Wednesday, 8–9:30AM

WA01

Carmichael

Advances in Behavioral Health

General Session

Session Chair

Jonas Oddur Jonasson, MIT Sloan School of Management, Somerville, MA

1 Online Learning for Restless Bandits: Scheduling Interventions for Maternal Health

Lily Xu, Harvard University, Cambridge, MA

Restless multi-armed bandits (RMABs) extend multi-armed bandits to allow for stateful arms, where the state of each arm evolves restlessly depending on whether that arm is pulled. RMABs have been applied to critical sequential decision-making problems including scheduling health interventions. However, solving RMABs requires knowing transition dynamics, which are often unknown upfront, particularly in healthcare applications. Here, we propose the first online learning algorithm based on the Whittle index policy, using an upper confidence bound (UCB) approach. Specifically, we estimate confidence bounds of the unknown transition probabilities and formulate a bilinear program to compute optimistic Whittle indices. Our algorithm, UCWhittle, achieves sublinear $O(H \sqrt{T \log T})$ frequentist regret in T episodes with a constant horizon H. Empirically, we demonstrate that UCWhittle achieves improved performance on a real maternal and childcare dataset from an NGO in India.

2 Miwaves: Designing an Online Rl Algorithm for a Clinical Trial

Susobhan Ghosh[1], Susan A. Murphy[1], Pei-Yao Hung[2], Lara Coughlin[2], Erin E. Bonar[2], Yongyi Guo[1], Inbal Nahum-Shani[2], Mashfiqui Rabbi[3], Maureen Walton[4], [1]Harvard University, Boston, MA, [2]University of Michigan, Ann Arbor, MI, [3]Optum Labs, Seattle, WA, [4]University of Michigan, Ann Arbor, MI

MiWaves is a digital intervention aimed at reducing cannabis use among emerging adults who use cannabis regularly and have some motivation to change. It delivers smartphone prompts that contain intervention content to reduce cannabis use and engagement strategies that are grounded in psychology, HCI, and marketing. Given that excessive prompts can lead to user disengagement and habituation, we are developing an RL algorithm to personalize the timing of prompt delivery. This talk mainly focuses on the challenges involved in the design of such an RL algorithm, including the development of a simulation testbed, ensuring stability of learning in an online low data setting, etc.

3 Personalizing TB Treatment Adherence Support

Jackie W. Baek[1], Justin J. Boutilier[2], Vivek Farias[3], Jonas Oddur Jonasson[4], Erez Yoeli[4], [1]NYU Stern School of Business, Berkeley, CA, [2]University of Wisconsin - Madison, Madison, WI, [3]MIT, Cambridge, MA, [4]MIT Sloan School of Management, Cambridge, MA

Lack of patient adherence to treatment protocols is a main barrier to reducing the global disease burden of tuberculosis (TB). Using data from a completed RCT, we study the operational design of a treatment adherence support (TAS) platform, focusing on personalization. We propose two types of personalization and demonstrate how each type can substantially improve the cost-effectiveness of the platform.

WA02

Jackson

Decision Analytics for Public Health Policy Making

General Session

Session Chair

Shan Liu, University of Washington, Seattle, WA

1 A Sequential Calibration Approach to Estimate Behaviors During the Early COVID-19 Pandemic in Minnesota

Zongbo Li[1], Shannon B. McKearnan[1], Szu-Yu Kao[1], Erinn C. Sanstead[2], Mink J. Pamela[2], Alisha Simon[2], Stefan Gildemeister[2], Karen M. Kuntz[1], Eva A. Enns[1], [1]University of Minnesota, Minneapolis, MN, [2]Minnesota Department of Health, St. Paul, MN, Contact: li001932@umn.edu

We describe an approach to model calibration and behavior parameter estimation used in the development and application of the Minnesota COVID-19 model. We address the computational challenges of frequent re-calibration with a sequential calibration approach, which takes advantage of previous calibration results and reduces the number of parameters to be estimated in each round of calibration, improving algorithm convergence to best-fitting parameter values. Facilitated by access to unique state-level COVID-19 data sets, we use our model calibration approach to disentangle age-specific contact parameter estimates from other changing pandemic elements.

2 Optimal Budget Allocation to Vaccine Promotion Campaigns Considering Disease Transmission and Opinion Propagation

Serin Lee, Shan Liu, Zelda B. Zabinsky, University of Washington, Seattle, WA, Contact: serinlee@uw.edu

In order to combat vaccine hesitancy and anti-vaccination movements, vaccine campaigns are being promoted. Our study identifies optimal budget allocation for vaccine promotion campaigns among different age and geographical groups, with the goal of minimizing disease burden. Our model incorporates coupled dynamics of disease transmission and opinion dynamics within a networked compartmental model. Calibrated to Clark County, WA during the COVID-19 pandemic, from late 2022 to early 2023, the optimization algorithm identifies a set of near-optimal solutions. We conduct sensitivity analyses on disease and opinion parameters, such as vaccine effectiveness and power of persuasion.

3 A Microsimulation Model of Monkeypox (Mpox) in Los Angeles County (LAC): Implications for Future Disease Prevention and Control Strategies Among Men Who Have Sex with Men (MSM)

Citina Liang[1], Sze-chuan Suen[1], Chenglin Hong[2], Andrea Kim[3], Rita Singhal[3], Paul Simon[3], Mario Perez[3], Ian Holloway[2], [1]University of Southern California, Los Angeles, CA, [2]University of California, Los Angeles, Los Angeles, CA, [3]Los Angeles County Department of Public Health, Los Angeles, CA, Contact: citinal@usc.edu

The 2022-2023 Mpox outbreak in Los Angeles County (LAC) raised questions around how to best prepare and respond to emergent infectious disease outbreaks. We developed a microsimulation model for LAC among the most affected population, men who have sex with men (MSM). The model incorporated disease transmission, progression, and recovery by race/ethnicity, age, and HIV status. We compared vaccination strategies (magnitude, targeting, and timing), and reductions in sexual contact frequency. Our findings highlighted the importance of risky sexual behaviors and of targeted vaccination efforts for people living with HIV (PLWH) in preventing and controlling future Mpox outbreaks.

WA03

Varley

COVID-19 Analytics: Insights and Strategies

General Session

Session Chair

Hossein Piri, Haskayen School of Business-University of Calgary, Calgary, AB, Canada.

1 First or Second Doses First? Vaccine Allocation Under Limited Supply

Ming Hu[1], Chaoyu Zhang[2], Yun Zhou[3], [1]University of Toronto, Minneapolis, MN, [2]University of Toronto, Toronto, ON, Canada; [3]McMaster University, Hamilton, ON, Canada. Contact: cyu.zhang@rotman.utoronto.ca

How to allocate limited two-dose vaccines, such as mRNA vaccines, between the first vs. second doses provoked a heated public debate during COVID-19 in January 2021. In this paper, we study the optimal vaccine allocation between the first vs. second doses with a constant stream of vaccine supply by formulating it as an optimal control problem under disease transmission to minimize the total number of infections over a planning horizon. We demonstrate that the optimal vaccine allocation policy has a bang-bang structure: there exists a threshold on the one-dose vaccine efficacy, above (resp., below) which choosing the "First Doses First" (FDF) (resp., "Second Doses First" (SDF)) policy is optimal. Using COVID-19 vaccination data, we calculate thresholds for different countries in January 2021 to recommend to governments whether to use the FDF or SDF policy. Lastly, we demonstrate that our model can also be extended to account for boosters doses.

2 Scheduling of a Multi-Clinic Healthcare Facility in the Course of a Pandemic

Hossein Piri[1], Mahesh Nagarajan[2], Steven Shechter[2], [1]University of Calgary, Calgary, AB, Canada; [2]University of British Columbia, Vancouver, BC, Canada. Contact: hossein.piri@ucalgary.ca

Due to the social distancing requirement during the COVID-19, the elevator capacity in high-rise buildings has been reduced by 50-70 %. The reduced elevator capacity results in queue build-up and increases the elevator wait time, which makes social distancing challenging in the lobby and elevator halls. This could increase the chance of the spread of the disease and would pose significant safety risks. Therefore, it is necessary to design an intervention that could help safely managing the elevator queues and reduce the elevator wait times. In this work, we focus on minimizing the elevator wait time in a multi-clinic facility by controlling the people arriving at the elevator halls, which is possible by optimizing the clinic schedule.

3 A Cost-Benefit Analysis of Policy Stringency During the COVID-19 Crisis Using U.S. State Data

Manfred W. Keil[1], Yao Li[2], [1]Claremont McKenna College,

Claremont, CA, [2]Northwestern University, Evanston, IL, Contact: mkeil@cmc.edu

The paper investigates the relationships between cumulative Coronavirus mortality rates, economic losses, and the degree of stringency over the most recent economic downturn and recovery using a simultaneous equation approach. These variables and a number of exogenous variables form a system which we estimate by an appropriate system estimator (3SLS) for the cross section of 50 U.S. states. This specification enables us to calculate the benefit-cost ratio of saving lives by policy stringency. We find that costs and benefits are of the same order of magnitude in general. Some states would have profited by increased average stringency, some by less.

4 Identifying Areas of Low-Access to the COVID-19 Vaccine: A New Objective Framework Incorporating Mobility Data

Joseph K. Agor, Oregon State University, Corvallis, OR, Contact: joe.agor@oregonstate.edu

In this work, we propose and validate a new Mobility Data-Driven (MDD) framework to identify areas that have low access to the COVID-19 vaccine. We collected geospatial mobility data to an objective approach for determining areas of low access. We identify census tracts in Oregon with low access to the COVID-19 vaccine. Ten spatial and social measures of access are utilized to compare the proposed framework to current methods. We find that, for equitable distribution of a resource like the COVID-19 vaccine, leaders should utilize objective data (like mobility data) to assist them in determining a populations ability to obtain that resource.

WA05

Toronto Ballroom II

Decision Processes to Model Healthcare Applications

General Session

Session Chair

Alba Olivares Nadal, University of Zurich, Zürich, Switzerland.

1 Efficient Discovery of Cost-Effective Policies in Sequential, Medical Decision-Making Problems

Narges Mohammadi[1], Reza Skandari[2], [1]Imprial College Business School, London, United Kingdom; [2]Imperial College Business School, London, United Kingdom. Contact: n.mohammadi19@imperial.ac.uk

Cost-effectiveness analysis is used by policymakers to prioritize healthcare interventions. We develop an efficient algorithm that discovers the cost-effectiveness frontier and policies for sequential stochastic optimization problems and use it to devise easy-to-implement hearing loss screening strategies for patients with cystic fibrosis. We prove the theoretical properties of the solution methods.

2 Optimizing Treatment Allocation to Maximize the Health of a Population

Alba Olivares Nadal, University of Zurich, Zürich, Switzerland. Contact: alba.olivares@business.uzh.ch

We use MDPs to model the task of optimally allocating treatment amongst patients while fulfilling capacity constraints. The complexity of such a problem may be very high because healthcare populations may be large enough that gathering information of the current status of each patient and tracking the evolution of their covariates is untenable. To address this challenge we develop the so-called measurized theory, which allows to model MDPs that optimize the distribution of treated and untreated patients instead of dealing with identifed patients. This abstraction transforms a complicated problem into an intuitive formulation and sets the stage for delivering clinically implementable solutions.

3 When Should Fractional-Dose Vaccines be Used?

Francis de Véricourt[1], Jérémie Gallien[2], Naireet Ghosh[2], [1]European School of Management and Technology, Berlin, Germany; [2]London Business School, London, United Kingdom. Contact: nghosh@london.edu

Fractional-dose vaccines constitute an important potential intervention when available vaccine stockpiles are limited during an epidemic. While fractional-dose vaccines help expand coverage, they are less efficacious and hence lead to a slower buildup of population immunity when the speed of vaccine administration is constrained. We use an optimal control model to analyze this tradeoff and derive a simple and easily implementable vaccination policy relying on a combination of full and fractional-dose vaccines. We perform extensive numerical experiments to investigate the population health benefits and risks associated with this policy relative to simpler alternatives.

WA06

Toronto Ballroom 3: Harris

Data-driven Decision Making in Healthcare

General Session

Session Chair
Hossein Hejazian, McGill University, Montreal, QC, Canada.

1 Static and Online Appointment Scheduling in the Face of Show-Up Uncertainty
Mina Dalirrooyfard[1], Elaheh Fata[2], Yuriy Nevmyvaka[3], Vedat Verter[2], [1]Morgan Stanley, London, United Kingdom; [2]Queen's University, Kingston, ON, Canada; [3]Morgan Stanley, New York, NY

One of the challenges that medical facilities face is the no-show behavior of already booked patients. To reduce the doctor's idle time cost, schedulers overbook patients, while keeping in mind the waiting cost exerted on patients. The goal of the medical facility is to minimize the expected sum of patients' waiting cost, the doctor's idle and overtime costs. We first study the static problem, where the scheduler knows the set of patients and their characteristics in advance. Next, we study the online setting and propose algorithmic solutions for scheduling patients as they come in over time.

2 To Extend or Not to Extend? Dynamic Shift Lengths in Workforce Planning
Negar Ganjouhaghighi[1], Marco Bijvank[1], Alireza Sabouri[2], [1]University of Calgary, Calgary, AB, Canada; [2]Haskayne School of Business, University of Calgary, Calgary, AB, Canada. Contact: negar.ganjouhaghi1@ucalgary.ca

Emergency Departments face the challenging task of scheduling physicians to meet uncertain patient demand in the future. To better match physician availability with patient arrivals, we consider the possibility of dynamically extending shifts. A Markov Decision Process is formulated to decide on extending a shift by balancing the cost associated with shift extensions and the cost of patients waiting. Our numerical results suggest that shift extensions can reduce expected wait times by 25% with the same number of physician hours compared to strategies that create static shifts.

3 Modeling and Optimization of Public Health Policy-Making for Epidemics
Khalil Al Handawi, Université de Montréal, Montreal, QC, Canada. Contact: khalil.al.handawi@umontreal.ca

Policy makers solicit forecasts from Infectious disease models to inform their public health policies.

We present a mechanistic and a data-driven model for simulating infectious diseases such as COVID-19. The former model is useful for modeling pandemics in their nascency when historical data is scarce, while the latter is useful for nowcasting when a sufficient history of the pandemic has been observed. We will also show how derivative-free optimization can be used to assist in public health policy-making using projections from the infectious disease models and facilitate the development of data-driven models through hyperparameter optimization.

4 The Impact of Hospital and Patient Characteristics on Psychiatry Readmissions
Hossein Hejazian[1], Beste Kucukyazici[2], Javad Nasiry[3], Vedat Verter[2], Daniel Frank[4], [1]McGill University, Montreal, QC, Canada; [2]Queen's University, Kingston, ON, Canada; [3]McGill University, Montreal, QC, Canada; [4]Jewish General Hospital, Montreal, QC, Canada. Contact: hossein.hejazian@mail.mcgill.ca

The "practice makes perfect", which constitutes a positive volume-outcome relationship, may change in people-centric environments, such as health systems. We study the operational characteristics of hospitals contributing to the re-admission of psychiatry patients. We utilize a data set of about 15,000 psychiatry patients admitted to 25 hospitals and find that the number of patients admitted to a hospital increases the risk of readmission, whereas this risk reduces with the hospital specializing in certain diagnosis classes. We propose that the hospital length of stay (LOS) mediates these effects. These relationships are also moderated by patient characteristics. Moreover, we find a nonlinear relationship between LOS and the risk of readmission. We provide evidence on the negative volume-outcome and nonlinear LOS-outcome relationships. Our results provide insights for policymakers to manage the flow of psychiatric patients and the burden imposed on the health systems by unplanned readmissions from patients with chronic disorders.

WA07

Toronto Ballroom 4: MacDonald
Health Disparities Research
General Session

Session Chair
Kristen Hassmiller Lich, Gillings School of Global Public Health, University of North Carolina at Chapel Hill, Chapel Hill, NC

Session Chair
Karen T. Hicklin, University of Florida, Gainesville, FL

1 Towards Trans-Inclusive Workplaces - When Do Female Directors Matter?
Dwaipayan Roy, Yo-Jud Cheng, University of Virginia Darden School of Business, Charlottesville, VA, Contact: royd@darden.virginia.edu

Although female directors may be intrinsically motivated to advance trans-inclusive health benefits, their underrepresented status may constrain their ability to do so. Using longitudinal data on Fortune 500 firms, we find no association between proportion of female directors and a firm's likelihood to provide trans-inclusive health benefits. However, firms with higher female directors are more likely to provide trans-inclusive health benefits when they are headquartered in states with more trans-inclusive health laws and when there are more young board directors. We highlight the role of board demographics in helping firms to be trans-inclusive.

2 Quantify Childbirth Care Inequity for Socioeconomically Disadvantaged Groups

Emily Fainman[1], Di Gao[2], [1]Texas State University, San Marcos, TX, [2]Sam Houston State University, Huntsville, TX, Contact: c_z88@txstate.edu

Obstetrical and neonatal health care disparities among socioeconomically disadvantaged groups are persistent, prevalent, and complex. We quantify inequity of quality childbirth health care for socioeconomic disadvantaged groups and cover the periods of prenatal, perinatal, and newborn cares. We aim to promote equitable access for socioeconomic disadvantage women and their newborns to high-quality childbirth health services, by developing a comprehensive quality score for childbirth care.

3 To Turing and Beyond? Not yet for Chatbot in Clinical Settings

Aaron Lai[1], Thomas Ming[2], Daniel Young[3], Cyrus Chan[4], [1]Manifest Medex, Emeryville, CA, [2]HKU SPACE Community College, Hong Kong, Hong Kong; [3]Kyushu University, Fukuoka, Japan; [4]Dublin High School, Dublin, CA, Contact: aaron.lai@st-hughs.oxon.org

Chatbots are increasingly popular in healthcare. However, they are limited in clinical settings. Why? The obstacles include the philosophical limitations of knowledge acquisition, the linguistic and cultural differences in human-computer interaction, and the task-oriented product design. To overcome these barriers, one needs to address these challenges in a complex clinical workflow. This talk will discuss the foundations of clinical decision making, the importance of having human-like responses and its linguistic choices, and the urgency of health equity and cultural considerations.

4 Adoption Platform Design to Improve Outcomes for Children with Disabilities

Ludwig Dierks[1], Vincent Slaugh[2], Utku Unver[3], [1]Kyushu University, Nishi-ku, Japan; [2]Cornell University, Ithaca, NY, [3]Boston College, Boston, MA, Contact: vws8@cornell.edu

Children with disabilities age out of the U.S. child welfare system without a family resource at disproportionately high rates, resulting in worse life outcomes. Matching platforms seek to serve these children but struggle to identify high-capability families and direct them to children with high needs. We introduce a high-level model for an adoption platform and analytically derive the optimal child-matching mechanism that incentivizes families to truthfully represent their capabilities. We find that the ability to match high-needs children to high-capability families depends on the ratio of the number of low-needs children to low-capability families and discuss other managerial insights.

WA08

Toronto Ballroom 5: Lismer

Advances in Technology-Enabled Healthcare

General Session

Session Chair

Wilson Lin, [1</sup]

1 Does Advertising Matter to Emergency Department Patients? the Effect of Advertising on Hospital Choice, Travel Distances, and Mortality Rates

Tae Jung Yoon[1], TI Tongil Kim[2], Simon Kim[2], [1]KAIST College of Business, Seoul, Korea, Republic of; [2]University of Texas at Dallas, Richardson, TX, Contact: taejung.yoon@kaist.ac.kr

In the US healthcare industry, consumers have taken a more active role in choosing hospitals, coupled with hospitals increasing spending on emergency care advertising. This is in contrast to a common belief that advertising may not be effective for emergency patients. Using a dataset of individual patient choices in Florida between 2012 and 2015, we examine the effect of hospital TV advertising on emergency patients' choice of hospitals and subsequent health outcomes. We find that patients are more likely to choose hospitals that advertise on TV, with substantial heterogeneity across demographics and health conditions. We further conduct counterfactuals—a ban on hospital advertisements. Our results suggest that hospital advertising leads to increased mortality rates. Decomposing this mortality rate change further, we show that 24% of the increase is due to increased travel distance, and the rest due to change in quality of treatment. These results suggest needs to examine the practice of hospital advertising toward emergency patients.

2 How Does Telemedicine Shape Physicians' Behavior? an Empirical Study on the Adoption Effect of Telemedicine

Manqi Li, Renmin University of China, Beijing, China. Contact: limanqi@rmbs.ruc.edu.cn

This study examines the impact of telemedicine adoption on physicians' utilization of care, patients' access to care, and mental healthcare quality. Employing the changes-in-changes (CIC) approach and a large claims dataset, we assess the effect on: 1) interval length between visits, 2) number of new patients accepted by a physician, and 3) time to remission and attrition from care. Our findings indicate that telemedicine leads to shorter intervals between visits, attributed to improved physician efficiency and the need for more frequent patient interactions due to partial information. Additionally, physicians accept more new patients, mainly urban, tech-savvy individuals with better access to required technology. However, there is no significant impact on quality of care. These insights highlight the advantages and unintended consequences of telemedicine adoption as it becomes increasingly prevalent in healthcare service delivery.

3 Growing use of Remote Patient Monitoring: A Step in the Right Direction or too Much too Soon?

Mitchell Tang[1], Ariel Stern[1], Ateev Mehrotra[2], [1]Harvard Business School, Boston, MA, [2]Harvard Medical School, Boston, MA, Contact: mtang@hbs.edu

Remote patient monitoring (RPM) use has grown rapidly, with most use by primary care providers (PCPs) for hypertension management; however, its impacts are unclear. To fill this gap, we estimated RPM's impact on hypertension care in 2021. Using traditional Medicare claims, we compared changes over time for hypertension patients of high-RPM practices to those of matched controls with no RPM use. RPM use was associated with improved medication adherence and more medication changes, but also increases in PCP visits and overall spending. We highlight which patients benefit most from RPM and when there is the greatest impact on medication changes, with implications for optimal RPM use and reimbursement.

4 Does Telemedicine Affect Physician Decisions? Evidence from Antibiotic Prescriptions

TI Tongil Kim[1], Shujing Sun[1], Guihua Wang[2], [1]University of Texas at Dallas, Richardson, TX, [2]The University of Texas at Dallas, RICHARDSON, TX, Contact: ti.kim@utdallas.edu

Telemedicine did not reach its full potential until the COVID-19 pandemic spurred its unparalleled adoption. This sudden shift in the setting of healthcare delivery raises questions regarding possible changes in clinical decision-making. Using a unique set of patient-provider encounter data from the U.S. in 2020 and 2021, we examine the effect of telemedicine on antibiotic prescription errors for urinary tract infections. We consider two types of prescription errors: prescribing when not recommended by guidelines (type I errors) and not prescribing when recommended (type II errors). We find a significantly lower likelihood of overall prescription errors (type I and II errors combined) with telemedicine relative to in-person encounters. We also find heterogeneous effects by a provider's patient volume and the patient-provider relationship. Further analyses show that the reduction in prescription errors is mainly attributable to type I errors, and that patient health outcomes are not compromised when care is delivered via telemedicine.

WA09

Johnston

Data-Driven Patient Decision-Making

General Session

Session Chair

Vishal Ahuja, Southern Methodist University, Dallas, TX

Session Chair

Yingchao Lan, University of Nebraska-Lincoln, Lincoln, NE

1 The Impact of Primary Care Regularity on Health Outcomes

Yingchao Lan[1], Vishal Ahuja[2], Aravind Chandrasekaran[3], [1]University of Nebraska-Lincoln, Lincoln, NE, [2]Southern Methodist University, Dallas, TX, [3]The Ohio State University, Columbus, OH, Contact: yingchao.lan@unl.edu

The role of care continuity is acknowledged in the healthcare delivery where patients seen by the same providers develop social ties that allows for increase in trust in their relationships. While care continuity is important, it is quite possible for patients to see the same providers but do this in a short time interval or on a sporadic basis. This may not be ideal for chronic patients who require regular interactions throughout the year to ensure well-being. Regularity is defined as the time interval between consecutive primary care visits for a patient in a given quarter. Leveraging a unique dataset, this research studies the impact of primary care regularity on health outcomes for diabetic patients.

2 Breaking the Vicious Cycle: Community Corrections Placement Support with an MDP Approach

Xiaoquan Gao[1], Pengyi Shi[2], Nan Kong[2], [1]Purdue

University, Lafayette, IN, [2]Purdue University, West Lafayette, IN, Contact: gao568@purdue.edu

Community corrections provide alternatives for incarcerations, which can reduce jail overcrowding and recidivism rate particularly for individuals with substance use disorder. We study the placement decisions for community corrections and relevant capacity planning via an MDP model and prove structural properties for policy insights. To address complex dependence between the optimal placement and system congestion, we leverage a two-timescale approach to develop algorithmic solutions. The case study demonstrates the strength of our dynamic policy and provides insights into the capacity and staff planning for the community corrections.

3 Ambiguous Dynamic Treatment Regimes: A Reinforcement Learning Approach

Soroush Saghafian, Harvard University, Cambridge, MA

Researchers in different domains often want to use observational data and provide recommendations that can yield causal improvements. When using available methods, they often have to rely on assumptions that are violated in real-world applications (e.g., medical decision-making or public policy), especially when (a) the existence of unobserved confounders cannot be ignored, and (b) the unobserved confounders are time-varying (e.g., affected by previous actions). Motivated by a case study of finding superior treatment regimes for patients who underwent transplantation in our partner hospital (Mayo Clinic), we introduce a new methodology termed Ambiguous Dynamic Treatment Regimes (ADTRs), in which the causal impact of treatment regimes is evaluated based on a "cloud" of causal models. We then develop new reinforcement learning algorithms and run detailed experiments using real-world patient level data.

4 Estimating Activity And Sleep Goals For Bipolar Disorder Patients

SIDIAN Lin, Soroush Saghafian, Jessica M. Lipschitz, Harvard University, Cambridge, MA, Contact: sidianlin@g.harvard.edu

The development of mobile health technologies gives rise to the possibility of long-term monitoring for chronic diseases such as mental disorders. In this study, we focus on bridging causal inference and offline reinforcement learning to give better treatment suggestions to bipolar disorder patients. We also share some insights on how to translate causal inference and offline RL techniques to the complex real-world data. Given that mood transitions widely exist in most mental disorders, such design can be easily applied to other mental illnesses where new policies can be learned and evaluated in a more accurate and safer way.

WA10

Casson

Towards Advancing Global Health

General Session

Session Chair

Amir Karimi, The University of Texas at San Antonio, San Antonio, TX

1 Leapfrogging for Last-Mile Delivery in Health Care

Harriet Jeon[1], Claudio Lucarelli[1], Jean Baptiste Mazarati[2], Donatien Ngabo[3], Hummy Song[1], [1]The Wharton School, University of Pennsylvania, Philadelphia, PA, [2]University of Global Health Equity, Rwanda, Kigali, Rwanda; [3]Ministry of Health, Rwanda, Kigali, Rwanda.

Last-mile delivery is one of the most challenging and costly facets of the supply chain. We examine whether and the extent to which a technological innovation---delivery drones---leapfrogs traditional remedies that increase geographical connectivity---specifically, paving roads. Using data from Rwandan public hospitals that transfuse blood (i.e., transfusing facilities), we examine the impact of adopting drone delivery for blood transport on the inventory management of blood products and on health outcomes. We compare these effects to the impact of paving roads.

2 Procurement of Reproductive Health Commodities in LMICs: The Impact of Female Decision-Makers

Amir Karimi[1], Dwaipayan Roy[2], [1]The University of Texas at San Antonio, San Antonio, TX, [2]University of Virginia Darden School of Business, Charlottesville, VA, Contact: a.karimi@utsa.edu

Drawing on past research showing that female decision-makers tend to prioritize issues "in ways that seem to better reflect women's preferences," we empirically evaluate the relationship between female decision-makers in governmental positions and procurement of reproductive health commodities in LMICs.

3 Business Model Innovation for Ambulance Systems in Developing Countries: "Coordination and Competition"

Andre Du Pin Calmon[1], Andreas Gernert[2], Gonzalo Romero[3], Luk N. Van Wassenhove[4], [1]Scheller College of Business, Georgia Institute of Technology, Atlanta, GA, [2]KLU, Hamburg, Germany; [3]Rotman, University of Toronto, Toronto, ON, Canada; [4]INSEAD, Fontainebleau Cedex,

France. Contact: gonzalo.romero@rotman.utoronto.ca
Several LMICs' emergency transportation systems do not have a centralized emergency number. Instead, they have many independent ambulance providers, each with a small number of ambulances. Using a free-entry equilibrium model, we show that in such decentralized systems, the coverage is at most 71.54\%, regardless of the ETS's profitability. We examine three business models that address this issue: (i) a competitor-only business model; (ii) a platform business model, where an entrepreneur coordinates existing providers; and (iii) an innovative platform-plus business model, where an entrepreneur combines (i) and (ii): setting-up a platform and acquiring platform-owned ambulances.

WA11

Tom Thomson

AI, Bias, and Public Health

General Session

Session Chair

Margret Bjarnadottir, University of Maryland, College Park, MD

1 Assessing Dataset Quality to AI Bias and Healthcare Disparities: A Study on EHR-Based Prediabetes to Diabetes Risk Prediction Model

Junjie Luo[1], Gordon Gao[2], Ritu Agarwal[3], [1]School of Medicine, Johns Hopkins University, Baltimore, MD, [2]Johns Hopkins University, Baltimore, MD, [3]Johns Hopkins Carey Business School, Baltimore, MD, Contact: jluo41@jhmi.edu
AI's predictive power can amplify healthcare disparities between advantaged and disadvantaged groups. In the dataset, disadvantaged patients often deviate more from the truth, resulting in AI ranking advantaged patients higher and allocating more resources to them. It's important to assess dataset quality before training advanced AI for decision-making. In this study, we assess dataset quality by asking three key evaluation questions: (1) Are disadvantaged patients adequately represented in the cohort? (2) Are disadvantaged patients' input features significantly different from reality compared to those of advantaged patients? (3) Are the outcome labels for disadvantaged patients less reliable? To illustrate the effects of dataset quality on AI bias, we utilize real electronic health record data from a large hospital system and develop deep-learning AI models to predict the risk score of transitioning from prediabetes to diabetes. Our study highlights how the three dataset dimensions can contribute to AI bias across different groups.

2 Enhancing Social Listening and Media Monitoring with Natural Language Processing

Nasim Lari, Kenyon Crowley, Accenture Federal Services, Arlington, VA, Contact: nasim.lari@accenturefederal.com
Misinformation and disinformation regarding vaccines came into the spotlight with the recent COVID-19 pandemic resulting in a decrease in vaccine confidence and vaccination rates. Our work presents Natural Language Processing and other machine learning techniques as effective ways to enhance social listening and media monitoring by identifying where misinformation or disinformation originate and helping inform targeted campaigns based on demographics and other socioeconomic factors to counter the spread of false information. Our framework enables the understanding of sentiments around vaccines and public health interventions, and identification of at-risk communities.

3 The Interplay Between Racial Disparities and Ambiguity in Medical Decision Making: A Study of Breast Cancer

Margret Bjarnadottir[1], Ritu Agarwal[2], Wedad Elmagraphy[1], Nawar Shara[3], [1]University of Maryland, College Park, MD, [2]Johns Hopkins Carey Business School, Baltimore, MD, [3]Medstar Medicine, Washington, DC, DC
The presence of health disparities and inequities has been widely documented. Research shows that minorities and otherwise marginalized populations experience the most severe adverse effects from disparities. It is an open question whether variation in physician decision making can be explained by patient's socio-demographic characteristics and the financial context, and the impact of implicit or explicit bias. We use electronic health records and cancer registry data on 2000 patients diagnosed with breast cancer to address these questions via regression modeling and machine learning approaches.

WA12

Osgood West

Data-driven Healthcare Analytics: Learning, Optimization, and Empirical Analysis

General Session

Session Chair

Yiwen Jin, University of British Columbia, Sauder School of Business, Vancouver, BC, Canada.

1 Closer to Home: Partnering to Distribute Vaccinations Under Spatially Heterogeneous Demand

Jingyuan Hu, UCLA Anderson School of Management, Los Angeles, CA

This study examines how COVID-19 vaccination site selection contributes to socioeconomic disparities in the US. By analyzing data from California, the study finds that residents in low health areas are more sensitive to distance than those in high health areas. The study proposes an optimal facility location problem to mitigate distance inequalities and suggests that partnering with public high schools or dollar stores could increase vaccinations by 1.8 million and 1.4 million, respectively. The study offers a quantitative framework to improve vaccine accessibility for marginalized populations.

2 The Interplay Between Safety-Net Hospital Utilization and Experiential Quality Ratings

Ankita Shirahatti[1], Anita L. Tucker[2], [1]Questrom School of Business, Boston, MA, [2]Boston University, Boston, MA, Contact: ashiraha@bu.edu

Safety-net hospitals have historically been tasked with caring for underserved populations in the United States. Despite major advances in accessibility to elite, non-safety-net hospitals (e.g. through Medicaid expansion), several studies have shown that demand for healthcare has not shifted away from safety-net hospitals among underserved patient populations. In this paper, we derive experiential quality features from online reviews for safety-net hospitals in Massachusetts to extricate specific hospital features valued by underserved patients. Using a discrete choice framework, we then test the hypothesis that safety-net hospitals provide better healthcare experiences for underserved patients by meeting this population's unique needs.

3 On The Performance of Greedy Algorithm To Solve Appointment Scheduling Problems In Healthcare Settings

Sina Khosravinia, Yun Zhou, McMaster University, Hamilton, ON, Canada. Contact: khosrs3@mcmaster.ca

In both primary care and surgical settings in healthcare systems, it is well-acknowledged that healthcare providers' (i.e., doctors', nurses', etc.) time is one of the most valuable resources. Typically, appointment scheduling systems are implemented in those settings to manage customer demand. Reducing the idle time while maintaining short waiting times could be challenging knowing that appointment scheduling problems are difficult to solve as it is combinatorial in nature and involves uncertainties with regard to appointment durations, no-shows, etc. In this research, we will study the performance of the greedy method in solving appointment scheduling problems in healthcare settings.

4 Smooth Contextual Bandits: Bridging the Parametric and Nondifferentiable Regret Regimes

Yichun Hu, Cornell University, New York, NY

We study nonparametric contextual bandits in which the expected reward functions belong to a Holder class with smoothness parameter □. We show how this interpolates between two extremes that were previously studied in isolation: nondifferentiable bandits (□ at most1), with which rate-optimal regret is achieved by running separate noncontextual bandits in different context regions, and parametric-response bandits (infinite □), with which rate-optimal regret can be achieved with minimal or no exploration due to infinite extrapolatability. We develop a novel algorithm that carefully adjusts to all smoothness settings, and prove its regret is rate-optimal by establishing matching upper and lower bounds, recovering existing results at the two extremes. In this sense, our work bridges the gap between existing literature on parametric and nondifferentiable contextual bandits and between bandit algorithms that exclusively use global or local information, shedding light on the interplay of complexity and regret in contextual bandits.

5 Dynamic Service Allocation with Returns: Application to Admission and Discharge Control with Readmission in Hospital

Hossein Abouee-Mehrizi[1], Ya-Tang Chuang[2], Michael Jong Kim[3], Xinyuan Zhang[3], [1]University of Waterloo, Waterloo, ON, Canada; [2]National Cheng Kung University, Tainan, Taiwan; [3]University of British Columbia, Vancouver, BC, Canada. Contact: chuangyatang@gs.ncku.edu.tw

We study a dynamic allocation problem in capacity-limited health facilities such as intensive care units (ICUs), where early discharges may lead to patient readmission. Specifically, we consider the optimal control of admissions and discharges to minimize both system congestion and patient health-related costs. We develop a Markov control model that explicitly tracks patients' health evolution and readmission dynamics. We adopt a restless bandit framework to solve the problem in a decentralized manner, and the optimal policies are characterized.

WA13

Osgood East

Healthcare OM: Advances on costs and quality

General Session

Session Chair

Felix Miedaner, Ostfalia University of Applied Sciences, Wolfsburg, Germany.

1 Determining the Costs and Patient Journeys of Assisted Reproductive Technology Fertility Care Pathways

Maura Leusder[1], Hilco J. Elten[2], Kees C. T. B. Ahaus[1], Carina G. J. M. Hilders[1,3], Evert J. P. van Santbrink[4], [1]Erasmus University, Rotterdam, Netherlands; [2]Nyenrode Business University, Breukelen, Netherlands; [3]Reinier de Graaf Gasthuis, Delft, Netherlands; [4]IVF Voorburg, Reinier de Graaf Gasthuis, Voorburg, Netherlands. Contact: leusder@eshpm.eur.nl

The costs of delivering fertility care treatments are largely unknown and highly variable. Patients desire a quick time to pregnancy, but trajectories take months to years. Reimbursement amounts assume fixed sums per treatment, despite evidence suggesting that patient-level cost, outcome, and duration variation can be significant. We developed a cost calculation tool using time-driven activity-based costing (TDABC) and metro mapping, which incorporates patient-level input variables. We leverage this model with a unique data set of detailed electronic health records to explicate the patient journeys using process mining, and to estimate the potential impact of artificial intelligence (AI) embryo selection. Our results indicate that fertility treatments show substantial cost variability and can significantly vary in duration when considering the patient journey from initial consultation to ongoing pregnancy. We explore the policy and business implications of these findings.

2 How Consecutive Working Days and Experience Influence Individual Perceived Fatigue of Nurses- an Analysis on Neonatal Wards

Helena Müller[1], Michael Becker-Peth[2], Ludwig M. Kuntz[3], [1]University of Cologne, Cologne, Germany; [2]Erasmus University Rotterdam, Rotterdam, Netherlands; [3]University of Cologne, Köln, Germany. Contact: helena.mueller@wiso.uni-koeln.de

Purpose: Previous research has shown the impact of fatigue on outcomes in hospital settings. Our study contributes with a longitudinal data set at the individual level to this research. Methods: The data were collected as part of the Neo-CamCare project using a combined approach of an observational study and a standardised diary questionnaire. The data set includes 1,191 daily questionnaires from 65 nurses on three different neonatal wards. The study period on each ward lasted 6 months. Results: First results indicate that consecutive working days are associated with perceived individual fatigue. Under certain conditions this process is moderated by nurses' experience.

3 Capacity Constraints, Information Gathering, and Quality of Care: Evidence from a Behavioral Experiment with Pediatricians

Bernhard Roth[1], Anna K. Stirner[2], Daniel Wiesen[2], [1]Cologne University Hospital, Cologne, Germany; [2]University of Cologne, Cologne, Germany. Contact: stirner@wiso.uni-koeln.de

We study how capacity constraints affect physicians' willingness to gather additional information to support their therapy decisions, the utilization of information and quality of care. Using a framed field experiment with pediatricians (n=247), we vary the extent to which physicians' capacity is constrained by two parameters: Availability of decision support and information gathering costs. Physicians' willingness to gather information decreases as capacity constraints increase, while utilization of information is not affected. Our results suggest that decreasing capacity constraints can be an effective way to enhance the use of decision support and thus improve quality of care.

4 Service Quality Implications of Extended Periods of Consecutive Working Days: An Empirical Study of Neonatal Intensive Care Nursing Teams

Felix Miedaner[1], Ludwig Kuntz[2], Kerstin Eilermann[2], Bernhard Roth[2], Stefan Scholtes[3], [1]Ostfalia University of Applied Sciences, Wolfsburg, Germany; [2]University of Cologne, Cologne, Germany; [3]University of Cambridge, Cambridge, United Kingdom. Contact: f.miedaner@ostfalia.de

When managers respond to unexpected surges in demand, staff sickness or staff vacancies they will often rely on team members working extended periods of consecutive working days. This may have potential negative consequences on quality and safety, outweighing the gains of safe workload levels. We study the interplay between workload levels and extended periods of consecutive working days and their impact on service quality in 62 German NICUs. Using survival analysis, we estimate the impact of average consecutive working days of nursing teams on the time to full enteral feeding of the patient and moderating effects of workload (nurse-to-patient ratio) and task complexity. We find that the level of average consecutive working days has a statistically significant and clinically relevant negative impact on the time to enteral feeding of a newborn in critical care. While for less complex patients the negative

impact occurs only in combination with high workloads per worker, complex patients are negatively impacted independently of workload levels.

WA14

Fitzgerald

Data Mining and Healthcare Analytics 1

Contributed Session

Session Chair

Joseph Mollick, Texas A&M University - Corpus Christi, Corpus Christi, TX

1 Septic Shock Prediction and Knowledge Discovery Through Temporal Pattern Mining

Joseph K. Agor, Oregon State University, Corvallis, OR, Contact: joe.agor@oregonstate.edu

Temporal pattern mining can be used to identify trends in a patient's health status over time. However, too many patterns can limit knowledge discovery and practical bedside implementation in acute care settings. We propose a framework to find a small number of relevant temporal patterns in electronic health records for the early prediction of septic shock. We find that model-based feature selection approaches yield the best prediction performance among these techniques. However, from a knowledge discovery perspective, it may be worthwhile to sacrifice a small amount of prediction power for actionable patient health information through the implementation of a contrasted grouping approach.

2 Leveraging Off-Season Mock CAHPS Survey Data for Root-Cause Analysis and Predictive Modeling to Improve Member Engagement and Satisfaction

Frank Song, Albert Lee, Inland Empire Health Plan, Rancho Cucamonga, CA, Contact: frank.song@iehp.org

We will share how IEHP used off-season mock survey data for root-cause analyses and predictive modeling to support data-driven decision and optimization efforts to improve the member experience and validate vendor modeling results for accuracy and effectiveness. We will demonstrate how this off-season data offers an opportunity for health plans to elevate the member experience, amplify quality improvement activities, and improve HEDIS submission effectiveness.

3 Updating Clinical Risk Stratification Models Using Rank-based Compatibility

Erkin Ötleş[1], Brian T. Denton[2], [1]University of Michigan, Ann Arbor, MI, [2]Industrial and Operations Engineering, University of Michigan, Ann Arbor, MI, Contact: eotles@umich.edu

Updating clinical machine learning models is necessary to maintain performance, but may cause compatibility issues, affecting user-model interaction. Current compatibility measures have limitations, especially where models generate risk-based rankings. We propose a new rank-based compatibility measure and loss function that optimizes discriminative performance while promoting good compatibility. We applied this to a mortality risk stratification study using MIMIC data, resulting in more compatible models while maintaining performance. These techniques provide new approaches for updating risk stratification models in clinical settings.

4 Application of Text Mining in Healthcare: A Review of Scholarly Literature

Joseph Mollick[1], Judy Toscano[2], [1]Texas A&M University - Corpus Christi, Corpus Christi, TX, [2]Optum Health, Corpus Christi, TX

A systematic literature review (SLR) was performed on the most relevant scholarly journal articles related to the application of text data mining in the field of healthcare. The articles were synthesized and classified using common themes and contexts where text mining methods were applied. The main authors, collaboration groups, publication outlets, theoretical frameworks and constructs were identified. Hypotheses regarding application of text mining in healthcare have been developed. A framework for identifying opportunities for application of text mining in healthcare has been proposed.

WA15

University

Markov Decision Processes

Contributed Session

Session Chair

Fateme Akbari, McMaster University, Hamilton, ON, Canada.

1 Going Faster to See Further: GPU-Accelerated Value Iteration and Simulation for Blood Product Inventory Management

Joseph Farrington[1], Kezhi Li[1], Wai Keong Wong[2], Martin Utley[1], [1]University College London, London, United

Kingdom; [2]University College London Hospitals NHS Foundation Trust, London, United Kingdom. Contact: ucabjmf@ucl.ac.uk

Finding optimal replenishment policies for perishable inventory such as blood products is computationally challenging. We demonstrate, with scenarios from three recent papers, that optimization using value iteration can be extended to problems with over 16 million states using the Python library JAX to efficiently utilize the parallel computing power of consumer-grade GPU hardware. We compare the optimal policies from value iteration with heuristic policies fitted using simulation optimization implemented with JAX, which supports large-scale parallel evaluation of multiple candidate policies.

2 Cost-Effective Analysis of Health Screening in Markov Decision Processes

Masahiko Sakaguchi[1], Aiko Kurushima[2], Masayuki Horiguchi[3], [1]Osaka Electro-Communication University, Osaka, Japan; [2]Sophia University, Tokyo, Japan; [3]Kanagawa University, Yokohama, Japan. Contact: horiguchi@kanagawa-u.ac.jp

In this presentation, we consider the analytical method to evaluate screening program by Markov decision model. Using the public vital statistics in Japan, such as disease and survival rates, we evaluate the validity of scenario to breast cancer screening program which minimized the risk as complementary rate of 10-years survival rates in several scenarios in partially observed Markov decision processes(MDPs). We also discuss the construction of mathematical modeling by MDPs in prostate cancer screening in order to evaluate it in economically and relevant lifetime costs such as QOL and QALYs.

3 Partially Observable Reinforcement Learning Under Unevenly Spaced Missing Data with Application to Blood Glucose Management

Haiyan Yu[1], Jiao Xiang[2], Nan Kong[3], Li Luo[2], Ching-chi Yang[4], [1]Chongqing University of Posts and Telecomms, Chongqing, China; [2]Sichuan University, Chengdu, China; [3]Purdue University, West Laffye, IN, [4]The University of Memphis, Memphis, TN, Contact: yuhy@cqupt.edu.cn

Incompleteness of data seriously affects the efficacy of decision-making. For example, in glucose management for diabetic patients, incompleteness in the observational data when monitoring patient health status must be accommodated in aiding medical decisions. This paper proposes a method of partially observable reinforcement learning (PORL) for sequential decision-making on an incomplete data set. In this method, the Metropolis-Hastings (M-H) algorithm is adapted for the incomplete-data imputation. Our method is shown to be effective under different intervals of time spacing in unevenly spaced time series and is expected to help develop more useful digital health tools.

