Case Western Reserve professor helps control infectious diseases with models and math

December 19 2008

Can an algebraic equation hold the secret to eradicating malaria or schistosomiasis? A Case Western Reserve University mathematics professor is utilizing the combination of algorithms and models in an effort to assist his medical colleagues in the fight against infectious diseases.

Professor David Gurarie is developing mathematical models to track and analyze symptoms, treatment outcomes and environmental conditions that affect diseases like malaria and schistosomiasis, also known as "snail fever." These models would allow doctors to make predictions towards effective treatment.

"Generally there is a fair amount of interest in using mathematic models in life sciences," Gurarie said. "Such models applied to biological systems can help researchers to understand the data they collect and address problems where traditional methods (based lab or filed study) fail. By understanding the data, we can make predictions about where new diseases may emerge, how they spread in the environment, and whether we'll be able to control future outcomes."

Gurarie has worked closely with Charles King, Peter Zimmerman, Ron Blanton and other faculty from the Center for Global Health and Disease at the Case Western Reserve School of Medicine.

"I was lucky to have people in the School of Medicine interested in mathematical modeling, and we've been working very productively together, on several projects and papers," he said.

Most recently, Gurarie and King have published a paper on controlling schistosomiasis, a chronic parasitic disease that can damage internal organs and impair cognitive growth and development in children.

"Age-and Risk-Targeted Control of Schistosomiasis-Associated Morbidity Among Children and Adult Age Groups" appeared in *The Open Tropical Medicine Journal* 2008.

Schistosomiasis is commonly found in many regions of Africa, Asia and South America. The disease affects more than 200 million people. The most common way of getting schistosomiasis in developing countries is by contact with infected snails in lakes, ponds and other water bodies - which act as a natural reservoir of the disease.

A drug called praziquantel can treat human infection, so the World Health Organization (WHO) advocates control of the disease by periodical administration of the drug.

However, any interruption in the treatment program will gradually bring it back to precontrol levels, which puts a substantial burden on many developing nations (with limited health resources). To complicate matters the disease is now spreading to new habitats through irrigation projects, or other changes in land-water use. Tourism, refugee movement and migration in general are bringing the disease into new areas in Africa and into urban environments like in northeast Brazil. It also reemerges in some places considered clear of parasites in earlier interventions (Southern China).

"While schistosomiasis is unlikely to spread to any developed country because of sanitation and clean water, or urban environments that limit the spread of mosquito habitats, the story in a place like China is different, as they use human waste for fertilizer and recently saw reemergence," Gurarie said.

A challenge facing the WHO is how to eradicate the disease, or bring it to a "manageable level," despite limited financial resources. In other words, can an "optimal" (in terms of cost and efficacy) control program based on drug treatment and snail eradication be developed?

The best answer to these questions cannot be found through testing, medical research or past experience alone. But modeling can provide useful tools and insights, Gurarie says.
"Realistically, you can't put the entire complex system into your model. But one tries to include enough 'realism' along with mathematical/computational efficiency, then plug it into the computer to run simulations and make predictions." he said. "Essentially you create the tool to run experiments that would be prohibitive or unfeasible in real life. It's like creating virtual mice in the computer. "

By examining past cases and gathering statistics related to the disease, the researchers are able to further fine-tune their algorithms and models. The models quantify things like effects of drug treatments or socioeconomic conditions, giving those working towards a cure data, facts and figures to guide public health policies.
The most recent project looked at the effect of schistosomiasis on late-age morbidity and early-childhood development. It examined the potential value of focused prescreening efforts. The researchers found prescreening had little effect in areas where initial mass treatment covered a large fraction of the population, allowing future treatment to focus on areas that lack the initial coverage.

Models and the results often take the form of graphs, charts, equations and procedures based on the specifics of each case. Understanding the basic biology of host-parasite interactions is important, says Gurarie, but

other factors like population dynamics, control history, environmental and social factors all come into play.
Gurarie's malaria research looks at the development of drug - resistance by the malaria parasite, as well as the insecticide resistance by carrier mosquitoes. He published several papers with his colleagues at Case Western Reserve and at the National Institutes of Health (F. Ellis McKenzie).

"In the past to fight malaria, scientists have used drug treatment and insecticides (to kill mosquitoes which carry malaria) on a mass scale. For a while the strategy has worked; they were able to reduce malaria incidence to small numbers," he said. "It all lasted until the parasite developed resistance to drugs and mosquitoes – to insecticides, which reversed most of earlier progress. Today we see a dramatic upsurge of the disease in many places worldwide. While the fight against malaria proceeds on multiple fronts (new drugs, diagnostics, and vaccines), an important question remains- 'how can one do interventions in a way to either slow or prevent drug resistance?'"

The goal of his modeling is to allow predictions to be made on both the individual and community levels in transitioning to different treatment options.

Currently, the malaria project was extended to other mosquito-borne diseases, like Dengue fever (a joint project with colleagues at Case Western Reserve and the Federal University of Bahia, Brazil), and filariasis.

Along with research on infectious diseases Gurarie is also involved in the development of new educational programs at Case Western Reserve, including Framework for Global Health and undergraduate research at the interface of mathematics and biology, among others.

Source: Case Western Reserve University