 Mutation in Voltage-Gated Sodium Channel Gene of Aedes Aegypti in Mexico. *Journal of the American Mosquito Control Association.* **27**(4) (December): 357–362.

Simard F, Nchoutpouen E, Claude Toto J, et al. Geographic Distribution and Breeding Site Preference of Aedes albopictus and Aedes aegypti (Diptera: Culicidae) in Cameroon, Central Africa. *Journal of Medical Entomology*. **42**(5): 726-731.

Simmons, C. P., Farrar, J. J., van Vinh Chau, N., & Wills, B. (2012). Dengue.*New England Journal of Medicine*, *366*(15), 1423-1432.

Soumare, MKF, and J E Cilek. 2013. The Effectiveness of Mesocyclops Longisetus (Copepoda) for the Control of Container-Inhabiting Mosquitoes in Residential Environments 1. *Journal of the American Mosquito Control Association.* **27**(4) (May 15): 376–383.

Spiegel, Jerry, Shannon Bennett, Libby Hattersley,et al. 2005. Barriers and Bridges to Prevention and Control of Dengue: the Need for a Social–Ecological Approach. *EcoHealth*. **2**(4) (November 4): 273–290.

Strauss, J. and D. Thomas. 2008. Health over the life course. In *Handbook of Development Economics Volume 4*. Eds. T. Paul Schultz and John Strauss. Elsevier Press. Chapter 54: 3375-3474.

Strauss, John and Duncan Thomas. 1998. Health, nutrition and economic development. *Journal of Economic Literature*. **36**(2): 766-817.

TDR & WHO. 2009. *Dengue: Guidelines for diagnosis, treatment, prevention and control*. Geneva, Switzerland: WHO Press.

TDR & WHO. 2012. *Handbook for clinical management of dengue*. Geneva, Switzerland: WHO Press.

Thomas, D D, C A Donnelly, R J Wood, et al. 2000. Insect Population Control Using a Dominant, Repressible, Lethal Genetic System. *Science*.

Thomas, Duncan and John Strauss. 1997. Health and wages: Evidence on men and women in urban Brazil. *Journal of Econometrics*. **77**: 159-185.

Toledo Romani, Maria E, Veerle Vanlerberghe, et al. 2007. Achieving Sustainability of Community-Based Dengue Control in Santiago De Cuba. *Social Science & Medicine*. **64**(4) (February): 976–988.

Tun-Lin W, Lenhart A, Nam VS, et al. 2009. Reducing costs and operational constraints of dengue vector control by targeting productive breeding places: A multi-country non-inferiority cluster randomized trial. *Tropical Medicine & International Health*. **14**: 1143-53.

Turelli, Michael. 2010. Cytoplasmic Incompatibility in Populations with Overlapping Generations. Evolution **64**(1) (January): 232–241.

Werren, J H, and D M Windsor. 2000. Wolbachia Infection Frequencies in Insects: Evidence of a Global Equilibrium?. Proceedings of the Royal Society B: Biological Sciences. **267**(1450) (July 7): 1277–1285.

Werren, John H. 1997. Biology of Wolbachia. A*nnual Review of Entomology*. **42**(1): 587–609.

Wirth, M C, and G P Georghiou. 1999. Selection and Characterization of Temephos Resistance in a Population of Aedes Aegypti From Tortola, British Virgin Islands. *Journal of the American Mosquito Control Association*. **15**(3): 315–320.

Whitmarsh, L. 2009. What's in a name? Commonalities and differences in public understanding of "climate change" and "global warming." *Public Understanding of Science*. ***18***(4): 401–420.

WHO. 2013. Research Priorities for the Environment, Agriculture and Infectious Diseases of Poverty.

WHO. 2012. *Global strategy for dengue prevention and control*. Geneva, Switzerland: WHO Press.

WHO. 2004. *Global Strategic Framework for Integrated Vector Management*. Geneva, Switzerland: WHO Press.

WHO. 1997. *Division of Emerging and other Communicable Diseases Surveillance and Control. Emerging infectious diseases: World Health Day 1997 information kit*. Geneva, Switzerland: WHO Press.

WHO Media Centre. 2012. Dengue and severe dengue: Fact sheet N°117.

Ziman, John M. 2000. *Real Science: What It Is, And What It Means*. New York: Cambridge University Press.