4 Behavior Change Detection in Older Adults Using Reinforcement Learning Methods

Fateme Akbari, McMaster University, Hamilton, ON, Canada. Contact: akbarif@mcmaster.ca

I provide a novel approach for behavior change detection in older adults by examining the Activities of Daily Living sequences. This approach can benefit older adults in several ways, including early detection of health conditions and maximizing self-sufficiency. I introduce an Inverse Reinforcement Learning (IRL)-based method for detecting behavior anomalies in older adults through the analysis of ADL sequences. The problem will be modelled as a Markov Decision Process. Using the IRL method, the reward function, which drives an individual to perform ADLs, is inferred from observed trajectories of behavior. The reward function will then be utilized to detect potential behavior anomalies.

5 Optimal Policies for Cancer Screening Under Budget Constraints

Susana Mondschein[1,2], Felipe Subiabre[1], Natalia Yankovic[3,2], [1]Universidad de Chile, Santiago, Chile; [2]Instituto Sistemas Complejos de Ingenieria, Santiago, Chile; [3]Universidad de los Andes, Santiago, Chile.

We develop a framework for the evaluation of public cancer screening policies, allowing a decision maker to compare them and find one that is optimal for some effectiveness measure, e.g. survival probability, under a global budget constraint that considers the tradeoff between the costs of testing and treatment.

To this end we use semi-Markov processes analysis over a base model of natural cancer history that has been calibrated for different risk groups.

Applying this framework to base models from the CISNET model literature, we show that the optimal policy results in more aggressive testing on groups at higher risk. We are also able to find better policies than current ones at the same expected costs.

WA16

Richmond

Quality and accessibility of healthcare products and services

General Session

Session Chair
Jun Li, Ross School of Business, University of Michigan, Ann Arbor, MI

Session Chair
Xinyu Liang, University of Michigan, MI

1 Generic Drug Effectiveness an Empirical Study on Health Service Utilization and Clinical Outcomes
Xinyu Shirley Liang, Jun Li, Ravi Anupindi, University of Michigan, Ann Arbor, MI

Generic drugs have generated over 2.4 trillion dollars in savings. The cost-saving benefit can only be realized when drug effectiveness is ensured. In this paper, we study the effectiveness of generic drugs and address the endogeneity using instrumental variables by exploiting the market entry of generic atorvastatin, which aims to alleviate the risk of cardiovascular disease. We find that generic usage leads to higher healthcare utilization. In addition, it appears less effective in reducing patients' low-density lipoprotein cholesterol levels and improving clinical symptoms. The effect is more prominent among medically fragile patients. Furthermore, the effectiveness varies across generics from various manufacturers, particularly between authorized manufacturers and others generic manufacturers, highlighting the potential conformance quality control issue. Overall, our paper highlights the aggregate impact of generic drug usage and effective variations across manufacturers with implications for healthcare stakeholders.

2 Classifying Group Affect During Dance Therapy Sessions with Older Adults to Promote Overall Wellbeing
Yizhu Li, University of Toronto, Toronto, ON, Canada

Dance therapy is increasingly being used as an effective intervention to improve overall health and well-being of older adults, including those living with cognitive impairments and dementia. In particular, positive changes in affect (emotions, moods) resulting from engaging in dance therapy have been directly associated with improved cognitive functioning in older adults. In this talk, we introduce our novel learning-based group affect detection and classification system to recognize and classify group affect through user movements during dance therapy. Extensive results demonstrate that our classification system can accurately classify a group of older adults' affect in real-time. Our proposed group affect system can be used to monitor user affect in various group-based physical and cognitive stimulating activities, emphasizing its versatility and adaptability.

3 The Effect of Opioid Shortages on Drug Overdose Deaths
Basil Issac, Xinyu Liang, University of Michigan, Ann Arbor, MI, Contact: basilisc@umich.edu

Opioid shortages have become a growing concern in the United States. This paper extends the literature on the health impact of drug shortages with its broad focus on multiple shortage episodes in the United States and estimating its impact on a large sample of affected individuals across the country. We identify geographical variation in the incidence of opioid shortages across the United States and quantify its effect on a range of health outcomes - drug adherence, utilization, and overdose deaths. This offers insight into the unintended consequences of policies aiming to restrict the supply of opioids and can inform future policy-making to tackle the opioid crisis.

4 Valuing Nursing Productivity in the Emergency Department
Hao Ding, Sokol Tushe, Diwas KC, Donald Lee, Emory University, Atlanta, GA

We quantify the increase in productivity in emergency departments (ED) from increasing nurse staff. We then estimate the associated revenue gains for the hospital and the associated welfare gains for society. Academic/practical relevance. The United States is over a decade into the worst nursing shortage crisis in history, fueled by chronic under-investment. To demonstrate to hospital managers and policymakers the benefits of investing in nursing, we clarify the positive downstream effects of doing so in the ED setting. We use a data set of patient visits to the ED of a major U.S. academic hospital. Time-dependent hazard estimation is used to study how the real time service speed of a patient varies with the state of the ED, including the time-varying workload of the assigned nurse. A counterfactual simulation is used to estimate the gains from increasing nurse staff in the ED. Results. We find that lightening a nurse's workload by one patient is associated with a 14%service speedup for every patient under the nurse's care. Simulation studies suggest that adding one more nurse to the busiest 12-hour shift of each day can shorten stays and avert $160,000 in lost patient wages per 10,000 visits. The reduction in service times also free up capacity for treating more patients and generate $470,000 in additional net revenues for the hospital per 10,000visits. In determining whether to invest in more nursing resources, hospital managers need to look beyond whether payer reimbursements alone.

Wednesday, 10–11AM

P01

Toronto Ballroom I & II

Plenary - Healthcare in Ontario: Using Quantitative Decision Tools to Achieve Goals

Plenary Session

1 Healthcare in Ontario: Using Quantitative Decision Tools to Achieve Goals

Matthew Anderson, Ontario Health, Toronto, ON, Canada.

Matthew Anderson is an experienced healthcare leader, team builder, and advocate for positive change. He is widely respected across Ontario's healthcare system for his intense focus on the needs and experiences of patients and caregivers. Before joining Ontario Health, Matthew was president and CEO of Lakeridge Health, one of the largest community hospital systems in the province. He spent more than three years overseeing the operation of five hospitals with four emergency departments and more than 5,000 physicians and staff, working with community partners to build a regional system of care for families in the Durham Region. Matthew has been working in healthcare since 1992, and he quickly rose through the ranks. He became Chief Information Officer of University Health Network (UHN) in 1998, and a vice president at UHN in 2000. In 2008, he was named CEO of the Toronto Central Local Health Integration Network and in 2010, became CEO of William Osler Health System.

Wednesday, 11:15AM–12:45PM

WB01

Carmichael

Modeling and Optimization for Public Health Policy

General Session

Session Chair

Pooyan Kazemian, Case Western Reserve University, Cleveland, OH

1 Robust Combination Testing: Methods and Application to COVID-19 Detection

Sanjay Jain[1], Jonas Oddur Jonasson[2], Jean Pauphilet[3], Kamalini Ramdas[3], [1]University of Oxford, Oxford, United Kingdom; [2]MIT Sloan School of Management, Cambridge, MA, [3]London Business School, London, United Kingdom.

We propose an analytical methodology, based on robust optimization, that provides a structured way for policymakers to optimally combine results from multiple tests for increased predictive accuracy. Our methodology is robust to noisy and partially missing input data and incorporates operational constraints. We apply our methodology to two datasets describing COVID-19 rapid antibody and antigen test performance. We find that combining only three rapid tests increases out-of-sample area under the curve (AUC) by 4% (6%) compared with the best performing individual test for antibody (antigen) detection.

2 Algorithm, Human, or the Centaur: How to Enhance Clinical Care?

Agni Orfanoudaki, Oxford University, Oxford, United Kingdom.

There is a growing amount of evidence that machine learning (ML) algorithms can be used to develop accurate clinical risk scores for a wide range of medical conditions. However, the degree to which such algorithms can affect clinical decision-making is not well understood. Our work attempts to address this problem, investigating the effect of algorithmic predictions on expert judgment. We develop a ML model and compare its performance with that of medical experts in the task of predicting 30-day readmissions after solid-organ transplantation. We find that our model is not only more accurate in predicting clinical risk but can also positively influence human judgment. To capture potential synergies between human experts and the algorithm, we propose a human-algorithm "centaur" model. We show that implementing the centaur model could reduce the average patient readmission rate by 26.4%, yielding up to a $770k reduction in annual expenditure at our partner hospital and up to $67 million savings in overall U.S. healthcare expenditures.

3 Sharing is Caring: Data-Driven Resource Sharing During the Pandemic

Esmaeil Keyvanshokooh[1],

Amid local outbreaks of COVID-19, many hospitals canceled elective procedures to preserve ventilator capacity for COVID-19 patients. The virus spreads at varying rates, causing demand for care to peak at different times across different regions. Hence, sharing scarce portable resources can help alleviate local capacity shortfalls. We develop a data-driven adaptive robust simulation optimization method for allocating and relocating ventilators among different

regions of multiple states to satisfy demand with fewer total ventilators. Proof of concept is given by a case study of sharing ventilators among regions in Ohio and Michigan.

WB02

Jackson

Planning and Preparedness for Emergencies

General Session

Session Chair

K.H. Benjamin Leung, University of Toronto, Toronto, ON, Canada.

1 Deploying A Robust Active Preference Elicitation Algorithm: Experiment Design, Interface, And Evaluation For COVID-19 Patient Prioritization

Caroline Johnston, Patrick Vossler, Simon Blessenohl, Phebe Vayanos, University of Southern California, Los Angeles, CA, Contact: cmjohnst@usc.edu

Preference elicitation uses AI or optimization to learn stakeholder preferences. The online robust preference elicitation method of Vayanos et al. (2020) outperforms other methods in simulation in terms of learning individuals' true utility. However, it makes multiple assumptions that are hard to verify in reality. We validate the method's performance in deployment using policies for prioritizing COVID-19 patients for scarce resources. We build a platform for preference elicitation and recruit MTurk workers (n = 193) to give preferences via a small number of pairwise comparisons. We show that the robust method recommends a policy with higher utility for 21% more users compared to random queries.

2 Trauma Bay Re-Design: A Human-Centred Approach

Rejuana Alam[1], Richard Hoang[2], Avery Nathens[2], Michael W. Carter[1], [1]University of Toronto, Toronto, ON, Canada; [2]Sunnybrook Health Sciences Centre, Toronto, ON, Canada. Contact: rejuana.alam@mail.utoronto.ca

Trauma bays are chaotic places due to frequent rotation of staff from different medical disciplines, and urgency in providing required treatment. The suboptimal and ad-hoc design of trauma bays has led to staff dissatisfaction and potential safety and quality concerns. We utilize various empirical frameworks with considerations from management science and participatory design to trauma bay re-design with emphases on active engagement from stakeholders, application of user-centred design principles, and usability testing with quantitative and qualitative metrics. We discuss latest progress on a case study at Sunnybrook Health Sciences Centre in Toronto.

3 Health Economic Evaluation of Data-Driven Public Access Defibrillator Locations: From Maximizing Coverage to Maximizing Health Outcomes

Robin Buter[1], Hendrik Koffijberg[1], Hans van Schuppen[2], Remy Stieglis[2], Derya Demirtas[1], [1]University of Twente, Enschede, Netherlands; [2]Amsterdam University Medical Center, Amsterdam, Netherlands. Contact: r.buter@utwente.nl

Improving survival from out-of-hospital cardiac arrest (OHCA) is an important but difficult public health challenge. To increase survival, volunteer responder systems (VRS) have been implemented in many countries to dispatch and guide nearby registered volunteers towards the location of the OHCA or an automated external defibrillator (AED). In this presentation, we show health economic evaluation of additional AEDs to be used in a VRS, positioned to maximize estimated health outcomes.

4 Cost-Effectiveness of Drones for Cardiac Arrest Response

Muhammad Maaz[1], K.H. Benjamin Leung[1], Justin J. Boutilier[2], Sze-chuan Suen[3], Timothy Chan[1], [1]University of Toronto, Toronto, ON, Canada; [2]University of Wisconsin - Madison, Madison, WI, [3]University of Southern California, Los Angeles, CA, Contact: m.maaz@mail.utoronto.ca

Early application of a defibrillator is one of the most important determinants of mortality and morbidity in cardiac arrests. Drones are increasingly studied as a way to quickly get defibrillators to cardiac arrest patients. However, the cost-effectiveness of such programs has not been studied. We use a Markov model to study the cost-effectiveness of drone-delivered defibrillators, taking into account the costs of the drones themselves and costs to the healthcare system. Our results show that they are cost-effective.

5 Modelling Fairness, Equity, and Efficiency Trade-Offs in Public Defibrillator Placement

K.H. Benjamin Leung[1], Gareth Clegg[2], Diane Lac[2], Timothy C.Y. Chan[1], [1]University of Toronto, Toronto, ON, Canada; [2]The University of Edinburgh, Edinburgh, United Kingdom. Contact: benkh.leung@mail.utoronto.ca

The maximum coverage location problem (MCLP) is a useful approach to determine optimal locations to publicly accessible defibrillators for out-of-hospital cardiac arrest, and has been shown to outperform population-guided heuristics and clinical guidelines. Prior research has focused

on maximizing spatial coverage of cardiac arrests across the whole study region; however, this may lead to allocations that are inequitable or unfair across communities of varying geographies, demographics, and socioeconomic levels. We introduce formulations that incorporate trade-offs between the efficiency, equity, and fairness of coverage across study subregions, and compare the standard MCLP with our proposed formulation using cardiac arrest and defibrillator location data from Scotland.

WB03

Varley

Modeling COVID-19 Interventions

General Session

Session Chair

Maria Esther Mayorga, North Carolina State University, Raleigh, NC

1 Simulation Optimization of COVID-19 Random Screening Tests in K-12 Schools

Julie L. Swann, North Carolina State University, Raleigh, NC

Due to the low vaccination rate of COVID-19 among children in the US, measures need to be considered for children to attend school safely. Random screening tests are one of the measures that have been widely implemented within K-12 schools. In our study, we simulated the disease transmission within K-12 schools using a compartmental SEIR model and applied multi-objective simulation optimization using genetic algorithms to help schools find the best way to utilize testing resources. By solving the optimization problem, we find the best planning of random screening tests that minimizes the cumulative infections in school.

2 Effective Screening Strategies for Safe Opening of Universities Under Omicron and Delta Variants of COVID-19

Marie Jeanne Rabil[1], Sait Tunc[1], Douglas R. Bish[2], Ebru Korular Bish[2], [1]Virginia Tech, Blacksburg, VA, [2]University of Alabama, Tuscaloosa, AL, Contact: mariejeanne@vt.edu

As new COVID-19 variants emerge, and disease and population characteristics change, screening strategies may need to evolve. We develop screening strategies for the safe operation of college campuses, which can be customized based on population demographics and vaccination status. Our model considers co-circulating variants with different disease dynamics, and variant- and dose-dependent vaccine efficacy, and provides multidimensional metrics on infections/hospitalizations/deaths; peak daily hospitalizations; and the tests required. Using the Spring 2022 academic semester as a case study, we provide key guidelines on effective and efficient routine screening strategies.

3 Distance-Based Critical Node Detection for Strategic Vaccination Policies

Faraz Khoshbakhtian[1], Hamidreza Validi[2], Mario Ventresca[3], Dionne Aleman[4], Randy Giffen[5], Proton Rahman[6], [1]University of Toronto, Toronto, ON, Canada; [2]Texas Tech University, Lubbock, TX, [3]Purdue University, Lafayette, IN, [4]University of Toronto, Toronto, ON, Canada; [5]IBM Canada, St. John's, NL, Canada; [6]Eastern Health, St. John's, NL, Canada. Contact: faraz.khoshbakhtian@mail.utoronto.ca

Effective vaccination policies are vital for controlling infectious diseases. We formulate the vaccination problem as the distance-based critical node detection problem (DCNDP) and present a novel approach for optimal vaccination under budget constraints. We introduce a lightweight integer programming model for 2-hop DCNDP and a divide-and-conquer pipeline for near-optimal solutions on large networks. Applied to a simulated contact network of a Canadian province (&gt500K nodes) during COVID, our method reduces 2-hop connectivity by 84% with 20% vaccine coverage. We integrate agent-based pandemic modeling and machine learning to generate implementable policies from the model solutions.

4 Data Science Responses to an Evolving Pandemic

Sandy Preiss, RTI International, Durham, NC

Over the past three years, the COVID-19 pandemic has evolved through many phases. Curve flattening, vaccine uptake, new variants, safe reopening - each phase has presented new analytical challenges. Throughout the pandemic, RTI International has brought the tools of data science to bear on these challenges. In 2020, we provided weekly forecasts of hospital occupancy to help the NC government allocate resources. During the omicron surge, we used a simulation model to study how nursing homes could reduce infections among residents. As federal agencies added COVID-related questions to surveys, we used natural language processing to quickly extract insights from new data. Now, we are working to learn more about long COVID, a poorly understood condition that continues to affect millions of people. Throughout these projects, we have learned one key lesson: for data science to realize its potential impact on public health, it must be practiced in close collaboration with subject matter experts and the people with boots on the ground.

5 Excess Deaths During the COVID-19 Pandemic

Ian Ludden, Sheldon H. Jacobson, Janet Jokela, University of Illinois, Urbana, IL, Contact: shj@illinois.edu

The COVID-19 pandemic hastened hundreds of thousands of deaths in the US. Many of these excess deaths are directly attributed to COVID-19, but others stem from the pandemic's social, economic, and health care system disruptions. We apply cohort-specific death risk odds ratios to assess excess deaths across different age and gender cohorts. Death risks for most cohorts were significantly higher in 2021 than in 2015-2019, both with and without deaths involving COVID-19. But total death risks for the 65+ age groups declined from 2020 to 2021.

WB06

Toronto Ballroom 3: Harris

Emergency Logistics

General Session

Session Chair

Valérie Bélanger, HEC Montreal, Montreal, QC, Canada.

1 A Simulation Study of the Operational Effects of Expanding Secondary Triage of Calls for Medical Emergencies

Luc de Montigny[1], Gabriel Lavoie[1], Aman Verma[2], Valérie Bélanger[3], Nadia Lahrichi[4], [1]La Corporation d'urgences-santé, Montreal, Canada, Montreal, QC, Canada; [2]McGill University, Montreal, QC, Canada; [3]HEC Montreal, Montreal, QC, Canada; [4]Polytechnique Montréal, Montreal, QC, Canada. Contact: valerie.3.belanger@hec.ca

EMS systems are challenged by chronic staffing shortages, steadily growing call volumes, especially for non-urgent care, and the concomitant role as a gateway to primary healthcare. In response, many systems are introducing or expanding secondary triage to manage demand without abandoning patients. The safety of secondary triage is moderately well documented. However, there has been little study of its effects on operational efficiency. In this project, we use a discrete-event simulator, based on 2019 procedures and data from a large urban EMS system in Canada, to analyze scenarios that consider secondary triage alone and in combination with enhancement to primary triage. Key performance indicators include response time (RT), lights-and-siren travel (LST), ambulance reassignments (AR) and system utilization rates (UR). Our results suggest that combining enhanced secondary and primary triage could improve RT for all priorities, while producing important reductions in LST and AR, and non-trivial improvements to UR.

2 Heterogeneous Aerial Fleet Planning Using Simulation Models to Improve Interhospital Transport

Joëlle Cormier[1], Valerie Belanger[1], Marie-Eve Rancourt[2], [1]HEC Montreal, Montreal, QC, Canada; [2]HEC Montréal, Montreal, QC, Canada. Contact: joelle.cormier@hec.ca

Interhospital emergency transfer is a critical operation to provide specialized care to many patients in remote areas. This project focuses on strategic decisions, which include the composition of the aircraft fleet, the number of aircraft and the location of the hangars. Real data input and simulation modeling were used to improve the fleet of fixed-wing aircraft in the Canadian province of Québec. This study made it possible to develop a methodology to assess the various trade-offs at the strategic level that can be replicated in other territories. The results offer concrete recommendations on the functioning of an aerial interhospital evacuation service.

3 Humanitarian Shelter Network Design and Evacuation Planning Problem: An Application to Flood Preparedness in Haiti

Maedeh Sharbaf[1], Valérie Bélanger[2], Marie-Ève Rancourt[1], [1]HEC Montréal, Montreal, QC, Canada; [2]HEC Montreal, Montreal, QC, Canada. Contact: maedeh.sharbaf@hec.ca

We present a decision-support tool for flood preparedness developed through a collaboration with the World Bank. The shelter network design and evacuation planning problem is formulated as a risk-based bi-level optimization model with time-varying characteristics (e.g., evacuee behavior and disaster propagation) and tested using socio-demographic and GIS data of Haiti. As a first attempt toward incorporation of human behavior in an optimization model, we contribute to the literature by modelling the response of the population to an evacuation order (e.g., evacuation participation rates, mobilization times, route choices of the evacuees).

WB07

Toronto Ballroom 4: MacDonald

Healthcare Disparities and Equity

General Session

Session Chair

Carolina Vivas-Valencia, The University of Texas at San Antonio, San Antonio, TX

1 Systems-Based Modeling to Estimate the Impact of Community Interventions in Neonatal Abstinence Syndrome (NAS)

Diana Lopez-Soto, North Dakota State University, Fargo, ND

Opioid-based Neonatal Abstinence Syndrome (NAS) has increased in the US in recent years. Due to its complexity, effective interventions should mitigate long-term consequences for the mother, her child, and the community. A systems-based model is used to evaluate the effects of community interventions through simulation. Results show that the implementation of multiple interventions reduces 32% of NAS cases, and increases more than 300% the number of women completing treatment. However, effective implementation would require the involvement and coordination of several stakeholders.

2 Multivariate Time Series Classification in the Presence of Uncertain Predictors with an Application in Medical Decision Making

Maryam Kheirandish Borujeni, Shengfan Zhang, University of Arkansas, Fayetteville, AR

Multivariate time series classification (MTSC) has a broad application in healthcare, human activity recognition, cyber-security, finance, marketing, automated disease detection, and anomaly detection. Among several MTSC techniques, long short-term memory (LSTM) models are an effective technique specifically to model longitudinal trajectories for health and disease with discrete predictors. However, health data have inherent uncertainties, which impacts the performance of LSTM models and limits the application of such models in practice. Existing studies on uncertainty quantification of deep neural networks often assume a normal distribution associated with data uncertainty. Many uncertainty quantification techniques are established for regression deep neural networks that are not directly applicable for classification purposes. In this research, we introduce a framework to deal with input uncertainties when using LSTM models for classification.

3 Breaking the Boarding Barrier: A Multi-Objective Optimization Approach to Enhance Mental Health Care Access

Nathan Adeyemi[1], Kayse Lee Lee Maass[2], [1]Northeastern University, Boston, MA, [2]Northeastern University, Boston, MA, Contact: adeyemi.n@northeastern.edu

Extended wait times in emergency departments (EDs) have remained an issue for patients requiring critical psychiatric care. This problem is exacerbated by the need for external transfers due to a lack of on-site treatment options, especially for vulnerable patients. Boarded patients do not receive specialized care, contribute to ED overcrowding, and strain hospital resources. To tackle this issue, we propose a multi-objective optimization problem where psychiatric beds are reallocated among inpatient units based on age within hospitals. It employs a large-scale discrete event simulation model to obtain objective function values aimed at improving both efficiency and equity of inpatient care access. This optimization problem is accompanied by a novel solution algorithm derived from simulated annealing where the estimated efficient solution set is iteratively updated. The preliminary trials have demonstrated encouraging outcomes, showing statistically significant decreases in each of the three objective measures.

4 Targeted Naloxone Co-Dispensing with Prescription Opioids: A Data-Driven Simulation Modeling Analysis

W. Alton Russell, McGill University, Montreal, QC, Canada. Contact: alton.russell@mcgill.ca

Many US states require co-prescribing overdose-reversing drug naloxone alongside opioids to certain patients, but criteria for which patients should receive naloxone vary. A lack of outcomes data limits our understanding of which prescription opioid patients should receive naloxone. Combining data-driven methods and microsimulation, we estimate the effectiveness and cost-effectiveness of targeted naloxone dispensing to patients receiving opioids based on various clinical criteria in a large multi-payer US cohort. With a view towards informing health equity implications, we also estimate the distribution of benefits across sociodemographic groups.

WB08

Toronto Ballroom 5: Lismer

Healthcare Analytics

General Session

Session Chair

Rema Padman, Carnegie Mellon University, Pittsburgh, PA

1 Implementation of a Postpartum Depression Prediction Model into the Electronic Health Records

Yiye Zhang, Weill Cornell Medicine/Cornell University, New York, NY

Postpartum depression is a serious mental health condition after childbirth. Risk detection using electronic health records could reduce the burden of screening during prenatal care, but concerns for algorithmic bias should be carefully

evaluated prior to implementation. I will discuss our work on the development of a risk prediction model using EHR. In particular, this talk will focus on the post-development model validation and fairness evaluation as the model goes through an implementation process at NewYork-Presbyterian Hospital/Weill Cornell Medicine.

2 Themis: A Framework for Cost-Benefit Analysis of COVID-19 Non-Pharmaceutical Interventions

Dimitris Bertsimas[1], Michael Lingzhi Li[2], Saksham Soni[1], [1]Massachusetts Institute of Technology, Cambridge, MA, [2]Harvard Business School, Boston, MA, Contact: mili@hbs.edu

Since December 2019, the world has been ravaged by the COVID-19 pandemic. To combat the spread of COVID-19, governments have issued unprecedented non-pharmaceutical interventions (NPIs). Despite their proven effectiveness in reducing virus transmission, the policies often carry significant economic and humanitarian cost. In this paper, we create a data-driven framework, THEMIS, that allows us to compare the costs and benefits of a large class of NPIs in any geographical region across different cost dimensions. As a demonstration, we analyzed thousands of alternative policies across 5 countries and compared with historical reality. Our results show that short but severe restrictions (complete lockdown for 4-5 weeks) generally produced the best results for developed countries, but only if the speed of reopening is slow enough to prevent a resurgence. Developing countries exhibited very different trade-off profiles and results suggest that severe NPIs such as lockdowns might not be as suitable for developing countries in general.

3 Multi-Stage Cardiac Surgical Readmission Prediction

Xinyu Yao[1], George Huaien Chen[1], Karmel S. Shehadeh[2], Arman Kilic[3], Rema Padman[1], [1]Carnegie Mellon University, Pittsburgh, PA, [2]Lehigh University, Bethlehem, PA, [3]Medical University of South Carolina, Charleston, SC, Contact: xinyuyao@andrew.cmu.edu

Hospital readmissions after surgical procedures are burdensome for patients as well as the healthcare system. In this paper, we propose an interpretable model that predicts whether a patient will be readmitted to the hospital within 30 days after being discharged, based on data available at different time steps (e.g., at the preoperative stage, right after completion of the surgery, and at the time of hospital discharge). Our model is an attention-based recurrent neural network model, where the features available at different time steps vary. We demonstrate our framework on cardiac surgery data from a major health system, where we find that our proposed framework can achieve competitive prediction accuracy while identifying how the importance of features varies over time.

4 Group-Based Trajectory Modeling of Kidney Disease in Patients Affected by Type 2 Diabetes

Alessandro Guazzo[1,2], [1]University of Padua, Padua, Italy; [2]Carnegie Mellon University, Pittsburgh, PA, Contact: alessandro.guazzo@studenti.unipd.it

Diabetes is a chronic disease characterized by elevated blood glucose levels that, if not properly controlled, may lead to numerous complications. One of the most common diabetes complications is chronic kidney disease (CKD). Insights on the progression of CKD in diabetic patients are needed to provide clinicians with useful instruments to improve the quality of care. Utilizing electronic health records data of Italian diabetic patients we applied group-based trajectory modeling (GBTM) in order to detect patient risk groups and uncover typical progressions of CKD.

WB09

Johnston

The Promise of Personalized Medicine

General Session

Session Chair

Hossein Piri, Haskayen School of Business-University of Calgary, Calgary, AB, Canada.

1 Value of Information Analysis for External Validation of Risk Prediction Models

Mohsen Sadatsafavi[1], Tae Yoon (Harry) Lee[1], Laure Wynants[2], Andrew Vickers[3], Paul Gustafson[4], [1]The University of British Columbia, Vancouver, BC, Canada; [2]Maastricht University, Maastricht, Netherlands; [3]Memorial Sloan Kettering Cancer Center, New York, NY, [4]The University of British Columbia, Vancouver, BC, Canada. Contact: msafavi@mail.ubc.ca

Clinical prediction models are often developed and validated using finite samples. We apply value-of-information methods to quantify the consequence of the resulting uncertainty in their net benefit (NB). We define the Expected Value of Perfect Information (EVPI) as the expected NB loss due to not confidently knowing which decision confers the highest NB at a given risk threshold. We propose bootstrap-based and asymptotic methods for EVPI computations. Data from an international clinical trial is used as a case study. Value-

of-information methods can be applied to the NB calculated for clinical prediction models to provide a decision-theoretic perspective to the consequences of uncertainty.

2 Individualized Dynamic Patient Monitoring Under Alarm Fatigue

Hossein Piri[1], Tim Huh[2], Steven Shechter[3], Darren Hudson[4], [1]Haskayen School of Business-University of Calgary, Calgary, AB, Canada; [2]University of British Columbia, Vancovuer, BC, Canada; [3]University of British Columbia, Vancouver, BC, Canada; [4]University of Alberta, Edmonton, AB, Canada. Contact: hossein.piri@ucalgary.ca

Hospitals are rife with alarms, many of which are false. This leads to alarm fatigue, in which clinicians become desensitized and may inadvertently ignore real threats. We develop a partially observable Markov decision process model for recommending dynamic, patient-specific alarms in which we incorporate a cry-wolf feedback loop of repeated false alarms. Our model takes into account patient heterogeneity in safety limits for vital signs and learns a patient's safety limits by performing Bayesian updates during a patient's hospital stay. We develop structural results of the optimal policy and perform a numerical case study based on clinical data from an intensive care unit.We find that compared with current approaches of setting patients' alarms, our dynamic patient-centered model significantly reduces the risk of patient harm.

3 The Time Value of Sequential Information

Yangyang Xie[1], Jue Wang[2], [1]University of Science and Technology of China, Hefei, China; [2]Queen's University, Kingston, ON, Canada. Contact: jw171@queensu.ca

In sequential decision problems, the value of a piece of information depends on when it is collected during the horizon. Common intuition suggests that information is more valuable the earlier it is received, as it can be utilized for a longer duration. We show that this may not be the case for imperfect information, which can be less valuable the earlier it is utilized in the horizon. We characterize the su□icient conditions for imperfect information to be less or more valuable when obtained earlier. These results establish an order of information with respect to time, allowing the information providers to identify when a piece of information is more valuable.

WB10

Casson

Innovative Approaches to Resource Management for Social Goods

General Session

Session Chair

Xiaoquan Gao, Purdue University, Lafayette, IN

1 Shortening Emergency Medical Response Time with Unmanned Aerial Vehicle-Ambulance Joint Operations

Xiaoquan Gao1, Nan Kong2, Paul Griffin3, 1Purdue University, Lafayette, IN, 2Purdue University, West Lafayette, IN, 3The Pennsylvania State University, University Park, PA, Contact: gao568@purdue.edu

Unmanned aerial vehicles (UAVs) can improve emergency medical service (EMS) logistics by quickly delivering medical interventions with the help of bystanders. We formulate a Markov decision process to jointly optimize the dispatching and redeployment of UAVs and ambulances in real-time. To tackle the curse of dimensionality, we adopt an approximate dynamic programming approach with neural network-based value function approximations. Our approach outperforms existing benchmarks and provides guidance for effectively incorporating UAVs into EMS operations. By highlighting the potential advantages of using UAVs, we hope to encourage their wider adoption in the EMS field.

2 Integrated Planning and Control of Drone Networks for Emergency Medical Response

Jamal Chu[1], Sheng Liu[2], Wei Qi[3], Timothy Chan[2], [1]University of Toronto, Toronto, ON, Canada; [2]University of Toronto, Toronto, ON, Canada; [3]Tsinghua University, Beijing, Canada. Contact: jamal.chu@mail.utoronto.ca

Drones have been proposed as a supplemental response to medical emergencies such as cardiac arrest and anaphylactic shock through the delivery of time-critical supplies. Recent work has focused on separate drone base placement and heuristic dispatch policies via two-stage models, which may lead to performance loss compared to an integrated model. We first propose a new dispatch policy and prove that it is optimal under the assumption that drones have non-overlapping coverage zones. We then propose a novel stochastic integer program to jointly optimize base placements and dispatch policies and compare our integrated placement-dispatch model to a two-stage model.

3 A Simulation-Based Performance Evaluation Model for Decision Support on Drone Location and Delivery Scheduling

Zabih Ghelichi[1], Monica Gentili[2], Pitu B. Mirchandani[3], [1]BNSF Railway, Fort Worth, TX, [2]University of Louisville, Louisville, KY, [3]Arizona State University, Tempe, AZ,

Contact: monica.gentili@louisville.edu
This research proposes a simulation-based performance evaluation model for the drone-based delivery of aid items to disaster-affected areas. The model can be used to perform analytical studies, to evaluate the performance of drone delivery systems for humanitarian logistics, and to support the decision-making on the operational design of the system - on where to locate drone take-off points and how to optimize the assignment and scheduling of delivery tasks to drones.

4 A Simulation Based Model for Evaluating Perishability and Distribution in a Broccoli Microgreen Supply Chain

Jessye Talley, Morgan State University, Baltimore, MD, Contact: jessye.bemleytalley@morgan.edu
Microgreens have grown in popularity as many consumers seek out healthy food choices. Specifically, this research will focus on broccoli microgreens because of their cancer fighting properties. Some of the challenges associated with microgreen supply chains are perishability, harvesting, and storage. A simulation model is used to evaluate production and distribution strategies.

5 A Two-Stage Stochastic Optimization Model for Patient Evacuation Problem in Wildfire with Heterogeneities and Time-Windows

Jonathan Patrick, Shahryar Moradi, Antoine Saure, University of Ottawa, Ottawa, ON, Canada. Contact: smora005@uottawa.ca
In response to the threat of wildfires, disaster management methods seek to alleviate the consequences. This study presents a two-stage stochastic optimization model to evacuate patients (those unable to evacuate themselves) from fire-affected areas with uncertain time-windows. The model addresses heterogeneities, such as multi-priority patients, multiple vehicle types, temporary and permanent shelters. The proposed model can be viewed as a vehicle routing problem with time-windows, with the objective of rescuing as many patients as possible while maximizing cost-efficiency.

WB11

Tom Thomson

Applied Forecasting Models in Hospital Administration

General Session

Session Chair

Natalia Summerville, Memorial Sloan Kettering Cancer Center, Cary, NC

1 Forecasting Labor and Delivery Admissions

Shrey Gupta, Shen Juin Lee, Archit Kaila, Duke University, Durham, NC, Contact: s.gupta@duke.edu
The WakeMed Health & Hospitals' Labor and Delivery department aims to improve budget planning by building predictive models to forecast patient arrivals and estimate the length of stay for various patient types. Two predictive models are built: one to forecast patient arrivals on a weekly basis for the next 12 weeks and another to estimate the Length of Stay by the type of delivery. An Application Programming Interface (API) is also developed to run the models independently. The objective is to aid in forecasting near-term deliveries and uncovering occupancy constraints. This project has the potential to identify trends and cost-saving opportunities in the Labor and Delivery unit. By analyzing historical data and testing various algorithms, such as time series forecasting and regression models, the project aims to provide the best-in-class forecasting accuracy for the L&D department.

2 Time Series Modeling Techniques for Forecasting Healthcare Costs by Age and Gender

Mahesh Joshi[1], Youngjin PARK[2], [1]SAS Institute Inc., Cary, NC, [2]SAS Institute, Seoul, Korea, Republic of. Contact: mahesh.joshi@sas.com
Recent years have seen an increasing need to analyze the financial impact of gender differences and longer life expectancies. Researchers are exploring treatment designs that take patients' gender and age into account. For example, according to the Centers for Disease Control and Prevention (CDC) in the United States, about 26% of women over the age of 65 have osteoarthritis, compared to only 18% of men in the same age group. Accurate forecasting of healthcare costs can provide financial benefits to patients, providers, and payers.
We analyze CDC cost data of participants from age groups 46 to 75 who have chronic and preventive episodes. Aggregated monthly time series of average costs show different patterns by episodes, gender, and age group. We use an automatic time series pattern detection algorithm to group series into segments so a suitable time series modeling method can be applied to each segment. We also try different treatments for gender and age group variables. Our results show the effect of these strategies on healthcare cost forecasting.

3 Long-Term Patient Volume Forecasting at Memorial Sloan Kettering Cancer Center

Joanna Seirup, Memorial Sloan Kettering Cancer Center
Memorial Sloan Kettering, like other healthcare organizations, needs long-range forecasts of patient volume for strategic, resource, and financial planning. As we look 10 years into the future, models based solely on quantitative data about the past become less useful. To overcome this challenge, we developed a framework to think about patients flowing into and out of our system and the types and amount of treatment activities they receive during that time. By limiting complexity to a small number of "assumption levers" that control the relationship between patients entering our system and treatment volumes, we were able to use this framework to have meaningful conversations with stakeholders that blended their clinical predictions about upcoming trends in cancer care with quantitative information on past trends. While 10-year forecasting has a wide range of error, this approach allowed us to create a reasonable prediction that fits within the larger narrative of how we believe cancer care will change over this time.

4 Forecasting Pediatric In-Patient Census

Natalia Summerville, Christopher Springer, Tiffanny Newman, Michael Riley, Memorial Sloan Kettering Cancer Center, New York, NY
Understanding expected in-patient census is critical in most hospital settings, but even more relevant for a pediatric ward, which has specialized resources such as nurses' teams, post-operating rooms, in/out patient rooms, etc. and patient overflow needs to be avoided at all costs. Expected patient census requires many elements, some known that can be extracted from real-time databases and some unknowns. This presentation is focused on the modeling of the unknown elements such as LOS (length of stay) and emergency admissions. Given the low patient volume (as compared to adult population) using traditional statistical methods presents a challenge.

WB12

Osgood West

Analytics for Healthcare Operations

General Session

Session Chair
Nan Liu, Boston College, Chestnut Hill, MA

Session Chair
Miao Bai, University of Connecticut, Storrs, CT

1 Service Mining: Data-Driven Simulation of Congestion Effects in Healthcare

Opher Baron[1], Dmitry Krass[2], Arik Senderovich[1,3], [1]University of Toronto, Toronto, ON, Canada; [2]Rotman School of Management, University of Toronto, Toronto, ON, Canada; [3]York University, Toronto, ON, Canada. Contact: opher.baron@rotman.utoronto.ca
Evaluating the impact of congestion, and of interventions designed to reduce it, is an ever-present issue in healthcare. One main challenge is that changes in delay of one patient may propagate to impact other patients. Thus, a proposed intervention creates both direct effects and indirect ones that impact patients via its impact on congestion. Standard data driven predictive models ignore causality thus while they can well estimate direct effects they cannot well estimate indirect ones. We create a data driven simulation model that estimates both effects. We show that reducing specialists consult times decreases the length of stay with indirect effects that are up to 10x larger than direct ones.

2 Helping the Captive Audience: Advance Notice of Diagnostic Service for Hospital Inpatients

Miao Bai[1], Nan Liu[2], Zheng Zhang[3], [1]University of Connecticut, Storrs, CT, [2]Boston College, Chestnut Hill, MA, [3]Zhejiang University, Hangzhou, China. Contact: miao.bai@uconn.edu
Inpatients are often treated as "on-demand" for hospital diagnostic service, and they are notified only when service capacity is available. This arrangement causes chaos and inefficiencies in operations. We propose "advance notice", an innovative scheduling paradigm that strikes a fine balance between the classic advance scheduling and allocation scheduling paradigms.

3 Mass Vaccination Scheduling: Trading off Infections, Throughput, and Overtime

Shanshan Luo, Steven Shechter, University of British Columbia, Vancouver, BC, Canada. Contact: shanshan.luo@sauder.ubc.ca
Mass vaccination is essential for epidemic control, but long queues can increase infection risk. We focus on scheduling arrivals at mass vaccination sites to minimize a tri-objective function of infection risk, throughput, and overtime. Leveraging multi-modularity results from a related optimization problem, we construct a solution algorithm and find that our model-based policy significantly outperforms an equally-distributed, equally-spaced schedule. We also discuss managerial insights regarding the optimal schedule's structure and compare it to the well-known "dome-shaped" policies in appointment scheduling problems.

4 How Does Patience Change While Waiting? Dynamically Studying Abandonments in an Emergency Department Waiting Room

Yaniv Ravid[1], Philipp Afèche[1], Vahid Sarhangian[2], Rouba Ibrahim[3], Junqi Hu[4], [1]University of Toronto, Rotman School of Management, Toronto, ON, Canada; [2]University of Toronto, Toronto, ON, Canada; [3]University College London, London, United Kingdom; [4]University of Illinois at Urbana Champaign, Champaign, IL, Contact: y.ravid@rotman.utoronto.ca

Patients who leave without being seen (LWBS) pose a significant operational challenge to many emergency departments (ED). It has been shown that ex-post static covariates, such as the rate of service they observe, affect patients' survival times in the waiting room. While such results provide valuable insights into an important operational problem, they do not translate into actionable knowledge that can prescribe patients' likelihood to abandon while they are waiting. To overcome this challenge, we study how patients' probability of abandoning changes as they observe different events in the waiting room. We construct a dynamic hazard model and describe patients' wait using time-dependent covariates. We provide managerial insights and implications on waiting-room design that may lower the rates of LWBS. We also develop real-time prediction algorithms that assign abandonment probabilities to patients in a real setting. We test our predictions on hold-out samples and show that prediction of abandonments is possible in real-world settings.

WB13

Osgood East

Empirical Healthcare Operations

General Session

Session Chair

Kraig Delana, University of Oregon, Eugene, OR

Session Chair

Christopher J. Chen, Indiana University Kelley School of Business, Bloomington, IN

1 Multi-Channel Healthcare Operations: The Impact of Video Visits on the Usage of In-Person Care

Tan Lekwijit[1], Hummy Song[2], Christian Terwiesch[3], Krisda Chaiyachati[4], [1]W. P. Carey School of Business, Arizona State University, Tempe, AZ, [2]The Wharton School, University of Pennsylvania, Philadelphia, PA, [3]University of Pennsylvania, Philadelphia, PA, [4]Penn Medicine, Philadelphia, PA, Contact: hummy@wharton.upenn.edu

Using data from a large health system, we examine how the introduction of video visits impacts in-person demand for care when it comes to primary care-related needs. We find that the introduction of video visits increases demand for primary care provider (PCP) visits by 20% and the demand for emergency department (ED) visits by 30%. Patients who have poorer access to in-person care are more likely to initiate care via a video visit rather than an in-person visit, and the increase in in-person demand arises primarily from these patients who live farther from their place of care and who seek an appointment with a PCP who is busier than usual. In addition, we find that video visits are unlikely to provide definitive care that can successfully conclude an episode.

2 The Role of Physician Integration in Alternative Payment Models: The Case of the Comprehensive Joint Replacement Program

Christopher J. Chen1, Kraig Delana2, 1Indiana University Kelley School of Business, Bloomington, IN, 2University of Oregon, Eugene, OR

We empirically examine the role of both horizontal and vertical integration of orthopaedic surgeons in driving heterogeneity in the impact of the Comprehensive Joint Replacement (CJR) alternative payment program. Using a quasi-experimental difference-in-difference-in-differences approach, we find CJR hospitals with high horizontal and vertical integration see an increase in both hospital costs and risk-adjusted complication rates of 3.17% & 1.18, respectively, while others see either a decrease or no change in these measures. Moreover, we present evidence showing integration affects physician care decisions regarding length-of-stay and discharge disposition that explain the changes in costs and quality.

3 The Impact of Hospital-Physician Integration on Hospital Volume Competition

Kraig Delana[1], Jong Myeong Lim[2], [1]University of Oregon, Eugene, OR, [2]Tuck School of Business at Dartmouth, Hanover, NH, Contact: jong.myeong.lim@tuck.dartmouth.edu

We model the impact of physician-hospital integration on hospital competition for volume. We find that preferential admission policies for integrated physicians can lead to suboptimal patient-hospital matches. We explore information disclosure and payment policy reforms as potential solutions.

WB14

Fitzgerald
Data Mining and Healthcare Analytics 2
Contributed Session

Session Chair

Fauziya Yakasai, York University, Toronto, ON, Canada.

1 Fairness-Aware Competing Risks Analysis to Predict Hospital Readmission

Libo Li, University of Southampton, Southampton, United Kingdom.

With the prevalence of hospital readmission driven by a wide range of causes, there is a genuine interest among healthcare organizations to make use of data-driven approaches to predict and reduce readmission. Furthermore, patient-level care requires continuing efforts on a range of patient portfolios to monitor the indicators and risk/likelihood of future readmission. We discuss the useability of divergence measures in competing risks analysis that could enrich analytical insights into readmission risk. Our research shows that such a research design is beneficial to both monitoring the predictive outcome data and making use of patient outcome data for predictive model building.

