# Health Systems: The Next Generation

### Friday, September 16, 2016

Technology Square Research Building, Georgia Tech

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# Poster Abstracts

**1. Multidimensional Measures of Health Disparity**
*Shatakshee Dhongde (Georgia Tech)*

Health disparities refer to population-specific differences in the presence of disease, health outcomes, quality of health care and access to health care services that exist across racial, ethnic, regional groups. In order to successfully reduce health disparities we need to accurately measure the extent of health deprivations in different groups.In this project, I develop an innovative multidimensional framework to measure health disparities. The new approach takes into account the interdependence between health outcomes, provision and quality of health care and socio-economic factors influencing the quality of health. High levels of disparities continue to exist among racial and ethnic groups of the elderly in the U.S. I demonstrate the value and feasibility of the proposed approach, by undertaking a pilot study comparing health disparities among individuals aged 55 and above, by race.By using data from the American Community Survey on more than 1 million elderly adults, I find that American Indians and Blacks were the most deprived population subgroups.

**2. Optimal Multi-Modality Screening Policies for Women at High Risk of Breast Cancer**
*Caglar Caglayan, Turgay Ayer (Georgia Tech)*

Women with breast density, family history of breast or ovarian cancer, or BRCA1 and BRCA2-mutation-carriers are at higher risk of breast cancer. For such women, non-mammographic modalities such as ultrasound or MRI, adjunct to or instead of mammogram, can be beneficial but they lead to an increased screening cost. Considering both potential health benefits and financial aspects, we study this multi-modality breast cancer screening problem and identify cost-effective optimal screening policies.

**3. An Analytics Approach to Hypertension Management**
*Anthony Bonifonte, Turgay Ayer, Ben Haaland; Peter Wilson (Georgia Tech; Emory University)*

Blood pressure (BP) is a significant controllable risk factor for cardiovascular diseases, the leading cause of death worldwide. Antihypertensive drug treatment can control elevated blood pressure and reduce the

risk of future cardiovascular outcomes. While a limited number of intervention strategies has been evaluated via randomized controlled trials (RCTs) previously, considering all possible combinations of systolic and diastolic BP to initiate treatment or intensify treatment through RCTs would be prohibitive.

In this work, we propose models that use statistics and optimization to identify the optimal systolic/diastolic BP threshold levels for initiating BP or for increasing the treatment dosage. Unlike many other conditions where screening at regular time intervals is in place(e.g., cancer screening, chronic disease surveillance), BP measurements can be made at arbitrary time points (e.g., during any office visit for any reason). In that regard, unlike many of the existing models proposed for medical decision making, our models may be parametrized by arbitrarily timed observations, and predict the effects of treatment options for arbitrary time into the future. We carefully parameterize and calibrate our models using the Framingham heart study, one of the key studies in CVD domain. Our findings indicate that consideration of multiple threshold levels instead of a single threshold value for initiating and intensifying treatment might improve the overall health outcomes, which may guide the development of further trials in this area.

### 4. Optimizing Human Waste Collection to Improve Sanitation

*Jan Vlachy; Brian McInnis; Ivana Petrovic; Kevin Lo, Jen Helsby, Joe Walsh (Georgia Tech; Cornell University; Brown University; University of Chicago)*

Sanergy is a franchise-based sanitation service that licenses toilets to local entrepreneurs in Nairobi. Entrepreneurs apply to operate a Sanergy toilet within the informal settlements, at markets, bus stops and schools, and Sanergy contracts to collect and treat the human waste. This economic model expands access to clean sanitation for those who dwell within the informal settlements, while supporting local economy. Currently, Sanergy operates about 700 toilets and collected over 1,500 tonnes of feces and about as much urine in 2015 alone.

We focused on improving the collection operations and particularly the Sanergy's collection schedule. In the past, Sanergy had collected each toilet every day. While this was possible when there were a few hundred toilets, Sanergy has grown to outpace its collection strategy. Additionally, not every toilet needs to be collected every day because some toilets fill more slowly.

Recently, Sanergy has started to experiment with different scheduling schemes. To support such flexible collection schedules, we have implemented a model to construct weekly collection schedules in a data-driven way, such that Sanergy picks up low-fill toilets only occasionally. At the same time, this collection model ensures that toilets do not exceed the capacity too often and that they are collected frequently enough so as not to smell. The collection model uses as an input the waste model, which predicts how much feces and urine accumulate in each toilet every day.

