Application for US-Africa Advanced Studies Institute on Mathematical Modeling of Infectious Diseases in Africa

Applicant: Shweta Bansal

In an era of globalization and bioterrorism, infectious diseases have become an increasing threat and can have a devastating impact on human life. The need for a better understanding of the spread and persistence of infectious diseases in human host populations is increasingly important. Most pathogens require close contact between the host they are infecting and a new susceptible host for successful transmission. Thus, the nature and structure of contacts among individual hosts is of extreme importance to the spread of disease.

My dissertation work is focused on the use of mathematical and computational tools to merge epidemiology with the behavioral ecology of hosts as well as the evolutionary ecology of pathogens. We make use of network models to explicitly capture the patterns of interaction that underlie disease transmission and develop analytical tools to quantify the impact of the underlying structure on the spread of infectious disease and aid with the design of efficient intervention strategies to prevent further spread of disease.

Some of the epidemiological issues I have considered in the past are:

a) The selection of individuals to vaccinate before an epidemic (especially in the case of a vaccine shortage) so that morbidity and mortality are minimized during the epidemic [1].
b) The patterns of immunity conferred by an epidemic and the impact this has on future outbreaks [2].
c) The effects of transportation (such as air travel) on the propagation of disease throughout the world [3].
d) The spread of disease among communities (or meta-populations), and the effectiveness of local public health interventions [4].

A topic I am interested in exploring in the near future is pathogen evolution. The interaction between an evolving strain of disease and the short-term changes in a host population lead to complex disease dynamics. These dynamics have yet to be fully captured in individual-based models, and doing so will certainly be non-trivial. The issue that is of particular interest to me is of the influence of control measures (such as vaccination) on the evolution of virulence. This is a topic especially relevant to emerging diseases or cases in which resources for control measures are limited.

The matter of infectious disease control in Africa is both urgent and challenging. Mathematical models can give much insight into the complex interplay of host behavior, pathogen evolution and the environment that occurs in African communities. Along with the host of standard public health concerns, I expect that there are certain features that are different and specific to disease spread in the communities of Africa that must be taken into account. For example, the movement of populations in the more remote areas of African countries is surely very different than in that in the cities of developed countries. The question of disease invasion and persistence must be tackled differently in each of these scenarios. Additionally, the optimized distribution of public health resources is certainly a more sensitive problem when the resources are not just limited but scarce, as they often are for developing countries.

During the Institute, I would like to learn about the modeling challenges that arise and are specific to African diseases and populations; and learn about the approaches various researchers have taken to tackle them. I would be especially interested in collaborating with African scientists who may have empirical epidemiological data which would be very powerful when combined with our theoretical models. My background in handling issues such as distribution of limited public health resources and disease transmission through small inter-connected communities is hopefully relevant. I am enthusiastic about the chance to apply those techniques to specific cases found in African communities.

Attending the Advanced Studies Institute and Capstone Workshop will be a necessary and preliminary step towards a research effort that I can continue with my advisor, Professor Lauren Ancel Meyers at the University of Texas at Austin. I look forward to this exciting opportunity, and hope that I can contribute towards mitigating existing epidemiological challenges in Africa.

References

1. **Bansal, S**. Pourbohloul, B., Meyers, L.A. Quantitative design of influenza vaccination. *PLoS Medicine*. Oct 2006
2. Ferrari, M., **Bansal, S.**, Meyers, LA., Bjornstad, O. Network frailty and the geometry of herd immunity. *Proceedings of the Royal Society B.* Oct 2006
3. **Bansal, S**. Economo, E. Pourbohloul, B. Meyers, L.A. The role of air travel in the propagation of infectious disease. [In preparation.]
4. **Bansal, S.** Sanders, M. Meyers, L.A. Community structure and the consequences for disease spread. [In preparation].