2 AI-Driven Forecasting of Healthcare Expenses

Omid Nohadani[1], Alessandro Previero[2], [1]Benefits Science Technology, Boston, MA, [2]Benefits Science Technology, Boston, MA

The widespread adoption of employer health benefits, coupled with the rising cost of healthcare, underpins the necessity to accurately forecast a company's medical claims expenses. Current actuarial approaches trend previous costs, yet often significantly deviate from the realized sums. Our data-centric method groups all enrolled members into one entity, thus leveraging limit laws to stabilize the variability in healthcare costs. To forecast, we incorporate medical information and solve a holistic robust linear regression via a MIQP formulation. In a real-world implementation, our method achieves 41% R^2 over a pertinent baseline, and yields interpretable results in the input feature space.

3 Does Pursuing Hospital Accreditation Tend to Improve Hospital Technical Efficiency?

Aaron Bonnett[1], Gregory R. Heim[2], Rogelio Oliva[2], [1]Texas A&M University, College Station, TX, [2]Texas A&M University, College Station, TX, Contact: abonnett@mays.tamu.edu

We use data from the *American Hospital Association* hospital database in a stochastic frontier analysis (SFA) to address whether hospital accreditation is associated with hospital efficiency. Our main findings indicate hospital accreditation is associated with an increase in hospital efficiency. We contribute to the healthcare OM literature by providing one of the first panel-based SFA analyses of the associated impact that hospital accreditation has on hospital efficiency. Our findings give hospital administrators and other stakeholders useful knowledge that should help hospital administrators in the decision-making process of whether or not to obtain hospital accreditation.

4 Does a Destined Soul Mate Exist?: Data-Driven Method to Determining the Factors Influencing Big-Big Pharma Companies' Successful R&D Partnerships

Fauziya A. Yakasai, York University, Toronto, ON, Canada. Contact: fyaky4@yorku.ca

The COVID-19 pandemic triggered unusual partnerships between big pharmaceutical companies. Big pharma companies have started seeking R&D collaboration with their traditional rivals. However, the companies have been struggling with finding big R&D partners who could contribute to their successful partnerships because their experiences were limited to partnerships with small players. This research project seeks to identify the factors contributing to successful partnerships between big-big pharma companies, applying machine learning and statistical techniques to our original data set from world patent data and public companies' data.

WB15

University
Scheduling
Contributed Session

Session Chair

Beju Rao, Amruta, Inc., Fredericksburg, VA

1 Clinic Scheduling with Number Appointment System in Taiwan

Hui-Chih Hung, Jun-Min Wei, Ssu-Ying Chen, National Yang Ming Chiao Tung University, Hsin-Chu, Taiwan. Contact: hhc@nycu.edu.tw

Due to highly uncertain consultation times, the number appointment system is widely adopted in clinics of Taiwan. With modern technology, patients have the real-time

consultation number and can decide their own show times at clinic. As a result, some patients may show out too late and the cumulative consultation time is right-skewed distributed. In a vicious circle, the doctor's makespan becomes an issue. Models are built to mimic patients' behavior of estimating their own show time. Some penalty rules can be applied to these late patients who miss their appointment numbers. Our goal is to optimize the penalty mechanism, such that the weights aggregated objectives are minimized.

2 The Scheduling of Medical Students at Ghent University

Babak Akbarzadeh[1], Broos Maenhout[2], [1]University of Gent, Ghent, Belgium; [2]Ghent University, Ghent, Belgium. Contact: babak.akbarzadeh@ugent.be

This paper presents a heuristic approach to solve the complex task of assigning medical students to internships at local hospitals while taking into account conflicting requirements from stakeholders such as the university's educational requirements, limited hospital capacity, and student preferences. The proposed methodology uses decomposition-based steps and control mechanisms to achieve high-quality student rosters that meet the software requirements of the university. Computational experiments were conducted on real-life data from the 2020-2021 academic year to validate the performance of the heuristic and its different improvement mechanisms.

3 A Novel Three-Stage Decision-Making Framework for Surgical Scheduling with Demand Uncertainties

Haoliang Pan, Tsinghua University, Beijing, China. Contact: phl22@mails.tsinghua.edu.cn

We work for the surgical scheduling system of a partner hospital in Jiangsu Province, China. We propose a novel three-stage decision-making framework for surgical scheduling. The core idea is to disassemble the various uncertainties into different stages. We develop mathematical programming models for each decision-making stage. The experiments via historical data from the partner hospital indicate that our framework could improve 16.4% of yearly amount of surgeries for the partner hospital. Our approaches are being developed and integrated into the information system of the partner hospital.

4 Optimal Scheduling of Patient Appointments Under Uncertainty

Beju Rao, Amruta, Inc, Fredericksburg, VA, Contact: beju.rao@amrutainc.com

Healthcare providers are operating in a challenging environment due to staff burnout, supply shortages, anxious patients, and changes in revenue. These challenges are impacting patient appointment scheduling, resulting in longer patient waiting times to get an appointment and during appointments. Provider staff are burdened by COVID-19 protocols and increased patient volumes. The provider staff are also experiencing longer idle times and overtime work. We apply prediction and optimization methods to determine optimal scheduling policies and practices to reduce patient waiting and provider idle times and to increase patients seen and revenue. We present results from a clinic and next steps.

WB16

Richmond

Operations Management in Emergency Care

General Session

Session Chair

Zhankun Sun, City University of Hong Kong, Kowloon, Hong Kong.

Session Chair

Huiyin Ouyang, the University of Hong Kong, Hong Kong, Hong Kong.

1 Emergency Department Modeling with Time-Varying Physician Productivity

Huiyin Ouyang[1], Zhankun Sun[2], [1]The University of Hong Kong, Hong Kong, Hong Kong; [2]City University of Hong Kong, Kowloon, Hong Kong. Contact: oyhy@hku.hk

Motivated by an intriguing observation on the time-varying physician productivity, we study a continuous-time optimal control problem to understand the transient behavior of individual physicians within their shifts in emergency departments (EDs). By applying Pontryagin's maximum principle, we characterize the optimal policy and provide insights into physician capacity, productivity, and throughput. We leverage the insights to model the complex ED system as a time-varying multi-server queue with shift-hour-dependent service rates. Validation using data from two Canadian EDs shows that our model can accurately capture the time-of-day-dependent patient waiting times.

2 Managing Capacity Reservation for Low-Priority Strategic Patients

Marco Bijvank[1], Guanlian Xiao[2], [1]University of Calgary, Calgary, AB, Canada; [2]Cape Breton University, Sydney, NS, Canada. Contact: marco.bijvank@haskayne.ucalgary.ca

We study a healthcare system that operates two parallel tracks, i.e., a shared track and a dedicated track, to serve two priority classes of patients. High-priority patients are assigned to the dedicated track for prompt service following a FCFS principle. When the dedicated track is relatively busy, high-priority patients are diverted to the shared track with a non-preemptive priority over low-priority patients. Low-priority patients are strategic, and they choose to join the waiting queue on the shared track, or to balk from the system. Their join-or-balk decision is made based on the utility of joining after obtaining delay information. In our study, we consider two types of expected waiting time information to be revealed to low-priority patients: long-term expected waiting time, and real-time expected waiting time.

3 Elective Surgery Sequencing and Scheduling Under Uncertainty

Xiaojin Fu[1], Jin Qi[1], Chen YANG[1], Han Ye[2], [1]Hong Kong University of Science and Technology, Hong Kong, Hong Kong; [2]Lehigh University, Bethlehem, PA, Contact: cyangap@connect.ust.hk

We consider a sequencing and scheduling problem with uncertain durations of surgeries in the context of an operating theatre. From real data collected from a hospital, we observe the common practice, namely "to follow", in which surgeries are conducted sequentially and immediately one after another, according to a specific schedule. Based on this practice, we propose a mathematical framework to balance the risk of delay and idling using the Punctuality Index, which takes into consideration both the probability and intensity of delay and idle time. The scheduling problem is solvable in polynomial time when the sequence is given. The framework can also accommodate a robust setting when the underlying probability distribution is not fully available. For practical use, we propose two effective heuristics for sequencing decisions by approximating the model. Using the real data, we demonstrate that our framework is significantly better than the risk-neutral and probability maximizing approaches in both performance and computational efficiency.

4 Air Pollution and Doctors' Work Performance: Evidence from Extubation Failure in the Intensive Care Unit

Yongjian Zhu[1], Jingui Xie[2], Yugang Yu[1], Zhichao Zheng[3], Haidong Luo[4], Oon Cheong Ooi[4], [1]University of Science and Technology of China, Hefei, China; [2]Technical University of Munich, Heilbronn, Germany; [3]Singapore Management University, Singapore, Singapore; [4]National University Hospital, Singapore, Singapore. Contact: danielzheng@smu.edu.sg

Previous studies on air pollution and healthcare have focused on demand-side effects, but we extend this to study the provider-side effects on doctors' work performance. Using a unique dataset of extubation events in a Singapore intensive care unit, we find that air pollution exposure lowers doctors' extubation performance and reduces adherence to extubation protocols. Workload has a non-linear moderating effect on the relationship between air pollution and performance. These findings highlight an unexplored environmental risk to doctors' work performance and suggest management activities to fight air pollution.

Wednesday, 1:45–3:15PM

WC01

Carmichael

Modeling Uncertainty and Optimization Methods for Healthcare Applications

General Session

Session Chair
Shukai Li, Department of Industrial Engineering and Management Sciences, Northwestern University, Evanston, IL

Session Chair
Sanjay Mehrotra, Northwestern University, Evanston, IL

1 Rationing Scarce Healthcare Capacity: A Study of the Ventilator Allocation Guidelines During the Covid-19 Pandemic

Margret V. Bjarnadottir1, David Anderson2, Tolga Aydinliyim3, Eren Basar Cil4, 1University of Maryland, College Park, MD, 2Villanova University, Villanova, PA, 3Baruch College, CUNY, New York, NY, 4University of Oregon, Eugene, OR, Contact: mbjarnad@umd.edu

The primary objective of this study is to assess the existing priority rules in place for allocating scarce ventilator capacity and propose improved priority schemes. Using Machine Learning and Queueing Simulation we assess three priority schemes: i) a policy mimicking the existing practice; ii) a policy focused on incremental survival probability; and iii) a policy that additionally considers resource utilization. Our findings highlight that a policy that considers resource utilization achieves a demonstrable improvement in expected lives saved while limiting racial disparities.

2 Presenter

Simrita Singh, Leavey School of Business at Santa Clara University, Santa Clara, CA, Contact: ssingh17@scu.edu

Physicians regularly face the challenge of differential diagnosis, i.e., differentiating between diseases with similar symptoms. As a first step, a physician forms an initial belief for each possible disease. In the second step, the physician conducts more tests and examinations over multiple periods to arrive at a single diagnosis. We model the second step of the multi-period differential diagnosis problem as a Markov Decision Process. We use the qualitative insights from the structure of the optimal policy to characterize conditions under which common rules of thumb used by physicians may or may not be optimal. We discuss two approaches to constructing computationally tractable heuristics. We also use our analytical results to develop an economic index for tests and use it to construct a tailored heuristic. Further, we propose a novel integration of information relaxation and a regression-based functional approximation technique to formulate a tractable mixed-integer linear program to obtain an upper bound.

3 Balancing Patient Convenience and Healthcare Costs: A Personalized Recommendation Approach Using Reinforcement Learning

Tianjian Guo, Indranil R. Bardhan, Wen Wen, McCombs School of Business, UT Austin, Austin, TX, Contact: tianjian.guo@mccombs.utexas.edu

Precision medicine aims to deliver personalized healthcare and provide the most effective care to patients based on their unique characteristics. In this study, we propose a multi-objective reinforcement learning approach for creating personalized recommendations related to diabetes preventive care. Our approach minimizes patient inconvenience and total annual treatment costs and indicates trade-offs between optimizing patient convenience and patient treatment costs. The results suggest that changing the behavior of just 20% of our patient population can reduce the average treatment cost for all patients by 25% and the count of preventive care visits by 36% for patients under 65. Our approach can encourage patients to change their behavior by providing targeted incentives, achieving greater utilization of preventive care while lowering total healthcare costs by reducing costly hospital and emergency room visits.

4 Optimizing Resource Allocation in Parallel Any-Scale Two-Sided Queues with Application to Waiting Time Equity in Organ Transplant

Shukai Li[1], Sanjay Mehrotra[2], [1]Department of Industrial Engineering and Management Sciences, Northwestern University, Evanston, IL, [2]Northwestern University, Evanston, IL, Contact: shukaili2024@u.northwestern.edu

We study the capacity sizing problem of multiple waitlists with a flexible combination of efficiency-equity objective and constraints, motivated from managing organ transplant systems. Particularly, we allow the system to include limited-scale waitlists. Each waitlist is modeled as a non-fluid queue with patient abandonment. In equity considerations, we use finite approximation to evaluate the system performance as an alternative to the commonly used asymptotic analyses, whose accuracy relies on a large scale assumption. We develop an algorithm that optimizes the capacity level at each waitlist and show that the optimality gap of our algorithm disappears as we increase the order of finite approximation. We show through a numerical study that our solution based on a non-fluid queueing model improves resource utilization compared with solutions prescribed by a fluid model. We also observe the allocation equity can be improved by appropriately increasing the proportion of organs allocated to waitlists with small scales or high death risks.

WC02

Jackson

Simulation Analysis for Health Policy Development and Clinical Decision Making

General Session

Session Chair

Nan Kong, Purdue University, West Lafayette, IN

1 Improving Treatment Outcomes in Hemodialysis Patients: Personalized Vascular Access Recommendations While Considering Patient Frailty

Yiwen Cao[1], Sze-chuan Suen[1], Eugene Lin[2], Karen Woo[3], Mariana Murea[4], [1]University of Southern California, Los Angeles, CA, [2]University of Southern California, Los Angeles, CA, [3]University of California, Los Angeles, Los Angeles, CA, [4]Wake Forest University School of Medicine, Winston-Salem, NC, Contact: ycao0253@usc.edu

Hemodialysis patients must rely on vascular accesses (catheter, arteriovenous [AV] fistula, or AV graft) for effective dialysis. Different access types may result in differences in durations until maturation, functional usage length, expected patient life span, and complication incidents. While clinical guidelines recommend AVF for most patients, vascular access outcomes vary with patients' physiologic function (frailty levels), and a graft may be more appropriate for some patient subgroups. However, it is not clear which patient frailty

groups should consider grafts as a primary option in vascular access. In this work, we developed a microsimulation model of lifetime treatment for hemodialysis patients. We captured the performance of vascular access types and expected health outcomes with respect to patient characteristics including frailty, gender, and age. We performed scenario analyses to provide cohort-specific recommendations for vascular access choice.

2 Cost-Effectiveness of Population-Based Screening for Chronic Obstructive Pulmonary Disease in China

Qiushi Chen[1], Yiwen Fan[2], Simiao Chen[2], 1The Pennsylvania State University, University Park, PA, 2Heidelberg Institute of Global Health, Heidelberg, Germany. Contact: q.chen@psu.edu

China has the highest disease burden of chronic obstructive pulmonary disease (COPD) in the world. Given its high prevalence and low diagnosis rate in China, population-based screening for COPD may present a meaningful intervention for improving early diagnosis of COPD and patients' long-term health outcomes; however, its cost-effectiveness has not been studied in the literature. In this study, we aim to evaluate and compare the cost-effectiveness of different population-based screening policies for COPD in China.

3 Simulation Analysis for Return-to-Play from Sports-Related Concussion

Gian-Gabriel P. Garcia[1], Lauren Czerniak[2], Mariel Sofia Lavieri[2], Spencer Liebel[3], Kathryn Van Pelt[4], Paul Pasquina[5], Michael McCrea[6], Thomas McAllister[7], Steven Broglio[2], [1]Georgia Institute of Technology, Atlanta, GA, [2]University of Michigan, Ann Arbor, MI, [3]University of Utah School of Medicine, Salt Lake City, UT, [4]Synaptek, Lexington, KY, [5]Uniformed Services University of the Health Sciences, Bethesda, MD, [6]Medical College of Wisconsin, Milwaukee, WI, [7]Indiana University School of Medicine, Indianapolis, IN, Contact: giangarcia@gatech.edu

Concussion is the most common type of traumatic brain injury in the United States. For athletes with sports-related concussion, the decision of when to return-to-play (RTP) is critical to mitigating the risk of future injuries. Currently, there are no exact criteria for determining the timing of RTP, and as such, the decision is often left to the judgment of a medical provider. In this research, we use data from a large nationwide dataset on sports-related concussion in collegiate sports to build Hidden Markov Markov Models for concussion recovery in both the pre-RTP and post-RTP phases. Then, we use simulation to estimate the relationship between the timing of return-to-play and subsequent injury risks after RTP. We show that these estimates can help to guide athlete-specific return-to-play decisions, stratified by sport and sex. Our results suggest that the timing of RTP should be tailored to each individual athlete's risk of subsequent injury after RTP.

4 Quantifying the Health Benefit and Disparity of Reducing Exposure to Secondhand Smoke in New York City: A Cardiovascular Disease Microsimulation Study

You Zhou[1], Nan Kong[1], Yan Li[2], [1]Purdue University, West Lafayette, IN, [2]The New York Academy of Medicine, Rego Park, NY, Contact: zhou1129@purdue.edu

Exposure to secondhand smoke can increase the risk of cardiovascular disease events among nonsmokers, e.g. stroke and coronary heart disease. In order to quantify the health benefit of reducing exposure to SHS, we employed a well established and validated microsimulation model (CVD Policy Model) to simulate the CVD events and the associated health cost reduction, and the quality-adjusted life years gained by reducing exposure to SHS for adults in New York City. In the model, the population socioeconomical and physical profiles were sampled from the dataset of NYC Health and Nutrition Examination Survey. The relative risk of SHS on CVD events were pooled from the recent meta-analyses.

WC03

Varley

Policies for Managing and Mitigating COVID-19

General Session

Session Chair

Ujjal Kumar Mukherjee, University of Illinois, Urbana-Champaign, Champaign, IL

1 Towards Enabling the Last-Mile Logistics of Vaccine Supply Chains: Learnings from COVID-19 Vaccine Administration

Bhupinder Singh Juneja[1], Ujjal Kumar Mukherjee[2], Kingshuk K. Sinha[1], [1]University of Minnesota, Minneapolis, MN, [2]University of Illinois, Urbana-Champaign, Champaign, IL, Contact: junej003@umn.edu

Vaccine administration and coverage are among primary ways to minimize impact of pandemic. However, there is widespread disparity in vaccine coverage across locations. We analyze the effect of the enablers of last mile of vaccine supply chains along three dimensions: logistical connectivity, delivery infrastructure, and informational connectivity. Our results suggest that all three dimensions of the last-mile delivery and administration of vaccines improve vaccine

coverage. Further, we demonstrate that improving enablers of last mile of vaccine supply chain is more beneficial for locations characterized by relatively higher prevalence of socio-economic and demographic risk factors.

2 Informational Value of Visual Nudges During Crises: Improving Public Health Outcomes Through Social Media Engagement Amid COVID-19

Sebastian Souyris[1], Anton Ivanov[2], Zhasmina Tacheva[3], Abdullatif AlZaidan[4], Albert C. England[5], [1]Rensselaer Polytechnic Institute, Troy, NY, [2]University of Illinois at Urbana-Champaign, Champaign, IL, [3]Syracuse University, Buffalo, NY, [4]University of Illinois at Urbana Champaign, Champaign, IL, [5]OSF HealthCare Heart of Mary Medical Center, Champaign, IL, Contact: souyrs@rpi.edu

We conceptualize and empirically evaluate how large organizations can utilize visual nudges on social media to improve public health. We construct a unique dataset, including Instagram, Twitter, and Facebook images. We study the effect of visual nudging on COVID-19 positivity using econometric and epidemiological models. When institutional actors share more images containing mask-related information on Instagram, their positivity rates decrease by up to 25%. Moreover, empirical evidence indicates that the value of visual nudging is most prominent if communicated three to five weeks ahead of time. Our results demonstrate the informational value of visual nudges to improve public health outcomes.

3 Hotspots for Emerging Epidemics: Multi-Task and Transfer Learning over Mobility Networks

Mehmet Eren Ahsen, University of Illinois, IL

A new data-driven framework has been proposed to identify potential hotspots, or locations that contribute significantly to the spatial diffusion of infections, in order to effectively implement mitigation policies for epidemics like COVID-19. The framework uses advanced analytical methodologies, including interpretable long short-term memory models, multi-task learning, and transfer learning, and considers both within- and across-location mobility as the primary driving factor for infection diffusion over a network of connected locations. Transfer learning from past influenza transmission data is used to augment the signals of infection diffusion and hotspot emergence. The effectiveness of a hotspot-based policy is compared to a pure infection load-based policy and the state-wide lockdown policy currently in use, showing that the hotspot-based policy can reduce new infections by up to 21% and achieve almost similar performance as a state-wide lockdown. The inclusion of transfer learning improves hotspot prediction accuracy by 53.4% compared to using only COVID-19 data. Overall, this framework presents a practical solution to the problem of hotspot identification, which can help policy makers make more informed decisions related to the control of epidemics.

4 COVID-19 Test-to-Stay Program for K-12 Schools: Opt-In Versus Opt-Out Policies

Ujjal Kumar Mukherjee, University of Illinois, Urbana-Champaign, Champaign, IL

The Test-to-Stay program for school level COVID-19 testing was administered via two different enrollment policies—opt-in and opt-out. In this paper, we study the relative impacts of the two enrollment policies on the testing and the positivity rate with data spanning Sep-Nov 2021 from 259 schools in Illinois. Our results indicate a 42.6% higher testing rate and 33.1% lower positivity rate in schools that chose the opt-out policy, compared to those that adopted the opt-in policy.

WC04

Toronto Ballroom I

INFORMS HAS Competition Finalists

Award Session

Session Chair

Nan Liu, Boston College, Chestnut Hill, MA

Session Chair

Vishal Ahuja, Southern Methodist University, Dallas, TX

WC05

Toronto Ballroom II

Modeling and Improvement of Stochastic Systems in Healthcare

General Session

Session Chair

Nan Liu, Boston College, Chestnut Hill, MA

1 Recent Advances in Value-Based Adaptive Clinical Trials

Stephen E. Chick[1], Spyros Zoumpoulis[2], Andres Alban[3], [1]INSEAD, Fontainebleau, France; [2]INSEAD, Fontainebleau, France; [3]Harvard Medical School, Boston, MA

We present value-based adaptive clinical trials as a real option to learn about the health and financial benefits to health technology innovation and adoption decisions, give examples of recent advances in the methods, and how they related to examples from precision medicine for sepsis management and from UK-based publicly funded trials for health interventions.

2 Budgeted Information Reveal in Sequential Experiments with Digital Health Application

Kyra Gan[1], Esmaeil Keyvanshokooh[2], Susan A. Murphy[1], [1]Harvard University, Boston, MA, [2]Mays Business School, Texas A&M University, College Station, TX, Contact: keyvan@tamu.edu

Motivated by the digital health applications, we formulated the problem of deciding the optimal timing for reaching out to patients when they fail to take pro-treatment actions given a limited budget. We develop a set of different online learning and optimization algorithms with theoretical performance guarantees. A case study is used to show the effectiveness of our algorithms in practice.

3 Data-Driven Capacity Estimation in a Healthcare System

Yawo Kobara, Opher Baron, Dmitry Krass, University of Toronto, Toronto, ON, Canada.

Data-driven capacity estimation is a significant issue in practical queuing theory. Several models put forth in the literature typically assume the presence of complete information. In many practical settings only a subset of these timestamps is available. This paper presents two simple algorithmics to estimate the capacity of a partially observable G/G/c queue. The observer sees only the arrival and departure times and wishes to estimate the number of servers. Using both, synthetic data, and data from the emergency department of a large hospital, our results show for a stationary G/G/c system, our algorithms produce extremely accurate estimates of the number of servers based on limited data.

4 Convexity in Transient Queues and Implications on Dynamic Appointment Scheduling

Alex Kuiper[1], Christos Zacharias[2], [1]University of Amsterdam, Amsterdam, Netherlands; [2]University of Miami, Coral Gables, FL, Contact: A.Kuiper@uva.nl

The inter-day (which day?) and intra-day (when?) appointment scheduling problems are often studied in isolation, whereas in reality, they are intertwined. If the waiting list becomes too large (small), one would want to extend (reduce) the appointment book, but such decisions directly impact the optimality of the schedule. Using a continuous intra-day scheduling paradigm, these problems are connected in a dynamic environment. Extending convexity properties of the appointment scheduling problem renders the corresponding dynamic program amenable to building upon recent advances in literature.

Since the optimal solution is not tractable, two intra-day scheduling paradigms are introduced: a theoretical approach (based on re-optimization) and a heuristic, which is based on schedules that exhibit so-called sequential refinability. Together, they bound the optimal policy for the dynamic inter/intra-scheduling problem. At the same time, their small difference underscores the potential of using this heuristic in healthcare practice.

WC06

Toronto Ballroom 3: Harris

Data-Driven Applications in Healthcare

General Session

Session Chair

Jiayi Liu, Virginia Tech, Blacksburg, VA

1 Learning from Quality Signal to Improve Public Policy Fairness: Evidence from the Hospital Readmissions Reduction Program

Mohamad Soltani[1], Robert Batt[2], Hessam Bavafa[3], [1]University of Alberta, Edmonton, AB, Canada; [2]Wisconsin School of Business, UW-Madison, Madison, WI, [3]Wisconsin School of Business, Madison, WI, Contact: soltani@ualberta.ca

Policymakers often employ quality indicators to evaluate the performance of an organization and to provide incentives for quality improvements. A potential concern, however, is that a specific quality indicator may not truly reflect the quality that is attributed to the performance of the organization. We explore the effects of the Hospital Readmissions Reduction Program (HRRP) on 30-day readmissions in over 2,000 hospitals with wide geographical coverage within the U.S. Whereas the policy is indifferent between readmission reduction during the 30-day time window, we find that the level of improvement depends on the timing of readmission. We attribute this difference to the control that hospitals have over readmissions. This finding shows that 30-day readmission rate does not provide an accurate quality signal, and thus HRRP is not fair toward hospitals that treat low-income patients with limited access to care. We suggest an alternative quality indicator that provides a more accurate and fairer measurement of hospitals performance.

2 Does Telehealth Reduce Rural-Urban Care-Access Disparities? Evidence from COVID-19 Telehealth Expansion

Shujing Sun[1], Guihua Wang[2], [1]The University of Texas at Dallas, Richardson, TX, [2]The University of Texas at Dallas, RICHARDSON, TX

Using a unique set of national healthcare claims data, we investigate the effect of telehealth expansion policy on rural-urban healthcare-access disparities. Leveraging a difference-in-differences design, we compare the total number of visits to urban and rural providers before and after telehealth expansion. We find an enlarged disparity in rural-urban healthcare access, with the rural-urban gap in total patient visits increasing by 3.9% due to telehealth expansion. We then examine the underlying mechanisms that drive the enlarged disparity. Our findings are important to policy makers, healthcare providers, and researchers seeking to understand the broad implications of telehealth expansion on rural-urban disparities and further promoting and integrating remote care delivery into the healthcare system.

3 Estimating Patient Health Transition from Data Censored by Treatment-Effect-Based Policies

Qian Luo[1], Hai Wang[2], Zhichao Zheng[2], Haidong Luo[3], Oon Cheong Ooi[3], [1]Xi'an Jiaotong-Liverpool University, Suzhou, China; [2]Singapore Management University, Singapore, Singapore; [3]National University Hospital, Singapore, Singapore. Contact: danielzheng@smu.edu.sg

Treatment-effect-based decision policies leverage predictive information to recommend treatments. However, such policies can censor observations of patients' health transitions and distort the estimation of transition probability matrices (TPMs). We propose a model to recover the true TPMs from censored observations. Our estimated TPM is consistent, asymptotically normally distributed, and maximizes the log-likelihood of the data. We demonstrate the advantages of our model against benchmark methods using hypothesized data. We also apply our model to estimate patient health transitions in an ICU extubation problem.

4 Time to Recover Market Share: Lasting Effects of Supply Chain Disruptions on Firm Performance

Minje Park[1], Anita Carson[2], Rena Conti[2], [1]Columbia Business School, New York, NY, [2]Boston University, Boston, MA, Contact: minje.park@columbia.edu

This study investigates the enduring effects of supply chain disruptions on firms' market share. Specifically, we examine the impact of supply-side disruptions on pharmaceutical products, measuring the extent to which lost market share persists even after the product has resumed production. Our results indicate that market share loss due to supply chain disruptions is not entirely recovered even after production has been restored. These findings underscore the significance of investing in supply chain resilience and prompt recovery as a means of mitigating the long-term effects of supply chain disruptions on market share.

WC07

Toronto Ballroom 4: MacDonald

COVID-19 and Health Equity

General Session

Session Chair

Julie Simmons Ivy, Guest, Cary, NC

Session Chair

Jennifer Mason Lobo, University of Virginia, Charlottesville, VA

1 Understanding Patient Portal use Disparities: Whether Patients Engage, How Patients Engage, and How Providers Respond

Mitchell Tang[1], Rebecca Mishuris[2], Lily Payvandi[3], Ariel Stern[1], [1]Harvard Business School, Boston, MA, [2]Mass General Brigham, Boston, MA, [3]Boston Medical Center, Boston, MA, Contact: mtang@hbs.edu

The onset of the COVID-19 pandemic drove substantial growth in patient portal use -- increases that have persisted years into the pandemic. We examined portal use in 2021 among primary care patients at Boston Medical Center. We found Black and Hispanic patients were less likely to use the portal, and when they did, were less likely to access "bi-directional" functionalities requesting action from providers. Messages from Black and Hispanic patients were also 20% less likely to receive a response from an attending physician. Our work underscores the need for interventions addressing not only disparities in patient portal engagement, but also care team responses to patient portal messages.

2 Using Freedom of Information Laws to Collect and Analyze Data on Covid in Marginalized Populations

Aparna Komarla, Covid In-Custody Project (www.covidincustody.org), Berkeley, CA, Contact: aparna.komarla@gmail.com

The lack of high-quality COVID-19 data creates gaps in public health leaders' decision-making and limits academic researchers' ability to model health outcomes. These

limitations disproportionately affect marginalized groups, such as incarcerated populations. We leverage image recognition, web scraping and analytics to scrape COVID-19 data in public records obtained from law enforcement agencies, compile it into an accessible dataset, and make it available to the public. We show that the COVID-19 pandemic in California jails is a perfect example of the opportunity to bring technology and policy together in the public sector at a state and local level.

3 Vaccine Distribution Through Augmented Companion Programsmay Improve Health Outcomes and Equity

Marie-Laure Charpignon, Massachusetts Institute of Technology, Cambridge, MA

The supply of such variant-specific vaccines is limited, with shortages for routine COVID-19 boosters exacerbated by federal budget rationing. This reality warrants the design and assessment of new vaccine allocation mechanisms. Based on a successful precedent in Massachusetts, we propose an augmented companion vaccination program, whereby individuals aged 65+ are vaccinated first, with household members. We use an agent-based model (ABM) incorporating household structure to quantify the impact on morbidity and mortality. In U.S.-based simulations, the program outperformed randomization and exclusively age-based prioritization, reducing infections and deaths by up to 4% and 7%, respectively.

WC08

Toronto Ballroom 5: Lismer

Advances in Healthcare Operations

General Session

Session Chair

Wilson Lin, Santa Clara University, Santa Clara, CA

1 Algorithmic Interventions to Prevent Burnout in ICU Workforces

Ken Moon, The Wharton School, University of Pennsylvania, Philadelphia, PA, Contact: kenmoon@wharton.upenn.edu

In recent decades, hospitals have pursued operational efficiency at the expense of increasing on-the-job stress for their intensive care nursing staff. The resultingly "quicker and sicker" workflows lead to elevated rates of provider turnover and burnout. In collaboration with the University of Pennsylvania hospital system, we equipped the nurses staffing three highly sophisticated ICUs with biometric sensors during their shifts. We design and train learning algorithms to identify exceptionally stressful workflows and intervene based on data in near real-time.

2 Mitigating Abandonment in Online Services: A Randomized Lab Experiment on Sunk Cost and Delay Announcement

Jimmy Qin[1], Carri Chan[1], Jing Dong[2], [1]Columbia Business School, New York, NY, [2]Columbia University, New York, NY, Contact: qqin23@gsb.columbia.edu

Advancements in technology have led to the integration of online services alongside traditional in-person offerings. Previous research has shown that telemedicine patients are more likely to abandon when they experience in-clinic delays. To understand the underlying mechanisms and potential interventions for reducing abandonment, we conduct a lab experiment to study participants' willingness to wait for a reward in the presence of delays. We identify two mechanisms - sunk cost and delay announcement - that could potentially explain abandonment behavior during online waits. Through a randomized experiment on Amazon Mechanical Turk, we find that injecting sunk cost, providing delay announcement, or utilizing both levers are equally effective in significantly decreasing the abandonment rate. Our research highlights the important roles of sunk cost and delay announcement in mitigating abandonment during online waits.

3 How Recreational Cannabis Legalization Affects Hospital Operations: Workload Ramifications and Speeding up Care for Other Patients

Max Yakovlev[1], Maria R. Ibanez[2], [1]Kellogg School of Management, Evanston, IL, [2]Kellogg School of Management, Evanston, IL, Contact: maksim.yakovlev@kellogg.northwestern.edu

Many US states have legalized recreational cannabis in the last decade. Using a difference-in-differences approach, we study the effect of recreational cannabis legalization (RCL) on hospital operations. We find that RCL alters the workload of hospital staff by changing the patient mix: While there is a null effect on total inpatient admissions, more cannabis-related patients are admitted, increasing workload complexity. More strikingly, hospitals speed up care for non-cannabis patients, with RCL lowering lengths of stay by 2.6%. We attribute this phenomenon to cannabis generating workload for hospital staff that reduces the resources available to other patients.

4 Appointment Interval Sizing at a Pediatric Dentistry

Yao Li[1], Jan A. Van Mieghem[2], Itai Gurvich[3], 1Kellogg, Northwestern University, Evanston, IL, [2]Northwestern University, Evanston, IL, [3]Northwestern University, Kellogg School of Management, Evanston,, IL

A lot of clinics adopt a slot appointment system: they set their appointment lengths (interval sizes) and fill the patient appointments into the predetermined slot. We look for the best interval size to minimize the weighted cost of patient waiting time and care provider idleness. With punctual single patient type and a single server, the process simplifies to a D/G/1 queue. We show analytical results together with numerical simulations. With a mixture of two or more patient types, we allow for multiple block sizes to be chosen when scheduling. The process is represented by a G/G/1 queue, for which we show an approximation of the queue and provide an algorithm to find the optimal interval size.

WC09

Johnston

Machine Learning to Support Kidney Transplantation Decisions

General Session

Session Chair

Osman Ozaltin, North Carolina State University, Raleigh, NC

Session Chair

Sait Tunc, Virginia Tech, Blacksburg, VA

1 Presenter

Cong Yang, [1]</sup>

The kidney-paired donation (KPD) program is considered the most effective solution for addressing the shortage of deceased kidney donors. This leads to a popular problem, the kidney exchange problem (KEP), in the field of healthcare operations research. Recently, a new technology has been developed that converts an organ into a universal blood type organ, reducing the possibility of blood type incompatibility between pairs in the KPD pool. In this study, we propose a new integer programming model for the KPD program that considers the implementation of this technology. We perform simulations and analysis based on real-world data, and our findings suggest that the technology has the potential to increase the number of transplants arranged through the KPD program.

2 Interpretable Score Models for Predicting Discard Risk of Deceased Donor Kidneys

Ruoting Li[1], Osman Ozaltin[1], Sait Tunc[2], Matthew Ellis[3], [1]North Carolina State University, Raleigh, NC, [2]Virginia Tech, Blacksburg, VA, [3]Duke University, Durham, NC, Contact: oyozalti@ncsu.edu

Despite their growing shortage, more than 20% of the donated kidneys are discarded, a substantial proportion of which is due to organ quality and matching this quality to a recipient's needs. Therefore, mechanisms to expeditiously match available organs at higher risk for discard with patients that may benefit from these organs are critical. This study aims to predict the discard risk of deceased donor kidneys using interpretable models. We propose risk scores models using two approaches. First, we develop a discard risk score without using KDRI. In the second approach, we extend KDRI to estimate discard risk. We present a computational evaluation of prediction performance and drive key insights into factors affecting discard risk.

3 Machine Learning-Based Kidney Allocation Mechanisms

Sean Berry[1], Berk Gorgulu[2], Sait Tunc[3], Mucahit Cevik[1], [1]Ryerson University, Toronto, ON, Canada; [2]University of Toronto, Toronto, ON, Canada; [3]Virginia Tech, Blacksburg, VA, Contact: mcevik@ryerson.ca

Kidney disease is the 9th leading cause of death in the US, and kidney transplantation is often the choice treatment for end-stage kidney disease resulting in better health outcomes. The kidney allocation practice can be further enhanced as it is often subjective relying on heuristic methods that can result in some patients waiting longer than necessary for a suitable organ match. Our work presents a novel machine learning-based approach to the kidney allocation problem, which can be used to achieve faster theoretical kidney acceptance times compared to the current allocation process.

4 Dynamic and Spatial Analysis of Organ Discard Risk

Sait Tunc[1], Xin Li[2], Osman Ozaltin[2], Ruoting Li[2], Matthew Ellis[3], [1]Virginia Tech, Blacksburg, VA, [2]North Carolina State University, Raleigh, NC, [3]Duke Health, Durham, NC, Contact: sait.tunc@vt.edu

Many indices and risk scores have been proposed in the literature to identify organ at high risk of discard, however, they ignore the spatial and dynamic nature of the organ allocation systems, thus missing an opportunity to make timely and effective interventions to save organs from discard. This paper proposes a comprehensive discard risk prediction framework using state-of-the-art cause-specific and all-cause survival models that incorporate the dynamic and spatial information revealed through the match run

process. We then illustrate the performance of the proposed framework on the U.S. kidney allocation system using nationwide match run and deceased donors datasets.

WC10

Casson

Food Security and Health Implications

General Session

Session Chair

Jon M. Stauffer, Texas A&M University, College Station, TX

1 Retail Food Donations and Humanitarian Operations

John Lowrey, Northeastern University, Boston, MA, Contact: j.lowrey@northeastern.edu

This is an empirical study of the food banks' retail food donation procurement dynamics. Using Donor Source Reports for 417 retail stores across two US states, we examine the efficiency of retail food donations, which is a ratio of the volatility in donation volumes to the volatility in pickup frequency. We find that weekly consistency drives efficiency for hypermarkets, whereas monthly pickup seasonality drives efficiency for mid-sized stores. Higher efficiency increases aggregate distributions downstream to end beneficiaries in humanitarian supply chains, which drives impact.

2 Improving Food Bank Equity and Delivery Capacity with Mobile Pantries

Jon M. Stauffer[1], Manoj Vanajakumari[2], Subodha Kumar[3], [1]Texas A&M University, College Station, TX, [2]University of North Carolina Wilmington, Wilmington, NC, [3]Fox School of Business, Temple University, Philadelphia, PA, Contact: manojuv@uncw.edu

Distribution equity is an important aspect of humanitarian operations and food banks. However, food bank equity is difficult since they do not directly control partner agencies that distribute their food. Using local food bank data, we illustrate how mobile pantries can fill food bank capacity and equity gaps.

3 Covid-19 and Its Impacts on Hospital Operational Performance Measures in California

David D. Cho[1], Yu Wang[2], [1]California State University, Fullerton, Fullerton, CA, [2]University of North Carolina, Wilmington, Wilmington, NC, Contact: davcho@fullerton.edu

Using data reported by California Department of Health Care Access and Information and the U.S. Department of Health & Human Services, we empirically investigate how performance measures such as patient average length of stay are affected by COVID-19 prior to the development of vaccines for over 300 hospitals in California. We identify the differences in impacts for urban and rural counties in California.

WC11

Tom Thomson

Data-Driven Decision Making in Healthcare

General Session

Session Chair

Agni Orfanoudaki, Oxford University, Oxford, United Kingdom.

1 Interpretable Design of Multi-Agent Mobile Health (Mhealth) Applications

Mohammad Zhalechian[1], Soroush Saghafian[1], Yoshimi Fukuoka[2], [1]Harvard University, Cambridge, MA, [2]University of California-San Francisco, San Francisco, CA, Contact: mzhale@umich.edu

Recent advances in mobile health (mHealth) technologies have provided the opportunity to deliver personalized interventions to users regardless of their location. We introduce a multi-agent mHealth setting, where decisions are made by a "manager" as well as several "agents." Each agent is responsible for a unique aspect of the user's health (e.g., sedentary behavior, diet, or physical activity). The manager's role is to coordinate the agents such that the mHealth application achieves its overall goal of forming healthy habits for users. We develop a holistic framework with a provable performance guarantee, and calibrate it using clinical trial data. Our framework sequentially determines the agent the manager should select at each interaction with the user, as well as the intervention taken by that agent. Using data, we show how such a holistic framework helps forming healthy habits for users.

2 Prediction-Driven Admission Control in the Emergency Department

Jing Dong, Columbia University, New York, NY

In this work, we study how to utilize demand and boarding time forecasts in designing admission control policies for the Emergency Department (ED). We build a specialized stochastic model for the ED and focus on a highly time-varying environment, where both the arrival rate and the processing rate for inpatient admission can vary greatly over time. We derive a simple admission control policy for transfer

patients that explicitly takes future arrival and processing rates into account and achieves near-optimal performance. Our results quantify the value of proactive admission control in managing ED congestions.

3 Optimization of Care for Short-Stay Patients Through Observation Beds

Jong Myeong Lim[1], Robert Shumsky[2], [1]Tuck School of Business at Dartmouth, Hanover, NH, [2]Dartmouth College, Hanover, NH, Contact: jong.myeong.lim@tuck.dartmouth.edu

We study the use of an observation service to provide efficient care for short-stay patients. We first measure the impact of implementing an observation service on the efficiency of care provided for short-stay patients. We then investigate the potential of using predictive analytics to aid in selecting patients to be placed in observation beds.

4 Selecting Exceptional Responders with Statistical Guarantees

Michael Lingzhi Li[1], Kosuke Imai[2], [1]Harvard Business School, Boston, MA, [2]Harvard University, Boston, MA, Contact: mili@hbs.edu

Who benefits the most from a treatment? To answer this question, there is a fast-growing literature that proposes machine learning and/or optimization methods to discover exceptional responders. However, it is often difficult to provide statistical guarantees for these methods due to the multiple testing problem. We propose a new evaluation framework that enables the construction of confidence intervals on the performance of exceptional responders. In particular, the intervals are uniformly valid for any population subset selected by a machine learning algorithm, and thus enables safe optimization of exceptional responders with statistical guarantees. The proposed framework does not require modeling assumptions or resampling methods and is generally applicable to any machine learning algorithm.

5 Interpretable Framework For Optimal Sepsis Treatment With Limited Resources

Lien Le[1], Angela Lin[2], Dessislava Pachamanova[3], Georgia Perakis[2], Omar Skali Lami[4], [1]Newton-Wellesley Hospital, Newton, MA, [2]Massachusetts Institute of Technology, Cambridge, MA, [3]Babson College, Wellesley, MA, [4]MIT / McKinsey & Company, Cambridge, MA, Contact: aglin@mit.edu

Sepsis is a life-threatening response to infection that is responsible for over 250K deaths per year in the US as well as the largest portion of hospitalization costs. Deciding which treatments to give sepsis patients in intensive care units (ICU) with limited resources is a challenging problem, as sepsis is a broad heterogeneous condition, and timely treatment is extremely critical to patient outcomes. In this work, we propose a clinical decision-making framework for treating sepsis patients in the ICU. This framework includes building a concise Markov Decision Process (MDP) model from observed data, finding optimal treatment policies using risk-averse value iteration algorithms, and formulating a tractable optimization problem that leverages the value iteration solution to allocate scarce resources. Upon testing our framework on a real ICU dataset, we see a 14% increase in number of patients successfully discharged, 8% decrease in number of deaths, and over two-fold decrease in length of ICU stay.

WC12

Osgood West

Practice-oriented session -- Hospital operations

General Session

Session Chair
Martin Copenhaver, MA

Session Chair
Christopher Sun, ON, Canada.

1 From Theory to Practice to Impact: Applying or Techniques to Healthcare from Within and Without

Amy Cohn, University of Michigan, Ann Arbor, MI

Like many attending this conference, I began my career as a "traditional academic" in operations research, exploring different application areas to apply my tools and have impact. I became progressively more interested and involved in healthcare until ultimately landing in a split role of Professor (50% in Industrial and Operations Engineering at the University of Michigan) and Chief Transformation Officer (50% in Michigan Medicine). I look forward to sharing some of my lessons learned, to sparking discussion, and to providing guidance for future practitioners.

2 Data-Driven Modeling of Inpatient Ward Network: Capacity Allocation in a Network

Jing Dong[1], Pengyi Shi[2], Fanyin Zheng[1], [1]Columbia University, New York, NY, [2]Purdue University, West Lafayette, IN

We combine tools from econometrics and queueing theory to develop a data-driven modeling approach for patient flow. The method is applied to study capacity allocation decisions in the inpatient ward network. Our modeling approach has

two important components: 1) We empirically estimate the patient routing decisions using a discrete choice model and causally quantify the load-balancing behavior. 2) We build a queueing network model with multiple classes of patients, multiple types of servers, and time-varying arrival and discharge patterns. The two components combined allow us to accurately quantify the equilibrium network effects, and thus provide more reliable capacity allocation prescriptions.