We further implemented a data-driven staffing model. This model produces a spreadsheet indicating how many workers Sanergy will need for every route in the coming week on basis of the collection model and the waste model. We expect that these changes will help Sanergy break even on their logistics operations and expand more rapidly to provide more people in informal settlements with toilet access.

### 5. POLSA Algorithm and Surface Surveillance

*Benjamin Ide, Sung Ha Kang, Haomin Zhou, Eric Sabo, Seong Jun Kim (Georgia Tech)*

This research investigates the problem of finding a globally shortest possible path for a sensor to follow to survey a specified region. We consider sensors that have a finite range and regions with obstacles to both the sensor's movement and sensing ability.

Motivating this is the quickly declining price of drones and potential applications to surveying e.g., for heartbeats in disaster areas, mines in war zones, et cetera. We are also motivated by the unsolved asteroid surveying problem and finding a better solution than that provided by Zalgaller.

The path optimization with limited sensing ability (POLSA) algorithm developed by Kang et al. is extended to surveillance of surfaces of objects in a 3d region with promising results that imply usefulness in the previously mentioned motivating cases. Here we present the POLSA algorithm itself.

### 6. Value of Inventory Information in Allocating Flu Vaccines with Limited Supply

*Zihao Li, Pinar Keskinocak, Julie Swann (Georgia Tech)*

Influenza has resulted in approximately 970 thousand hospitalizations in the United States during 2015 alone, and 3 to 49 thousand deaths annually. Timely vaccination can significantly reduce the disease burden and save lives. However, flu vaccine supply is often limited, in part due to the production process. We study the allocation of limited vaccine supply when the uptake rates vary geographically. We derive strategies that use inventory information to determine where vaccines should be sent and compare them to strategies that are population based. We quantify how many cases of flu can be prevented, how much wasted inventory is saved, and the unmet demand under both policies. The results emphasize the need for greater visibility in public health supply chains.

### 7. Prioritizing Hepatitis C Treatment in U.S. Prisons

*Turgay Ayer, Can Zhang, Anthony Bonifonte; Anne Spaulding; Jagpreet Chhatwal (Georgia Tech; Emory University; Harvard Medical School)*

About one out of six inmates in the United States (U.S.) is infected with hepatitis C virus (HCV). The high prevalence of HCV in prison systems offers a unique opportunity to control the HCV epidemic. New HCV treatment drugs are very effective but providing treatment to all inmates is prohibitively expensive, which precludes universal HCV treatment in prison systems. As such, current practice recommends prioritizing treatment for HCV. In this study, we propose a restless bandit modeling framework to support hepatitis C treatment prioritization decisions in U.S. prisons. We first prove indexability for our problem and derive several structural properties of the well-known Whittle's index, based on which, we derive a closed-form expression of the Whittle's index for patients with advanced liver disease. From the interpretation of this closed-form expression, we anticipate that the performance of the Whittle's index would degrade as treatment capacity increases; and to address this limitation, we propose a capacity-adjusted closed-form index policy. We parameterize and validate our model using real-world data. We test the performance of our proposed policies using a detailed, clinically-realistic simulation model and show that our policy can significantly improve the overall effectiveness of hepatitis C treatment. Our results also shed light on several controversial issues in hepatitis C treatment prioritization in the prison setting: 1) considering remaining sentence length of inmates and injection drug use status in addition to liver health state in prioritization decisions can lead to a significant performance improvement; 2) patients with longer remaining sentence lengths should not always be prioritized, and prioritizing patients with shorter remaining lengths may be preferable especially when linkage-to-care rate outside prison system is limited while treatment capacity in prison system is relatively large; and 3) among patients with advanced liver disease, IDUs should not be prioritized unless their reinfection is very-well controlled.

