Engineers improve allocation of limited health care resources in resource-poor nations

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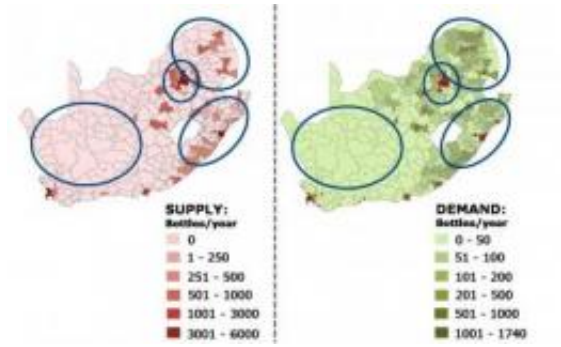

The supply of breast milk (left) is twice as large as the demand (right) in South Africa. Breast milk demand (indicated by a red dot for a neonatal unit in the right hand image) is spread out in the northeast provinces and on the east coast where the population is more rural and poor. Using this data, Georgia Tech systems engineers created models to strategically determine how a nongovernmental organization in South Africa should expand its breast milk donation and distribution network to the whole country. Credit: Georgia Tech/Melih Celik

In the developing world, allocating limited health care resources as effectively and equitably as possible is a top priority.

To address that need, systems engineers at the Georgia Institute of Technology are using computer models to help resource-poor nations

improve supply chain decisions related to the distribution of breast milk and non-pharmaceutical interventions for malaria. They are also forecasting what health care services would be available in the event of natural disasters in Caribbean nations.

"We are using mathematical models implemented in user-friendly tools like Microsoft Excel to improve the allocation of limited resources across a network, especially in resource-poor settings," said Julie Swann, an associate professor in the H. Milton Stewart School of Industrial and Systems Engineering at Georgia Tech.

Swann reported on three global health case studies designed to improve the allocation of limited health care resources on Feb. 19, 2012 at the annual meeting of the American Association for the Advancement of Science (AAAS) in Vancouver, Canada.

For the first project, Swann and a group of graduate students created models to strategically determine how a nongovernmental organization (NGO) in South Africa should expand its breast milk donation and distribution network to the whole country. In the network, healthy mothers donate breast milk, which is stored in a local repository, transferred to a milk bank to be processed and then distributed to neonatal units where mothers cannot provide it themselves because of disease status or physical inability.

"We wanted to determine how we could provide breast milk to the most people while also being geographically equitable in terms of access," explained Swann, who holds the Harold R. and Mary Ann Nash chair at Georgia Tech. "We looked at the cost of equity and how that changed the distribution design."

A team of engineers from Georgia Tech are evaluating Puerto Rico's disaster preparedness plans by analyzing the country's hospital networks and predicting bottlenecks in the system. The blue circle indicates the areas in Puerto Rico that would experience increased hospital congestion following an 8.0 magnitude earthquake off the cost of San Juan. Credit: Georgia Tech/Ben Johnson

To determine where the organization should expand its network and the best way to do so, the team used operations research to examine the existing and proposed locations in the network as well as what type of transportation would work best to cover the increased geographic area. The model recognized that breast milk supply increases with higher income and education levels and low HIV prevalence, while breast milk demand increases with lower income and education levels and high HIV prevalence.

The researchers recently recommended locations for expansion to the NGO and advised the organization to pay a courier service to carry the milk to the neonatal units, in order to balance cost and reliability and improve efficiency. Volunteers, who are inherently less reliable, were driving the milk from one location to another.

In another project, done in collaboration with the World Health Organization, Swann and a team of undergraduate and graduate students used models to optimize the distribution of non-pharmaceutical interventions for malaria, such as nets or sprays, with pilot data from a

country in Africa called Swaziland.

Their models provided a time-based deployment plan for the country, including details on what geographic zones to target for spraying, when to deploy in each zone, how many people can be protected in each zone, what resources should be located at the distribution centers, and the opening and closing dates of the distribution centers.

The researchers showed that using a systems approach to examine allocation decisions could increase the number of people covered with the same amount of funding by more than 25 percent. The team worked with Pinar Keskinocak, a professor in the Stewart School of Industrial and Systems Engineering at Georgia Tech, to develop a teaching game based on the work. The game has been used worldwide in classes of humanitarian students.

For the third project, Swann and a team of graduate students are using technology to estimate the performance of disaster preparedness plans in advance of an event. The project is part of the Caribbean Hazard Assessment Mitigation and Preparedness (CHAMP) initiative, which is supported by a Georgia Tech alumnus and led by Reginald DesRoches, a professor in the School of Civil and Environmental Engineering at Georgia Tech.

In Puerto Rico, Swann's team evaluated the existing hospital networks and other health care provider locations described in the island's emergency preparedness plans.

"To forecast the country's ability to provide health services following an earthquake, we took population data and overlaid it with projections of earthquake locations and severity to estimate the capacities and amount of congestion that would result at health care facilities," said Swann.

The researchers recently presented the initial results of their study to the Puerto Rico Department of Health and made recommendations for health care resources and hospital capacities based on predicted bottlenecks in the system. They are currently examining Belize's hurricane evacuation plans. Keskinocak and Stewart School of Industrial and Systems Engineering associate professor Ozlem Ergun and visiting assistant professor Pelin Pekgun-Cakmak are also contributing to the CHAMP initiative.

"We have found that technology innovations like mathematical models can help to solve problems in global and public health, such as the allocation of limited health care resources," noted Swann.

Provided by Georgia Institute of Technology