3 Studying the Impact of Physician Work Behavior on Emergency Department Operations

Lesley Meng[1], Huifeng Su[2], Rohit Sangal[3], Edieal J. Pinker[4], Andrew Ulrich[3], [1]Yale School of Management, Yale University, New Haven, CT, [2]Yale School of Management, New Havnen, CT, [3]Yale School of Medicine, Yale University, New Haven, CT, [4]Yale School of Management, New Haven, CT

In this study we examine the impact of individual physician work behavior on Emergency Department Operations.

4 The Burden of Evidence for Operations Research in Hospitals

Martin Copenhaver, Massachusetts General Hospital & Harvard Medical School, Boston, MA

What evidence is used to make strategic operational decisions in hospitals? In this talk, we will explore this question (and resulting challenges and opportunities) through a variety of examples. In particular, we consider the conceptual divide in medical versus operational decision making, how metrics of success can differ between hospital stakeholders and the academic community, and the implications for the practice of operations research.

WC13

Osgood East

Frontiers in Healthcare Operations Management

General Session

Session Chair

Michael Freeman, INSEAD, Singapore, Singapore.

Session Chair

Jiatao Ding,

1 The Impact of Surgeon Daily Workload and Its Implications for Operating Room Scheduling

Yiwen Shen[1], Carri Chan[2], Fanyin Zheng[3], [1]HKUST Business School, Hong Kong, Hong Kong; [2]Columbia Business School, New York, NY, [3]Columbia University, New York, NY, Contact: yiwenshen@ust.hk

In healthcare service systems, the workload level can substantially impact service time and quality. We investigate this relationship in the context of cardiac surgery. Using 5,600 cardiac surgeries in a large hospital, we quantify how individual surgeon's daily workload (number of cases performed in a day) affects surgery duration and patient outcomes. To handle the endogeneity issue, we construct novel instrument variables using hospital operational factors. We find surgeon's high daily workload leads to longer OR times and post-surgery length-of-stay. We develop a scheduling model that incorporates the estimated effects and show that it can lead to substantial improvement.

2 The Cost of Task Switching: Evidence from Emergency Departments

Yiwen Jin[1], Yige Duan[2], Yichuan Ding[3], Mahesh Nagarajan[1], Garth Hunte[4], [1]University of British Columbia, Sauder School of Business, Vancouver, BC, Canada; [2]University of British Columbia, Nanjing, [3]McGill University, Montreal, QC, Canada; [4]University of British Columbia, Vancouver, BC, Canada. Contact: yiwen.jin@sauder.ubc.ca

Emergency department (ED) physicians treat patients with different symptoms and constantly switch between tasks. Using comprehensive data sets on patient visits and lab tests in two EDs, we investigate the impact of task switching on physician productivity, quality of care, and patient routing. To address endogenous patient selection, we construct an instrumental variable called switching likelihood that exploits the exogenous composition of waiting patients. We find a 10% increase in the switching frequency of physicians reduces the number of patients treated per hour by 10.4% - 15.6%. However, we find it has no significant influence on treatment quality. By exploring the heterogeneous impact on physician productivity among different patient pairs from data, we propose a data-driven queue management method to best partition patients into two queues. Based on the simulation of implementing the proposed two-queue system in our collaborating EDs, we find that the average waiting time is reduced by about 40%.

3 Can Predictive Technology Help Improve Acute Care Operations? Investigating the Impact of Virtual Triage Adoption

Jiatao Ding[1], Michael Freeman[1], Sameer Hasija[2], [1]INSEAD, Singapore, Singapore; [2]Insead, Singapore, Singapore. Contact: jiatao.ding@insead.edu

Healthcare and technology companies have been developing and deploying virtual triage tools designed to help patients make better and more efficient self-triage decisions. This

paper develops a queueing game model to investigate the impact of virtual triage in the acute care setting and policies to maximize its efficacy. We find that, due to its decentralized nature, when virtual triage excessively recommends emergency (primary) care, it could bring about a decrease in ED (GP) visits. Another finding is that for any arbitrary patient self-triage accuracy, the adoption of informative virtual triage can worsen system performance, even when the virtual triage recommendation is reasonably accurate. To unlock the potential operational benefits of virtual triage, we characterize the optimal virtual triage accuracy subjective to the receiver operating characteristic (ROC) curve. We then investigate how the optimal accuracy changes when patient composition and acute care cost parameters change and as the triage capability of the tool improves.

4 A Continuous Scoring Model for Fair Liver Transplant Allocation

Shubham Akshat[1], S. Raghavan[2], [1]Carnegie Mellon University, Pittsburgh, PA, [2]University of Maryland-College Park, College Park, MD

The United States Department of Health and Human Services is interested in increasing geographical equity in access to liver transplant. They have approved a continuous scoring framework for all the organs, but the exact policy parameters are yet to be decided. We develop a novel method to design heterogeneous scoring functions for continuous scoring policy in the deceased donor liver transplantation that equalizes supply to demand ratios across transplant centers.

WC14

Fitzgerald

Data Mining and Healthcare Analytics 3

Contributed Session

Session Chair

Adam DeHollander, University at Buffalo, Buffalo, NY

1 Deep Learning to Suggest Proper Diagnostic Follow-Up of Emergency Department (ED) Patients with Incidental Lung Nodules

Leo J. Qian[1], Christoph Wald[2], Ranjith Tellis[3], [1]Lexington High School, Lexington, MA, [2]Beth Israel Lahey Hospital and Medical Center, Burlington, MA, [3]Philips Research North America, Tewksbury, MA, Contact: leo.j.qian@gmail.com

In the US, 5.8% of eligible patients for lung cancer screening were enrolled in 2021. With rising use of ED imaging, incidental pulmonary nodule management can help detect lung cancer. Nodules need to be detected and classified. Proper recommendations can get the patient to the CT they need. It is hard to distinguish true nodules from benign findings on chest x-ray (CXR). In multi-year data from a L1 trauma center, we found 13% of CXR reports with nodules didn't mention follow-up. Our AI model predicts if CT is needed based on report content, with 91.30% accuracy. Our method can evaluate if proper recommendation is provided, reduce radiologist variability, and contribute to early lung cancer detection.

2 Administrative Claims-based Predictive Model for Pediatric Asthma Exacerbations

Mandana Rezaeiahari[1], Clare Brown[1], Arina Eyimina[1], Anthony Goudie[1], Mick Tilford[1], Akilah Jefferson[2,3], [1]University of Arkansas for Medical Sciences, Little Rock, AR, [2]University of Arkansas for Medical Sciences, Little Rock, AR, [3]Arkansas Children's Research Institute, Little Rock, AR, Contact: mrezaeiahari@uams.edu

We identified a cohort of 22,631 asthmatic children aged 5-18 years with 2 years of continuous Medicaid enrollment in the Arkansas All-Payer Claims Database (2018-2019). Conditional random forest was used to predict asthma-related hospitalizations or ED visits in 2019, with conditional variable importance values used to describe feature contribution. The model yielded an area under the curve of 72%, sensitivity of 56% and specificity of 76% in both the development and validation cohorts. Previous inpatient, ED, total number of reliever and controller medications, problems related to upbringing as well as rural-urban area codes were the most important features.

3 Feature Extraction of Rare Diseases Using Machine Learning Approaches

Mohammad Joghataee[1], Kushagra Kushagra[1], Aysun Tekin[2], Ashish Gupta[3], Vitaly Herasevich[4], Ognjen Gajic[5], John O'Horo[6], Juan Pablo Domecq[2], [1]Auburn University, Auburn, AL, [2]Mayo Clinic, Rochester, MN, [3]Auburn University, Auburn, AL, [4]Mayo Clinic, Rochester, MN, [5]Mayo Clinic, Rochester, MN, [6]Mayo Clinic, Rochester, MN, Contact: azg0074@auburn.edu

Diagnosing atypical pathogen-induced sepsis and other rare infectious diseases is a complex and challenging problem. A-priori Identification of features using machine learning can facilitate improved outcomes and resource utilization. This study utilizes electronic medical records (EMRs) to predict rare, atypical infections. Models are built using various linear and non-linear techniques such as Logistic Regression, SVM,

Random Forests, neural networks, etc., and evaluated based on different performance metrics. Findings demonstrate the application of interpretable and best prediction models for rare disease identification, including feature extraction using Shapley values.

4 Improving Hospital Emergency Departments in Real-Time Using an AI-Based Approach that Considers Stochastic Events and Process Path Changes

Adam DeHollander, University at Buffalo, Buffalo, NY, Contact: adamdeho@buffalo.edu

Emergency department crowding harms patient care and staff job satisfaction. Current solutions like simulation and mathematical programming have limitations in generalizability and handling uncertainty. To address this problem, we propose modeling the ER as a game, where queuing decisions and patient assignment are moves for a player, and patient arrivals are moves by an opponent. By leveraging techniques from chess programming, we aim to develop a robust decision-making tool for the ER. The project is in its early stages, but it shows promising potential for improving ER efficiency.

WC15

University

COVID-19 and Public Health Policy

General Session

Session Chair

Marie-Laure Charpignon, Massachusetts Institute of Technology, Cambridge, MA

1 Association Between Social Vulnerability and Place of Death at Granular Geographical Resolution During the First Two Years of COVID-19 in Massachusetts

Marie-Laure Charpignon[1], Shauna Onofrey[2], Monina Klevens[2], Maimuna Majumder[3], [1]Massachusetts Institute of Technology, Cambridge, MA, [2]Massachusetts Department of Public Health, Cambridge, MA, [3]Harvard Medical School Computational Health Informatics Program, Boston, MA

A person's place of death depends on multiple factors. In an infectious diseaseemergency, death at home can indicate delayed intervention. We assessed theassociation between social vulnerability and place of death in Massachusetts,via the linkage of individual-level surveillance records and death certificatesand further stratification by residential zipcode. Between March, 2020 andFebruary, 2022, the adjusted likelihood of inpatient death was 1.12 (95% CI:1.04-1.22) and 1.39 (1.27-1.52) times higher among individuals residing inzipcodes of moderate and high vulnerability, respectively.

2 Do Patient Navigators Help Improve COVID-19 Vaccination Rates?

Jiajia Qu[1], Raj Sharman[2], Lavlin Agrawal[3], [1]University of Texas Permian Basin, Odessa, TX, [2]State University of New York-Buffalo, Buffalo, NY, [3]State University of New York at Buffalo, Buffalo, NY, Contact: qu_j@utpb.edu

Our research investigates the effectiveness of a patient navigation program in improving COVID-19 vaccination rates. Our study used data from an accountable care organization (ACO) that employs patient navigators. At the outset, we employed Propensity Score Matching (PSM) and Inverse Probability Weighting (IPW) methods. It may be noted that we accounted for selection bias and other identification issues. Our results show that the deployment of navigators positively impacts vaccination rates in some communities.

WC16

Richmond

Healthcare Analytics

General Session

Session Chair

Guihua Wang, The University of Texas at Dallas, RICHARDSON, TX

Session Chair

Daniel Zheng, Singapore.

1 First Dose or Second Dose? a Study of Vaccination Policy with Supply and Capacity Constraints

Miao Bai[1], Qi (George) Chen[2], Cuihong Li[1], [1]University of Connecticut, Storrs, CT, [2]London Business School, London, United Kingdom. Contact: miao.bai@uconn.edu

We study the problem of allocating limited vaccine supply over time between first-dose and second-dose usage with vaccine administration capacity constraints. Based on the stylized SIR model, our analytical and numerical results establish the value of strategically delaying the vaccination campaign and prioritizing second-dose usage before switching to prioritizing first-dose usage.

2 Adaptive Server Behavior to Schedule Deviations and Its Consequences: Evidence from Operating Rooms

Yiwen Jin[1], Yichuan Ding[2], Steven Shechter[3], Jugpal Arneja[4], [1]University of British Columbia, Sauder School of Business, Vancouver, BC, Canada; [2]McGill University, Montreal, QC, Canada; [3]University of British Columbia, Vancouver, BC, Canada; [4]University of British Columbia, Vancouver, BC, Canada. Contact: yiwen.jin@sauder.ubc.ca
We study how clinical teams adaptively respond to real-time deviations from the planned operating room (OR) schedules and whether this affects patient readmission and reoperation rates. We empirically explore these questions using a unique surgery data set that includes actual and scheduled surgery time stamps. We construct a dynamic panel model and utilize the Arellano-Bond approach to identify adaptive behavior. We identify a new type of adaptive server behavior within schedules, which complements the existing scheduling and behavioral queueing literature. We then leverage the scale of deviation start as instruments and present a causal study that a faster-than-scheduled procedure duration erodes surgical quality by increasing 30-day readmission and reoperation rates. This can assist managers in scheduling surgeries to achieve desired efficiency-quality trade-offs.

3 Optimizing Emergency Department Staffing and Scheduling Decisions with Consideration of Part-Time Work Shifts

Na Geng[1], Xiuxian Wang[1], Andrea Matta[2], Liping Zhou[1], [1]Shanghai Jiao Tong University, Shanghai, China; [2]Politecnico di Milano, Milano, Italy.
Emergency department (ED) staffing and scheduling are two important and interrelated operational decisions, and have great influences on the performance of ED. To provide timely services, ED managers must arrange an adequate number of physicians to a set of work shifts for the time-varying demands. To address this problem, this paper proposes a new way to increase the flexibility by introducing part-time work shifts with a fixed starting time and duration to serve patients in peak hours. A two-stage optimization framework is proposed to solve the weekly staffing and scheduling problem with consideration of both fixed work shifts and part-time work shifts. Stage I is a weekly staffing problem, which determines the staffing levels of both fixed and part-time work shifts. To solve this high-dimensional problem, a problem-specific decomposition method and a simulation-based optimization method are proposed. Numerical experiments show the benefits of part-time work shifts, and validate the effectiveness of the two-stage optimization framework.

4 Linking Medication Errors to Supply Chain Disruptions: Evidence from Heparin Shortages Caused by Hurricane Maria

Minje Park[1], Anita Carson[2], Rena Conti[2], [1]Columbia Business School, New York, NY, [2]Boston University, Boston, MA, Contact: minje.park@columbia.edu
Despite their frequency, there is scant research studying how substitutions in response to pharmaceutical supply chain disruptions impact medication errors in hospitals. We study this causal relationship using a natural experiment: hurricane damage to factories that produce heparin, an important drug used frequently in hospitals. Applying the synthetic control method, we find that the hurricane-related pharmaceutical supply chain disruption increased heparin medication error rates. In addition, we find significant spillover effects. The supply chain disruption increased medication error rates of a substitute drug.

Wednesday, 3:45–5:15PM

WD01

Carmichael

Stochastic Models for Efficient Allocation of Medical Resources

General Session

Session Chair

F. Safa Erenay, University of Waterloo, Waterloo, ON, Canada.

1 Optimizing Screening Policies for Hospital-Acquired Infections Using MDP: The Case of MRSA Surveillance Among Exposed Roommates in Canadian Hospitals

Esma Akgun[1], F. Safa Erenay[2], Sibel A. Alumur[2], [1]University of Waterloo, Waterloo, ON, Canada; [2]University of Waterloo, Waterloo, ON, Canada. Contact: eakgun@uwaterloo.ca
The optimal screening time and method for the exposed roommates of Methicillin-Resistant *Staphylococcus Aureus* (MRSA) carriers are unknown. We aim to build a Markov Decision Process model to predict the MRSA spread and progression and optimize the screening policy while minimizing the cost of mitigating MRSA spread, the number of colonized patients, and the number of missed MRSA cases. We present a model that considers the spread of the infection within the room structure of a hospital. Although presented with the MRSA disease, our approach can be applied to predict the spread of other hospital-acquired infections.

2 Application of Markov Decision Process to Minimize the Cancer Drug Wastage

Krishna Sabareesh Rajangom[1], Fatih Safa Erenay[1], Qi-Ming He[1], Avram Denburg[2], [1]University of Waterloo, Waterloo, ON, Canada; [2]SickKids Hospital, Toronto, ON, Canada. Contact: ksrajangom@uwaterloo.ca

High wastage of leftover cancer drugs, due to mismatching dose requirements (based on body surface area or weight) and available drug vial sizes, is a major concern given ever-increasing drug costs. The wastage could be reduced through vial sharing, dose rounding, optimal vial sizes, and better inventory management under restricted time window for sharing left-over drugs. We developed Markov decision processes to minimize drug wastage and derive policies for developed and developing countries using medical data. We also propose simple-good policies for practicality.

3 Prognostic Factors Affecting Als Progression Through Disease Tollgates

Haoran Wu[1], F. Safa Erenay[2], Osman Ozaltin[3], Ozden Onur Dalgic[4], Mustafa Y. Sir[5], Qi-Ming He[2], Brian Crum6, Kalyan Pasupathy[7], [1]Sun Yat-sen University, Guangzhou, China; [2]University of Waterloo, Waterloo, ON, Canada; [3]North Carolina State University, Raleigh, NC, [4]Massachusetts General Hospital/ Harvard Medical School, Boston, MA, [5]Amazon, Redmond, WA, [6]Mayo Clinic, Rochester, MN, [7]University of Illinois at Chicago, Chicago, IL

This study captured amyotrophic lateral sclerosis (ALS) progression based on timing of several critical events, or ALS tollgates. With an augmented dataset, time trajectories of passing ALS tollgates after the first visit in the database were derived using Kaplan-Meier analyses. Next, a log-rank test was used to identify significant prognostic factors for ALS progression pathways. In addition, a decision-tree-based classification was applied to specify ALS phenotypes displaying different disease progression aggressiveness through tollgates. The impairment level in a segment at the first visit impacted all subsequent ALS progression in that segment, while the phenotype at the first visit further characterized ALS progression speed. Future research may focus on jointly considering all risk factors for characterizing risk groups with different progression aggressiveness, which would better facilitate prediction of individualized ALS progression and shared discussion/decision-making between patients and clinicians.

4 A Metamodel-Based General-Purpose Simulation Calibration Approach

Taghi Khaniyev[1], Elif Sena Işık[2], Turgay Ayer[3], Jagpreet Chhatwal[4], Ismail Fatih Yildirim[5], [1]Bilkent University, Ankara, Turkey; [2]Bilkent University, Ankara, Turkey; [3]Georgia Tech, Atlanta, GA, [4]Harvard Medical School, Mass General Hospital, Boston, MA, [5]Value Analytics, Istanbul, Turkey.

For most realistic simulation models, the calibration process is computationally expensive. This study aims to develop an efficient metamodel-based calibration tool that balances the trade-off between accuracy and computational efficiency. In our approach, we efficiently estimate the output values using artificial neural networks (ANN). After training an ANN, a simulation calibration is carried to find the parameter combination that provides an output closest to a target outcome by making use of a mixed integer programming formulation over trained neural networks. To evaluate the performance of the proposed calibration tool, we used a publicly available influenza simulation model by Chao et al., FluTE. The proposed approach accurately identified the regions in the parameter space likely to provide optimal parameter configurations. Furthermore, it provided significantly superior computational performance. Further research is in progress to improve the robustness and computational efficiency of the optimization models.

5 Catheter Planning with Stochastic Modeling Approach in the Neonatal Intensive Care Unit

Cansu Dagsuyu[1,2], Fatih Safa Erenay[1], Ali Kokangul[3], Nejat Narli[4], [1]University of Waterloo, Waterloo, ON, Canada; [2]Adana Alparslan Turkes Science and Technology University, Adana, Turkey; [3]University of Cukurova, Adana, Turkey; [4]University of Cukurova, Adana, Turkey. Contact: cdagsuyu@atu.edu.tr

Catheters that are used for treatment in the neonatal intensive care unit have a high risk of infection. There are numerous catheter varieties, each with its own infection rate and replacement (i.e., lifetime after placement). This complicates catheter selection, placement and sequence. The primary purpose of developed MDP model is determined as minimizing the rate of infection due to the catheter placement to the patient, taking into account the randomness of the patient's treatment period. For this purpose, performance measures such as expected total cost and expected wasted catheter lifetime are also taken into account in evaluating the efficiency of policies. Ideal catheter plans are determined with the developed MDP model under different constraints for patients in the neonatal intensive care unit.

WD02

Jackson

Analytics and Modeling for Combatting Substance Use Epidemic

General Session

Session Chair
Qiushi Chen, Penn State University, University Park, PA

Session Chair
Jagpreet Chhatwal, Harvard Medical School, Mass General Hospital, Boston, MA

1 Estimating County-Level Prevalence of Opioid use Disorder: A Bayesian Hierarchical Model that Synthesized Publicly Available Data

Zixuan Feng[1], Qiushi Chen[1], Le Bao[1], Paul Griffin[2], Sarah Kawasaki[1], [1]Penn State University, University Park, PA, [2]Pennsylvania State University, University Park, PA, Contact: zixuan.feng@psu.edu

Understanding the opioid use disorder (OUD) burden is critical in combating the opioid epidemic. Although OUD prevalence estimates have been readily available at the national and state levels, it has been poorly understood at the county level in most states. To fill this gap, we developed a Bayesian hierarchical model to estimate the county-level OUD prevalence, leveraging multiple publicly available county-level socioeconomic factors and healthcare-related and opioid-related metrics. We first fitted the model to county-level OUD prevalence estimates available in Massachusetts, which showed satisfactory accuracy with an average absolute percentage error of 10.84% from the leave-one-out analyses. We then performed the full data analysis including other states to estimate the OUD prevalence for counties in those states.

2 Predictability Of Opioid and Drug Overdose Risk In The United States And Opportunities For Interventions

Hawre Jalal, University of Ottawa, Ottawa, ON, Canada. Contact: hjalal@uottawa.ca

Join for an analysis of accidental drug overdose death rates in the United States, and the temporal patterns that are revealed. Dominating this trajectory is a predictable pattern of long-term exponential growth, with the rate of overdose deaths increasing in every successive birth year cohort for the past 45 years. Although the curve has occasionally deviated from the long-term trajectory, it has historically returned to the expected trajectory. A better understanding of the causes of these patterns may lead to improved control policies, at a minimum, greater awareness of the patterns will improve policy evaluation.

3 Bayesian Modeling of the Impact Naloxone use on Opioid-Related Overdoses in North America

Michael A. Irvine, BC Centre for Disease Control, Vancouver, BC, Canada. Contact: mike.irvine@bccdc.ca

Estimation of Take Home Naloxone (THN) kit use and impact is an important component in understanding the full impact of interventions in the on-going North America opioid overdose epidemic. Estimating impact is challenged by under-reporting and biasing of data. This talk will discuss recent research within the application of Bayesian modeling in this field in the estimation of total THN kit use and the impact on intervened overdoses and mortality. I will discuss two modeling approaches that estimate THN use on site orders data and a saturation model used in the estimation of probability of THN use for a witnessed overdose event. These models are applied to BC, Canada and all US states respectively.

4 Modeling the Impact of Sustaining Public Health Interventions to Reduce Opioid-Related Overdose Deaths in Kentucky, Massachusetts, New York, and Ohio

Jagpreet Chhatwal[1], Peter Mueller[1], Qiushi Chen[2], Neeti Kulkarni[1], Madeline Adee[1], Gary Zarkin[3], Marc LaRochelle[4], Amy Knudsen[1], Carolina Barbosa[3], [1]Harvard Medical School, Massachusetts General Hospital, Boston, MA, [2]Penn State University, University Park, PA, [3]RTI International, Research Triangle Park, NC, [4]Department of Medicine, Boston University School of Medicine, Boston, MA

In 2021, over 80,000 Americans died from an opioid overdose. Using data from multiple datasets, we developed a system dynamics model that simulates the opioid epidemic in Massachusetts, New York, and Ohio, from 2020 to 2026. We found that a 2- to 5-fold scale-up in initiation and retention of medications for opioid use disorder along with increased supply of naloxone could reduce overdose deaths by 13-17% in Kentucky, 17-27% in Massachusetts, 15-22% in New York, and 15-22% in Ohio after two years, compared with the status quo. Sustaining these interventions for three additional years could further reduce deaths. However, the positive impact of interventions is washed out if interventions are not sustained.

WD03

Varley

Stochastic Models for Managing COVID-19 Operations with Spatial Uncertainty

General Session

Session Chair
Adam Diamant, Schulich School of Business, Toronto, ON, Canada.

1 Two-Stage Distributionally Robust Optimization for Network Balancing Problems
Aliaa Alnaggar[1], Andre Augusto Cire[2], Adam Diamant[3], [1]Toronto Metropolitan University, Toronto, ON, Canada; [2]University of Toronto Scarborough, Rotman School of Management, Toronto, ON, Canada; [3]Schulich School of Business, Toronto, ON, Canada. Contact: aliaa.alnaggar@torontomu.ca
We propose a two-stage distributionally robust optimization problem for capacity rebalancing where resources are located at nodes of a network. The first stage establishes node capacities, while the second stage transfers resources across network links after observing demand. We show that, for partial moment ambiguity sets, the problem may be solved exactly for general second-stage networks via a separation algorithm, where the subproblem is a mixed integer second order cone program. Using publicly available data, we illustrate the benefits of the approach for repositioning ICU beds across hospitals.

2 Stochastic Spatio-Temporal Disease Transmission Modeling in Small-Scale Settings
Sherwin Doroudi[1], Mohammad Delasay[2], Kang Kang[3], Alexander Wickeham[1], [1]University of Minnesota, Minneapolis, MN, [2]Stony Brook University, Stony Brook, NY, [3]Evidera, Minneapolis, MN, Contact: sdoroudi@umn.edu
We propose a related family of stochastic models for disease transmission in small-scale settings (e.g., grocery stores). Our models are built upon foundational assumptions that are common in the scientific literature on disease transmission. Specifically, we examine settings where individuals arrive to and depart from a (possibly congestion-prone) system over time due to random processes. Each model has a risk metric (e.g., the system-specific basic reproduction rate or the probability of infection) that allows us to evaluate the efficacy of various interventions. Using queueing-theoretic techniques and the notion of sojourn time overlaps, we derive exact analytic expressions for these metrics for some of these models, and propose algorithms that can determine these metrics numerically for other models. In addition to presenting our findings, we identify a number of challenge open problems that form the outline of a broader research agenda that seeks to better understand the mathematics of disease transmission in small-scale settings.

3 Optimizing Interfacility Patient Transfer Decisions During a Pandemic
Timothy Chan[1], Jangwon Park[1], Frances Pogacar[2], Vahid Sarhangian[1], Fahad Razak[1], Amol Verma[1], [1]University of Toronto, Toronto, ON, Canada; [2]Ontario Health, Toronto, ON, Canada.
During the COVID-19 pandemic in Ontario, a province-wide initiative began to transfer patients between hospitals. We propose a queueing model of patient flow within and between hospitals of a healthcare system and leverage the model to optimize patient transfer decisions. We validate our queueing model using historical data from 20 hospitals and quantify the value of patient transfer in terms of balancing the burden of COVID patients and number of patient days with more than 95% occupancy in ICUs and wards.

4 Effective Service Policies to Process MRI Backlog of Patients in Ontario Prior to and as a Result of the COVID-19 Pandemic
Opher Baron[1], Andre Augusto Cire[2], Adam Diamant[3], Eugene Furman[4], [1]University of Toronto, Toronto, ON, Canada; [2]University of Toronto Scarborough, Toronto, ON, Canada; [3]Schulich School of Business, Toronto, ON, Canada; [4]American College of Greece, Athens, Greece.
Based on the severity of their initial prognosis, patients are prioritized for MRI scans within certain time frames, which is problematic in light of the mounting backlog caused by COVID-19. We model the system as a multi-class queueing network with time-varying arrivals that accumulate priority based on how long they have waited. We solve a corresponding optimal control problem for concave and convex accumulating priority cost functions. Utilizing a dataset of MRI encounters in Ontario, we show the superiority of our policies. We suggest that a convex cost function benefits the patients who have waited the longest, while concave cost functions result in lower waiting times for patients on average.

WD04

Toronto Ballroom I

Keynote Panel - Health Equity: More Than a DEI Issue

Keynote Session

1 Health Equity: More than DEI (Panel Discussion)
Vishal Ahuja, Southern Methodist University, Dallas, TX, Contact: vahuja@smu.edu

Health equity can seem like a moral initiative and receive a low priority, operationally. However, achieving health equity (or moving in that direction) should be seen as an opportunity and therefore worthy of leadership endorsement and firm investment due to its potential to improve care quality, enhance hospital cost efficiencies, and increase market share. The panel features three industry executives: Amy Goad, Managing Director at Sendero Consulting, Dr. Steve Miff, CEO at Parkland Center for Clinical Innovation, and Trudy Sullivan, Chief DEI Officer at Health Catalyst, and will explore the key components to successful implementation of health equity initiatives from an operational lens.

2 Panelist
Amy Goad, Sendero Consulting

3 Panelist
Steve Miff, Parkland Center for Clinical Innovation

4 Panelist
Trudy Sullivan, Health Catalyst

WD05

Toronto Ballroom II
Queueing Models in Healthcare
General Session

Session Chair
Sait Tunc, Virginia Tech, Blacksburg, VA

Session Chair
Ruochen Wang, Virginia Tech, Blacksburg, VA

1 Patient Prioritization in Emergency Departments
Daniel Adelman[1], Thomas Spiegel[2], Kanix Wang[3], Gizem Yilmaz[4], [1]University of Chicago, Booth School of Business, Chicago, IL, [2]University of Chicago, Chicago, IL, [3]University of Cincinnati, Cincinnati, OH, [4]University of Chicago, CHICAGO, IL, Contact: wang2xk@ucmail.uc.edu
In this study, we aim to unravel the decision-making process underlying the assignment of patients to available beds in Emergency Departments (EDs) and examine the ramifications of queue jumping on waiting times and medical outcomes. Leveraging historical data, we train an array of machine learning algorithms to accurately forecast the subsequent patient to be assigned to a bed, evaluate the resulting patient outcomes, and recommend operational refinements. We then assess the impact and externalities of patient prioritization, focusing on waiting times and medical outcomes such as length of stay (LOS), mortality, risk of admission, and ED bounce-backs. This empirical research, conducted within the framework of personalized medicine, offers valuable insights into improving patient prioritization in emergency care settings.

2 Targeted Priority Mechanisms in Organ Transplantation
Ruochen Wang[1], Sait Tunc[1], Burhaneddin Sandikci[2], Matthew Ellis[3], [1]Virginia Tech, Blacksburg, VA, [2]Istanbul Technical University, Istanbul, Turkey; [3]Duke Health, Durham, NC, Contact: rcwangise@vt.edu
This paper designs and analyzes implementable voluntary nudge mechanisms that promote, but not enforce, higher utilization of organs as well as efficient matching between organs and patients without mandating a complete redesign of the system. In particular, we study targeted priority mechanisms, which give priority to a target class of candidates on a pre-defined set of organs if they agree to limit their pool of organ offers to this targeted set. We then characterize the equilibrium behavior of the agents under such mechanisms, identify the impact of these mechanisms on several performance metrics, and investigate their optimal design.

WD06

Toronto Ballroom 3: Harris
Empirical Healthcare Analytics
General Session

Session Chair
Shujing Sun, University of Texas at Dallas

1 Predicting ICU Length of Stay: A Parsimonious Explainable AI Approach
Tianjian Guo[1], Indranil R. Bardhan[1], Ying Ding[2], [1]McCombs School of Business, UT Austin, Austin, TX, [2]UT Austin, Austin, TX, Contact: tianjian.guo@mccombs.utexas.edu
Intensive care units (ICUs) are crucial hospital resources, and accurately predicting patient length of stay (LoS) during ICU visits is vital for efficient resource allocation. This research aims to understand the trade-offs between prediction performance, interpretability, and resource utilization for ICU LoS prediction. We developed a deep learning model that fuses clinical data of different modalities for prediction and utilizes explainable AI methods to understand the importance of individual clinical features. Our results suggest that the predictive performance of machine learning methods, namely XGBoost using patient administrative data, diagnosis, and vital signs, is similar to the performance of deep learning

approaches but at a fraction of the computation time. Our study provides insights that can help hospital managers utilize routine clinical data for efficient clinician staffing, utilization, and patient discharge planning.

2 Predicting Medical Device Recalls Leveraging Regulatory Submission Characteristics

Yi Zhu[1], Soumya Sen[1], Alexander Everhart[2], Pinar Karaca-Mandic[1], [1]University of Minnesota, Minneapolis, MN, [2]Harvard University, Cambridge, MA

Hundreds of medical devices are recalled annually due to severe health or even death risks. Accurately and timely predicting these recalls is crucial in preventing medical malpractice. We propose a machine-learning-based framework for predicting medical device recalls by leveraging the characteristics of existing devices (known as predicates) referenced in their 510(k) filings. The framework contains three steps: extracting predicate data from 510(k) filings, constracting predicate network to extract useful predictors, and applying machine learing models for prediction. Our study has potential impacts across the medical device and life science industries.

3 The Effect of Online Follow-Up Services on Offline and Online Physician Demand: Evidence from Chronic Disease

Anqi Zhao[1], Qian Tang[2], Yang Gao[1], [1]Singapore Management University, Singapore, Singapore; [2]Singapore Management Unviersity, Singapore, Singapore. Contact: ygao@smu.edu.sg

The adoption of online follow-up services by physicians provides their offline patients with an important channel for medical follow-ups. Using detailed service data from a Chinese online healthcare community (OHC), the present study scrutinizes the rarely studied effect of adopting online follow-up services on offline and online physician demand in the context of chronic disease. The results consistently demonstrate that adopting online follow-up services leads to higher offline physician demand. Interestingly, in contrast to the channel substitution effect documented in the literature, we find that providing online follow-up services also increases online physician demand. Furthermore, the results of mechanism tests reveal that online follow-up services affect online demand by boosting physicians' online exposure and increasing the availability of information on their online service characteristics to patients. We also find that an increase in physician demand does not lead to decreased service quality.

WD07

Toronto Ballroom 4: MacDonald

To Future Medical Failures: Racial and Gender Bias in Research

Panel Session

Session Chair

Behshad Lahijanian, Georgia Institute of Technology, Atlanta, GA

Session Chair

Gian-Gabriel P. Garcia, Georgia Institute of Technology, Atlanta, GA

1 To Future Medical Failures: Racial and Gender Bias in Research

Behshad Lahijanian, Georgia Institute of Technology, Atlanta, GA

Diversity, equity, Inclusion (DEI) is an inherently complex issues, and everyone makes their trade-off between perfect equality and dealing with historical inequality. Researchers always suffer from these biases between different genders, races, and under-represented minorities. This gender bias is more critical in human life. What's missing is an in-depth understanding of how women and men of different races respond differently to medications and other therapies, as well as other variables that profoundly influence human health. In this panel discussion, we will discuss these biases in healthcare research.

2 Panelist

Enid Montague, University of Toronto, Toronto, ON, Canada.

3 Panelist

Gian-Gabriel P. Garcia, Georgia Institute of Technology, Atlanta, GA

4 Panelist

Jovan Julien, Institute for Technology Assessment Massachusetts General Hospital / Harvard Medical School, Atlanta, GA

5 Panelist

W. Alton Russell, McGill University, Montreal, QC, Canada.

WD08

Toronto Ballroom 5: Lismer

Digital Healthcare Operations

General Session

Session Chair

M. Eric Johnson, Vanderbilt University - Owen Graduate School of Management, Nashville, TN

1 Objective Measurement of Operating Room Capacity Utilization Among Surgeons Using Clustering and Data Envelopment Analysis

Vikram Tiwari[1], Roger Dmochowski[2], Warren S. Sandberg[3], [1]Vanderbilt University Medical Center, Nashville, TN, [2]Vanderbilt University Medical Center, Nashville, TN, [3]Vanderbilt University School of Medicine, Nashville, TN, Contact: vikram.tiwari@vanderbilt.edu

Measuring OR utilization is challenging due to bi-level capacity disaggregation between surgical services and surgeons. Cluster analysis helped identify unique groups of surgeons that have similar surgical booking patterns. For each cluster, Data Envelopment Analysis based ranking of surgeons reveals performance of individuals relative to their peers with respect to how efficiently the individual converts a set of inputs into outputs. This objectively assists surgical services chiefs in reallocating capacity among surgeons.

2 Estimating Hospital Departments' Overall Quality of Clinical Supervision Using Mixed Effects Model of Mandatory Peer Evaluation of Each Clinician

Franklin Dexter[1], Bradley J. Hindman[2], Richard Epstein[3], [1]University of Iowa, Anesthesia, Iowa City, IA, [2]University of Iowa, Iowa City, IA, [3]University of Miami, Miami, FL, Contact: franklin-dexter@uiowa.edu

Peer review of hospital clinicians is mandatory (e.g., US biannual ongoing professional practice evaluation). We use supervisees' (e.g., nurse practitioners') daily or weekly evaluations. We consider how analytically to estimate overall hospital department performance without extra surveys, rather by using the ratings of the individual clinicians encompassing the department. We used 48,788 evaluations of 115 anesthesiologists by 202 residents and fellows to show statistical reliability and validity of treating raters as a random effect. We effectively run a random effect meta-analysis to estimate overall proportional incidence of all department evaluations being best possible.

3 Assessing the Impact of Health Information Exchange on Hospital Data Breach Risk

Sung Choi[1], Min Chen[2], Xuan Tan[3], [1]University of Central Florida, Orlando, FL, [2]Florida International University, Weston, FL, [3]Santa Clara University, Santa Clara, CA, Contact: Sung.Choi@ucf.edu

Objective: The objective of this study was to empirically examine the impact of hospitals' HIE engagement on their data breach risk. Materials and Methods: A balanced panel dataset included 4,936 US community hospitals spanning the period 2010-2017. The relationship between HIE engagement and hospital data breaches was modeled using a difference-in-differences specification controlling for time-varying hospital characteristics. Results: HIE engagement was associated with a 0.672 percentage point increase in the probability of an IT breach three years after the engagement. Discussion: Moving toward widespread health information exchange has important cybersecurity implications that can significantly impact both patients and healthcare organizations.

4 Hospital It Multi-Sourcing and Digital Debt: The Value of Shared Experience Among Vendors

Seung-Yup Lee[1], Sriram Narayanan[2], Eric Johnson[3], Vikram Tiwari[4], [1]University of Alabama at Birmingham, Birmingham, AL, [2]Michigan State University, East Lansing, MI, [3]Vanderbilt University, Nashville, TN, [4]Vanderbilt University Medical Center, Nashville, TN, Contact: eric.johnson@vanderbilt.edu

Many organizations, like hospitals, significantly rely on specialized IT markets (i.e., software vendors) to construct and manage digital platforms. This study focuses on the US healthcare industry to better understand the impact of IT sourcing decisions and the impact of the technological distance among software firms. We operationalize hospital IT sourcing configurations and technological distance at the hospital level, using longitudinal panel data for U.S. hospitals from 2005 to 2017, and empirically evaluate their impact on hospital financial and quality performance. We show that while IT integration-related factors have differential influences on hospital performance, the technological distance among the software firms supporting a hospital is a significant moderator. This study provides novel insights into planning IT platform investments in pursuit of cost efficiency, revenue performance, and patient experience.

WD09

Johnston

Data-Driven Personalized Healthcare

General Session

Session Chair

Manaf Zargoush, McMaster University, Hamilton, ON, Canada.

1 Cluster-Based Trajectory Analytics for the Sequence of Functional Loss and Recovery Among Older Adults Using Big Data

Ghazal Khalili[1], Manaf Zargoush[2], Kai Huang[3], [1]McMaster University, Hamilton, ON, Canada; [2]Health Policy & Management, DeGroote School of Business, McMaster University, Hamilton, ON, Canada; [3]McMaster University, Hamilton, ON, Canada. Contact: khalilig@mcmaster.ca

The ability to perform activities of daily living (ADLs) independently is a critical measure of health status, and losing this ability affects one's quality of life. Our research analyzes the trajectories of patients undergoing functional decline and recovery. Studying ADL pathways has notable benefits, such as predicting and tailoring personalized treatments to prevent or minimize functional loss. Various techniques have been used to investigate ADL trajectories. However, no study has examined typical functional decline and recovery trajectories using clustering and sequence analysis approaches. We also apply a Markov model in the clustering phase to overcome computational challenges.

2 Fairness Considerations for Data-Driven Personalized Decisions

Manaf Zargoush[1], Vedat Verter[2], [1]DeGroote School of Business, McMaster University, Hamilton, ON, Canada; [2]Queen's University, Kingston, ON, Canada. Contact: zargousa@mcmaster.ca

Care fragmentation (CF) occurs when patients receive care from various care providers across multiple hospitals without efficient coordination and integrated clinical information. This issue is more challenging among older patients who are often medically complex or frail because they may have multiple diseases and require many care transitions across healthcare settings. In this study, we propose a data-driven predictive-prescriptive analytics framework that leverages machine learning, decision analysis, and massive, longitudinal data collected over 13 years in Ontario to provide actionable, evidence-based insights regarding CF. We first predict patients at the risk of CF, where the predictions are fed into a prescriptive framework to identify the optimal intervention strategies. We further examine the fairness implications of the proposed analytical framework at both predictive and prescriptive stages to ensure parity among patients and comprehensively assess algorithmic bias using various notions of fairness.

3 A Data-Driven, Evidence-Based, Personalized Approach for Enhancing Seniors' Transitions Through Ontario'S Continuing Care System

Saina SehatKar Langrodi, Somayeh Ghazalbash, McMaster university, Hamilton, ON, Canada.

Seniors often need continuing care services (CCS), provided in long-term care (LTC) or home care. In Ontario, a drastic increase in transitions from acute care to LTC has doubled the waitlist. It is critical to leverage homecare services to minimize unnecessary LTC utilization. To achieve this, we first investigate the factors influencing seniors' CCS transitions using massive data. Then, we predict the personalized probable destination and the risk of mortality and readmission after placement to each facility using machine learning. This information provides valuable insights into finding the most suitable destination for each senior and it can be used to optimize resource allocation.

4 Opening the Black-box: Explainable AI Uncovers Novel Interaction Effect for Allogeneic Hematopoietic Stem Cell Transplant

Yiyang Qu[1], Hamed Shourabizadeh[1], Dionne Aleman[1], Louis-Martin Rousseau[2], Fotios Michelis[3], [1]University of Toronto, Toronto, ON, Canada; [2]Polytechnique Montreal, Montreal, QC, Canada; [3]Princess Margaret Cancer Centre, Toronto, ON, Canada.

Allogeneic hematopoietic stem cell transplant (HSCT) is a curative treatment for patients with hematologic diseases, e.g., leukemia and lymphoma. Despite the significant therapeutic benefits, HSCT is associated with risks and complications. We develop machine learning models to predict specific patient-donor pair survival outcomes by their pre-transplant features, using single-center data to capture hidden but important patient factors. Our predictions improve on the conventional Cox regression due to the ability to capture complex high-dimensional relationships. We then adapt SHAP values, an explainable AI method, to discover new and significant feature-outcome communicable to clinicians, specifically finding and validating that the CD34+ cell dose should be tailored by patient age for acute leukemia patients.

WD10

Casson

Humanitarian Operations

General Session

Session Chair

Telesilla Olympia Kotsi, The Ohio State University, Columbus, OH

Session Chair

Karthik V. Natarajan, Carlson School of Management,

University of Minnesota, Minneapolis, MN

1 Fleet Composition Management of Humanitarian Organizations in Response to Armed Conflicts

Telesilla Olympia Kotsi[1], Maria Besiou[2], Alfonso Pedraza-Martinez[3], [1]The Ohio State University, Columbus, OH, [2]Kuehne Logistics University, Hamburg, -, Germany; [3]Indiana University, Bloomington, IN, Contact: kotsi.1@osu.edu

We investigate transportation expenses of a humanitarian organization (HO) that operates in armed conflict settings. We combine a multi-year proprietary data set to study fleet decisions of vehicle rentals and subcontracting. Rentals are relatively expensive but do not permit security breaches because nonprofit authorized staff members drive the rented vehicles. Subcontracting is relatively cheap but permits security breaches because subcontracted drivers outside the nonprofit drive the cars. We use econometric models to find that in areas of armed conflict the HO prefers vehicle rentals to subcontracting.

2 Designing Public Health Supply Chains for Developing Countries: Evaluating the Transition from Pull Distribution to Informed Push Distribution in Senegal

Karthik V. Natarajan, Carlson School of Management, University of Minnesota, Minneapolis, MN, Contact: knataraj@umn.edu

Access to crucial reproductive health commodities is often limited in developing countries due to frequent stock-outs at last-mile health facilities. In this study, we evaluate the effect of a transition from *pull distribution* to *informed push distribution* in terms of improving the last-mile availability of contraceptives. Leveraging the transition from pull distribution to informed push distribution in Senegal—a developing country that redesigned its public health supply chain—we conduct empirical analyses on novel field data to identify the effect of the transition. Our results indicate that the transition to the informed push model significantly reduces stock-outs, reduces frontline health worker workload, and increases client satisfaction, especially in health facilities with less mature Logistics Management Information System (LMIS) practices and under-developed road infrastructure. Our findings offer actionable insights for resource allocation by identifying health facilities that benefit the most from the transition.

3 Information Management for Disaster Response: The Role of Operational Updates and Crew Experience

Alfonso J. Pedraza-Martinez, Indiana University, Bloomington, IN

Relief organizations typically release operational updates on their websites and social media during their response to disasters. Operational updates include information about the amount of resources (e.g., crew and engines) deployed. Due to the stressful and uncertain conditions that characterize disasters, operational updates may scare people at risk. Fear may lead to poor decision-making, which jeopardizes disaster response operations. Focused on a disaster response setting, our multi-method research examines how the operational updates that relief organizations release on social media impact people's emotions and actions.