### 8. Identification and Allocation of Increased-Risk Encephalitis Organs

*Hannah K. Smalley, Nishi Anand, Dylan Buczek, Nicholas Buczek, Pinar Keskinocak, Timothy Lin, Tanay Rajore, Joel Sokol, Muriel Wacker; Sridhar Basavaraju, Brian Gurbaxani, Teresa Hammett, Matthew Kuehnert (Georgia Tech; Centers for Disease Control and Prevention)*

We developed two decision-support tools to aid organ transplant physicians (and patients) in the identification and allocation of organs that carry the risk of infectious encephalitis. The Infectious Encephalitis Risk Calculator assesses whether a donor (and his/her organs) may have infectious versus non-infectious encephalitis, using statistical imputation, cross-validation, and several regression techniques. Compared to current practices used by physicians to distinguish between infectious and non-infectious encephalitis, the Infectious Encephalitis Risk Calculator improves the prediction accuracy from 70% to 92%. The Liver Transplant Decision Aid helps patients and physicians evaluate the trade-offs between accepting and rejecting an increased-risk encephalitis (IRE) liver, using Cox Proportional Hazards models. 53% of the patients who died on the waitlist in 2006 would have had a higher one-year survival probability if they had taken an IRE liver with an infection risk of 100% versus remaining on the waitlist. Thus, the Liver Transplant Decision Aid can enable a better allocation of high-risk organs and reduce the number of deaths on the waitlist. Finally, we also present descriptive models to provide wait times customized to patient characteristics.

**9. Infusion Center Process Improvement and Patient Wait Time Reduction**
*Joseph Baek, Tony Li, Allen Liu, Jimmy Micali, Jack Sun, Mo Shen, Emilie Wurmser, Pinar Keskinocak (Georgia Tech)*

The objective of this project is to reduce the patient wait time of the ambulatory infusion center of Emory Winship Cancer Institute. We developed a Real-time Visibility Tool and a Check-in Folder Policy based on the results of scenario analysis via Simio simulation model incorporating time series data sets both from Emory Winship Cancer Institute and manual time study. After implementing the proposed policies on site for a month, we observed a 28% decrease in patient wait time. Scenario analysis via simulation successfully isolated the bottlenecks of the treatment flow and derived the solutions that reduced the wait time of the patients at the infusion center.

**10. Design of efficient pulse configurations for heart stimulation. A Theoretical, numerical and experimental study.**
*Neil Hardy, Flavio Fenton (Georgia Tech); Hila Dvir (Tel Aviv University)*

We aim to find the optimal waveform for pacemaker use, and to offer a theoretical explanation for its advantage. We show that a truncated exponential wave form is much more effective than a square pulse with the same charge. we demonstrate the optimized wave form in numerical experiments as well as in vitro using rabbit hearts. We found that tissue can be excited with a truncated exponential that uses 10% the current of a square pulse.

**11. The Physical Exam - How Often Should You Go?**
*Thomas Henderlong, Quinn Dolan, Kyle Seebohm, Kristen Olivera, Michelle Jeng, Kasey Joyce, Zach Meyer (Georgia Tech)*

While 44 million Americans schedule a periodic physical exam every year, there is currently no agreement that the costs of these exams result in measurable health benefits. Low-risk asymptomatic adults may be receiving expensive, unnecessary screenings while high-risk or undiagnosed asymptomatic adults may not be receiving the screenings that could potentially detect a preventable chronic disease. Studies have been done assessing the overall effectiveness of physical exams, however, this project targets subgroups of people that could benefit from varying levels of screening at a periodic health exam. The objective is to quantify the costs and benefits to make recommendations on the frequency of periodic physical exams and how they can be better utilized for these different subgroups.

The approach uses a Markov chain model with discrete states and transition probabilities representing a patient's progression through diabetes, depression, and cardiovascular disease. The results were analyzed with a focus on quantifying cost and quality of life benefits for these sub-populations with different risk factors.

The simulation model's results demonstrated that an annual screening interval is the most cost-effective for low income subgroups. Two year screenings are recommended for the rest of the population. The value of the model's recommendations is derived from the difference in the potential cost savings and quality of life benefits of these screening frequencies compared to the current use of the physical exam. There is a significant disparity between the model recommendations and current utilization for the lowest income subgroups. Having these patients follow the model-recommended annual frequency rather than the 3-4 year current state interval would result in measurable quality of life benefits. More than 65% of high income adults are currently being screened annually and could save costs by following the model's 2 year interval recommendation.