4 Managing Last-Mile Supply Chains for Emergency Response - Case Study of Etra in South Sudan and Ukraine

Yuehwern Yih[1], Dawei Wang[2], Lionel Lajous[3], [1]Purdue University, West Lafayette, IN, [2]Merck & Co., Inc., Kenilworth, NJ, [3]Catholic Relief Services, Baltimore, MD, Contact: yih@purdue.edu

Globally, more than 100 million people are forcibly displaced by wars and natural disasters. Donations pour in from around the world, but aid organizations are overwhelmed in their efforts to get the supplies to the hands of those in need. Currently, paper forms and spreadsheets are commonly used to track commodities so real-time monitoring and data-driven decisions are extremely challenging. This presentation will discuss the challenges in the global humanitarian supply chains, a proposed solution, ETRA, for emergency response, and case studies of deploying ETRA in South Sudan and Ukraine.

WD11

Tom Thomson

Machine Learning and Analytics in Healthcare Research

General Session

Session Chair

Yingchao Lan, University of Nebraska-Lincoln, Lincoln, NE

Session Chair

Vishal Ahuja, [1</sup>

1 Dynamic Physician Staffing During a Pandemic

Joel Goh[1], Huijun (Yvonne) Zhu[2], [1]NUS Business School, Singapore, Singapore; [2]National University of Singapore, Singapore, Singapore.

We study a dynamic model of healthcare service provider staffing in the context of an infectious disease pandemic. In the model, physicians are split into two teams, a "hot" team that serves patients who have the infectious disease, and a "clean" team that serves regular patients. A unique feature of the model is that service providers can themselves be infected with the disease, which takes them out of service for a period of recovery. Through the model, we analyze the structure of dynamic optimal policies for staffing these two teams.

2 Combining Pre-Approval Clinical Trials and Post-Approval Spontaneous Adverse Event Reporting for Improved Safety Signaling

John M. Silberholz[1], Fernanda Bravo[2], Yunliang Chen[3], [1]University of Michigan Ross School of Business, Ann Arbor, MI, [2]UCLA Anderson School of Management, Los Angeles, CA, [3]University of California, Berkeley, Berkeley, CA, Contact: josilber@umich.edu

A classical question in pharmacovigilance is how to combine pre-approval RCTs and post-approval surveillance data to increase the power for side effect detection. A key step is to learn the degree to which the observational data is biased before one can combine it with unbiased clinical trial data. In this work, we propose a model that uses information about common toxicities to help de-bias the observational data on rare toxicities through the correlation of bias among different toxicities (e.g., correlation due to co-reported drugs, indications, and patient health). Using Bayesian statistics, we analyze the benefit of "cross"-debiasing and identify the situation where such benefit is largest. Numerical experiments using real data from the FDA Adverse Event Reporting System (FAERS) suggest significant values of using cross-debiasing to improve drug safety signaling.

3 Optimal Patient Pathway Design for AI-Augmented Healthcare

Simrita Singh[1], Tinglong Dai[2], [1]Santa Clara University, Santa Clara, CA, [2]Johns Hopkins University, Baltimore, MD, Contact: ssingh17@scu.edu

We seek to understand the role of artificial intelligence in a healthcare delivery system. The service design decision is whether the patient should see AI or the physician first. The ``AI-first'' strategy views AI as a gatekeeper for the encounter with the physician, whereas the ``physician-first'' strategy treats AI as a second opinion that the physician seeks before reaching the final diagnosis. We model and analyze the diagnostic performance under these two strategies, yielding insights into when AI should be used as a gatekeeper or as a second opinion. For both strategies, our model incorporates the decision-making process that hinges on an initial signal, known as the anchor. In light of this anchoring effect, using AI as a gatekeeper may not necessarily increase missed diagnoses. Nor does it necessarily decrease false-positive diagnoses and hence unnecessary treatments. We show that using AI as a second opinion leads to fewer missed diagnoses but may or may not reduce false-positive diagnoses.

4 Estimating Treatment Effects from Observational Data Using a Hidden Markov Model

Tongqing (Angelina) Chen, John R. Birge, University of Chicago, Chicago, IL, Contact: tchen10@chicagobooth.edu

Treatment effect plays an essential role in the medical decision-making process and is a critical criterion for drug testing and development. However, with unobservable confounders, the treatment effect estimation can be invalid. In this work, we develop a model using observational data in which the confounder is partially observable to estimate the treatment effect. We assume that observability can be correlated with the treatment and confounder which relax the assumptions posted by the existing works. Using maximum likelihood estimators and a hidden Markov Chain structure, the model is proved to be identifiable under some general conditions.

WD12

Osgood West

Hospital Operations Management and Patient Outcomes

General Session

Session Chair

Leily Farrokhvar, California State University Northridge, Porter Ranch, CA

1 Improving Emergency Department to Hospital Wards Patient Flow: A Partially Flexible Strategy

Leily Kamali Farrokhvar[1], Mahdi Shakeri[2], Babak Haji[3], [1]California State University, Northridge, Northridge, CA, [2]University of Calgary, Calgary, AB, Canada; [3]Sharif University of Technology, Tehran, Iran, Islamic Republic of. Contact: leily@csun.edu

We propose a partially flexible approach for admitting emergency department patients to hospital wards with the goal of minimizing board time while avoiding negative impacts on quality of care and staff satisfaction. The proposed partially flexible routing policy is developed

by applying principles of process flexibility and adopting Matrix Analytics and Probability Generating Functions. Our simulation results show that the proposed policy performs similar to a fully flexible design in terms of boarding time while maintaining the quality of care and staff satisfaction.

2 Optimal Sepsis Patient Treatment Using Human-In-The-Loop Artificial Intelligence

Akash Gupta[1], Michael Lash[2], Senthil Nachimuthu[3], [1]California State University - Northridge, Northridge, CA, [2]University of Kansas, Lawrence, KS, [3]Universtiy of Utah, Salt Lake City, UT

Sepsis is one of the leading causes of death in Intensive Care Units (ICU). The strategy for treating sepsis involves the infusion of intravenous (IV) fluids and administration of antibiotics. Determining the optimal quantity of IV fluids is a challenging problem due to the complexity of a patient's physiology. In this study, we develop a data-driven optimization solution that derives the optimal quantity of IV fluids for individual patients. The proposed method minimizes the probability of severe outcomes by controlling the prescribed quantity of IV fluids and utilizes human-in-the-loop artificial intelligence. We demonstrate the performance of our model on 1122 ICU patients with sepsis diagnosis extracted from the MIMIC-III dataset. The results show that, on average, our model can reduce mortality by 22%. This study has the potential to help physicians synthesize optimal, patient-specific treatment strategies.

3 Health on Loan: The Effect of Local Credit Availability on Hospital (Re)admissions

Jun Li[1], Yuan Ma[2], Andrew Wu[1], [1]Ross School of Business, University of Michigan, Ann Arbor, MI, [2]University of Michigan, Ann Arbor, MI, Contact: yuanmato@umich.edu

Similar to for-profit firms, hospitals rely on debt, including bank credit, loans and bonds, to finance their operating expenses and investments. We quantify the effect of debt availability on the health outcomes in the local community. Exploiting an exogenous increase in local credit supply due to the discovery of shale oil and gas, we show that an 1% increase in local bank deposits is associated with a 0.8% decrease in local inpatient admissions, which is concentrated in small hospitals. This is consistent with hospitals using local financing to increase quality of care, with an increase in equipment and facility investments and a reduction in readmission rates in several disease categories.

4 Healthcare Outcome Prediction Using Non-Linear Gradient-Based Feature Selection

Leily Farrokhvar[1], Sadaf Kabir[2], [1]California State University Northridge, Northridge, CA, [2]West Virginia University, Morgantown, WV, Contact: leily@csun.edu

The availability of data and advanced data analysis tools in the healthcare provide significant opportunities for developing accurate estimates of health parameters which can eventually lead to improved clinical decision-making, high-quality healthcare services, and improved patient outcomes. However, medical data often include irrelevant and redundant variables that may increase the complexity while decreasing the performance of the predictive model. In this study, we propose a non-linear gradient-based feature selection method to identify the most significant features in the prediction of different health parameters. The model can successfully increase the prediction performance with a reduced-size feature set.

WD13

Osgood East

Enhancing Care Access through Improved Resource Management

General Session

Session Chair
Pengyi Shi, Purdue University, West Lafayette, IN

Session Chair
Xiaoquan Gao, Purdue University, Lafayette, IN

1 Guiding Physicians with Time-Dependent Patient Selection Policies

Mahdi Shakeri[1], Marco Bijvank[2], [1]University of Calgary, Calgary, AB, Canada; [2]University of Calgary, Calgary, AB, Canada. Contact: mahdi.shakeri@ucalgary.ca

Physicians in emergency departments (EDs) have their own discretion to select the next patient to be seen. We develop a new decision-making model to find patient selection rules that guide ED physicians. The optimal control problem formulation includes many characteristics from practice: patient acuity (or severity), patient wait times, returning patients, and patient hand-offs (at the end of a physician's shift). Numerical results illustrate that our time-dependent policy can significantly reduce the number of hand-offs given the same expected length of stay or wait time for initial treatment.

2 The Impact of Psychiatric Outpatient Follow-Up Visit Frequency on Clinical Outcomes and Waiting Times

Martin Cousineau[1], Vedat Verter[2], Gustavo Turecki[3], [1]HEC

Montréal, Montréal, QC, Canada; [2]Queen's University, Kingston, ON, Canada; [3]Douglas Institute, McGill University, Montréal, QC, Canada. Contact: martin.cousineau@hec.ca

This study determined whether naturally-occurring, but significantly different, outpatient follow-up frequencies are associated with clinical outcome and service waiting time. It was conducted in an outpatient setting. Participants consisted of 340 patients with major depressive disorder who were randomly assigned to four psychiatrists and were followed at a variable frequency defined by the clinician. Patients were assessed at baseline and at every visit with structured interviews and self-reported questionnaires. These groups were also compared according to their baseline characteristics, treatment and appointment frequencies. Little's law was used to estimate the impact of modifying the appointment frequencies on the service waiting time. While variations in appointment frequencies do not appear to have a major impact on clinical outcomes, they could be managed to achieve significant improvements in the accessibility of the clinic.

3 Using Dynamic Origin-Destination Estimation Using Road Traffic Sensor Data for Disease Control Insights

Suyanpeng Zhang[1], Han Yu[1], Peng Dai[2], Sze-chuan Suen[1], Maged M. Dessouky[1], Fernando Ordonez[3], [1]University of Southern California, Los Angeles, CA, [2]Industrial and System Engineering University of Southern California, Los Angeles, CA, [3]Universidad de Chile, Santiago, Chile. Contact: ssuen@usc.edu

Lockdowns during COVID caused major disruptions to commerce, education, and leisure. We exploit traffic sensor data in Los Angeles to infer origin-destination outcomes for transportation flow before, during, and after lockdown to understand possible effects to overall population movement. We then incorporate this data into analyses to help provide insight into optimal vaccine resource allocations.

WD14

Fitzgerald

Data Mining and Healthcare Analytics 4

Contributed Session

Session Chair

Marjorie Curry, MML Dynamics, Garland, TX

1 An Examination of Trendy Factors that Influence Patients' Willingness to Share

Jiajia Qu, Lili Gai, Jingbo Zhang, University of Texas Permian Basin, Odessa, TX, Contact: qu_j@utpb.edu

This study uses Structural Equation Modeling to examine the trendy factors, including patients' information seeking on various outlets, like social media platforms, and perception of source trustworthiness, source credibility, message authentication, etc., that may facilitate patients' willingness to share using 2022 HINTS data. Findings of this study provide insightful implications to evolvement of healthcare information system, healthcare providers, and healthcare professional education. The results also offer directions for future empirical studies.

2 On Reducing Medically Unnecessary Cesarean Deliveries: The Design of Payment Models for Maternity Care

Emily Fainman[1], Beste Kucukyazici[2], TING WU[3], [1]Texas State University, San Marcos, TX, [2]Quuen's University, Kingston, ON, Canada; [3]Nanjing University, Nanjing, China. Contact: tingwu@nju.edu.cn

This data-driven study focuses on the design of financial incentives to reduce unnecessary C-sections, resulting in enhanced birth quality with alleviated economic burden for healthcare systems. Using a semi-supervised learning algorithm, we are able to identify medically unnecessary planned C-Sections, and also quantify the maternity risk index for stylish analytical models under principal-agent framework. We then propose easily implementable and robust pay-for-performance models, which results in risk sharing between payer and physicians, and coordination among any group of physicians.

3 A Predictive Model and Optimal Coders Assignment for Hospital Inpatient Chart

Manas Ghosh, McMaster University, Hamilton, ON, Canada. Contact: ghoshm5@mcmaster.ca

All hospitals across Canada need to submit inpatient clinical records or charts to the Canadian Institute of Health Information (CIHI). The health information professionals (clinical coders) complete the clinical coding task by deciding the appropriate diagnosis or procedure code. A predictive model has been proposed to classify the complexity of the clinical records. These records are then optimally assigned to the coders to complete the charts quickly to meet the submission deadline. The health record manager also benefitted from the model to estimate the total working hours and budget to meet their target.

4 A Predictive Analytics Approach for Ventilators and Other Critical Medical Resources

Luv Khandelwal, Anteneh Ayanso, Brock University, St Catharines, ON, Canada. Contact: lk20ks@brocku.ca
Developed a predictive analytics approach for ventilators and other critical medical resources for future COVID-19-like pandemics. Using open-source data, we employed an ensemble of existing time series analysis techniques to predict ventilators at a population level. As part of the robustness checks, we tested the model for infection rates using historical periods of varying severity and transmission. Implications for other critical medical resources are discussed. Proposed approach performs better than individual techniques, and can be extended to population levels where data is scant.

5 The Fallacy of Correlation and the Case for Simple Descriptive Statistics

Marjorie Curry, MML Dynamics, Garland, TX
Do you know the formulae for correlation, covariance, and standard deviation? Why do covariance and standard deviation formulae divide sums of n terms by n - 1? Many statistics textbooks and software packages hide formulae, and when they do should formulae, they omit the starting and stopping points for sums. Why are there no Unicode symbols for summation with starting and stopping points? Why is variance described as the square of standard deviation as opposed to describing standard deviation as the square root of variance? This paper explores questions and answers and presents a simplified approach to Descriptive Statistics with an extension to Classification, Regression and Deep Learning.
Descriptive Statistics, Classification, Regression, and Deep Learning infiltrate every industry, including the healthcare industry. This paper will give medical personnel the tools they need to make medical diagnoses with accuracy and precision and to target radiation and chemotherapy treatments with specificity.

WD15

University
Healthcare Quality and Safety
Contributed Session

Session Chair
Bogdan C. Bichescu, The University of Tennessee, Knoxville, TN

1 A Qualitative Dual-Site Analysis of the Pharmacist Discharge Care (PHARM-DC) Study

Onyeche Oche, University of Iowa, Iowa City, IA
The PHARMacist Discharge Care (PHARM-DC) intervention is a pharmacist-led Transitions of Care (TOC) program intended to reduce 30-day hospital readmissions and emergency department visits. Focus groups and interviews were employed to explore the perspectives of healthcare providers and administrators on the intervention, and to identify factors contributing to intervention success and sustainability. Four themes were identified, including, Organizational, Pharmacist, and Patient Factors Contributing to TOC, Medication Challenges in TOC at Admission and Discharge, TOC Communication and Discharge Follow-up, and Opportunities for Improvement and Sustainability.

2 Design Thinking and Design of Experiments: A Methodological Approach to Optimizing Emergency Department Processes

Eman Ouda[1], Andrei Sleptchenko[1], Mecit Can Emre Simsekler[2], [1]Khalifa University, Abudhabi, United Arab Emirates; [2]Khalifa University of Science and Technology, Abu Dhabi, United Arab Emirates. Contact: emanoudaeo@gmail.com
A human-centered approach and interdisciplinary collaboration are required to improve the quality of care in emergency departments. This study proposes the integration of design thinking, experiment design, and discrete event simulation. The results demonstrate successful implementation through the integration of the methodology in different design phases, comprehension, abstraction, ideation, testing, and implementation, that enhance each other. Practical implications for healthcare providers and managers highlight the potential of this approach to improve emergency care processes.

3 The Effects of Process Variation and Hospital-Physician Integration on Hospital-Acquired Conditions

Bogdan C. Bichescu[1], Haileab Hilafu[2], [1]The University of Tennessee, Knoxville, TN, [2]University of Tennessee, Knoxville, TN, Contact: bbichescu@utk.edu
Hospitals are under increased pressure to improve patient safety and reduce the incidence of hospital-acquired conditions (HAC). Despite significant efforts made in recent years to improve patient safety and clinical quality, there still exists an incomplete understanding of the antecedents of HAC. This study leverages secondary data from Florida hospitals to investigate the impact of process variation and physician affiliation on HAC. Our study offers implications for theory and practice and points to underutilized levers available to hospital administrators for reducing HAC.

WD16

Richmond

Efficiency, Access, and Optimization in Healthcare Operations

General Session

Session Chair

Sina Ansari, Driehaus College of Business, DePaul University, Chicago, IL

1 Improving Rural Access to Care

Masoud Kamalahmadi[1], Rodney P. Parker[2], Kurt M. Bretthauer[2], Jonathan Eugene Helm[2], [1]University of Miami, Coral Gables, FL, [2]Indiana University, Bloomington, IN, Contact: mkamalahmadi@miami.edu

We explore the effect of expanding healthcare services in underserved rural areas of the U.S. on their residents' access to care and utilization of healthcare services. Using data from a large healthcare system, we show that opening healthcare clinics improves access to care and affects demand in the entire network.

2 Approximate Dynamic Programming for Platelet Inventory Management

Hossein Abouee-Mehrizi[1], Mahdi Mirjalili[2], Vahid Sarhangian[3], [1]Waterloo University, Waterloo, ON, Canada; [2]Univeristy of Toronto, Toronto, ON, Canada; [3]University of Toronto, Toronto, ON, Canada.

We propose an approximate dynamic programming approach for determining ordering quantities of platelets for hospitals ordering their blood products from a central supplier. We illustrate the performance of the approach in a case study using data from a network of hospitals in Hamilton, Ontario.

3 Technician Scheduling in Dialysis Centers

Sina Ansari[1], Farbod Farhadi[2], Francisco Jara-Moroni[3], [1]Driehaus College of Business, DePaul University, Chicago, IL, [2]Roger Williams University, Bristol, RI, [3]Universidad Diego Portales, Santiago, Chile. Contact: sina.ansari@depaul.edu

We develop mathematical models to minimize the operating costs at large-scale hemodialysis centers. We then simulate challenging instances based on the data from our collaborating hemodialysis center to evaluate the performance of our proposed models in practice. Our findings can help clinic managers at hemodialysis centers to better manage operating costs by accurately estimating the staff requirements

Thursday, 8–9:30AM

TA01

Carmichael

Bridging the Gap: Integrating Social Determinants and Health Disparities into Decision Analytic Models

General Session

Session Chair

Chaitra Gopalappa, University of Massachusetts, Amherst, Amherst, MA

Session Chair

Xinmeng Zhao, Amherst, MA

1 Incorporating Race/Ethnicity in an HIV Agent-Based Simulation Model

Arden Baxter[1], Chaitra Gopalappa[2], Alex Viguerie[1], Paul G. Farnham[1], [1]CDC, Atlanta, GA, [2]University of Massachusetts, Amherst, Amherst, MA, Contact: tsw3@cdc.gov

Racial/ethnic disparities in HIV incidence persist in the United States. These disparities can be attributed to differences in HIV prevalence and social determinants of health associated with decreased access to/use of prevention, care, and treatment services. To better understand how these differences relate to health disparities, it is important to include racial/ethnic dynamics into modeling techniques. We present the methods by which we included race/ethnicity in the Progression and Transmission of HIV (PATH 3.0) model. We show how PATH 3.0 can be used to quantify differences in HIV incidence by race/ethnicity and the influence of the HIV continuum of care and mixing patterns on disparities.

2 Joint Modeling HIV and HPV for Synergistic Evaluations of Common Behavioral and Structural Interventions

Xinmeng Zhao, Chaitra Gopalappa, University of Massachusetts, Amherst, Amherst, MA, Contact: xinmengzhao@umass.edu

Persons living with HIV have a disproportionately higher burden of other sexually transmitted diseases (STDs). Causal factors include both behavioral and biological. While pharmaceutical and care support interventions help address biological risk of coinfection, as social and economic conditions are common drivers of behaviors, structural interventions are key part of behavioral interventions. Joint modeling STDs can help evaluate optimal intervention

combinations for overall disease prevention. We applied a recently developed mixed agent-based compartmental (MAC) simulation technique to HIV and HPV in the U.S. population and conducted numerical analyses to evaluate the contribution of behavioral and biological factors to risk of cervical cancer among women with HIV. Our results suggest that the higher risk of HIV-HPV co-infection is attributed to both biological factors and behavioral factors, thus the need for both care and behavioral interventions.

3 A Simulation Model of the Interarrival Time and Quality of Liver Offers for Transplantation

Jiahui Luo[1], Wesley Javier Marrero[1], Mariel Sofia Lavieri[2], David W. Hutton[2], Neehar D. Parikh[2], [1]Thayer School of Engineering at Dartmouth, Hanover, NH, [2]University of Michigan, Ann Arbor, MI, Contact: Jiahui.Luo.TH@dartmouth.edu

Simulation has become an increasingly popular tool for studying healthcare problems due to its ability to model complex systems and predict outcomes. In this work, we model the frequency and quality of liver offers received by a patient in the organ transplantation waiting list. We use parametric and nonparametric methods to model the interarrival time of liver offers, and simulate new liver offers from these approaches. Then, we use machine learning to predict the quality of liver offers. We integrate our simulation models with the machine learning approach to mimic how often a liver offer of a specific quality will become available for patients in the liver transplantation waiting list.

4 Mechanistic Modeling of Social Conditions into Disease Predictions for Intervention-Analyses- Application to HIV

Chaitra Gopalappa, Amir Khoshegbhal, University of Massachusetts, Amherst, Amherst, MA, Contact: chaitrag@umass.edu

As social and economic conditions are key determinants of HIV, the 'National HIV/AIDS Strategy (NHAS)', in addition to care and treatment metrics, aims to address mental health, unemployment, food insecurity, and housing instability, as a strategic plan for the 'Ending the HIV Epidemic' initiative. Mechanistic models of HIV, used for intervention decision analyses, typically model care and sexual behaviors and simulate transmissions as functions of those behaviors. We expanded this framework to first simulate behaviors as functions of social conditions. We used Markov random field to estimate joint probability distributions between social conditions and behaviors, and incorporated it in a national-level agent-based network model, Progression and Transmission of HIV (PATH 4.0), to simulate behaviors as functions of social conditions and HIV transmissions as a function of behaviors. As demonstration for potential application to intervention analyses, we conducted two numerical analyses.

TA02

Jackson

Telemedicine, Access to Care and Health Outcomes

General Session

Session Chair

Jane Iversen, [1]</sup>

1 Impact of Telehealth on Appointment Adherence in Ambulatory Care

Masoud Kamalahmadi, Christos Zacharias, Howard Gitlow, University of Miami, Coral Gables, FL, Contact: mkamalahmadi@miami.edu

We study the effect of telehealth on patients' adherence to medical appointments in ambulatory care. Using data from a large medical system, we show that telehealth is effective in reducing patient no-shows and improving their punctuality.

2 Improving Unit and Hospital-Wide Efficiency: An Empirical Study of a Dedicated Observation Unit

Temidayo Adepoju[1], Anita L. Carson[2], Christopher Manasseh[3], Cherisse Carlo[4], [1]Rutgers Business School, Newark, NJ, [2]Boston University, Boston, MA, [3]Boston Medical Center (BMC), Boston, MA, [4]Boston University Medical Center, Boston, MA

Observation units play an important role in hospital capacity and cost management because they treat Emergency Department (ED) patients who are too sick to be discharged home, but not sick enough for their care to be reimbursed at the level of hospital inpatients. In July 2018, to free up inpatient bed capacity for *"vulnerable patients"* and reduce costs, the Dedicated Observation Unit (DOU) at our study hospital changed its admission criteria and modified its processes so that it could efficiently treat *"observation patients"* and a wider variety of patients, with higher medical complexity than it had previously, and who used to be cared for in the inpatient unit which we call "*short-stay patients*". To achieve this, the DOU created structures to enable it coordinate effectively amongst the cross-functional group of healthcare professionals that care for observation patients; as well as with external collaborators who provide support to the DOU.

3 Tele-Follow-Up and Outpatient Care

Wei Gu[1], Meng Li[2], Shujing Sun[3], [1]University of Science and Technology Beijing, Beijing, China; [2]University of Houston, Houston, TX, [3]University of Texas at Dallas, Richardson, TX

We examine the value of telemedicine in improving access to follow-up care by collaborating with a large Asian hospital that sequentially adopted the tele-follow-up service in different departments. We find that the adoption of telemedicine significantly increases the follow-up volume by 54%. Moreover, telemedicine generates positive spillover effects on onsite care provision, with onsite follow-up visits increasing by 10.7% and onsite initial visits increasing by 5.7%. The mechanism tests show that the increased patient volume is jointly driven by changes in individual patients' visit frequency and the patient base. In particular, patients switch from the in-person to the telemedicine channel for follow-up appointments, and the tele-follow-up service attracts new patients to the hospital for initial care. We further leverage patient heterogeneity to examine the differential demand elasticity. Finally, we show that tele-follow-up improves patient care quality, as evidenced by a significant reduction in the readmission rate.

4 Study of Health Outcomes in a Technology Enabled Virtual Setting

Maxim Terekhov, University Of Florida, Gainesville, FL

This paper presents an empirical analysis of health insurance claims data to explore telemedicine outcomes. Specifically, I utilize causal forests and a retrospective matched case control study design to demonstrate statistically significant changes in costs, utilization, and medication adherence of telehealth users.

TA03

Varley

Modeling and Optimization: A Powerful Tool for Improving Healthcare

General Session

Session Chair

Hussein El Hajj, Santa Clara University, Santa Clara, CA

1 Algorithmic Advances to Help Address Healthcare Provider Scheduling Problems with Ill-Defined Constraints

Daiwen Zhang[1], Amy Cohn[2], [1]University of Michigan, Ann Arbor, Ann Arbor, MI, [2]University of Michigan, Ann Arbor, MI, Contact: dwzhang@umich.edu

When applying OR techniques to healthcare applications, we have learned that in addition to "hard constraints" (a solution is not viable if these are violated) and "soft constraints" (preferences that often require trade-offs), there are also often constraints of a third time, which clinicians sometimes refer to as "hard constraints unless you can't satisfy them." In other words, these are rules that should be enforced but sometimes have to be broken when no truly feasible solution exists. We present an integer programming-based algorithm to assist decision makers in recognizing the possible options for achieving feasibility so that they can choose the least undesirable solution.

2 Targeted Testing with Pooling

Alex F. Mills[1], Serhan Ziya[2], [1]Baruch College, City University of New York, New York, NY, [2]University of North Carolina, Chapel Hill, NC, Contact: alex.mills@baruch.cuny.edu

We study the question "who should be tested" for a disease like COVID-19 when patients are heterogeneous and tests are limited. Using a two-stage model, we show that the answer to this question changes when pooled testing is an option, and develop a targeted testing policy that is simple and easy to implement.

3 Development and International External Validation of a Model Predicting Iron Marker Recovery After Blood Donation

Chen-Yang Su, W. Alton Russell, McGill University, Montreal, QC, Canada.

This study aims to develop a model to predict iron recovery, which would allow for individualized approaches to prevent iron deficiency in repeat blood donors. We developed machine learning models using data from U.S. and South African donors and quantified uncertainty using conformal prediction. Our models were most accurate in predicting hemoglobin but not as accurate in predicting ferritin levels. These results suggest that using predictive models can help manage iron deficiency while maintaining sufficient supply. Future work will look at donors from different countries and age groups.

4 Light Pareto Robust Optimization for Radiation Therapy Treatment Planning

Fahimeh Rahimi[1], Danielle A. Ripsman[2], Hossein Abouee Mehrizi[1], Houra Mahmoudzadeh[1], [1]University of Waterloo, Waterloo, ON, Canada; [2]University of Waterloo, Waterloo, ON, Canada.

Robust optimization (RO) has been proposed to mitigate breathing motion uncertainty during treatment in intensity-modulated radiation therapy (IMRT) planning for breast or

lung cancer. RO is a pessimistic approach that implicitly trades off average-case for worst-case treatment plan quality. Pareto robust optimization (PRO) provides a mechanism for improving nonworst-case plan outcomes, but often remains overly conservative in the average case. In this talk, we demonstrate a light Pareto robust optimization (LPRO) method for IMRT and demonstrate its clinical viability for improving the average-case plan quality while preserving robustness, in comparison to RO and PRO plans.
We show that without sacrificing robustness, the LPRO approach produces viable plans with true total-target irradiation. Furthermore, the plans produced were able to reduce the nonworst-case downside typical of RO, without the characteristic overdosing or average-case pessimism seen in prior models.

5 Sharing Economy for Efficient and Equitable Strategic Disaster Preparedness

Hussein El Hajj[1], Samir Elhedhli[2], Fatma Gzara[2], [1]Santa Clara University, Santa Clara, CA, [2]University of Waterloo, Waterloo, ON, Canada. Contact: helhajj@scu.edu

Disasters cause critical supply shortages and require immediate injection of resources. The main obstacle is often securing necessary resources to deploy and help. As a result, governments set aside capacity to use at time of crisis, or opt to rely on third parties, such as the private sector. Both options, however, may not be viable, as the former is expensive, and the latter is not reliable. To overcome this dilemma, we study the strategic disaster preparedness problem and propose a sharing economy model, in which the government engages private suppliers by investing in a portion of their resources to use when called upon. This strategy leads to an increase in social good, compared to traditional plans.

TA05

Toronto Ballroom II

Scheduling and Planning under Uncertainty in Healthcare

General Session

Session Chair

Opher Baron, University of Toronto, Toronto, ON, Canada.

Session Chair

Andre Augusto Cire, University of Toronto Scarborough, Rotman School of Management, Toronto, ON, Canada.

1 Robust Radiotherapy Planning with Spatially Based Uncertainty Sets

Noam Goldberg[1], Mark P. Langer[2], Shimrit Shtern[3], [1]Bar Ilan University Department of Management, Ramat Gan, Israel; [2]Indiana University, Indianapolis, IN, [3]Technion Israel Institute of Technology, HAIFA, Israel. Contact: noam.goldberg@biu.ac.il

Radiotherapy treatment planning is a challenging large-scale optimization problem plagued by uncertainty. Following the robust optimization methodology, we propose a novel spatially based uncertainty set for robust modeling of radiotherapy planning, producing solutions that are immune to changes in biological conditions. Our proposed uncertainty set realistically captures biological radiosensitivity patterns that are observed using recent advances in imaging, while its parameters are personalized for individual patients. We exploit this set's structure to devise a compact reformulation of the robust model. We develop a row-generation scheme to be able to solve real large-scale instances of this model. The formulation and algorithm are then extended to a relaxation-based scheme for enforcing the challenging yet clinically important dose-volume constraints. The computational performance of the developed algorithms as well as the quality and robustness of the computed plans are demonstrated on simulated and real imaging data.

2 Design of Patient Visit Itineraries in Tandem Systems

Nan Liu[1], Guohua Wan[2], Shan Wang[3], [1]Boston College, Chestnut Hill, MA, [2]Shanghai Jiao Tong University, Shanghai, China; [3]Sun Yat-sen Univerisity, Guangzhou, China. Contact: nan.liu@bc.edu

Multi-stage service is common in healthcare. One widely adopted approach to manage patient visits in multi-stage service is to provide patients with visit itineraries, which specify individualized appointment time for each patient at each service stage. We develop the first optimization modeling framework to design such visit itineraries. Due to interdependence among service stages, our model loses those elegant properties (e.g., L-convexity and submodularity) often utilized to solve the classic single-stage models. To address these challenges, we develop innovative reformulations and solution approaches. Our study shows that a well-designed patient visit itinerary which carefully addresses the interdependence among stages can significantly improve patient experience and provider utilization.

3 Dynamic Interday and Intraday Scheduling

Christos Zacharias[1], Nan Liu[2], Mehmet A. Begen[3],

[1]University of Miami, Coral Gables, FL, [2]Boston College, Chestnut Hill, MA, [3]Ivey Business School, Western University, London, ON, Canada. Contact: czacharias@bus.miami.edu

The simultaneous consideration of appointment day (interday scheduling) and time of day (intraday scheduling) in dynamic scheduling decisions is a theoretical and practical problem that has remained open. We introduce a novel dynamic programming framework that incorporates jointly these scheduling decisions in two timescales. Our model is designed with the intention of bridging the two streams of literature on interday and intraday scheduling and to leverage their latest theoretical developments in tackling the joint problem. We establish theoretical connections between two recent studies by proving novel theoretical results in discrete convex analysis regarding constrained multimodular function minimization. Grounded on our theory, we develop a practically implementable and computationally tractable scheduling paradigm with performance guarantees. Numerical experiments demonstrate that the optimality gap is less than 1% for practical instances of the problem.

4 A Hybridized Approximate Dynamic Programming and Neural Network for Distributed Ambulatory Care Scheduling

Jonathan Patrick[1], Onur Ozturk[2], Amirhossein Moosavi[1], [1]University of Ottawa, Ottawa, ON, Canada; [2]Telfer School of Management, University of Ottawa, Ottawa, ON, Canada. Contact: moosavi@telfer.uottawa.ca

This work studies an ambulatory care scheduling problem that offers multi-appointment multi-class multi-priority treatments in multiple campuses with multiple resources. A dynamic setting is considered with uncertain patient arrival and use of the emergency department. The problem is formulated as an infinite-horizon Markov decision process model and is accelerated using a neural network. An affine approximation architecture is used to approximate the value function. Then, an equivalent linear programming model is solved through column generation to compute approximate optimal policies.

5 Network Models for Centralized Surgical Scheduling with Heterogeneous Operating Time Distributions

Andre Augusto Cire[1], Carlos Henrique Cardonha[2], Adam Diamant[3], [1]University of Toronto Scarborough, Rotman School of Management, Toronto, ON, Canada; [2]University of Connecticut, Storrs, CT, [3]Schulich School of Business, Toronto, ON, Canada. Contact: andre.cire@rotman.utoronto.ca

We propose an approximation architecture for prescriptive models with probabilistic constraints that utilizes network-based encodings. Each network represents a compressed decision tree that establishes a sequence of decisions, and the size of these decision trees can be adjusted to relax or restrict the risk associated with violating the probabilistic constraint. We apply our approach to determine how best to schedule and sequence surgeries to reduce the surgical backlog brought on by the COVID-19 pandemic. In contrast to existing work, the network-based approach allows us to account for surgeon- and procedure-specific surgical durations. We compare our model to existing approximations for chance-constrained models using a dataset of approximately 24,000 surgeries and 80 surgeons to demonstrate its effectiveness at reducing the surgical backlog in a real-world setting.

TA06

Toronto Ballroom III

On Data, Learning, and Decision-Making: Methodology and Healthcare Applications

General Session

Session Chair
Mohsen Bayati, Stanford University, Stanford, CA

Session Chair
Wanning Chen, University of Washington, Bellevue, WA

1 The Efficacy of COVID-19 Testing and Vaccination in Schools

Yeganeh Ali Mohammadi, Ramesh Johari, David Scheinker, Kevin Schulman, Kristan Staudenmayer, Stanford University, Stanford, CA, Contact: yeganeh@stanford.edu

The COVID-19 pandemic led to widespread school closures despite the importance of keeping schools open. Our study aimed to investigate the effectiveness of regular testing and vaccination measures in mitigating safety concerns and keeping children safe in schools. Using data from the Los Angeles Unified School District, we found that regular testing was remarkably effective in containing COVID-19, with positivity rates consistently around eight times lower than in the entire Los Angeles County. We also conducted a natural clinical trial to examine the impact of vaccination on COVID-19 cases among children aged 12-18 and 5-11. Our results showed that vaccination was highly effective in reducing COVID-19 cases among children. Additionally, our study revealed a notable association between school

socioeconomic status and COVID-19 positivity rates, indicating the need for addressing socioeconomic disparities in COVID-19 prevention efforts.

2 Learning Heterogeneous Treatment Effects for Panel Data

Wanning Chen[1], Chenglong Ye[2], [1]University of Washington, Bellevue, WA, [2]University of Kentucky, Lexington, KY, Contact: wnchen@uw.edu

We propose an efficient method for estimating heterogenous treatment effects (HTE) for panel data by modeling it as a transfer matrix learning task. Learning HTE provides insights into personalized medical interventions, but existing matrix methods were only adapted to learn the average treatment effects better, and how to use them to enhance HTE estimation remains unknown. In this work, we first model HTE as a low rank matrix since similar units experience similar treatment effects. Then, we achieve superior HTE estimation task with a newly designed transfer matrix completion method (TMCM) by transferring learned knowledge between potential treated outcomes and potential control outcomes.

3 On Aligning Prediction Models With Clinical Experiential Learning: A Prostate Cancer Case Study

Jacqueline J. Vallon[1], William Overman[1], Wanqiao Xu[1], Neil Panjwani[2], Xi Ling[1], Sush Vij[1], Hilary P. Bagshaw[1], Sandy Srinivas[1], John Leppert[1,3], Erqi Pollom[1,3], Lei Xing[1], Mark K. Buyyounouski[1], Mohsen Bayati[1], [1]Stanford University, Stanford, CA, [2]University of Washington, Seattle, WA, [3]Palo Alto Veterans Affairs Hospital, Palo Alto, CA, Contact: jjvallon@stanford.edu

To increase estimation accuracy, advanced machine learning (ML) models trade off variance by injecting bias. However, in a healthcare setting, this artificial bias can lead to predictions that are inconsistent with the experiential learning of clinicians, limiting the models' use in clinical practice. In this project, we study this challenge by applying modern ML models to prostate cancer outcome predictions using the National Cancer Data Base. We hypothesize that integrating clinical expertise into the training of the ML models will reduce the inconsistencies without compromising model accuracy.

4 A Geometric Approach to Improve the Worst Case Performance of Thompson Sampling

Yuwei Luo, Stanford University, Stanford, CA, Contact: yuweiluo@stanford.edu

In this paper, we study Thompson Sampling (TS) for the stochastic linear bandit problem. TS is a popular policy to use in practice partly due to its strong empirical performance. In addition, it is known that TS achieves minimax Bayesian regret. However, its worst-case regret suffers from an extra multiplicative factor of order $\sqrt{d}$, which is recently shown to be unavoidable. Motivated by this discrepancy between the worst-case versus typical performance of TS, we derive an instance-dependent regret bound for TS that can be calculated efficiently in a "data-driven" manner through a geometric approach. This result enables us to detect and "course-correct" if TS performs poorly in any specific problem instance. We show a variant of TS based on our approach enjoys the minimax optimal worst-case regret of $O(d\sqrt{T})$ while keeping most of the properties of TS. Simulation results are presented to validate our insights and to compare our algorithm with the baselines.

TA09

Johnston

Optimization Under Uncertainty for Personalized Medicine

General Session

Session Chair

Erik Rosenstrom, North Carolina State University, Raleigh, NC

1 Who Goes Next? Optimizing the Allocation of Adherence-Improving Interventions

Daniel Felipe Otero-Leon[1], Mariel Sofia Lavieri[2], Brian T. Denton[3], [1]University of Michigan, Ann Arbor, MI, [2]University of Michigan, Ann Arbor, MI, [3]Industrial and Operations Engineering, University of Michigan, Ann Arbor, MI

Long-term adherence to medication is a critical factor in preventing cardiovascular disease (CVD). Physicians may recommend adherence improving interventions; however, these are costly and limited in their availability. We developed a binary integer program (BIP) model to select patients for intervention under budget constraints. We further studied a long-term adherence prediction model using dynamic logistic regression (DLR) model to predict the risk of future non-adherence. We trained and tested our model to longitudinal data for CVD in a large cohort of patients seen in the VA health system. We proposed an algorithm that combines the DLR and BIP models to decrease the number of CVD events.

2 Neural Temporal Point Processes for Modeling an Over-the-Phone Care Management Program

Mitchell Plyler[1], Min Chi[2], [1]North Carolina State University, Raleigh, NC, [2]North Carolina State University, Raleigh, NC
In this work, we leverage neural temporal point processes to model patient interactions with an over-the-phone care management program. Care management programs can help patients better understand their treatment options, coordinate future appointments, and generally receive better healthcare. Such programs can also benefit practices by reducing patient no-shows and total clinic visit time. We explored the impact of different data modalities such as past call outcomes, past call transcripts, future call purposes, and their combinations to predict the outcomes of the next call in the program. This work can be used to inform future interventions that could improve enrollment and retention in the care management program.

3 Leveraging Neural Network-Based Metamodels to Identify Optimal Dynamic COVID-19 Epidemic Control

Erik Rosenstrom[1], Julie Simmons Ivy[2], Maria Esther Mayorga[2], Julie L. Swann[2], [1]North Carolina State University, Raleigh, NC, [2]North Carolina State University, Raleigh, NC, Contact: erosens@ncsu.edu
Emerging disease spread, such as a COVID-19 variant, challenges policymakers to control rapidly growing hospitalizations from exceeding hospital capacity. We propose a dynamic nonpharmaceutical intervention policy (DNPIP) that is stationary relative to multiple epidemic waves but varies NPI usage according to the current state of disease spread. We define an optimal DNPIP to minimize the total usage of NPIs and excess hospitalizations relative to a parameter defining the relative weight of each to a decision-maker. To optimize DNPIPs computationally efficiently over a spectrum of weighting parameters, we translate a stochastic agent-based simulation of COVID-19 disease spread in North Carolina from July 1, 2021 - June 15, 2022, to a neural network metamodel for subsequent black-box optimization. The metamodel is trained to predict a hospitalization time series given a DNPIP from simulation-generated hospitalization time series for 1,250 DNPIP sampled policies. We study optimal DNPIPs from the state and county-level perspectives.

TA10

Casson

Analytics to Improve Operations in Human Milk Banks

General Session

Session Chair

Natalia Summerville, Memorial Sloan Kettering Cancer Center, Cary, NC

1 How Data Science Helps NICU Babies

Natalia Summerville, Memorial Sloan Kettering Cancer Center, New York, NY
Similarly to donated blood transfusions, albeit less known, donated maternal milk feeds are essential to support patients in critical conditions, specifically the little patients in newborn intensive care units (NICUs). Mother's milk for premature babies has been proven to reduce severe diseases such as necrotizing enterocolitis (NEC) and hospital re-admission rates. However, donation, collection, testing, pasteurization, and distribution of mother's milk are fairly complex. In this talk, we'll explore how mathematical optimization and machine learning methodologies have supported Milk Banks in North America, bringing more maternal milk to babies who need it.

2 Got (Optimal) Milk? Pooling Donations in Human Milk Banks with Machine Learning and Optimization

Rachel Wong[1], Rafid Mahmood[2], Ian Zhu[3], Deborah O'Connor[4], Debbie Stone[5], Sharon Unger[5], Timothy Chan[1], [1]University of Toronto, Toronto, ON, Canada; [2]Telfer School of Management, Mississauga, ON, Canada; [3]University of Toronto, Toronto, ON, Canada; [4]University of Toronto, Toronto, ON, Canada; [5]Mount Sinai Hospital, Toronto, ON, Canada. Contact: rache.wong@mail.utoronto.ca
Human donor milk provides critical nutrition for the millions of infants that are born preterm each year. While the macronutrients in donor milk are critical to infant development, they vary by donation. In collaboration with Rogers Hixon Ontario Human Milk Bank, we developed a data-driven framework to pool multiple donations using machine learning and optimization. Over a one-year trial, our implementation yielded significantly higher macronutrient content than current pooling practices, with the proportion of pools meeting clinical fat and protein targets increasing by approximately 31%, with a 60% decrease in recipe creation time.

3 Multi-Method Approach to Predicting and Creating Capacities for Winter Surge Volumes at a Children's Hospital

Tze Chiam, Lori Pelletier, Connecticut Children's, Hartford, CT, Contact: chiamt@gmail.com

As an effort to ensure sufficient capacity to provide care for pediatric patients at Connecticut Children's for the winter of 2022-2023, we utilized a multi-method approach. Triple-exponential smoothing was used to predict the volume in the emergency department, and computer simulation was then used to predict capacity needs in the ED, MedSurg and PICU based on a combination of pre- and post-COVID variables due to a changing population mix. Decision analysis and FMEA approaches were then used to explore potential capacities in the hospital system and to "create" safe spaces for surge volumes.

TA11

Tom Thomson

Data-driven Sequential Decision Making in Medicine

General Session

Session Chair

Arielle Andere, 1</sup

Session Chair

Hamsa Sridhar Bastani, Wharton School, Philadelphia, PA

1 Survival Bandits

Arielle Elissa Anderer[1], Hamsa Sridhar Bastani[2], John M. Silberholz[3], [1]The Wharton School, University of Pennsylvania, Philadelphia, PA, [2]Wharton School, Philadelphia, PA, [3]University of Michigan Ross School of Business, Ann Arbor, MI, Contact: aanderer@wharton.upenn.edu

This project adapts online learning techniques to scenarios with time-to-event data, where there is a delay between choosing an arm and observing feedback that is endogenous to the quality of the arm. We posit a multi-armed bandit algorithm that uses a cox-proportional hazards estimator. We theoretically analyze and prove guarantees on the regret under this algorithm. Lastly, we examine its performance on a dataset of metastatic breast cancer clinical trials, and compare it to that of other adaptive allocation schemes.

2 Presenter

Ziqian Zhu[1], Tim Huh[2], Steven Shechter[1], [1]University of British Columbia, Vancouver, BC, Canada; [2]University of British Columbia, Vancovuer, BC, Canada. Contact: ziqian.zhu@sauder.ucb.ca

Motivated by recent debates on Covid quarantining policies, we model test-retest and quarantining policies as a partially observable Markov decision process. Costs include testing, quarantining, and spreading the virus, while the state of Covid (truly "positive" or "negative") is partially observable. Daily decisions involve whether to test and/or quarantine. We derive structural results of the optimal cost function and optimal testing/quarantining policy under different modeling assumptions. We discuss how individuals, workplaces, and governments may differ in their preferred policies.

3 Multi-Armed Bandits with Endogenous Learning Curves: An Application to Split Liver Transplantation

Yanhan (Savannah) Tang[1], Andrew A. Li[2], Alan Scheller-Wolf[3], Sridhar R. Tayur[1], [1]Carnegie Mellon University, Pittsburgh, PA, [2]CMU Tepper, Pittsburgh, PA, [3]Tepper School of Business, Pittsburgh, PA, Contact: yanhanta@andrew.cmu.edu

Proficiency in many sophisticated tasks is attained through experience-based learning, in other words, learning by doing. For example, transplant surgeons need to practice difficult surgeries to master the skills required. A central planner must identify and develop surgeons with high aptitudes while ensuring that patients still have excellent outcomes and equitable access to organs. We formulate a multi-armed bandit (MAB) model in which parametric learning curves are embedded in the reward functions to capture experience-based learning and provisions are included to ensure that arms choices are subject to fairness constraints. We propose the L-UCB and FL-UCB algorithms that attain O(log t) regret on problems enhanced with experience-based learning and fairness. We show that our algorithms have superior numerical performance, and our algorithms could potentially help evaluate strategies to increase the proliferation of SLT and other technically-difficult medical procedures.

4 Does Machine Learning Improve Operational Efficiency? Evidence from the Design of an Emergency Department Vertical Processing Unit

Agni Orfanoudaki, Oxford University, Oxford, United Kingdom.

Addressing hospital emergency department (ED) overcrowding is a critical challenge for many healthcare systems worldwide. Many hospitals have been experimenting with innovative patient flow designs to address this challenge. A promising approach is to separate patients who can be served vertically and route them to a different area, termed the Vertical Processing unit, also known as the Rapid Medical Assessment (RMA) unit. However, successful implementation of this design significantly depends on understanding which patients and when they should be routed to the RMA unit. We develop and validate a machine learning model that accurately predicts when an arriving

patient can be served in the RMA unit. Subsequently, we develop an analytical model to minimize the average patient length of stay in an RMA-based ED. Our results suggest that the proposed RMA design outperforms traditional patient flow approaches due to the dynamic and efficient use of ED resources, especially in settings with a higher prevalence of high-acuity patient cases.

TA12

Osgood West

Applications in Healthcare Operations

General Session

Session Chair

Zahra Gharibi, California Satie University San Marcos, San Diego, CA

1 Effect of Shift Structure on Service-Worker Fatigue: Evidence from Emergency Department Caregivers

Chia-Chun Yang[1], Craig Froehle[1], Elizabeth E. Leenellett[2], [1]University of Cincinnati, Cincinnati, OH, [2]University of Cincinnati, Cincinnati, OH, Contact: yangcc@mail.uc.edu

It is well-established that worker fatigue can have deleterious consequences for work quality. However, less is known about how shift structure - an operational policy decision - influences worker fatigue. Using primary data from caregivers in an emergency department at a large, midwestern, academic hospital, we examine how shift duration and timing drive fatigue, and how the fatigue-reduction efficacy of workers' recovery time is affected by their between-shift activities. We conclude that operational policies should consider the effects of the shift schedule's structure on the fatigue experienced by workers and consider implementing policies that enhance fatigue recovery between shifts.

2 Physician Rostering Problem with Downstream Capacity Constraints

Yashi Huang[1], Arik Senderovich[2], Yaron Shaposhnik[1], [1]University of Rochester, Rochester, NY, [2]University of Toronto, Toronto, ON, Canada. Contact: yhu126@simon.rochester.edu

We study a physician rostering problem whereby providers are scheduled to weekly sessions during which they examine and consult patients. The sessions serve as a central coordination mechanism which determines the timing of preparatory as well as treatment activities that are scheduled around exams. We collaborate with a large hospital that specializes in cancer treatment, and develop an interactive interface that predicts demand for resources as well as optimizes the roster to improve load-balancing. We conduct numerical experiments to assess the potential improvement that can be obtained by optimizing the roster.

3 A Machine Learning Approach To Predict Deceased Donor Factors Affecting Organ Discard In The Us

Zahra Gharibi, Yuzhang Han, California Satie University San Marcos, San Diego, CA

Our study identifies factors contributing to the discarding of deceased donor organs using a machine-learning approach. The analysis we have conducted reveals several aspects affecting organ discard, including demographic, clinical, behavioral, and geographical factors. Our findings provide valuable insights into improving organ allocation and utilization to increase successful transplants and improve patient outcomes.

TA13

Osgood East

Empirical Research in Healthcare Operations: I

General Session

Session Chair

Raha Imanirad, Schulich School of Business, Toronto, ON, Canada.

1 The Allocation of Funds in Healthcare: Which Hospital to Support?

Lina Song, University College London School of Management, London, United Kingdom.

We provide an analytic framework to allocate healthcare resources to improve societal utility. Using an economic model of self-selection, we incorporate the patient's trade-offs between access and quality into the social planner's allocation decision. We examine the properties of optimal allocation of (a) hospital quality investment and (b) hospital closure (or bailout) in rural vs. urban settings. Based on the findings, we provide heuristics for allocation decisions based on the hospitals' location and quality. Finally, using a dataset of Medicare inpatient visits, we analyze the performances of our heuristics in comparison to various hospital financing policies.

2 Who is an Efficient Physician? Evidence from Emergency Medicine

Raha Imanirad, Schulich School of Business, Toronto, ON, Canada.

Improving the performance of the healthcare sector requires an understanding of the efficiency of care delivered by providers. Although this topic is of great interest to policymakers, researchers, and hospital managers, rigorous methods of measuring efficiency of care delivery have proven elusive. Through Data Envelopment Analysis (DEA), we make use of evidence from care delivered by emergency physicians, and develop efficiency scores that gauge physicians' performance. We then use these scores to shed light on factors that contribute to ED physician efficiency. Our findings serve as best practices for physicians and hospital administrators as they can learn from efficient physicians and what they do differently.

3 What Causes Delays in Admission to Rehabilitation Care? A Structural Estimation Approach

Jing Dong[1], Berk Gorgulu[2], Vahid Sarhangian[3], [1]Columbia University, New York, NY, [2]University of Toronto, Toronto, ON, Canada; [3]University of Toronto, Toronto, ON, Canada. Contact: bgorgulu@mie.utoronto.ca

The increase in demand for rehabilitation care has led to long admission delays. These delays not only affect patient outcomes but also lead to bed blocking in acute care. Admission delays can be caused by capacity constraints or extra processing requirements. It is important to identify different sources to delay to identify effective delay mitigation strategies accordingly. However, standard data only includes a single (combined) measure of delay, and the bed allocation decisions in practice can be quite complicated with multiple determinant factors. In this work, we develop a hidden Markov chain to identify and quantify different sources of delays. The estimation results are then combined with a queueing model to evaluate the effectiveness of different interventions to reduce admission delays.

TA14

Fitzgerald

Data Mining and Healthcare Analytics 5

Contributed Session

Session Chair

Joy Tong, London, United Kingdom.

1 Business Analytics: Emerging Practice and Research Issues in the Health Insurance Industry

Maxim Terekhov, University of Florida, Gainesville, FL

This paper summarizes emerging practice and research issues in the health insurance industry. We provide an industry overview, epitomize business analytics applications, and outline current and emerging problems of interest to key stakeholders and researchers in information systems, operations management, and healthcare management.

2 Leveraging Process Mining for the Improvement of Emergency Department Operations and Patient Outcomes

Kangah Park[1], Minseok Song[1], Me Yeon Lee[2], [1]Pohang University of Science and Technology (POSTECH), Pohang, Korea, Republic of; [2]Hallym University Sacred Heart Hospital, Anyang, Korea, Republic of. Contact: k.park@postech.ac.kr

Process mining is a research discipline that involves extracting process-related knowledge from event logs to obtain actionable insights. It is a powerful tool that allows for complex healthcare process analysis to identify operational inefficiencies and improve patient outcomes. To demonstrate its usability, we analyze a two-year event log retrieved from a Korean tertiary hospital ED. First, we investigate sources of delays in cases where multiple departments are involved. We also compare the processes and area usage patterns of acute and less acute cases. Then, we examine transfer cases to identify the causes of transfer decisions. Lastly, we develop a process-aware ED LOS prediction model.

3 Association Between Social Determinants of Health on Colorectal Cancer Care

Suman Niranjan[1], Chan Shen[2], Usha Sambamoorthi[3], Russell Torres[1], Abhinandan Chowdhury[4], [1]University of North Texas - Denton, Denton, TX, [2]Pennsylvania State University, Harrisburg, PA, [3]University of North Texas Health Science Center (UNTHSC), FortWorth, TX, [4]Savannah State University, Savannah, GA, Contact: suman.niranjan@unt.edu

The study aims to develop a prognostic model for predicting cancer care in older adults in the USA, focusing on colorectal cancer. The study will also examine bias in AI and ML algorithms based on race, ethnicity, and location. Supervised machine learning models will analyze a large dataset collected from multiple states, identifying patterns and factors that influence cancer care outcomes. This study has the potential to improve the quality of care and health outcomes for older adults in the US and address issues of bias in AI and ML algorithms. This approach can help identify patterns that influence cancer care outcomes, improving the quality of care and health outcomes for vulnerable population.

4 Advising Sophisticated Customers: Evidence from Health Insurance Brokers

Joy T. Tong, University of Western Ontario, London, ON, Canada. Contact: jtong@ivey.ca

Focusing on the employer-sponsored health insurance market, this paper examines how brokers advise large employers and the consequences of brokers' incentive changes. We find that a ban on brokers' kickbacks results in higher premiums and worse plan qualities. Better-governed firms control premium increases by discontinuing the brokerage service. The negative effect on premiums occurs for public firms, but not for private firms that are less sophisticated. Firms in more competitive brokerage markets experience less premium distortion. Overall, regulations on brokers' compensation can have unintended consequences on sophisticated customers.

TA16

Richmond

"Fairness" in Healthcare

General Session

Session Chair
David Rea, Lehigh University, Bethlehem, PA

Session Chair
Shannon Harris, Virginia Commonwealth University, Richmond, VA

1 Uncover Unfairness in Liver Transplants via Causal Discovery

Nil-Jana Akpinar[1], Violet (Xinying) Chen[2], Kyra Gan[3], Agni Orfanoudaki[4], [1]Carnegie Mellon University, Pittsburgh, PA, [2]Stevens Institute of Technology, Hoboken, NJ, [3]Harvard University, Boston, MA, [4]University of Oxford, Oxford, United Kingdom. Contact: vchen3@stevens.edu

Liver transplant is a life-saving medical procedure requested by thousands of patients every year in United States. The scarcity of available donor livers leads to the challenging task of distributing livers in an equitable and efficient manner. Despite significant efforts in transforming liver distribution policy to improve equity, there exists unfairness against certain groups. We adopt a causal perspective to investigate the present unfairness in US liver transplants. We apply causal discovery algorithms to construct causal graphs over selected attributes, e.g. MELD score, mortality on transplant waitlist, gender, ethnicity, etc. Based on the generated causal graphs, we identify paths indicative of unfairness, e.g. dependence between receiving liver and gender implies possible gender-based bias. This causal analysis approach is useful for uncovering hidden sources of unfairness and informing the design of targeted intervention for fairer liver transplant policy.

2 Do Busy Hospitals Discriminate when Making Transfer Decisions?

David Rea, Lehigh University, Bethlehem, PA

Busy hospitals can create dangerous environments for both patients and providers. One natural mitigation strategy is to transfer patients to other hospitals, known as an interhospital transfer (IHT). In this research, we provide empirical evidence of contrasting effects of busyness in the emergency department (ED) versus the inpatient ward (IP): patients who arrive when the ED (IP) is busy are less (more) likely to be transferred. Furthermore, we show that insurance status influences which patients are transferred and how long it takes to transfer them. All together, our results imply potential profit-seeking behavior by busy hospitals

3 Reducing Racial Disparities in Medical Appointment Scheduling by Eliminating Priority Appointment Slots

Shannon Harris[1], Karen T. Hicklin[2], Michele Samorani[3], [1]Virginia Commonwealth University, Richmond, VA, [2]University of Florida, Gainesville, FL, [3]Santa Clara University, Santa Clara, CA, Contact: harriss10@vcu.edu

Patient no-shows are a common problem for many outpatient clinics. Some scheduling systems employ machine learning to predict patients' individual no-show probabilities, and then employ these predictions to build the schedule. While this strategy results in higher-quality schedules, it also results in undesirable racial disparities due to the correlation of a patient's no-show probability with their race. In this paper, we analytically prove that disparity can be reduced by eliminating priority slots, or equivalently, overbooking the first slot of the clinic session. We prove our findings analytically and test their validity computationally on the data set of a large specialty clinic whose Black patients have a higher no-show probability than non-Black patients.

4 Evaluating Disparities in Critical Care Resources for COVID-19 Patients

Karen T. Hicklin[1], Adam Bouhadana[2], [1]University of Florida, Gainesville, FL, [2]University of Florida, Gainesville, FL, Contact: khicklin@ufl.edu

The COVID-19 pandemic has given rise to many complications in medical decision making. One of which is how critical care resources should be allocated among patients. According to The Society of Critical Care Medicine, current protocol dictates that critical care resources be

primarily for patients who need them but who are not too sick. These protocols could potentially have a greater impact on some racial groups than others. We model patient treatment pathways to evaluate if decisions in critical care protocols lead to increased mortality for minority groups through the modeling of disease progression as a function of various demographic factors such as gender, race/ethnicity, age, and BMI.

Thursday, 10–11AM

P02

Toronto Ballroom I-III

Plenary - Got (Optimal) Milk?

Plenary Session

1 Got (Optimal) Milk?

Timothy Chan, University of Toronto, Toronto, ON, Canada.

Human donor milk is considered the ideal nutrition for millions of infants that are born preterm each year. Donor milk is collected, processed, and distributed by milk banks. The macronutrient content of donor milk is directly linked to infant brain development and can vary substantially across donations, which is why multiple donations are typically pooled together to create a final product. Approximately half of all milk banks in North America do not have the resources to measure the macronutrient content of donor milk, which means pooling is done heuristically. We propose a data-driven framework combining machine learning and optimization to predict macronutrient content of deposits and then optimally combine them in pools, respectively. In collaboration with our partner milk bank, we collect a data set of milk to train our predictive models. We rigorously simulate milk bank practices to fine-tune our optimization models and evaluate operational scenarios such as changes in donation habits during the COVID-19 pandemic. Finally, we conduct a yearlong trial implementation, where we observe the current nurse-led pooling practices followed by our intervention. Pools created by our approach meet clinical macronutrient targets between 31% and 76% more often than the baseline, while taking 67% less recipe creation time. This is the first paper in the broader blending literature that combines machine learning and optimization. We demonstrate that such pipelines are feasible to implement and can yield significant improvements over current practices. Our insights can guide practitioners in any application area seeking to implement machine learning and optimization-based decision support.

Thursday, 11:15AM–12:45PM

TB01

Carmichael

Data Analytics for Optimizing Health Equity in Public Health

General Session

Session Chair

Gian-Gabriel P. Garcia, Georgia Institute of Technology, Atlanta, GA

Session Chair

Behshad Lahijanian, Georgia Institute of Technology, Columbia, MD

1 Equity-Promoting Integer Programming Approaches for Medical Resident Rotation Scheduling

Shutian Li[1], Karmel S. Shehadeh[1], Beth Hochman[2], Jacob Krimbill[2], Alexander P. Kossar[2], [1]Lehigh University, Bethlehem, PA, [2]Columbia University Medical Center, New York, NY

We present equity-promoting integer-programming approaches for medical resident rotation scheduling and a user-friendly tool that implements the proposed approaches. Numerical experiments based on a case study from a large surgical residency program illustrate the potential of the proposed approaches in automating the resident-to-rotation scheduling and improving equity among residents and their satisfaction.

2 Quantifying the Association Between Diabetes Complications and COVID-19 Outcomes: A Retrospective Study Using Electronic Health Records

Ni Luh Putu Paramita[1], Joseph Kapena Agor[2], Maria Esther Mayorga[1], Julie Simmons Ivy[3], Osman Ozaltin[1], [1]North Carolina State University, Raleigh, NC, [2]Oregon State University, Albany, OR, [3]Guest, Cary, NC, Contact: oyozalti@ncsu.edu

We perform a retrospective case-control study using EHRs to measure differences in the risks for COVID-19 severe outcomes among patients with diabetes complications. We show that diabetes complications increase the risks of COVID-19 infection, hospitalization, and worse health outcomes with respect to in-hospital mortality and longer hospital length of stay. There exists health disparities in COVID-19 outcomes across demographic groups in the

diabetes population. African American and Hispanic diabetes patients have higher odds of COVID-19 infection than White and Non-Hispanic diabetes patients, respectively. Hispanic patients have less access to the hospital care compared to non-hispanic patients when longer hospitalizations are needed due to their diabetes complications. Diabetes complications, which are generally associated with worse COVID-19 outcomes, are predominantly determining the COVID-19 severity in those infected patients resulting in less demographic differences in COVID-19 hospitalization and mortality.

3 Concussion Prediction Using Interpretable Machine Learning Models: An Evaluation of Baseline Testing in the NCAA-DoD CARE Consortium

Behshad Lahijanian[1], Gian-Gabriel P. Garcia[1], Julianne Schmidt[2], Rob Lynall[2], [1]Georgia Institute of Technology, Atlanta, GA, [2]University of Georgia, Atlanta, GA, Contact: blahijanian3@gatech.edu

Concussion affects millions of people annually and is a major public health concern. Baseline testing is a resource-intensive process that is considered essential to concussion management for student-athletes. However, the diagnostic value of baseline testing at the individual level is poorly understood. In this study, we design an interpretable machine learning-based framework to quantify the benefit of personalized baseline testing. Using Concussion Assessment, Research, and Education Consortium data, we find that normative references could be substituted in place of baselines for most athletes. Our study offers critical insights into a value-based approach to managing sports-related concussions.

4 Practical Implementation of Predictive Models Considering Racial Disparities: Cost-Effectiveness Modeling of Risk Score Cutoffs

Yiwen Cao, Sze-chuan Suen, University of Southern California, Los Angeles, CA, Contact: ycao0253@usc.edu

While identifying predictive models with high area under the curve (AUC) values is important, we additionally need to identify the best cut-off values for positive and negative labels before deploying predictive models in the field. We propose choosing the best threshold value is best using a cost-effectiveness framework. The optimal sensitivity-specificity pair along the frontier receiver-operating characteristic (ROC) curve would be the one that provides the highest incremental net monetary benefit when considering residual lifetime costs and quality adjusted life years (QALYs). We demonstrate this analysis for chronic kidney disease (CKD) prediction in non-diabetic, non-hypertensive patients across different race groups using a microsimulation to evaluate cost-effectiveness outcomes.

5 Algorithms, Disparities and Deaths of Despair: Evidence from Florida's use of NarxCare Scores

Emma Dean, University of Miami, Miami, FL

We study the addition of NarxCare, an opioid overdose risk scoring algorithm, to Florida's Prescription Drug Monitoring Program. NarxCare's algorithm predicts accidental overdose, but its inputs are correlated with complex disease and a lack of access to care. The impact of NarxCare on disparities is ambiguous: algorithmic decisions could counteract or reinforce preexisting biases. We run an event study with claims data for 7,148,266 Medicaid recipients in the state of Florida between 2016 and 2020. We find that opioid prescriptions, which had been dropping over time, stabilize in the months just after NarxCare roll-out. However, changes in opioid prescriptions were unequal across groups.

TB02

Jackson

Organ Allocation Policy

General Session

Session Chair

Sait Tunc, Virginia Tech, Blacksburg, VA

1 Does Strategic Placement of Deceased-Donor Kidneys Improve Outcomes?

Diwakar Gupta, University of Texas, Austin, TX

Some transplantprograms turn down kidney offers in batches while signaling the OPO that theywill accept that kidney for a lower ranked candidate at their center. Weexamine the prevalence, patterns, and consequences of strategic placements.

2 Rejection-Proof Mechanisms for Multi-Agent Kidney Exchange

Danny Blom, Eindhoven University of Technology, Eindhoven, Netherlands. Contact: d.a.m.p.blom@tue.nl

Collaboration between kidney exchange programs is essential, as the pool size is a vital aspect for the success of kidney exchange. A common objective is to maximize the total number of transplants. Nevertheless, organizations taking part in the collaboration often prefer to have those patients transplanted that are under their own control. Hence, collaborations often do not reach their full potential.

We study a new type of matching mechanism that proposes an exchange plan on the merged pool, such that there exists no incentive for ex-post strategic behavior. Our experiments show that such mechanisms output exchange plans that are close to optimal, while remaining tractable in practice.

3 Evaluating the Impact of Changes to Eurotransplant Organ Allocation Rules with Discrete Event Simulation

Hans C. de Ferrante[1], Bart Smeulders[1], Frits C. R. Spieksma[2], [1]Eindhoven University of Technology, Eindhoven, Netherlands; [2]Eindhoven University of Technology, Eindhoven, Netherlands.

Annually about 2,300 patients needing liver transplantation enter the Eurotransplant (ET) waitlist, while only 1,800 are transplanted. To prevent waitlist deaths and increase fairness in allocation, transplant experts affiliated with ET regularly propose modifications to ET allocation rules. We developed a discrete event simulator to help quantitatively evaluate the impact of such proposals in liver allocation. We illustrate utility of the tool by simulating simple changes to ET's exception policy system, which has been described to overprioritize eligible patients. Results suggest modest deprioritization of patients with exception points can reduce overall ET waitlist mortality by 5%.

TB03

Varley

Driving Progress in Public Health through New Frontiers in Operations Research

General Session

Session Chair

Hrayer Aprahamian, Texas A&M University, College Station, TX

Session Chair

Hadi El-Amine, George Mason University, Fairfax, VA

1 Predicting County-Level Opioid Overdose Deaths with Suppressed Data: A Cluster-Based Regression Model

Zixuan Feng[1], Qing Ye[2], Qiushi Chen[3], Weijun Xie[2], [1]Penn State, University Park, PA, [2]Georgia Institute of Technology, Atlanta, GA, [3]Penn State University, University Park, PA, Contact: zixuan.feng@psu.edu

Curbing the opioid crisis necessitates accurate county-level overdose death predictions for targeted intervention. Public data files suppress counties with less than 10 deaths, affecting over half of US counties and posing difficulty in studies using such datasets. We proposed a novel cluster-based regression model with a customized objective function to handle suppressed data, utilizing data from 10 states with the highest overdose death rates. Grouping similar counties, the model incorporated spatial aspects and enhanced prediction accuracy. It outperformed random forest, chosen as a benchmark for its popularity and robust performance in handling complex data and latent nonlinear relationships. Our model's superior performance and greater interpretability enable better resource allocation and effective intervention strategy decisions.

2 Discrete-Time Markov Chain Models with Covariate-Dependent Transition Probabilities for Disease Progression Modeling

Hanie Eskandari[1], Jourdain Lamperski[2], Mark S. Roberts[2], Mary Krauland[3], Praveen Kumar[3], Nisha Nataraj[4], Michaela Rikard[4], [1]University of Pittsburgh, Pittsburgh, PA, [2]University of Pittsburgh, Pittsburgh, PA, [3]University of Pittsburgh, Pittsburgh, PA, [4]Centers for Disease Control and Prevention, Atlanta, GA, Contact: lamperski@pitt.edu

Statistical models of individual-level disease progression play an important role in a number of public health studies. Typically these studies use simulation-based methods (SBMs) to calibrate the parameters of the models to target data. SBMs provide studies with the freedom to construct complex models and to use diverse types of target data. SBMs, however, can require large amounts of computation time, due to the potential need to run many simulations. In this talk we restrict our attention to using disease prevalence target data to calibrate a class of discrete-time Markov chain models that have covariate-dependent transition probabilities. We formulate the calibration problem as a non-convex optimization problem and consider solving it with first order methods that just require inexpensive (relatively speaking) matrix-vector multiplications (instead of simulations). We investigate the performance of our methods through computational experiments and apply them in a case study on Opioid Use Disorder.

3 Optimal Targeted Mass Screening in Non-Uniform Populations with Multiple Tests and Schemes

Jiayi Lin[1], Hrayer Aprahamian[1], George Golovko[2], [1]Texas A&M University, College Station, TX, [2]The University of Texas Medical Branch, Galveston, TX, Contact: hrayer@tamu.edu

This paper proposes a proactive optimization-based framework to design optimal targeted mass screening for non-uniform populations, aiming to maximize overall

classification accuracy under a limited budget. The framework considers population heterogeneity, different testing schemes, the availability of multiple assays, and imperfect assays. An efficient globally convergent threshold-style solution scheme is identified for the resulting multi-dimensional fractional knapsack problem. The proposed framework is demonstrated through a real-world case study on targeted COVID-19 screening in the United States, showing significant improvement over conventional practices and providing valuable managerial insights for distribution of testing schemes, assays, and budget across different geographic regions.

4 An Optimal Path Discovery Procedure for Regret-Based Multi-Period Problems with Applications to Infectious Disease Screening

Marwan Shams Eddin[1], Hadi El-Amine[2], Hrayer Aprahamian[3], [1]George Mason University, Fairfax, VA, [2]George Mason University, Fairfax, VA, [3]Texas A&M University, College Station, TX, Contact: helamine@gmu.edu

We propose an optimization framework to solve problems that involve parameters that are forecast to vary over a given time horizon. We model uncertainty in the forecast through the use of lower and upper bounds which can be seen as time-dependent confidence intervals. Our framework is applicable in long-term budget planning or resource allocation settings. We propose a model to minimize the maximum deviation from a so-called "ideal function," which we then show can be re-formulated as a narrowest path problem on an acyclic directed graph with weights determined by solving minimax regret problems. We devise an optimal path discovery iterative scheme that solve the problem efficiently. We then apply our proposed framework in two real-life settings: 1) large-scale screening of populations for West Nile Virus, and 2) the allocation of resources in blood donation centers. The results from both case studies show improvements in terms of both societal costs and detection rate.

TB09

Johnston

Radiotherapy Treatment Planning I

General Session

Session Chair

Arkajyoti Roy, The University of Texas at San Antonio, San Antonio, TX

Session Chair

Houra Mahmoudzadeh, University of Waterloo, Waterloo, ON, Canada.

1 Robust AI-Assisted Radiotherapy Planning

Arkajyoti Roy[1], Justin J. Boutilier[2], Ruiqi Li[3], Nikos Papanikolaou[3], [1]The University of Texas at San Antonio, San Antonio, TX, [2]University of Wisconsin - Madison, Madison, WI, [3]The University of Texas Health at San Antonio, San Antonio, TX, Contact: arkajyoti.roy@utsa.edu

Artificial intelligence (AI) can improve various aspects of the radiotherapy planning process. However, AI-assisted treatment planning inherently produces errors that can reduce the effectiveness of the resulting treatment and fast adoption of AI-based methods in clinical practice emphasizes an urgent need to develop methods to quantify and control for model error. We propose an integrated predictive-prescriptive modeling framework that fuses the predictive and prescriptive phases of the radiation therapy planning process to ensure that the final treatment plan is robust to model errors.

2 Adaptive Approaches to Liver Stereotactic Body Radiotherapy Under Geometry Uncertainty

Marina A. Epelman[1], Tracy Chen[1], Dan Polan[1], Victor Wu[2], Martha Matuszak[1], [1]University of Michigan, Ann Arbor, MI, [2]Amazon, Ann Arbor, MI, Contact: mepelman@umich.edu

In abdominal stereotactic body radiation therapy (SBRT), the patient's geometry can be different in each treatment fraction. Just prior to treatment, geometry can be updated using a CT, but fully re-optimizing the treatment is too operationally taxing. We propose a multi-stage stochastic programming model for treatment planning, in which possible geometries at each fraction are estimated, and we (re)optimize a set of plans based on biologically effective dose—one for each potential geometry—before the patient arrives. We report on advantages of this approach on retrospective patient cases.

3 Geometric Beam Angle Optimization for Radiation Therapy Treatment Planning

Danielle Ripsman[1], Sibel Alumur Alev[1], Houra Mahmoudzadeh[2], [1]University of Waterloo, Waterloo, ON, Canada; [2]University of Waterloo, Waterloo, ON, Canada. Contact: daripsman@uwaterloo.ca

Beam angle optimization (BAO) is a difficult but essential component of planning many types of radiation therapy treatment. Despite the wealth of proposed methodologies for optimal beam-angle selection in the literature with significant treatment quality gains, in practice, clinicians often opt for the selection of a fixed number of equidistant

beams, or manual iterative planning. This is due, in part, to the requirement for a secondary fluence map optimization (FMO) to validate any BAO selections and the resource-intense calculations needed to calculate the parameters for such a model at each iteration.In this talk, the BAO problem is modeled using a geometrical abstraction, allowing it to be considered in a single-stage column generation-driven set-covering framework. This novel abstraction allows for a reduction in the reliance of BAO modeling on sophisticated dose calculators, as well as eliminating the need for time-consuming BAO-FMO iteration.

4 Clinical Implementation of an Optimization Method for Breast Cancer Imrt with Sliding Windows

Scholar Sun[1], Ernest Osei[2], Johnson Darko[2], Houra Mahmoudzadeh[1], [1]University of Waterloo, Waterloo, ON, Canada; [2]Grand River Regional Cancer Centre, Waterloo, ON, Canada. Contact: s229sun@uwaterloo.ca

Sliding-window IMRT is a common technique used in radiation therapy wherein the beam is modulated unidirectionally by a set of tungsten leaves. The goal of the treatment is to deliver the prescribed tumour dosage while minimizing the dose to healthy tissues. This type of treatment can be difficult to plan, due to its exponentially large number of possible leaf arrangements. This talk presents the results of a novel mixed integer nonlinear program and its corresponding heuristic to optimize the delivery of a sliding-window IMRT procedure. We demonstrate the viability of this model in clinical planning using patient data and compare this with previous results from the literature.

TB10

Casson

Incorporating AI into Healthcare Delivery

General Session

Session Chair

SIDIAN Lin, Harvard University, Cambridge, MA

1 Should Race and Ethnicity be Used in Predictive Risk Models? Evidence from Diabetes Screening

Madison Coots, Soroush Saghafian, Sharad Goel, Harvard University, Cambridge, MA, Contact: mcoots@g.harvard.edu

Throughout the healthcare system, predictive algorithms are used to inform patient screening decisions for many diseases, including diabetes. Some recent work recommends using race and ethnicity in risk assessments to improve accuracy, but other work argues that doing so risks stigmatizing marginalized communities, potentially worsening health outcomes. We introduce a utility framework and show that under common utility functions, there is, perhaps surprisingly, minimal benefit from improved accuracy—both across the entire patient population and within patient subgroups—from including race and ethnicity in diabetes risk models. This is because few patients are subject to different screening decisions under different models, and, for those who are, the decision to screen is a close call, making them largely ambivalent. These findings suggest that past recommendations in diabetes screening likely overestimated the statistical benefits of using race and ethnicity, adding further nuance to the debate.

2 Evaluating the use of Heterogeneous Treatment Effects to Personalize Blood Pressure Treatment Decisions

John Giardina[1], Ankur Pandya[2], [1]Harvard University, Boston, MA, [2]Harvard T.H. Chan School of Public Health, Boston, MA, Contact: jgiardina@g.harvard.edu

Machine learning and causal inference methods are often used to calculate heterogeneous treatment effects (HTEs) from randomized controlled trials. These methods have been previously applied to estimate HTEs of blood pressure treatment; intensive treatment reduces the risk of cardiovascular disease but can have significant side-effects, so estimating HTEs could direct care to patients who will benefit most. Building on recently developed metrics to evaluate HTEs, we analyze the use of these estimates to personalize blood pressure treatment. We find that these estimates are often not robust enough to guide personalized treatment decisions and would only improve outcomes in specific contexts.

3 A Novel Evaluation Of The Dose Constraints Of An Adaptive Intervention Algorithm

Xiang Meng[1], Walter Dempsey[2], Nick Reid[3], Pedja Klasnja[2], Susan Murphy[1], [1]Harvard University, Cambridge, MA, [2]University of Michigan, Ann Arbor, MI, [3]University of Washington, Seattle, WA, Contact: xmeng@g.harvard.edu

The use of online adaptive algorithms in mobile health technologies has revolutionized health interventions, with notable examples showing promising results in improving health outcomes. However, optimizing dose constraints is crucial to ensure effective treatment delivery and maximize benefits for users. Two constraints of particular interest are the avg. treatment constraint and the uniformity constraint. The former involves setting limits on the number of times treatments are delivered to balance the need for effective

intervention with user engagement, while the latter involves randomizing treatments evenly across all potential risk times. To achieve both constraints, the Sequential Risk Time Sampling (SeqRTS) algorithm was developed and used in a trial to evaluate the effectiveness of anti-sedentary messages during sedentary behavior. We present an analyzing framework for evaluating whether the SeqRTS algorithm satisfied the two constraints and assesses its efficacy, providing insight into improving the algorithm.

TB11

Tom Thomson

Analytics and Machine Learning for Healthcare

General Session

Session Chair

Michael Li, Harvard Business School, Boston, MA

1 Personalized Breast Cancer Screening

Yu Ma, MIT, Cambridge, MA

Current national cancer screening guidelines heavily rely on patient age, neglecting other important medical characteristics. Furthermore, the inability to combine information across hospital systems due to the lack of a coherent records system poses another barrier to personalize screening decisions. We propose to use claims data to develop a novel machine learning and optimization based clinical support tool. We apply it to the study of 378,840 female patients to demonstrate that across different risk populations, personalized screening reduces the average delay in cancer diagnosis by 2-3 months, with even stronger benefits for individual patients.

2 Branch-and-Price for Prescriptive Contagion Analytics

Alexandre Jacquillat[1], Michael Lingzhi Li[2], Rame Martin[3], Wang Kai[4], [1]MIT Sloan School of Management, Cambridge, MA, [2]Harvard Business School, Boston, MA, [3]MIT, Cambridge, MA, [4]Tsinghua University, Beijing, China. Contact: alexjacq@mit.edu

We formalize a class of prescriptive contagion problems where a centralized decision-maker allocates shared resources across multiple segments of a population, each governed by contagion dynamics. These problems feature combinatorial resource allocation decisions, continuous time dynamics, and non-linear dynamics. We develop a branch-and-price methodology that combines (i) a set partitioning reformulation; (ii) a column generation decomposition; (iii) a novel clustering algorithm for discrete-decision continuous-state dynamic programming; and (iv) a novel tri-partite branching scheme to circumvent non-linearities. The algorithm scales to large realistic instances, significantly outperforming state-of-the-art benchmarks both in terms of solution quality and computational times. Our methodology can increase the effectiveness of vaccination campaigns by an estimated 50-70%, resulting in 17,000 extra saved lives over 12 weeks in a situation mirroring the COVID-19 pandemic.

3 Improving Stability in Decision Tree Models

Vassilis Digalakis[1], Dimitris Bertsimas[2], [1]Massachusetts Institute of Technology, Cambridge, MA, [2]Massachusetts Institute of Technology, Cambridge, MA, Contact: vvdig@mit.edu

Owing to their inherently interpretable structure, decision trees are commonly used in applications where interpretability is essential. Recent work has focused on improving aspects of decision trees, including their predictive power and robustness; however, their instability has been addressed to a much lesser extent. We take a step towards the stabilization of decision tree models through the lens of real-world health care applications. We introduce a distance measure for decision trees and use it to determine a tree's level of stability. We propose a methodology to train stable decision trees and investigate the existence of trade-offs that are inherent to decision tree models — including between stability, predictive power, and interpretability. We demonstrate the value of the proposed methodology through six case studies from the health care space due to the relevance of stability and interpretability in this space, and show that, on average, a 4.6% decrease in predictive power can improve the model's stability by as much as 38%.

4 Video Prescriptions as Digital Therapy: An Augmented Intelligence Approach

Rema Padman[1], Xiao Liu[2], Anjana Susarla[3], [1]Carnegie Mellon University, Pittsburgh, PA, [2]Arizona State University, Tempe, AZ, [3]Michigan State University, Lansing, MI, Contact: rpadman@cmu.edu

Health literacy is a widely recognized challenge worldwide, with many adults lacking the requisite skills to engage successfully in their health management. Recent developments in digital therapeutic solutions offer an opportunity to apply systems thinking combined with AI, ML and NLP methods to synthesize the myriad components of a multi-pronged approach to improve societal health literacy at scale. This talk will highlight some of these developments, with a focus on digital platforms and algorithmic artifacts in the healthcare delivery setting, to disseminate authoritative and accurate content for educating and empowering patients and the public.

TB12

Osgood West

Emerging Topics in Healthcare and Personalized Medicine

General Session

Session Chair

Esmaeil Keyvanshokooh, Mays Business School, Texas A&M University, College Station, TX

1 The Effects of Senior Living Communities on Healthcare Utilization and Outcomes

Ann Bartel, Carri Chan, Minje Park, Fanyin Zheng, Columbia Business School, New York, NY, Contact: minje.park@columbia.edu

This research investigates the impact of senior living communities, specialized housing arrangements for the elderly, on healthcare utilization and outcomes of Medicare enrollees. With the growing aging population, the number of senior living communities is rapidly increasing in the United States. The study findings provide insights into the effect of senior living facilities on healthcare costs and patient outcomes. We also discuss policy implications that suggest the potential benefits of senior living communities in reducing Medicare expenditures.

2 Primary Care Continuity, Frequency and Regularity Associated with Reduced Medicare Spending: An Observational Study

Dilara Sonmez[1], George Weyer[2], Dan Adelman[1], [1]University of Chicago Booth School of Business, Chicago, IL, [2]University of Chicago Medicine, Chicago, IL, Contact: dsonmez@chicagobooth.edu.tr

Reducing Medicare expenditures is a key objective of Medicare's transition to value-based reimbursement models. Improving access primary care is seen as an important way to reduce expenditures yet less is known about the how primary care visits should be organized to maximize patient level savings. This retrospective cohort study aims to examine the relationship between outcomes (savings in Medicare expenditures, risk-adjusted number of emergency department visits, and risk-adjusted number of hospitalizations) and the primary care practice patterns (visit frequency, regularity, and continuity of care).

3 The Impact of Historical Workload on the Nurses' Perceived Workload

Jing Dong[1], Carri Chan[2], Yi Chen[3], [1]Columbia University, New York, NY, [2]Columbia Business School, New York, NY, [3]Hong Kong University of Science and Technology, Hong Kong, Hong Kong.

The unprecedented volume and acuity of COVID-19 patients in the past three years highlighted the valuable and skilled work that nurses provide round the clock in hospital inpatient care, especially in the intensive care units. Increased nursing workload has been linked to nurse burnout and patient safety concerns, necessitating targeted approaches to better-managing nursing workload. In this work, we take an empirical approach to understanding the effect of historical workload on nurses' perceived workload. Quantifying this temporal effect of nursing workload allows us to design patient-to-nurse assignment policies that achieve a more balanced workload and create a fairer and safer working environment.

4 Contextual Reinforcement Learning Under Safe Exploration with Application to Type 2 Diabetes

Esmaeil Keyvanshokooh[1], Junyu Cao[2], [1]Mays Business School, Texas A&M University, College Station, TX, [2]The University of Texas at Austin, Austin, TX, Contact: keyvan@tamu.edu

In this talk, I will present new model and algorithm based on multi-armed bandits and online learning theory with theoretical performance guarantees, and show their application for optimizing treatment selection for type 2 diabetes.

TB13

Osgood East

On Allocating, Scheduling, and Accessing Resources in Healthcare

General Session

Session Chair

Yue Hu, University of Chicago, Chicago, IL

1 The Spillover Effect of Suspending Non-Essential Surgery: Evidence from Kidney Transplantation

Guihua Wang[1], Minmin Zhang[2], Tinglong Dai[3], [1]The University of Texas at Dallas, RICHARDSON, TX, [2]The University of Texas at Dallas, Richardson, TX, [3]Johns Hopkins University, Baltimore, MD

In this paper, we estimate the potential spillover effect of suspending non-essential surgery on patient access to essential health services, using deceased-donor kidney transplantation as the clinical setting. Using a difference-in-

differences approach, we estimate a state-level suspension of non-essential surgery led to a 23.6% reduction in the transplant volume. Our mediation analysis shows 38.7% of the spillover effect can be attributable to the change in healthcare employment, indicating these suspensions caused hospitals to reduce the size of their workforces required for all procedures, which ultimately had a negative impact on access to essential procedures.

2 A Data-Driven Approach for Identifying Candidates for Xenotransplant Human Clinical Trials

Baris Ata[1], Robert A. Montgomery[2], Jesse D. Schold[3], Y. Naz Yetimoglu[1], [1]The University of Chicago, Chicago, IL, [2]NYU Langone Health, New York, NY, [3]University of Colorado Anschutz Medical Campus, Aurora, CO, Contact: yyetimog@chicagobooth.edu

Xenotransplantation offers a potential solution to the scarcity of deceased-donor kidneys. The successful investigational transplants of genetically engineered pig kidneys to brain-dead patients suggest that the first human clinical trials are near. We use a data-driven approach to identify viable candidates for the first human clinical trials. Our method can flag patients with high statistical accuracy and suggest viable candidates for the first human clinical trials. That is, the great majority of the flagged patients have lower life expectancy in our test data set under the status quo than with a xenotransplant. However, it has a relatively low capture rate, i.e., it doesn't flag every patient who is a viable candidate. This poses a challenge for the later stages of clinical trials. A bucketing approach for grouping patients alleviates this problem by identifying a larger fraction of viable candidates.

3 Multiobjective Optimization for Allocating Livers for Transplantation

Sommer Elizabeth Gentry[1], Michal Mankowski[2], [1]Grossman School of Medicine, New York University, New York, NY, [2]Grossman School of Medicine, New York University, New York, NY, Contact: sommer.gentry@nyulangone.org

Organ allocation is a complex system in which every factor prioritized affects how other factors are prioritized. The Organ Procurement and Transplantation Network is eliminating a hierarchical category-based priority system in favor of a weighted combination of multiple objectives; designing the weights by committee vote might fail to converge on an acceptable system. We can use simulation optimization to maximize the survival benefit of transplantation while ensuring equity by making transplant rates similar among populations that differ by race, gender, et cetera. Using simulation optimization, we explore alternative designs to choose an allocation score that, for example, could minimize waitlist deaths while assuring comparable transplant rates for relevant subgroups (e.g. by age, race, ABO blood type, urban/rural). Our findings are directly applicable to liver allocation policymaking, using an approach that optimizes outcomes and supports transparency, an ethical cornerstone in transplantation.

4 AI-Augmented Gatekeeping: Combining Human and Machine Intelligence in a Public Health Screening Program

Jiatao Ding[1], Michael Freeman[2], Tinglong Dai[3], [1]INSEAD, Singapore, Singapore; [2]INSEAD, Singapore, Singapore; [3]Johns Hopkins University, Baltimore, MD, Contact: jiatao.ding@insead.edu

Autonomous AI systems, primarily constructed using deep neural networks, are increasingly used in healthcare settings and have great potential to improve public health screening programs. This study examines the cost-accuracy tradeoffs that policymakers face when deciding whether and how to integrate autonomous AI into a national screening program. In addition to characterizing outcomes in a black-box setting, our research sheds light on how the clinical workflow of public screening programs can influence the design of autonomous AI systems.

TB14

Fitzgerald

Game Theory Applications

Contributed Session

Session Chair

Susan E. Martonosi, Harvey Mudd College, Claremont, CA

1 Production and Inventory Strategies Under Centralized Auction Scheme

Nani Zhou, Tong Wang, Guohua Wan, Shanghai Jiao Tong University, Shanghai, China. Contact: nanizhou@sjtu.edu.cn

The Chinese government conducts a centralized procurement auction scheme to reduce drug prices, but it leads to drug shortages resulting from the monopoly manufacturer. By modeling a manufacturer's value function under three production modes, we explore the structural properties of inventory strategies. The numerical results show that appropriate commitments must be combined with a not-too-low bidding price and a stronger penalty cost to effectively reduce social welfare loss. Our research is endorsed by

industry practitioners and draws valuable conclusions for the government that drug shortage problems should be carefully considered when designing the auction scheme.

2 Pharmaceutical Competition with Risk-Sharing: A Game-Theoretic Perspective

Soodabeh Asadi Dezaki[1], Salar Ghamat[2], Greg Zaric[1], [1]Ivey Business School, Western University, London, ON, Canada; [2]Lazaridis School of Business and Economics, Laurier University, Waterloo, ON, Canada. Contact: sasadidezaki@ivey.ca

We study the use of risk-sharing agreements by pharmaceutical companies to establish market share in an oligopolistic market. We analyze the competition between an incumbent drug manufacturer and a market entrant that may encroach the market using risk-sharing agreements to increase its market coverage. In response to the entry of the new drug the incumbent may also adjust its price or introduce risk-sharing agreements. We find that price reduction by the incumbent can be a better response by the incumbent when there is a cost associated with the implementation of a risk-sharing agreement.

3 Competitive Incentive Plans to Encouraging Greater use of Home Hemodialysis

Maryam Afzalabadi, Mojtaba Araghi, Salar Ghamat, Wilfrid Laurier University, Waterloo, ON, Canada. Contact: mafzalabadi@wlu.ca

Most patients with end-stage renal disease (ESRD) are in need of long-term dialysis, and their quality of life can be significantly improved by receiving home-based hemodialysis (HHD). In order to facilitate promoting the HHD rate, in this paper, we study a healthcare system consisting of a payer and healthcare providers. We introduce a target-based and a competitive-based incentive plans, obtain their equilibrium solution, and analyze the behavior of system equilibria in different settings.

4 International Vaccine Allocation: An Optimization Framework

Abraham Holleran, Susan E. Martonosi, Michael Veatch, Harvey Mudd College, Claremont, CA

Theglobal SARS-CoV-2 (COVID-19) pandemic highlighted the challenge of equitablevaccine distribution between high- and low-income countries. High-incomecountries, such as the United States, were among the first to acquire therapidly developed vaccines against COVID-19. However, many such high-incomecountries were reluctant or slow to distribute extra doses of the vaccine tolower-income countries via the COVID-19 Vaccines Global Access (COVAX)collaboration [Clinton and Yoo 2022]. In addition to moral objections to suchvaccine nationalism, vaccine inequity during a pandemic could contribute to theevolution of new variants of the virus and possibly increase total deaths,including in the high-income countries. This paper uses the COVID-19 pandemicas a case study to identify scenarios under which it might be in a high-incomenation's own interest to donate vaccine doses to another country before its ownpopulation has been fully vaccinated. Using an epidemiological model embeddedin an optimization framework, we identify realistic scenarios under which adonor country prefers to donate vaccines before distributing them locally inorder to minimize local deaths. We demonstrate that a nondonor-firstvaccination policy can, under some circumstances, dramatically delay theemergence of more-contagious variants. Moreover, we find that vaccinedistribution is not a zero-sum game between donor and nondonor countries:weighting the objective function even slightly in favor of minimizing totaldeaths can achieve dramatic reduction in total deaths with only a smallincrease in donor-country deaths. The insights yielded by this framework can beused to guide equitable vaccine distribution in future pandemics.

TB15

University

COVID-19 Economics & Supply Chain

Contributed Session

Session Chair

Emily Fainman, Texas State University, San Marcos, TX

1 The Effect of COVID-19 Pandemic on Productivity of the U.S. Healthcare Industry

Seungjae Shin, Mississippi State University, Meridian, MS

This study reviews the productivity of the U.S. healthcare industry (ambulatory services, hospitals, and nursing and residential care facilities) for the past 22 years (2000 ~ 2021). The year 2020 was known as the start of the Covid-19 pandemic. This study investigated the labor productivity values of the U.S. healthcare industry and try to find any difference between before the Covid-19 pandemic and during the Covid-19 period. This study also investigated how the Covid-19 pandemic impacted the total factor productivity of the U.S. healthcare industry by using a Cobb Douglas production function on annual financial statement data in the North American stock exchange market.

2 Maximizing Efficiency of Mass Vaccination Clinics

Amir Janmohamed, Talha Hussain, Scarborough Health Network, Toronto, ON, Canada.

Mass vaccination clinics were critical to fighting COVID. Scarborough Health Network designed and implemented a circular model for vaccination that at least doubled throughput per vaccinator relative to other large clinics in the Greater Toronto Area. It reduced wait times for the community with a just in time delivery system. The model is spatially compact, can be set up in a variety of community settings and is a modular concept that can be scaled up to larger spaces as needed. This logistical setup was recognized by the Ontario Vaccine Table as the most efficient model.

3 Delivering in the Times of Covid: A Population-Based Study of Childbirths in the U.S

Emily Fainman, Texas State University, San Marcos, TX, Contact: c_z88@txstate.edu

We aim to investigate the impacts of the COVID-19 pandemic on childbirth outcomes, maternal and newborn healthcare in the U.S. By identifying changes in childbirths and associated health services before and after the onset of COVID-19, we provide valuable managerial insights for healthcare administration and professionals to provide high-quality health care for mothers and infants. The problems exposed by this global epidemic and corresponding improvements will contribute to precautious planning in possible national or global health crises in the future.

4 The Use of Analytics in Planning and Management of COVID-19 Supply Chains and Operations

Shabnam Khamooshi[1], Talitha Hampton[2], Tom Davis[3], [1]Accenture, Seattle, WA, [2]Novavax, Gaithersburg, MD, [3]Accenture, Boston, MA, Contact: shabnam.khamooshi@accenture.com

The rapid spread of COVID-19 in early 2020 rallied vaccine manufacturers around the world to pursue a defense against the deadly virus. For Novavax, the development of their worthy vaccine candidate led to the unprecedented growth of its supply chain network and the complexity of managing operations. This presentation identifies key challenges Novavax faced in planning, production, and global distribution of their new vaccine. It highlights the practical use of optimization and analytics solutions to resolve the challenges and to enable data-driven decision-making during turbulent times.

TB16

Richmond

Healthcare Operations Management 1

Contributed Session

Session Chair

Noah Chicoine, Northeastern University, Boston, MA

1 Analyzing Ontario's Emergency Department Closures in 222

David Savage[1], Ray Jewett[1], Spencer Keene[2], Peash Saha[3], Robert Ohle[1], Bradley Jacobson[1], Salimur Choudhury[3], [1]NOSM University, Thunder Bay, ON, Canada; [2]Algoma University, Sault Ste. Marie, ON, Canada; [3]Queen's University, Kingston, ON, Canada. Contact: dsavage@nosm.ca

Emergency departments (ED) across Canada, primarily rural, have experienced an unprecedented number of closures since the onset of the COVID19 pandemic. Our aim was to describe the ED closures that occurred in 2022 and model the effect on rural populations accessing emergency care. A spatial graph was developed to represent Ontario's population centres and the EDs. The effect of historical closures were first assessed to determine the travel burden placed on local populations. We then used the graph to evaluate which EDs could be closed with minimal impact to local populations. In northern Ontario, populations are required to travel significant distances due to the low density of EDs.

2 Improving Clinical Trial Processes: How Blockchain Supports Pharmaceutical Process Management

Afrooz Moatari-Kazerouni, Alejandro Chicas, Widener University, Chester, PA, Contact: amoatarikazerouni@widener.edu

Blockchain technology offers a secure and immutable platform for managing clinical trial data, which enhances data validity and inspires greater trust in findings. This research proposes a blockchain platform that enables interaction throughout the entire value chain of pharmaceutical drug development. It maps out the clinical trial process and identifies stakeholder perspectives to ensure the platform meets their requirements and expectations. The proposed platform enhances integrity, trust, and transparency of the clinical trials, benefitting patients by giving them better-controlled access to their data, and researchers by helping them maintain adherence to reporting requirements.

3 Designing Optimal Health Insurance Plans

Alessandro Previero[1], Omid Nohadani[2], [1]Benefits Science Technology, Boston, MA, [2]Benefits Science Technology, Boston, MA

The escalating cost of US healthcare underscores the necessity for health insurance that provides affordable and comprehensive coverage. Additionally, insurer's financial projections are often exceeded by traditional plan designs, inducing inflated premiums. We propose a novel non-convex optimization framework for designing insurance plans that maximizes benefits for individuals while adhering to the insurer's financial constraints. Our method jointly optimizes all plans offered, and preserves the structural difference among them. Our real-world results show that our solution satisfies the budget within 2% and reduces expected employee costs by 15%.

4 Characteristics of Estimated Resupply Date Information in Disrupted Pharmaceutical Supply Chains

Noah Chicoine, Jacqueline Griffin, Northeastern University, Boston, MA, Contact: chicoine.n@northeastern.edu

During drug shortages, health center pharmacists rely on estimated resupply dates (ERDs) from pharmaceutical manufacturers to make critical inventory management and health practice decisions. ERDs, by nature, are uncertain and inaccurate, often causing healthcare workers to make costly operations changes that could otherwise be avoided. In a first step towards assisting health care workers with inventory management under uncertain ERD information, we present and analyze two years of ERD data from a US hospital to reveal useful insights for health center pharmacies and future modeling efforts.

Thursday, 2PM–3:30PM

TC01

Carmichael

Analytical Methods for Improving Treatment Decision-Making

General Session

Session Chair

David W. Hutton, University of Michigan, Ann Arbor, MI

1 Simulation-Based Sets of Similar-Performing Actions in Finite Markov Decision Process Models

Wesley Javier Marrero, Thayer School of Engineering at Dartmouth, Hanover, NH

Markov decision process (MDP) models have been used to obtain and evaluate the performance of policies in various domains, such as treatment planning in medical decision making. However, in practice, decision makers may prefer other alternatives that are not statistically different from the actions in their initial policy of interest. To allow for decision makers' expertise and provide flexibility in implementing policies, this talk introduces a framework for identifying sets of similar-performing actions in finite MDP models.

2 Data-Driven Phenotyping in Traumatic Brain Injury

Hayley Falk, University of Michigan, Ann Arbor, MI, Contact: falkh@med.umich.edu

Most patients evaluated for traumatic brain injury (TBI) in the emergency department (ED) have a Glasgow Coma Scale (GCS) score of 15, which is typically referred to as "mild" TBI (mTBI). The prevailing attitude among ED clinicians is that most patients with GCS 15 TBI will recover quickly without intervention. However, 50-60% of patients are incompletely recovered 6-months after injury. Early and accurate identification of GCS 15 TBI phenotypes at high risk for incomplete recovery is essential for optimizing post-injury care. However, this task is challenging due to the substantial heterogeneity that exists within GCS 15 TBI. Therefore, we developed an unsupervised machine learning framework which identified five GCS 15 TBI phenotypes characterized by distinct biomarker and injury profiles.

3 Challenges in Modeling New Medical Interventions: Cost-Effectiveness of New Follicular Lymphoma Treatments

David W. Hutton[1], Yasmin Karimi[2], Manisha Lin[3], [1]University of Michigan, Ann Arbor, MI, [2]University of Michigan, Ann Arbor, MI, [3]University of Michigan, Ann Arbor, MI, Contact: dwhutton@umich.edu

Modeling the potential impact of new medical interventions can be challenging. Follicular Lymphoma is a cancer of the lymph system that can be challenging to treat in patients with refractory or relapsed disease. Several new therapies, such as CAR-T therapy and monoclonal antibodies are promising, but also expensive. Because these are new therapies, they have limited long-term data. We present calibration approaches to help simulate long-term prognosis that is consistent with available clinical trial and observational data. We also present sensitivity analysis on cost-effectiveness outcomes of these various new therapies for treatment of refractory or relapsed follicular lymphoma.

4 Modeling Resource Needs for Screening and Specialty Care in the U.S. Veterans Healthcare System

Amy Cohn, University of Michigan, Ann Arbor, MI

The US VA is committed to ensuring access to healthcare for its veterans population. This includes screening for diseases such as lung cancer and specialty care for conditions such as chronic liver disease. Both screening and specialty care require expensive and constrained resources. We present OR techniques for ensuring the efficient use of these resources.

TC02

Jackson

Steering Healthcare Decisions through Uncertainty

General Session

Session Chair

Hadi El-Amine, George Mason University, Fairfax, VA

1 Planning a Personalized Community Health Worker Intervention for Diabetes Care in Low- and Middle-Income Countries

Katherine B. Adams, University of Wisconsin-Madison, Madison, WI, Contact: kbadams@wisc.edu

Diabetes is a global health priority that disproportionately affects low- and middle-income countries (LMICs). In addition to being home to almost 90% of people with undiagnosed diabetes, it is estimated that fewer than 10% of people with diabetes in LMICs receive guideline-based diabetes treatment. Several studies have demonstrated the feasibility of using Community Health Worker (CHW) programs to provide affordable and culturally tailored solutions for early detection and management of diabetes. We propose an optimization framework to personalize CHW visits to maximize glycemic control at a community-level. We present structural and computation results using real data from India.

2 Robust Screening Policies in a Pandemic

Marwan Shams Eddin[1], Hadi El-Amine[2], Hrayer Aprahamian[3], [1]George Mason University, Fairfax, VA, [2]George Mason University, Fairfax, VA, [3]Texas A&M University, College Station, TX, Contact: helamine@gmu.edu

Emerging pandemics cause severe strains on the healthcare and economic systems. In this paper, we introduce a screening and quarantine intervention to control the disease progression. We account for testing mis-classification errors and address the dependency between the disease prevalence and screening strategies. We consider uncertainty in the disease dynamics that is dictated by societal interactions, infectivity rates, and the prevalence of the disease. To model the uncertainty we consider a stochastic and robust based approaches, in which for each, we develop a Markov-decision process formulation. We exploit the underlying structure of the problem to derive exact policies and improve computational time. To demonstrate the benefits of our framework, we consider a case study in which we simulate a pandemic in the average case and in antagonistic environments. Our results quantify the impact of early testing interventions on healthcare system costs.

3 ChatGPT's Role in Healthcare: What Twitter Tells Us About Public Sentiment

Patrick Baxter, Meng-Hao Li, Naoru Koizumi, Jiaxin Wei, George Mason University, Arlington, VA, Contact: pbaxter2@gmu.edu

Public discourse has hotly centered around ChatGPT's appropriate societal role since its inception late last year. Ostensibly missing from the literature is an examination of the nature of such public debates. This research aims to fill this gap for the healthcare industry by utilizing tweets on the subject since ChatGPT was launched. We cluster tweets on the subject into seven topics using the Latent Dirichlet Allocation (LDA) method. The results find that positive and neutral sentiments dominate discussions related to healthcare and ChatGPT on Twitter.

4 The Optimal Testing Sequence Problem for Living Kidney Donor Workup

Joshua Nielsen[1], Hadi El-Amine[2], Monica Gentili[1], Naoru Koizumi[3], [1]University of Louisville, Louisville, KY, [2]George Mason University, Fairfax, VA, [3]George Mason University, Arlington, VA, Contact: monica.gentili@louisville.edu

The Sequential Testing Problem (STP) seeks to minimize the total expected cost of administering a series of tests which determine the quality of a system. Motivated by the process of evaluating living kidney donors, we explore a variant of the STP which assumes that the probability of passing a given test is conditional upon passing the preceding test. We present an optimization model to solve the problem to optimality and greedy-based heuristics to approximate the solution.

TC03

Varley

Incentives in Healthcare

General Session

Session Chair
Sait Tunc, Virginia Tech, Blacksburg, VA

Session Chair
Marie Jeanne Rabil, Virginia Tech, Blacksburg, VA

1 Optimal Integration of Screening Strategies and Incentive Mechanisms for the Effective Mitigation of COVID-19

Marie Jeanne Rabil[1], Sait Tunc[1], Douglas R. Bish[2], Ebru Korular Bish[2], [1]Virginia Tech, Blacksburg, VA, [2]University of Alabama, Tuscaloosa, AL, Contact: mariejeanne@vt.edu

Integrating protective and preventative interventions including screening and vaccination is essential for managing infectious disease outbreaks, as COVID-19 demonstrates. Although the vaccination resources became abundant in the later stages of the pandemic, not all universities (or other closed communities) can mandate vaccination, let alone require individuals to report their vaccination status, thus it is important to create mechanisms that will increase voluntary compliance. We propose a novel approach to infection control on university campuses, and study strategies that integrate routine screening and nudge mechanisms (e.g., monetary incentive, or exemption from routine screening, for all vaccinated individuals) under limited resources, considering behavioral issues (e.g., utility for the monetary incentive, disutility towards vaccination or routine screening) of the campus population and an imperfect information on vaccination status.

2 Analysis of Compensation Contracts for Providers in Clinical Studies

Xueze Song[1], Mili Mehrotra[1], Tharanga Rajapakshe[2], [1]Universityof Illinois-Urbana-Champaign, Champaign, IL, [2]University of Florida, Gainesville, FL, Contact: xuezes2@illinois.edu

Participant retention is a significant challenge faced by clinical studies. In this work, we consider how the sponsor of a clinical study can motivate investigators and coordinators to improve participant retention for the study. We identify three different clinical study settings observed in practice and derive the optimal compensation contracts.

3 Improving Family Authorizations for Organ Donation via Budget-Neutral Contracts

Paola Martin[1], Diwakar Gupta[2], [1]Indiana University, Bloomington, IN, [2]University of Texas, Austin, TX, Contact: martipa@iu.edu

The successful recovery of deceased-donor organs depends on whether the donor hospital (DH) referred on time. Whereas Organ Procurement Organizations (OPOs) receive a standard fee for each transplanted organ, DHs do not receive compensation for referring in a timely manner. We analyze a budget-neutral incentive scheme that could increase the proportion of timely referrals. A calibrated numerical study shows that, depending on the DH's cost of effort required to increase the proportion of timely referrals, the proposed contract could lead to 1.3% more viable donors annually. Extending the same approach to all referrals received by the OPO could increase the number of viable donors by 9% annually.

TC09

Johnston

Radiotherapy Treatment Planning II

General Session

Session Chair
Houra Mahmoudzadeh, University of Waterloo, Waterloo, ON, Canada.

Session Chair
Arkajyoti Roy, The University of Texas at San Antonio, San Antonio, TX

1 A Two-Stage Column Generation Approach for Direct Aperture Optimization in IMRT

Amirhossein Vaeztehrani[1], Houra Mahmoudzadeh[2], [1]university of Waterloo, Waterloo, ON, Canada; [2]University of Waterloo, Waterloo, ON, Canada.

Intensity-modulated radiation therapy (IMRT) is a common treatment modality for cancer where radiation beams are planned over multiple angles that overlap on a cancerous region. Direct Aperture Optimization (DAO) deals with a complex Mixed-Integer Programming (MIP) problem that optimizes the shapes and intensities of apertures. Due to the complexity of this problem, column generation is used to solve the DAO problem tractably. However, a challenge with the column generation approach is that it can generate a large number of apertures, which result in clinically unacceptable treatment times. In this talk, we propose a two-stage approach in which we first optimize the aperture shapes and intensities, and in the second stage, we use a cut generation approach to limit the number of apertures. Our results demonstrate that the proposed approach limits the number of apertures generated while addressing the computational complexity of solving the large-scale DAO problem.

2 Evaluating Sampling Approaches in Radiation Therapy Treatment Planning

William Kwong, Danielle Ripsman, Houra Mahmoudzadeh, University of Waterloo, Waterloo, ON, Canada. Contact: w5kwong@uwaterloo.ca

The development of intensity-modulated radiotherapy (IMRT) plans is a computationally intensive process. In order to reduce the complexity of the process, the input data is often down-sampled prior to performing large-scale computations. While various sampling methods are frequently used, both clinically and in the literature, it is unclear which methods yield the highest quality results. In this talk, we compare different sampling methods against each other with the help of a custom MATLAB interface, designed to automate performance evaluation. We will touch on the inputs, outputs, and design of the interface, as well as demonstrating the evaluation process across 4 downsampling methods.

3 A Column Generation Algorithm for Approximating the Pareto Front in Direct Aperture Optimization

Mehdi Mahnam[1], Edwin Romeijn[2], Michel Gendreau[3], [1]Isfahan University of Technology, Isfahan, Iran, Islamic Republic of; [2]Georgia Institute of Technology, Atlanta, GA, [3]Polytechnique Montreal, Montreal, QC, Canada. Contact: m.mahnam@iut.ac.ir

This study addresses multi-objective direct aperture optimization, a radiation therapy treatment planning technique that simultaneously designs beam shapes and their corresponding intensities. We propose a Pareto-based column generation algorithm to obtain a set of non-dominated treatment plans that balance treating the tumor and sparing surrounding healthy tissues. We also develop a lower bound to assess the Pareto front approximation. The results in a bi-objective space for two prostate and head-and-neck cases demonstrate that our algorithm achieves an appropriate approximation of the Pareto frontier with a minimal number of apertures.

TC10

Casson

Innovations in Healthcare Delivery

General Session

Session Chair

qixuan Zhao, [1</sup]

1 Triage in the Intensive Care Unit

Franziska B. Metz, University of Twente, Enschede, Netherlands. Contact: f.b.metz@utwente.nl

During the pandemic, shortages of ICU resources occurred repeatedly. Especially intensive care bed are in short supply when more patients need an intensive care bed than there are ICU-beds available. Triage algorithms can be used to decide, which patient receives the bed and which does not. There are different algorithms and policies: non-score-based and score-based policies such as the Simplified Acute Physiology Score. Furthermore, a distinction can be made between ex-ante and ex-post triage policies. Using data from German ICUs, these algorithms can be compared and analyzed. Moreover, the data is used to develop new ideas related to ICU-triage. The goal of ICU-triage is maximizing the number of surviving ICU patients. In addition to presenting different policies and approaches, the focus will be on post-COVID-19. Ideas and answers will be provided to questions such as: What can be learned from situations from recent years and how can triage give physicians guidance in decision making.

2 Hospital Discharge Planning; Prediction of Time and Next Destination of ALC Patients

Mahsa Pahlevani[1], Majid Taghavi[2], Peter Vanberkel[3], [1]Dalhousie University, Halifax, NS, Canada; [2]Saint Mary's University, Halifax, NS, Canada; [3]Dahousie University, Halifax, NS, Canada.

Improved medical treatments for chronic conditions have allowed people to live longer, often accompanied by requiring an Alternate level of care (ALC). Since structured discharge planning can reduce hospital length of stay (LOS) and readmission rates while also enhancing patient satisfaction, this study seeks to utilize multiple Machine Learning (ML) algorithms to identify the most significant characteristics associated with patients requiring ALC. Also, it develops highly accurate prediction models that forecast the likelihood that an incoming patient will need ALC, the LOS, and the discharge destination of patients.

3 Modelling Acute Ischemic Stroke Treatment Process in a Single Center

Gizem Koca[1], Gordon Gubitz[2,3], John Blake[1], Noreen Kamal[1], [1]Dalhousie University, Halifax, NS, Canada; [2]Dalhousie University, Halifax, NS, Canada; [3]Nova Scotia Health, Halifax, NS, Canada. Contact: gkoca@dal.ca

Stroke is a devastating disease that can result in severe disability. Early treatment with intravenous thrombolysis and/or mechanical thrombectomy can be provided to eligible patients, alone or in combination, in a time-dependent manner. This study examines the many steps involved in the acute stroke treatment process in a single hospital and aims to identify strategies that will shorten treatment times. A Monte-Carlo simulation was developed to illustrate

the treatment process and the impact of changes. The model uses the processes and data from a time study conducted at the hospital.

4 A Nurse-to-Patient Assignment Problem with Stochastic Demand and Stochastic Skill Requirements

Dai N. Nguyen[1], Nadia Lahrichi[2], Chunlong Yu[3], [1]Université de Montréal, Montréal, QC, Canada; [2]Polytechnique Montréal, Montréal, QC, Canada; [3]Tongji University, Shanghai, China. Contact: dai.nguyen@umontreal.ca

In Home Health Care operations, assigning nurses to patients is a critical task that impacts the service quality and operational costs. Recent studies start to consider the uncertainties in patients' demand, but seldom take into account the fact that patients' conditions may change and require different services. To this end, we consider the uncertainties in both patients' demand and skill requirements, and propose several policies to minimize the nurse overtime cost and re-assignment penalty. The efficiency of the policies and the impact of the problem characteristic are evaluated through extensive computational experiments.

5 Machine Learning-Based Categorization Models for Surge Level in Emergency Medical Services

Qixuan Zhao[1], Peter Vanberkel[2], [1]Dalhosuie University, Halifax, NS, Canada; [2]Dahousie University, Halifax, NS, Canada. Contact: qixuan.zhao@dal.ca

This study proposes a machine learning and simulation-based approach for categorizing surge levels in Emergency Medical Services. Instead of using traditional performance metrics, this study will use simulation to evaluate the machine learning-based categorization models. Particularly, simulation's responses to different interventions based on different surge levels categorization are used to evaluate the machine learning models.

TC11

Tom Thomson

ML/OR in Healthcare: Bridging Research and Practice

Panel Session

Session Chair
Michael Lingzhi Li, Harvard Business School, Boston, MA

Moderator
Michael Lingzhi Li, Harvard Business School, Boston, MA

Panelist
Margaret L. Brandeau, Stanford University, Stanford, CA

Panelist
Russ Greiner, University of Alberta, Edmonton, AB, Canada.

Panelist
Steven Shechter, University of British Columbia, Vancouver, BC, Canada.

Panelist
Mehmet U.S. Ayvaci, The University of Texas at Dallas, Richardson, TX

TC12

Osgood West

Data-driven Healthcare Delivery

General Session

Session Chair
Jong Myeong Lim, Tuck School of Business at Dartmouth

1 Optimizing Initial Screening for Colorectal Cancer Detection with Adherence Behavior

Sarah Yini Gao, Yan He, Zhichao Zheng, Ruijie Zhang, Singapore Management University, Singapore, Singapore. Contact: yngao@smu.edu.sg

Two-stage screening programs are widely adopted for early colorectal cancer (CRC) detection. Individuals receiving positive outcomes in the first-stage (initial) test are recommended to undergo a second-stage test (colonoscopy) for further diagnosis. We study the initial test design—i.e., selecting cutoffs to report test outcomes—to balance the trade-off between screening effectiveness (i.e., cancer and polyps detection) and efficiency (i.e., colonoscopy costs), considering that not all individuals adhere to the guidelines to follow up with a colonoscopy after receiving positive outcomes. We integrate the Bayesian persuasion framework with information avoidance to model the problem. We apply the framework to Singapore's CRC screening design and calibrate the model using data from a nationwide survey in Singapore. Our results suggest that compared with the current practice, the optimal cutoff we propose can detect 20.83% more CRC and polyps incidences and prevent 26.97% colonoscopies.

2 What Drives Algorithm Use? An Empirical Analysis of Algorithm use in Type 1 Diabetes Self-Management

Wilson Lin[1], Song-Hee Kim[2], Jordan D. Tong[3], [1]Santa Clara University, Santa Clara, CA, [2]Seoul National University, Gwanak-gu, Korea, Republic of; [3]University of Wisconsin Madison, Madison, WI

Advancements in algorithms hold promise to better operations by improving users' decision-making. However, people sometimes fail to use algorithms, which could be a barrier from achieving such improvements. Using the bolus calculator (algorithm) use behavior from a field experiment on type 1 diabetes self-management, we show that 1) previous algorithm use increases future algorithm use, 2) being out of target with self-driven decisions increases subsequent algorithm use, while being out of target with algorithm-driven decisions does not impact algorithm use, 3) increasing the number of measurements provided to the user for a single algorithm input decreases algorithm use, 4) increasing one's need for precision increases algorithm use and 5) previous deviations from algorithm recommendations decrease future algorithm use.

3 ED Experiment in Displaying an Algorithmic Wait Time Prediction

Danqi Luo[1], Mohsen Bayati[2], Erica Plambeck[2], [1]UC San Diego, San Diego, CA, [2]Stanford University, Stanford, CA, Contact: d1luo@ucsd.edu

In a hospital that aims to have fewer patients leave the Emergency Department without being seen by a physician (LWBS), we field-tested two approaches for displaying an algorithmic prediction of low-acuity patients' wait time to see a physician. The first approach is the prediction rounded to a multiple of 10 minutes, and the second is an interval designed to communicate that the wait time could be even 20 minutes longer. Relative to the control with no wait time information, both approaches significantly reduce the likelihood of LWBS, with the interval approach being more effective. Improved waiting satisfaction, as indicated by our incentivized satisfaction survey of ED patients, and a higher anticipated wait time with the interval approach, indicated by our online experiment, may contribute to these effects. Consistent with prospect theory, we find that to the extent that patients' actual wait time exceeds the displayed wait time, they have higher likelihood to LWBS.

TC13

Osgood East

Responsible Scheduling in Health Care

General Session

Session Chair

Hummy Song, The Wharton School, University of Pennsylvania, Philadelphia, PA

1 The Impact of Online Self-Scheduling on Patient Access to Hospital Services

Lesley Meng[1], Hummy Song[2], Christian Terwiesch[3], [1]Yale School of Management, Yale University, New Haven, CT, [2]The Wharton School, University of Pennsylvania, Philadelphia, PA, [3]University of Pennsylvania, Philadelphia, PA, Contact: lesley.meng@yale.edu

Recent innovation in healthcare access has led to the launch of online patient platforms where patients are now able to digitally schedule and manage their own medical appointments within a health system. In many large academic medical centers, digital scheduling has become the default method for patients to request and schedule appointments, and many medical appointments are now made this way. In this study, we examine the impact of online self-scheduling access on patient scheduling and visit behavior at a large academic medical center.

2 Redesigning Shift Work to Incorporate Heterogeneous Worker Preferences

Harriet Jeon[1], Song-Hee Kim[2], Hummy Song[1], Kyeongsug Kim[3], Sangwoon Cho[3], Jeong Hee Hong[3], [1]The Wharton School, University of Pennsylvania, Philadelphia, PA, [2]Seoul National University, Gwanak-gu, Korea, Republic of; [3]Samsung Medical Center, Seoul, Korea, Republic of. Contact: hyjeon@wharton.upenn.edu

Shifts are the dominant way to work in many contexts requiring 24/7 coverage, including call centers, police departments, and hospitals. While the detriments of shift work are well-documented both at the individual and organizational levels, its deployment is often unavoidable given round-the-clock staffing needs. We explore a potential organizational lever—incorporating heterogeneous preferences over shift design—to mitigate ramifications of shift work in the context of acute care bedside nurses. Using survey, administrative, and shift data, we examine whether and the extent to which individual choice over dimensions of their shifts mitigates the impact of shift work on work (dis) satisfaction and turnover of nurses.

3 Improving Human Decision-Making with Machine Learning

Hamsa Sridhar Bastani[1], Osbert Bastani[2], Park Sinchaisri[3], [1]Wharton School, Philadelphia, PA, [2]University of Pennsylvania, Shenzhen, China; [3]University of California,

Berkeley, Berkeley, CA
Workers spend a significant amount of time learning how to make good decisions. Evaluating the efficacy of a given decision, however, is quite complicated as decision outcomes are often long-term and relate to the original decision in complex ways. We propose a novel machine-learning algorithm for extracting "best practices" from trace data and inferring interpretable tips that can help workers improve their performance in sequential decision-making tasks. To validate our approach, we design a virtual scheduling game in which participants learn to minimize service time. Our experiments show that the tips generated by our algorithm are effective at improving performance, significantly outperform tips generated by human experts and a baseline algorithm, and successfully help participants build on their own experience to discover additional strategies.

4 'I Quit': Schedule Volatility as a Driver of Voluntary Employee Turnover

Alon Bergman[1], Guy David[2], Hummy Song[2], [1]University of Pennsylvania, Wynnewood, PA, [2]The Wharton School, University of Pennsylvania, Philadelphia, PA, Contact: hummy@wharton.upenn.edu
We examine how employer-driven volatility in workers' schedules impacts their decision to voluntarily leave their job. Using time-stamped work log data of home health nurses, we construct and study an operational measure of schedule volatility. Using an instrumental variables approach, we find that higher levels of schedule volatility substantially increase workers' likelihood of quitting. Using policy simulations, we illustrate how schedule volatility, and employee turnover, could be mitigated.

TC14

Fitzgerald
Personalized Medicine
Contributed Session

Session Chair

Sunil Erevelles, UNC Charlotte, Charlotte, NC

1 The Impact of Practicality on the Effectiveness and Efficiency of Lung Cancer Screening Programs

Mehdi Hemmati[1,2], Andrew J. Schaefer[1], Iakovos Toumazis[2], [1]Rice University, Houston, TX, [2]The University of Texas MD Anderson Cancer Center, Houston, TX, Contact: itoumazis@mdanderson.org
Existing annual lung cancer screening recommendations fall short in ensuring the effectiveness of the screening program and are not optimal. In this study, we assessed the effectiveness and efficiency of alternative screening policies with fixed, predetermined screening frequencies and compare their performance against the optimal screening schedules obtained from the ENGAGE framework - a partially observable Markov decision process (POMDP) model. We found that screenings with predetermined frequencies may achieve reasonable levels of either effectiveness or efficiency but not both and quantified how much benefit we sacrifice to achieve practicality.

2 Real-Time Counting of Wheezing Events Using Deep Learning: Implications for Early Intervention

Dohyeong Kim[1], SungChul Seo[2], [1]University of Texas at Dallas, Richardson, TX, [2]Seokyeong University, Seoul, Korea, Republic of. Contact: dohyeong.kim@utdallas.edu
A long-term pattern and frequency of abnormal lung sounds must be monitored and analyzed based on real-time data collection and an automated classification algorithm. We used relatively long labeled breathing data to develop a real-time event counting algorithm based on a one-dimensional convolutional neural network and a long short-term memory network model. This counting algorithm determines the respiratory unit, classifies three breathing statuses (break, normal and wheezing) within the unit and records the frequency and pattern of abnormal sound. This real-time wheeze counter could upgrade existing studies that aim to predict lung diseases based on long-term breathing patterns.

3 Reliable Insight into Small Study Data by Means of Constrained Confidence Partioning

Andreas Brieden, UniBW Muenchen, Neubiberg, Germany. Contact: andreas.brieden@unibw.de
When analyzing data on the efficacy of new drugs, logistic regression often yields highly significant predictors, even when overall model goodness tends to be below average. Evaluation of the model on new data is then sometimes even worse, especially when study cohorts are small. The reliability of the analysis can usually be improved even for small study sizes using constrained confidence partitioning. In this paper, the method is exemplarily presented in the context of the analysis of data from a European study with almost 200 schizophrenic patients. The models obtained for this study are validated in a second step by means of the results of a comparable Canadian study with about 150 patients.

4 Contemporary and Genomic Healthcare Blockchain Marketplaces

SUNIL EREVELLES[1], Anthony Erevelles[2], Maanasi Bulusu[3], [1]University of North Carolina, Charlotte, Charlotte, NC, [2]GeneBlock, Charlotte, NC, [3]Carnegie-Mellon University, Pittsburgh, PA, Contact: sunil.erevelles@uncc.edu

A revolution is brewing in the healthcare marketplace. It is driven by the blockchain, representing a seminal paradigm shift, likely to fundamentally transform healthcare. The World Wide Web was designed for *sharing information,* while the blockchain is focused on *sharing value.* Healthcare faces major challenges in *trust, security*, *privacy*, *authenticity* and *transparency* in the years ahead. Blockchain is emerging as a key solution for overcoming these challenges. In this research, the authors propose a game-theoretic framework for contemporary and genomic healthcare blockchains, and present an initial theoretical framework and a model for a blockchain-centric healthcare marketplace.

TC15

University

COVID-19 Disease Modeling

Contributed Session

Session Chair

Fatemeh Navazi, DeGroote School of Business, McMaster University, Toronto, ON, Canada.

1 Adapting DRDC COVID-19 Prevalence Tools to Other Respiratory Illnesses

Pierre-Luc Drouin, Steve Guillouzic, Gregory Hunter, Matthew R. MacLeod, Defence Research and Development Canada - Centre for Operational Research and Analysis, Ottawa, ON, Canada. Contact: steve.guillouzic@forces.gc.ca

In 2020, Defence Research and Development Canada developed a suite of online decision-support tools to help the Canadian Armed Forces mitigate the risk of coronavirus disease 2019 (COVID-19) outbreaks. These tools were underpinned by a COVID-19 prevalence model that leveraged case data published openly by public health agencies. This presentation will discuss how we integrated the test positivity-based method of Chiu and Ndeffo-Mbah in response to the reduction in testing and reporting that followed the Omicron wave in early 2022. It will also examine how the tools are being adapted to report on other respiratory illnesses, such as influenza.

2 Estimating SARS-CoV-2 Infection Under-Reporting in Canadian Jurisdictions

Matthew R. MacLeod, Defence Research and Development Canada, Ottawa, ON, Canada. Contact: Matthew.MacLeod3@forces.gc.ca

The Canadian Armed Forces (CAF) is both the employer and healthcare provider for members across Canada. Throughout the COVID-19 pandemic, operational research scientists have provided estimates of SARS-CoV-2 infection to inform risk assessments for operationally critical activities. This presentation will discuss challenges of estimating under-reporting of infections across the country and its impact on CAF models. Estimating the level of under-reporting based on test positivity will be compared to estimates based on serology data collected by provincial authorities and Canadian Blood Services.

3 A Stochastic Model to Evaluate the Spread of COVID-19 in Various Environments

Pierre-Luc Drouin[1], Lynne Serré[1], Katerina Biron[2], [1]Defence Research and Development Canada -- Centre for Operational Research and Analysis, Ottawa, ON, Canada; [2]Defence Research and Development Canada -- Ottawa Research Centre, Ottawa, ON, Canada. Contact: Pierre-Luc.Drouin@ecn.forces.gc.ca

An epidemiological model suitable for applications to Canadian Armed Forces scenarios is presented. The model is based on an existing branching process that allowed for an analytical representation of the average number of infections caused by each infectious individual (the reproduction number). The presented model expands on the early model by incorporating mitigation strategies such as isolation at symptom onset, contact tracing and vaccination. It also adapted it into a full epidemiological model that applies to finite populations and permits the evaluation of disease progression in time.

4 Modeling COVID-19 Transmission with Dynamic Mode Decomposition

Noah Bridges, Andrés D. González, Talayeh Razzaghi, Charles D. Nicholson, University of Oklahoma, Norman, OK, Contact: noah.g.bridges-1@ou.edu

We propose the use of Dynamic Mode Decomposition, a data-driven, equation-free method, to identify distinct phases of disease transmission (where functional dynamics remain constant), geographic correlations within these phases, and the time-dynamic behavior associated with these phases. We develop an algorithmic approach to identify shifts in the functional dynamics to effectively model observed behavior both in the past and in real time. Finally, we explore how these insights can be leveraged to guide epidemic mitigation strategies and enhance the efficacy of traditional epidemiological modeling approaches.

5 Developing an Evidence-Based Decision Support System for Pandemic Control Policy Making: COVID-19 Case Study

Fatemeh Navazi, Yufei Yuan, Norm Archer, DeGroote School of Business, McMaster University, Hamilton, ON, Canada.

In this study, an evidence-based decision support system using a hybrid meta-heuristic-machine learning algorithm is developed to learn the patterns among Non-Pharmaceutical Interventions (NPIs) and Covid-19 reproduction rate and optimize NPI implementation levels. To do so, Covid-19 big data sets of Oxford University are analyzed for 11 populous European countries. Neural Networks forecasted the Covid-19 reproduction rate of about 80% with an acceptable mean absolute percentage error. Moreover, Particle Swarm Optimization (PSO) algorithm found the optimal level of NPIs for each country based on evidence minimizing the reproduction rate. Developed method is helpful for future pandemics.

TC16

Richmond

Healthcare Operations Management 2

Contributed Session

Session Chair

Dai Nguyen, Université de Montréal, Montréal, QC, Canada.

1 A Patient-Centered Purchasing of Physician Preferred Implants

Renato E. de Matta, University of Iowa, Iowa City, IA, Contact: renato-dematta@uiowa.edu

With implantable medical devices accounting for 40% to 60% of the cost of treatment, hospitals are looking for cost savings in their purchase of physician preferred implants. In conjunction with negotiating lower prices with medical device manufacturers, we show how a hospital could further lower its cost by cross training physicians to adopt each other's preferred devices. Using industry data, stochastic programming optimization solutions show improved patient outcomes and better patient satisfaction with stronger hospital financial performance and protection against demand uncertainty.

2 Peel Pack Planning Using Clustering and Decomposition Approach

Yixuan Wang[1], Satyaveer S. Chauhan[2], [1]Concordia Univerisity, Montreal, QC, Canada; [2]Concordia University, Montreal, QC, Canada.

In this study, we address the issue of excessive waste in surgical trays by proposing the implementation of custom peel packs. These peel packs could be in place of a new surgical tray. Our objective is to reduce waste by designing custom peel packs associated with multiple surgical procedures while ensuring that all the necessary instruments are available without opening a new main tray. We present one decomposition approach to finding the exact solution and a simplified fast approach based on clustering and mathematical programming to find the near-optimal solution in a fractional time compared to the exact approach. Numerical experiments demonstrate the performance of the presented approaches.

3 Integer Programming for Surgery Scheduling Under Uncertainty

Nicklas Klein, Robin Hauenstein, Nicola Travaglini, Norbert Trautmann, University of Bern, Bern, Switzerland. Contact: nicklas.klein@unibe.ch

Flexible operating rooms can be used for scheduled elective surgeries and randomly arriving emergency surgeries, both with uncertain durations. The scheduling problem we deal with consists of assigning given elective surgeries to operating rooms and determining their start times to minimize the sum of the room-assignment cost and the expected cost associated with delays or cancellations of surgeries and with idle- or overtime. We formulate this problem as a two-stage mixed-integer linear program; to tackle instances of realistic size and complexity, we propose a corresponding matheuristic.

4 Interpretable Prediction of Heart Attack Incidence Using Demographic Data

Amir Rastpour[1], Reidar Hagtvedt[2], Armann Ingolfsson[3], [1]Ontario Tech University, Oshawa, ON, Canada; [2]University of Alberta School of Business, Edmonton, AB, Canada; [3]University of Alberta, Edmonton, AB, Canada. Contact: amir.rastpour@ontariotechu.ca

The predicted time of travel from the onset of a heart attack until the patient is transferred to a treatment center is used to find the best location of treatment centers. We propose an Interpretable AI model to predict the number of heart attack patients in small geographical areas to provide useful estimates of travel times. Our model is based on Poisson and Negative Binomial regression models with a mean that is a linear function, without an intercept, of the population in a set of socioeconomic cohorts. Our model outperforms traditional count regression and neural network models.

5 Optimizing Home Health Care Services Through Integrated Districting and Nurse Allocation Under Stochastic Demand

Dai N. Nguyen[1], Nadia Lahrichi[2], María I. Restrepo[3], Soumen Atta[4], [1]Université de Montréal, Montréal, QC, Canada; [2]Polytechnique Montréal, Montréal, QC, Canada; [3]IMT Atlantique, Nantes, France; [4]Université de Montréal, Nova Gorica, Slovenia. Contact: dai.nguyen@umontreal.ca

This paper studies a joint districting and staffing problem in Home Health Care services, considering the demand uncertainty. The objective is to optimize the compactness and workload balance measures of both districts and nurses. The problem is formulated as a two-stage stochastic program, where the contiguity requirements are explicitly defined for both districts and territorial units assigned to nurses. To address the need for stability in districting for several years, the model includes the uncertainty in demand. The problem is analyzed in various settings encountered in practice. Extensive computational experiments are conducted to investigate the impact of problem characteristics.

Thursday, 3:30PM–4:15PM

POSTER01

Poster Session

Poster Session

1 Behaviour Quantification vis-a-vis Adoption of Public Policy Measures - Lessons from Non-pharmaceutical Measures during COVID-19 in Ontario

Rhiannon Loster, David Lyver, Sarah Smook, Lia Humphrey, Zahra Mohammadi, Edward Thommes, University of Guelph, Guelph, ON, Canada.

We provide a granular view of individual-level factors affecting COVID-19 disease transmission across Ontario, Canada in 2020. We estimate perceived risks of infection and personal discomfort (with non-pharmaceutical interventions (NPIs)) across 34 ON public health units. Using a time-dependent decision process (game), we estimate how average individuals in each PH region decide to minimize their risk and discomfort vis-a-vis NPI. With an ON SEIR model we show how these decisions intervened into the Covid-19 transmission process. Finally, we show model versatility, by applying it to other world regions.

2 Using Early Engagement Data from a Digital Health Solution to Predict Future Health Outcomes

Junjie Luo[1], Abhimanyu Kumbara[2], Anand Iyer[2], Mansur Shomali[2], Gordon Gao[1], [1]Johns Hopkins University, Baltimore, MD, [2]Welldoc Inc., Columbia, MD

Individual engagement is a critical element for a successful digital health solution (DHS). We examined real-world data from people with diabetes using a DHS, and we used glucose time in range (TIR) at 90 days as a health outcome. Continuous glucose data and DHS engagement data from a baseline period were used to predict the outcome variable. A LightGBM (gradient boosting) machine learning model predicted the outcome variable with 80% accuracy, with an AUC (area under curve) of 0.88. This highly accurate prediction model may support targeted and personalized care interventions in the future.

3 New Approaches to Identify Type 2 Diabetics in the Employer Sponsored Insurance (ESI) Space

Caitlyn Hall[1], Katherine Bobroske[2], Bea Capistrant[1], [1]JPMorgan Chase, Washington, DC, [2]Morgan Health, Cambridge, MA

Using standard Medicare definitions, many employers aim to identify members on their health plan with chronic conditions and connect them to appropriate resources to improve overall health. These definitions require longer eligibility requirements than most employers have on their employees due to attrition. However, many large employers have supplemental data to offset these claims-based limitations and increase the accuracy of condition prevalence estimation. Data from a large U.S. employer were analyzed to more comprehensively identify type 2 diabetics in the ESI space.

4 Investigation and Optimization of Mobile Health Data Collection to Inform Design of AI-driven Care Coordination for Adolescents with Epilepsy

Masoud Yeganegi[1], Jonathan Bidwell[2], Sharon Shu[3], Vinayak Ganeshan[3], Cam Escoffery[4], Elliana Kovitch[5], Cherise Fraizer[5], Sookyong Koh[5], Fawad Khan[1], Elizabeth D. Mynatt[6], [1]Ochsner Clinic Foundation, New Orleans, LA, [2]Ochsner Clinic Foundation, New Orleans, LA, [3]University of Queensland, New Orleans, LA, [4]Emory University, Atlanta, GA, [5]Children's Healthcare of Atlanta, Atlanta, GA, [6]Georgia Institute of Technology, Atlanta, GA, Contact: masoud.yeganegi@ochsner.org

This study examines AI-driven care coordination to optimize epilepsy management in adolescents using health data collection through mobile devices and evaluating long-term feasibility. 48 families participated in daily mobile surveys for 30 days. Random subsets received health-tracking devices and financial incentives. Data quality was assessed for consistency, reliability, and frequency. Reports agreed on seizure events but disagreed on medication intake and mood. Financial incentives didn't improve data quality. High-quality data is vital for AI-driven epilepsy management. Automated tracking and and AI assessment tools may benefit medication and mood reports.

5 Admitted Patients Without a Hemodialysis Center: Can They Be Safely Discharged?

Zulfi Husain[1], Rebecca Jaffe[2], [1]Thomas Jefferson University Hospitals, Philadelphia, PA, [2]Thomas Jefferson University Hospitals, Philadelphia, PA

Due to significant hemodialysis staffing and supply shortages complicated by the COVID-19 pandemic, availability of outpatient hemodialysis chairs is scarce. This results in long length of stay for patients awaiting chair assignment. A multidisciplinary team of clinicians and support staff mapped out a discharge process for HD patients with a coordinated pathway to facilitate HD via emergency department while waiting for in-center HD assignment. This program has efficiently provided dialysis through the ED with most patients preceding from intake to dialysis to discharge in under 12 hours. Thus far 50% of pathway patients have been assigned to community HD centers.

6 AutoML in Diabetes Diagnosis: Approaches, Efficacy, and Prospects

Lily Popova Zhuhadar, Aaron Wallace, Western Kentucky University, Bowling Green, KY, Contact: lily.popova.zhuhadar@wku.edu

AI advancements have led to innovative tools in healthcare, including using AutoML for diagnosing and managing diabetes. This research explores AutoML in diabetes predictive modeling, focusing on identifying risk factors and optimizing treatment plans. The goal is to refine the prediction model based on contributing factors. AutoML selected the best model, emphasizing key variables like glucose, BMI, Diabetes Pedigree Function, and blood pressure. While promising, it is vital to consider additional factors and data for improved model accuracy.

7 The Prevention and Care of Chronic Kidney Disease in Taiwan

Jia-Sin Liu, Kaohsiung medical university, Kaohsiung, Taiwan. Contact: sgazn.tw@gmail.com

Chronic kidney disease is a serious health condition that can progress to end-stage renal disease, which increases the risk of death and requires extensive medical resources for treatment such as dialysis or kidney transplantation. Taiwan has the highest incidence of end-stage renal disease in the world, but the prevalence of chronic kidney disease is not significantly higher than in other countries. While there is not enough evidence for Taiwan's unique factors in chronic kidney disease progression, Taiwan has implemented relevant care plans for the prevention and care of kidney disease based on existing theories.

8 Data-driven Robust Scheduling of Elective Patients

Nan Yang[1], Jingui Xie[1], Taozeng Zhu[2], [1]Technical University of Munich, Heilbronn, Germany; [2]Dongbei University of Finance and Economics, Dalian, China. Contact: nanyangemail@gmail.com

Hospital beds are important medical resources, and the scheduling of elective admissions by enforcing quotas could help to avoid bed shortages. However, the scheduling of elective admissions faces challenges mainly due to the uncertainty in the emergency admissions and the long stays. In this paper, we propose a robust satisficing approach to determine the quotas of elective admissions, which would best attain an acceptable admission target under extreme uncertainties without specifying uncertainty sets. The simulation tests based on MIMIC-IV dataset show that the robust satisficing model can withstand greater uncertainty compared to the existing robust optimization models.

9 Resource Utilization Prediction with Long-term Care Residents with Dementia: A Machine Learning Approach to Care Planning

Michael S. Dohan[1], Scott Magill[1], ShiKui Wu[1], Joshua J. Armstrong[2], [1]Lakehead University, Thunder Bay, ON, Canada; [2]Alzheimer Society of Canada, Toronto, ON, Canada. Contact: msdohan@lakeheadu.ca

This research seeks to predict resource utilization by long-term care residents with dementia, to aid long-term care in planning resources. Using RAI-MDS 2.0 data, Random Forest Classifier (RFC) predicted cognitive decline (AUC=0.62), Case Mix Index (CMI) Increase (AUC=0.63) and CMI Increase in residents with Dementia (AUC=0.7). Predictor variables include Body Mass Index, Physician Orders/Visits, Number of Medications and Ulcers. This level of prediction accuracy may not be practical in a clinical setting but is statistically significant and opens opportunities for further research.

10 Using Freedom of Information Laws to Collect and Analyze Data on COVID-19 in Marginalized Populations

Aparna Komarla, Covid In-Custody Project (www.covidincustody.org), Berkeley, CA, Contact: aparna.komarla@gmail.com

The lack of high-quality COVID-19 data creates gaps in public health leaders' decision-making and limits academic researchers' ability to model health outcomes. These limitations disproportionately affect marginalized groups, such as incarcerated populations. We leverage image recognition, web scraping and analytics to scrape COVID-19 data in public records obtained from law enforcement agencies, compile it into an accessible dataset, and make it available to the public. We show that the COVID-19 pandemic in California jails is a perfect example of the opportunity to bring technology and policy together in the public sector at a state and local level.

11 Investigating the Impact of Clinical Sentiment of Patients' Nursing Notes on Fall Risk Stratification by Mimicking Clinical Equipoise

Xiaolong Zuo[1], Jinxiang Tang[2], Haiyan Yu[1], [1]Chongqing University of Posts and Telecommunications, Chongqing, China; [2]Bishan Hospital Affiliated to Chongqing Medical University, Chongqing, China. Contact: yuhy@cqupt.edu.cn

Stratifying patients with high fall risks is an important alternative for tailoring of intervention based on assessment with nursing notes. However, the causal effects of the clinical sentiment of nursing notes on the fall risks of patients are still not well understood. Thus, we aimed to quantify its impact on fall risks from electronic health records (EHRs). The corpus data of the quasi-experiment was acquired from the nursing notes in the MIMIC IV dataset. Compared to the risk factors in the Morse fall scale, the clinical sentiment polarity takes a scale of 10 for predicting fall scales. We can employ the clinical sentiment analysis method to generate auto-encoding of the free-text nursing notes.

12 Reddit and Living Kidney Donation: User Classification Using Bert vs ChatGPT

Joshua Nielsen[1], LaShara Davis[2], Xiaoyu Chen[1], Amy Waterman[2], Monica Gentili[1], [1]University of Louisville, Louisville, KY, [2]Houston Methodist, Houston, TX, Contact: monica.gentili@louisville.edu

Many individuals who are supportive of living kidney donation (LKD) never become motivated to consider donating a kidney but might do so if they could be identified and exposed to educational campaigns. A dataset of 3,292 Reddit posts was coded by transplant experts based on recency and type of LKD post. We compared the multi-class classification performance between a Bidirectional Encoder Representations from Transformers (BERT) model and GPT-3.5-Turbo from OpenAI. We found that both approaches showed promising results, but struggled with nuances and ambiguities that lie in the boundaries among classes.

13 Drug Shortages Under Centralized Volume-based Procurement Contracts

Nani Zhou, Shanghai Jiao Tong University, Shanghai, China. Contact: nanizhou@163.com

The Chinese government proposes a centralized volume-based procurement contract to reduce drug prices, but it leads to drug shortages resulting from the monopoly manufacturer. By modeling the manufacturer's value function under different production modes, we explore the structural properties of inventory decisions. The numerical results show that appropriate commitments must be combined with not-too-low bid prices and stronger penalty costs to effectively reduce shortages. Our research is endorsed by industry practitioners and draws valuable conclusions for the government that shortage problems should be carefully considered when designing procurement contracts.

14 Joint Scheduling Of Automated External Defibrillators And First Responders With Coordination In Out-of-Hospital Cardiac Arrests

Kexin Cao[1], Xinglu Liu[1], Mingchuan Yang[2], Wai Kin (Victor) Chan[1], [1]Tsinghua University, Shenzhen, China; [2]Tsinghua University, Shenzhen, China. Contact: kexincao5@gmail.com

A one-minute delay in the treatment of out-of-hospital cardiac arrest (OHCA) reduces a patient's chance of survival by 10%, making the treatment extremely time-sensitive. However, timely real-time access to automated external defibrillators (AED) remains a challenge. This research focuses on the joint scheduling problem of AEDs and first responders for AED delivery. To guarantee a very short time limit, this research considers the coordination between multiple-type first responders and some other detailed factors. A mixed integer programming model is constructed for this problem and is solved by Gurobi. The experimental results reveal that a significant decrease in response time is achieved.

15 A Qualitative Dual-site Analysis Of The Pharmacist Discharge Care (PHARM-DC) Study

Onyeche Oche[1], Logan Murry[1], Michelle Keller[2,3,4], Joshua Pevnick[2,3], Jeffrey Schnipper[5,6], Korey Kennelty[1,7], [1]University of Iowa, Iowa City, IA, [2]Division of General Internal Medicine, Department of Medicine, Cedars-Sinai Medical Center, Los Angeles, CA, [3]Division of Informatics,

Department of Biomedical Sciences, Cedars-Sinai Medical Center, Los Angeles, CA, [4]Department of Health Policy and Management, UCLA Fielding School of Public Health, Los Angeles, CA, [5]Brigham Health Hospital Medicine Unit, Division of General Internal Medicine and Primary Care, Brigham and Women's Hospital, Boston, MA, [6]Harvard Medical School, Boston, MA, [7]The University of Iowa College of Medicine, Department of Family Medicine, Iowa City, IA, Contact: onyeche-oche@uiowa.edu

The PHARMacist Discharge Care (PHARM-DC) intervention is a pharmacist-led Transitions of Care (TOC) program intended to reduce 30-day hospital readmissions and emergency department visits. Focus groups and interviews were employed to explore the perspectives of healthcare providers and administrators on the intervention, and to identify factors contributing to intervention success and sustainability. Four themes were identified, including, Organizational, Pharmacist, and Patient Factors Contributing to TOC, Medication Challenges in TOC at Admission and Discharge, TOC Communication and Discharge Follow-up, and Opportunities for Improvement and Sustainability.

16 Implementing Predictive And Deep Learning Models For Rare Disease Detection

Ashish Gupta, Auburn University, Auburn, AL, Contact: azg0074@auburn.edu

Diagnosing atypical pathogen-induced sepsis and other rare infectious diseases is a complex and challenging problem. A-priori Identification of features using machine learning (ML) can facilitate improved outcomes and resource utilization. This study utilizes electronic medical records (EMRs) to predict rare, atypical infections. Models are built using various linear and non-linear ML techniques and evaluated based on performance metrics. Findings demonstrate the application of interpretable and best prediction models for rare disease identification using Shapley values.

17 Genomics Big Data And Blockchains: Cultivated Participant Pools

Sunil Erevelles[1], Erin Erevelles[2], Rita Winborne[1], [1]UNC Charlotte, Charlotte, NC, [2]GeneBlock, Charlotte, NC, Contact: sunil.erevelles@uncc.edu

Non-linear research, especially those encompassing more than one non-linear topic, such as "Genomic Big Data" and "Blockchain Marketplaces" are difficult to research, because participant pools with expertise on both non-linear, novel subjects are difficult to find. The authors suggest a new methodological procedure, called "The Cultivated Pool Methodology" that could solve this problem. This methodology has five steps. In addition to solving the expertise problem, the methodology also could result in an exponential growth of expertise in the participant pool.

Thursday, 4:30PM–6PM

TD01

Carmichael

Healthcare Contracts

General Session

Session Chair

Hessam Bavafa, Wisconsin School of Business, Madison, WI

1 NHS Advice & Guidance: A Game Theoretical Consideration

Zidong Liu, Feryal Erhun, Houyuan Jiang, University of Cambridge, Cambridge, United Kingdom. Contact: zl424@jbs.cam.ac.uk

In the UK, general practitioners (GPs) are the primary point of contact for medical treatment, and specialist care usually require a GP referral. In recent years, the growing demand of secondary care resources has placed increased pressure on gatekeeping functions. To address this, the Advice & Guidance (A&G) service has been introduced as an optional and additional telemedicine gatekeeper, while the regulation and payment of this service remain unclear. Our study evaluates the system's performance under different contractual and regulatory arrangements and proposes a contract design to maximize the A&G's potential in reducing inefficiencies.

2 The "Netflix Model": A New Payment Model for Asymptomatic Disease Management

Zhaowei She[1], Yueran Zhuo[2], Turgay Ayer[3], Jagpreet Chhatwal[4], [1]Singapore Management University, Singapore, Singapore; [2]Mississippi State University, Mississippi State, MS, [3]Georgia Tech, Atlanta, GA, [4]Harvard Medical School, Mass General Hospital, Boston, MA

Several state governments (e.g. Louisiana and Washington) recently entered into Netflix-style contracts with drug manufactures (Gilead and AbbVie), where the state Medicaid programs make a fixed lump-sum payment to a drug manufacturer in exchange for unlimited access of hepatitis C virus (HCV) drugs for its Medicaid patients. We analyzed this novel Netflix-style payment model from a mechanism design perspective, and characterized the conditions under which such a contract would be beneficial to both manufacturer or

payer. This study shows that the emergence of Netflix-style contracts improves the overall efficiency of pharmaceutical market. However, only those states with comprehensive HCV screening programs in place should considering switching to Netflix-style contracts.

3 Conditional Approval and Value-Based Pricing for New Health Technologies

Ozge Yapar[1], Stephen E. Chick[2], Noah Gans[3], [1]Indiana University, Kelley School of Business, Bloomington, IN, [2]INSEAD, Fontainebleau, France; [3]University of Pennsylvania, Philadelphia, PA, Contact: oyapar@iu.edu

Healthcare payers often make reimbursement decisions regarding new medical treatments under uncertainty. Conditional approval (CA) schemes (e.g., Cancer Drugs Fund) postpone reimbursement decisions until after the collection of post-marketing data to mitigate uncertainty regarding a treatment's cost-effectiveness. The design of CA schemes has not received much attention in the literature, however. Our game-theoretic model examines when to use a CA scheme, how to design the trial and market access, and how to negotiate reimbursement during and after the post-marketing trial. We find that the reimbursement price offered during a CA scheme's period of post-market data collection can drastically affect equilibrium outcomes. We also show that, contrary to the common view, price reduction and uncertainty reduction might not be substitutes.

TD02

Jackson

Using Decision Sciences to Inform Public Health Policy

General Session

Session Chair
Meghan O'Leary

1 Leveraging System Dynamics to Study and Strengthen Acute Crisis Mental Health Services as Systems

Raymond L. Smith[1], Kristen Hassmiller Lich[2], [1]East Carolina University, Greenville, NC, [2]University of North Carolina at Chapel Hill, Chapel Hill, NC, Contact: smithraym17@ecu.edu

Across the country, communities have faced decreasing inpatient psychiatric bed capacity as society has been called to provide care in less restrictive community settings. However, few communities have struck the right balance between outpatient and inpatient capacity to meet patient needs well and in a timely manner. This deficiency places burdens on patients and those who support them, emergency departments, and the criminal justice system. This presentation examines how acute crisis mental health services can be strengthened using a systems perspective and decision support modeling.

2 Cost-Effectiveness of Surgical Techniques for Repairing Inguinal Hernias by U.S. Payer

Meghan C. O'Leary, Lisa P. Spees, Arielle Perez, D. Wayne Overby, Stephanie B. Wheeler, Shannelle Campbell, University of North Carolina, Chapel Hill, NC, Contact: mcoleary@live.unc.edu

Inguinal hernias are prevalent and can be repaired using different surgical techniques, including open, laparoscopic, and, more recently, robotic-assisted repairs. In this decision tree analysis, we assumed the perspectives of Medicaid, Medicare, and U.S. private payers, simulated the post-surgical outcomes associated with each repair type, including complications, recurrences, and costs, and compared their relative cost-effectiveness, for a hypothetical cohort of patients with inguinal hernias. Based on the results of our probabilistic sensitivity analysis, we share recommendations about the choice of repair type for improving patient outcomes and accounting for payer-specific cost.

3 Including Implementation Considerations in Simulation Models: Applications to U.S. Sugary Drink Taxes and Health Warning Labels

Natalie Riva Smith[1], Kristen Hassmiller Lich[2], Anna Grummon[3], Marissa Hall[2], Shu Wen Ng[2], Leah Frerichs[2], [1]Harvard University, Boston, MA, [2]University of North Carolina, Chapel Hill, NC, [3]Stanford University, Stanford, CA, Contact: nataliesmith@hsph.harvard.edu

We used microsimulation modeling to compare two key national sugary drink policies (2-cent-per-ounce excise tax, health warning labels) and simulate their impact on type 2 diabetes in the US, accounting for real-world implementation considerations. A 2-cent tax policy would potentially avert 1.79 million cases of diabetes over 10 years, while a warning label policy would potentially avert 1.12 million cases. Sensitivity analyses showed that accounting for implementation considerations such as whether a tax was fully passed through or what sugary drinks were subject to the warning label policy can affect results, in some cases making the policies' effects quite similar.

4 Testing Screening Scenarios to Guide Program Planning for the Colorectal Cancer Control Program

Maria Esther Mayorga[1], Meghan C. O'Leary[2], Priscille Ruth

Koutouan[1], Kristen Hassmiller Lich[3], [1]North Carolina State University, Raleigh, NC, [2]University of North Carolina at Chapel Hill, Chapel Hill, NC, [3]Gillings School of Global Public Health, University of North Carolina at Chapel Hill, Chapel Hill, NC, Contact: memayorg@ncsu.edu

The CDC's Colorectal Cancer Control Program provides support to health systems serving low-income, medically underserved individuals to improve colorectal cancer (CRC) screening. Support historically included provision of screening for under-screened patients and transitioned to technical assistance with implementing clinic-level interventions. We used simulation to test scenarios about modality, screening frequency, and screening/follow-up adherence on CRC cases, deaths, and costs in this population. Results will inform how the CDC prioritizes its goals in future funding cycles (e.g., overall vs. targeted reach).

5 Estimating the Impact of Public Health Interventions on Overdose-Related Outcomes Among Persons with Opioid Use Disorder

Nisha Nataraj, Michaela Rikard, Kun Zhang, Xinyi Jiang, Gery Guy, Ketra Rice, Christine Mattson, Matt Gladden, Desiree Mustaquim, Zachary Illg, Puja Seth, Rita Noonan, Jan Losby, Centers for Disease Control and Prevention, Atlanta, GA

Opioid-involved overdoses remain at a high level in the United States. System dynamics models can identify opportunities for public health interventions to prevent overdoses. We developed a national model of persons with opioid use disorder (OUD) and estimated impacts of interventions, including increased treatment with medications for opioid use disorder (MOUD), reducing recurrence of OUD, and reducing nonfatal and fatal opioid-involved overdose risk. Interventions that combined increased MOUD initiation, reduced OUD recurrence, and reduced overdose risk were estimated to decrease nonfatal and fatal overdoses by 25%, decrease OUD prevalence by 24%, and increase MOUD prevalence by 135%.

TD03

Varley

Using Evidence-Based Approaches to Improve Health Care Delivery

General Session

Session Chair

Jacob Jameson, Allston, MA

1 Balancing Speed with Safety: An Analytical Approach to Improve FDA's Premarket Approval Pathway

Mohammad Zhalechian, Soroush Saghafian, Omar Robles, Anders Olsen, Ibrahima Dieye, Harvard University, Cambridge, MA, Contact: mzhale@umich.edu

For a medical device to be approved under the FDA's Premarket Notification 510(K) pathway, the manufacturer can submit a claim indicating that it is as safe and effective as another legally marketed device. This vague regulatory process has led to a high recall rate for devices approved under this pathway, raising important concerns over the approach used by FDA. To find ways to improve this process, we have assembled a unique large-scale dataset that includes information on devices approved under this pathway from 2008 to 2020. We develop machine learning models capable of predicting the chance of recall for each applicant device, and make use of them to provide a valuable tool for the FDA to improve its acceptance/rejection decisions.

2 Assessing Inpatient Utilization in Comprehensive Care Physician Model Using BCBS Claims Data

Hui Zhang[1], Andrea Flores[1], Jacob Jameson[2], David O. Meltzer[3], [1]The University of Chicago, Chicago, IL, [2]Harvard University, Allston, MA, [3]University of Chicago, Chicago, IL

The Comprehensive Care Physician (CCP) model at the University of Chicago reintegrates inpatient and outpatient care under the same physician for high-risk patients and showed reductions in hospitalization. In this study, we used Blue Cross Blue Shield (BCBS) claims to identify CCP-like physicians and compared hospitalization rates for their patients to those of patients whose primary care physicians (PCP) do not care for them in the hospital. Multivariate analyses results showed provision of inpatient and outpatient care by PCPs may increase or decrease hospitalization and is most likely to reduce hospitalization in patients with higher rates of prior hospitalization.

3 Comparing Patient Experience Survey Methods at an Urban U.S. Academic Medical Center

Thomas J. Best, University of Chicago, Chicago, IL

Hospital patient experience impacts insurer payments, hospital ratings, and perceived quality of care. Experience is formally measured via (e)mailed HCAHPS surveys with low response rates from medicine patients, so it is unclear whether mailed surveys adequately assess experience. Alternatively, our project informally measures similar experience indicators via phone. This empirical operations analysis studied over 17,000 responses to understand how

respondents to these 2 surveys differ, predictors of response, and potential impact of non-response on hospital perception of patient experience.

4 Improving ED Efficiency: Tradeoffs Between Batch Ordering and Sequentially Ordering Diagnostic Tests

Jacob Jameson[1], Arshya Feizi[2], Soroush Saghafian[3], [1]Harvard University, Cambridge, MA, [2]Boston University, Boston, MA, [3]Harvard University, Cambridge, MA, Contact: jacobjameson@g.harvard.edu

The accurate and expeditious diagnosis of patients in the emergency department (ED) is crucial for initiating appropriate treatment in a timely manner. Nevertheless, the optimal number of tests required to minimize diagnostic uncertainty remains unknown a priori. In situations where more than one diagnostic test is needed, it is more effecient for physicians to order theses tests in a batch. This study examines the comparative effects of sequential and batched test ordering strategies in the ED, specifically analyzing their implications for patient length of stay, hospital readmission, and resource utilization. We conduct a retrospective analysis of ED operational data to assess the effect of batching given various levels of patient complexity.

TD04

Toronto Ballroom I

Keynote Panel - Artificial Intelligence, Large Language Models, and the Future of Healthcare Delivery

Keynote Session

1 Artificial Intelligence, Large Language Models, and the Future of Healthcare Delivery

Tinglong Dai, Johns Hopkins University, Baltimore, MD

Panelist

Avi Goldfarb, University of Toronto, Toronto, ON, Canada.

Panelist

Ritu Agarwal, University of Maryland, College Park, MD

TD05

Toronto Ballroom II

Stochastic Models for Healthcare Operations

General Session

Session Chair

Pengyi Shi, Purdue University, West Lafayette, IN

Session Chair

Yue Hu, University of Chicago, Chicago, IL

1 Optimization in the Race to a Liquid Biopsy

Kyra Gan[1], Su Jia[2], Andrew A. Li[3], Sridhar R. Tayur[4], [1]Harvard University, Boston, MA, [2]Cornell, Ithaca, NY, [3]CMU Tepper, Pittsburgh, PA, [4]Carnegie Mellon University, Pittsburgh, PA

An accurate blood test for early-stage cancer is arguably the most important open problem in oncology, and the race to a solution is close to the finish. We will discuss the state of this race, and how optimization will play a role in reaching the finish line. In particular, we address a set of active learning problems that occur in the development of liquid biopsies via the lens of active sequential hypothesis testing (ASHT). This is a classic problem in which a learner seeks to identify the "true" hypothesis from among a known set of hypotheses, given a set of actions. Motivated by applications in which the number of hypotheses or actions is massive, we propose efficient algorithms and provide the first approximation guarantees for ASHT. Both of our guarantees are independent of the number of actions and logarithmic in the number of hypotheses. We evaluate the performance of our algorithms using both synthetic and real-world DNA mutation data, demonstrating that our algorithms outperform previously proposed heuristic policies by large margins.

2 Resource Allocation in Urban Search and Rescue Operations During a Flooding Emergency

Huiyin Ouyang[1], Zheqi Zhang[2], Sukriye Nilay Nilay Argon[3], Serhan Ziya[3], [1]The University of Hong Kong, Hong Kong, Hong Kong; [2]Walmart Global Tech, Hong Kong, Hong Kong; [3]University of North Carolina, Chapel Hill, NC, Contact: oyhy@hku.hk

We conducted a study on resource allocation in urban search and rescue during natural disasters, motivated by the emergency response efforts during Hurricane Harvey in 2017. Our research aimed to develop effective strategies for allocating limited resources to different areas when multiple requests from the same area share a common deadline. We modeled the resource allocation problem as a clearing system with limited rescue resources and impatient customers, and formulated it as a Markov decision process. We characterized the optimal policy for the single-server two-class model and found that it has a threshold structure, which we expressed explicitly. Leveraging this optimal structure,

we proposed a dynamic heuristic policy for the multi-class resource allocation problem, which we found to perform close to optimally in numerical simulations.

3 Dynamic Policies For Inter-hospital Patient Transfers

Timothy Chan, Jangwon Park, Vahid Sarhangian, University of Toronto, Toronto, ON, Canada. Contact: jangwon.park@mail.utoronto.ca

During the COVID-19 pandemic, a major challenge has been the geographic mismatch in demand for care and availability of healthcare resources. Inter-hospital patient transfers have thus emerged as a key aspect of the pandemic response in many countries including the U.S. and Canada. To gain insights into the structure of "good" transfer policies, we propose and study a class of transient queueing control problems. We consider multiple parallel queues, starting with a large imbalanced initial state, and seek discrete-time dynamic transfer policies that minimize the expected total cost over a finite horizon or until the system reaches a desirable state. We characterize the structure of the optimal policy for an associated fluid control problem and investigate the robustness of the structure for the original stochastic problem. Using simulation experiments, we illustrate the performance of fluid-based policies. Finally, we discuss how the results may be leveraged to find optimal policies in a high-fidelity stochastic model of patient flow.

TD06

Toronto Ballroom III

Stochastic Models in Healthcare Operations

General Session

Session Chair

Vahid Sarhangian, University of Toronto, Toronto, ON, Canada.

1 Feature-Based Priority Queuing

Simrita Singh, Leavey School of Business at Santa Clara University, Santa Clara, CA, Contact: ssingh17@scu.edu

Traditional queuing theory assumes types are known or perfectly observed, and each type is typically put in its type-specific queue which is prioritized using some version of the celebrated c-mu rule; we call this type-based queueing. We study feature-based priority queuing where types are not perfectly observed but are inferred from observed features using a ``classifier.'' A practically appealing approach combines an off-the-shelf classifier that predicts the type with type-based priority queueing. We propose a direct approach that optimizes the classifier to directly predict the priority queue from features. We study how the optimal number of priority queues and the assignment of features to queues changes with the classifier accuracy. We present a numerical study on a real data set of medical images utilized in digital triage in radiology. We find that, relative to type classification, optimal feature-based priority queuing can improve delay costs by up to 54% using state-of-the-art image classifiers.

2 Application of Multi-Armed Bandits in Split Liver Transplantation

Yanhan (Savannah) Tang[1], Andrew A. Li[2], Alan Scheller-Wolf[3], Sridhar R. Tayur[1], [1]Carnegie Mellon University, Pittsburgh, PA, [2]CMU Tepper, Pittsburgh, PA, [3]Tepper School of Business, Pittsburgh, PA, Contact: yanhanta@andrew.cmu.edu

This presentation discusses applying multi-armed bandits to the donated liver allocation problem. Specifically, we consider a setting where medical teams with different potentials learn a complex surgery called split liver transplantation (SLT) and become skilled over time. We formulate a multi-armed bandit (MAB) model, in which endogenous learning curves are embedded in the reward functions, to address the trade-off between discovering and developing talents (exploration) and utilizing a defined group of already-skilled medical teams (exploitation). To solve our MAB learning model, we develop the L-UCB and FL-UCB algorithms enhanced with dynamic learning and fairness. We discuss the simulation setup and show that our proposed algorithms have superior numerical performance compared to standard bandit algorithms in dynamic learning settings. Our algorithms could be applied to help evaluate strategies to increase the proliferation of SLT and other technically tricky medical procedures.

3 Prediction-Driven Surge Planning with Application in the Emergency Department

Yue Hu[1], Carri Chan[2], Jing Dong[3], [1]Stanford University, Stanford, CA, [2]Columbia Business School, New York, NY, [3]Columbia University, New York, NY, Contact: yh2987@columbia.edu

Optimizing emergency department (ED) nurse staffing decisions to balance the quality of service and staffing cost can be extremely challenging, especially when there is a high level of uncertainty in patient-demand. Increasing data availability and continuing advancements in predictive analytics provide an opportunity to mitigate demand-rate uncertainty by utilizing demand forecasts. In this work, we study a two-stage prediction framework that is synchronized with the base (made months in advance) and surge (made nearly real-time) staffing decisions in the ED. We quantify the benefit of the more expensive

surge staffing. We also propose a near-optimal two-stage staffing policy that is straightforward to interpret and implement. Lastly, we develop a unified framework that combines parameter estimation, real-time demand forecasts, and staffing in the ED.

4 Dynamic Scheduling of Home Care Providers

Adam Diamant[1], Andre Augusto Cire[2], [1]Schulich School of Business, Toronto, ON, Canada; [2]University of Toronto Scarborough, Rotman School of Management, Toronto, ON, Canada. Contact: adiamant@schulich.yorku.ca

Home care provides medical aid and social support to patients in their own homes. Our work proposes a dynamic scheduling framework to assist in the assignment of health practitioners to patients who arrive stochastically over time and are heterogeneous with respect to their health requirements, service duration, and region of residence. We analyze a class of asymptotic policies that balance practitioner workload in the long run while accounting for the combinatorial problem structure. We demonstrate the superiority of these policies in a simulation study that leverages data from a Canadian home care agency.

TD09

Johnston

Real-time and Data Driven Interventions

General Session

Session Chair

Masoud Yeganegi, Ochsner Hospital, New Orleans, LA

1 Real-Time Benefits Tools for Prescription Drugs: Characterizing Physician Interactions and Responses

Olivia Zhao[1], Anna Sinaiko[2], [1]Harvard Business School, Boston, MA, [2]Harvard T.H. Chan School of Public Health, Boston, MA, Contact: ozhao@hbs.edu

Real-time benefits tools (RTBT) inform physicians during prescribing about the estimated out-of-pocket (OOP) cost a patient faces for a drug. Prescribing more affordable drugs may improve adherence and health outcomes. How physicians interact with and respond to RTBTs is unknown. Our analysis of an RTBT implemented in a large system's primary care setting shows that the time spent addressing an RTBT alert is lower for "default-reliant" physicians and when savings between the physician's intended drug and the tool's suggested therapeutic alternative are larger. Over time, we observe prescribing respond to RTBT alerts, but with heterogeneous impacts across physician-types.

2 A Clinical Complexity- and Acuity-Based Model to Improve Efficiency of Emergency Department Operations

Chiara Morlotti[1], Mattia Cattaneo[1], Benny Mantin[2], Stefano Paleari[1], [1]University of Bergamo, Bergamo, Italy; [2]University of Luxembourg, Luxembourg, Luxembourg. Contact: chiara.morlotti@unibg.it

Traditional streaming processes in emergency departments (EDs) rely on the assessment of discrete severity levels, synthetizing two main components: clinical complexity and acuity. Relying on a 10-year dataset of ED accesses to a multi-hospital network, we study how operational decisions based on these two components can improve efficiency. First, we apply a factor analysis on triage data to assess clinical complexity and acuity. Second, we develop a model grounded on these two factors to predict severity and ED resource consumption. Finally, we compare traditional and model-derived performances for simulated ED operations, demonstrating efficiency gains in queue and resource management.

3 A Data-Driven Approach for Optimizing Stroke Intervention: A Case Study from an Advanced Comprehensive Stroke Center

Masoud Yeganegi[1], Fariba Farajbakhsh Mamaghani[2], [1]Ochsner Hospital, New Orleans, LA, [2]Tulane University, New Orleans, LA, Contact: masoud.yeganegi@ochsner.org

Stroke is a time-sensitive medical emergency, and swift interventions are critical to minimize disability and mortality. This study aims to analyze intervention effectiveness for stroke patients, leveraging data from a large comprehensive stroke center. We analyze stroke patient subpopulations, their response to various interventions, and resource constraints to develop a targeted model. Using real-world experience, we examine our approach in the context of improving patient outcomes over conventional practices. Ultimately, this study aims to guide policy makers in effectively allocating resources and implementing interventions for stroke patients in emergency care settings.

TD10

Casson

Analytics for Social Goods

General Session

Session Chair

Nan Liu, Boston College, Chestnut Hill, MA

Session Chair

Pengyi Shi, Purdue University, West Lafayette, IN

1 Online Learning with Randomized Neural Networks

Arielle Elissa Anderer[1], Hamsa Sridhar Bastani[2], Divya Singhvi[3], [1]The Wharton School, University of Pennsylvania, Philadelphia, PA, [2]Wharton School, Philadelphia, PA, [3]New York University, New York, NY, Contact: aea68@cornell.edu

This project adapts online learning techniques to unstructured data, focusing on neural networks. We posit a semi-parametric multi-armed bandit algorithm with context that uses a neural network for its underlying function approximation. We theoretically analyze and prove guarantees on the regret under this algorithm. Lastly, we examine its performance on a dataset of images of benign and malignant skin lesions, and compare it to that of other existing algorithms.

2 Treatment Planning of Victims with Heterogeneous Time-Sensitivities in Mass Casualty Incidents

Yunting Shi[1], Nan Liu[2], Guohua Wan[1], [1]Shanghai Jiao Tong University, Shanghai, China; [2]Boston College, Chestnut Hill, MA, Contact: nan.liu@bc.edu

Mass casualty incidents (MCI) lead to a sudden jump in patient demand, making it inevitable to ration medical resources. Informed by a unique timestamps dataset collected during a large-scale earthquake, we develop data-driven approaches to plan treatment of victims with heterogeneous time-sensitivities to do the greatest good to the greatest number. We identify conditions under which victims with a less critical initial condition have higher or lower priority than their counterparts in an optimal schedule---the priority order depends on victim deterioration trajectories and the resource (i.e., treatment time) availability. By demonstrating the value of adopting data-driven approaches in MCI response, our research holds strong potentials to improve emergency response and to inform its policy making.

3 Surveillance for Endemic Infectious Disease Outbreaks: Adaptive Sampling Using Profile Likelihood Estimation

Michael Fairley[1], Isabelle Jueli Rao[1], Margaret L. Brandeau[1], Gary L. Qian[2], Gregg S. Gonsalves[3], [1]Stanford University, Stanford, CA, [2]Stanford, Stanford, CA, [3]Yale School of Public Health, New Haven, CT, Contact: gqia189@stanford.edu

Endemic infectious diseases can cause outbreaks in highly susceptible subpopulations or connected networks of individuals. Limited testing resources make it challenging to detect these outbreaks quickly across regions. We develop an adaptive sampling algorithm using profile likelihood to estimate the distribution of positive tests for each location in a future period if sampled. The sampling is performed in the location with the highest estimated probability of triggering an outbreak alarm in the next period, using a semiparametric likelihood ratio test. The profile likelihood sampling method was compared to uniform random sampling and Thompson sampling and was found to be superior.

TD11

Tom Thomson

Healthcare Applications with Unstructured Data

General Session

Session Chair

Kimberly M. Villalobos Carballo, MIT

1 Tabtext: A Flexible and Contextual Approach to Tabular Data Representation

Kimberly Villalobos Carballo, Massachusetts Institute of Technology, Cambridge, MA

Tabular data is a prevalent and essential data format in applying machine learning tasks across various industries. However, they do not fully represent all available information in the tables, ignoring important contextual information such as column header descriptions. In addition, pre-processing data into a tabular format can remain a labor-intensive bottleneck in model production. In this work, we introduce a new processing and feature-extracting framework, TabText, which aims at extracting contextual information from tabular data structures and bypassing processing challenges by expressing their content as language and leveraging pretrained large language models (LLMs). We evaluate our framework on 9 healthcare prediction tasks ranging from patient discharge, ICU admission, expiration, and mortality. We show that augmenting tabular data with our TabText representations can improve the AUC performance of standard machine learning models by up to 6%.

2 Interpretable Tabtext

Matthew Peroni, Massachusetts Institute of Technology, Cambridge, MA, Contact: mperoni1@mit.edu

With the rise of highly capable language models, there is increasing interest in using natural language data to enhance downstream modeling tasks in the healthcare domain. In their TabText paper, Bertsimas et al. (2022) demonstrate

how encoding tabular patient data as language synthesizes information across different data structures and improves the accuracy of downstream models. However, all previous work uses black-box encoder models to generate feature representations in a way that causes any modeling to lose all interpretability. In this work, we develop modeling approaches that allow us to use both encoder and generative encoder-decoder language models to synthesize multiple data modalities in a way that yields interpretable prediction models. We demonstrate that in many cases, our interpretable method does not sacrifice model performance. We discuss the results of our method on a real-world clinical dataset, and demonstrate the potential of using language models to improve model performance without sacrificing interpretability.

3 Leveraging Deep Learning for Efficient and Accurate Segmentation in Radiation Oncology Treatment Planning

Leonard Boussioux, MIT, Cambridge, MA, Contact: leonard.boussioux@gmail.com

This study explores the effectiveness of using deep learning models to segment the gross tumor volume (GTV) and adjacent muscle structures, with an emphasis on ensemble modeling. An experienced radiation oncologist segmented five muscle structures and sacral chordoma GTV on CT images from 48 patients. Six DL auto-segmentation models were trained using 3D U-Net and Residual 3D U-Net architectures, and an average and optimally weighted average ensemble approach was applied to enhance prediction performance. Ensembles achieved the highest performance, significantly improving prediction quality and reducing the average muscle and tumor delineation time to 19 minutes. This approach generates expert-level muscle and tumor segmentation using DL and ensemble modeling, enhancing treatment planning efficiency and precision, particularly in sarcoma and other disease sites.

TD12

Osgood West

Healthcare Analytics: Insights and Strategies

General Session

Session Chair

Hossein Piri, Haskayen School of Business-University of Calgary, Calgary, AB, Canada.

1 Programmable Interface for Statistical & Simulation Models (Prism): Towards Greater Accessibility of Clinical and Healthcare Decision Models

Mohsen Sadatsafavi[1], Amin Adibi[2], Stephanie Harvard[1], [1]University of British Columbia, Vancouver, BC, Canada; [2]University of British Columbia, Vancouver, BC, Canada. Contact: msafavi@mail.ubc.ca

The rapid growth in healthcare data and the increasing demand for advanced analytics to support clinical decision-making and policy decisions has led to the development of an ever-increasing number of statistical and simulation models. However, proper vetting and utilization of these models is often hampered by the lack of a standardized interface and complex implementation. In this talk, we will present the PRISM platform, which aims to address this challenge by providing a cloud-based, model-as-a-service API for decision-analytics and clinical prediction models developed in R.

PRISM leverages the power of modern cloud computing and R's extensive ecosystem to create a unified interface that facilitates access to clinical and healthcare decision-analytic models across various applications and environments.

In this talk, we will discuss the core components of PRISM and present several case studies showcasing how PRISM can facilitate sharing and implementation of models in various healthcare domains.

2 Physician Staffing and Shift Scheduling at Emergency Departments with Time-Varying Productivity

Marco Bijvank[1], Negar Ganjouhaghighi[2], Alireza Sabouri[3], [1]University of Calgary, Calgary, AB, Canada; [2]University of Calgary, Calgary, AB, Canada; [3]Haskayne School of Business, University of Calgary, Calgary, AB, Canada. Contact: marco.bijvank@haskayne.ucalgary.ca

In this study, we develop a new approach to determine physician staffing levels and their actual schedule (which consists of the number of shifts, their start time, and their end time) for Emergency Departments. In particular, we include characteristics of practice that make these decisions more challenging. The main drivers are the time-varying demand from patients and the time-varying physician productivity (measured as the number of new patients seen by a physician). We develop a stochastic programming framework that is flexible to capture any probability distributions for both the patient arrival patterns and non-stationary productivity levels of the physicians. We show with the use of data how to capture patient arrivals and physician productivity for staffing and scheduling decisions to reduce patient wait times.

3 Predicting Intensive Care Unit Length of Stay and Mortality Using Generalized Additive Models

Lori Murray[1], Greg Zaric[2], [1]Kings University College at Western University, London, ON, Canada; [2]Ivey Business School, London, ON, Canada. Contact: lsincla3@uwo.ca

Outcome measures such as length of stay and mortality may be used as indicators for assessing and improving the quality of care within the intensive care environment. Previous studies have employed linear regression models that predict intensive care length of stay using patients' characteristics available on the day of admission. However, the predictive performance of the existing models are limited and there is little consensus on which is the best method for predicting individual patient length of stay. We present a new approach to predict intensive care length of stay and mortality using Generalized Additive Models (GAMs). GAMs are extensions of the linear models that allow modelling linear and nonlinear relationships in a flexible way. We developed and tested the GAMs using data from two intensive care units before and during the COVID-19 pandemic.

4 Real World Surgical Appointment Book Design via Mathematical Programming and Data Mining

Yariv N. Marmor, Baruda Academic College of Engineering in Karmiel, Karmiel, Israel.

We present a dynamic methodology that combines mathematical modeling and data mining to construct an appointment book for surgery in a large hospital to reduce the time from call to surgery. The methodology has an offline planning stage and a real-time online adjustment phase. We evaluate the algorithm on a real-world problem (about 1500 surgeries). Sensitivity analysis shows how the model parameters affect the performance of our model.

TD13

Osgood East

Empirical Healthcare Operations: When the Right Match Matters

General Session

Session Chair

Mohamad Soltani, University of Alberta, Edmonton, AB, Canada.

1 Can Employees' Past Helping Behavior be Used to Improve Shift Scheduling? Evidence from ICU Nurses

John M. Silberholz[1], Zhaohui Jiang[2], Yixin Iris Wang[3], Michael Sjoding[4], Deena Costa[5], [1]University of Michigan Ross School of Business, Ann Arbor, MI, [2]Carnegie Mellon University, Pittsburgh, PA, [3]University of Illinois at Urbana-Champaign, Champaign, IL, [4]University of Michigan Medical School, Ann Arbor, MI, [5]Yale School of Nursing, New Haven, CT, Contact: josilber@umich.edu

We define two measures of past helping behavior for employees assigned to a shift, and use ICU nursing data to show that both predict significantly reduced patient length of stay. Counterfactual analysis shows significant promise of scheduling pairs of employees who have previously helped each other to the same shift.

2 Emergency Department Boarding: Quantifying the Impact of Inpatient Admission Delays on Patient Outcomes and Downstream Hospital Operations

Huifeng Su[1], Lesley Meng[1], Rohit Sangal[2], Edieal J. Pinker[1], [1]Yale School of Management, New Haven, CT, [2]Yale School of Medicine, New Haven, CT, Contact: huifeng.su@yale.edu

Emergency Department (ED) boarding refers to the delay in transfer experienced by admitted patients from ED to inpatient units. Using an instrumental variable design, we find that on average, longer boarding times lead to longer hospital stays and a higher chance of escalation in care. Our findings also reveal that the impact of boarding differs across patients, suggesting that considering such heterogeneity when assigning inpatient beds could improve patient flow.

3 The Role of Peer Familiarity in Shared Service Delivery: An Investigation into Shared Medical Appointments

Nazli Sonmez[1], Kamalini Ramdas[2], Ryan Buell[3], [1]ESMT Berlin, Berlin, Germany; [2]London Business School, London, United Kingdom; [3]Harvard Business School, Boston, MA, Contact: nazli.sonmez@esmt.org

In shared service delivery, a group of customers is served at once. We examine how peer familiarity impacts service outcomes in shared service delivery in the context of shared medical appointments (SMA) - in which patients with similar chronic conditions meet with a doctor at once, and each receives one-on-one care in turn. Using data from the treatment arm of a prior multistage randomized controlled trial at a large hospital in India and an instrumental variable approach, we find that having familiar peers in the group significantly increases patient satisfaction, taking advantage of plausibly exogenous variation in peer familiarity. Our results shed light on an important aspect of how shared

medical appointment groups should be formed. The insights obtained could also be valuable when considering delivery innovation in other traditionally one-on-one service settings.

TD14

Fitzgerald
Public Health
Contributed Session

Session Chair
Niloofar Gilani Larimi, University of Victoria, Victoria, BC, Canada.

1 A Novel Choice Analysis Technique for Understanding Patients' Hospital Selection

Jungwoo Kim[1], Ji-Su Lee[2], Taesik Lee[3], [1]KAIST, Daejeon, Korea, Republic of; [2]KAIST, Daejeon, Korea, Republic of; [3]KAIST, Daejeon, Korea, Republic of. Contact: jungwoo415@kaist.ac.kr

This study addresses the persistent problem of out-of-geographic-coverage use of healthcare services in Korea, focusing on cancer patients' hospital choices. We propose a novel choice analysis method based on data aggregation technique, with which we capture the heterogeneous preference structures that exist within the population. Using this method, we were able to obtain detailed insights such as the fact that individuals in the high-income group are more sensitive to the quality of medical services in their area. These insights offer a promising avenue for understanding complex hospital choice behavior, potentially serving as a useful tool for designing effective policy interventions.

2 Estimating the Abundance of Homeless Individuals on Vancouver Island Using Electronic Health Data

Gracia Y. Dong, University of Toronto, Toronto, ON, Canada. Contact: gracia.dong@utoronto.ca

Homelessness is a difficult state to define, and difficult to measure and enumerate even if properly defined, as the population is rare and elusive. The majority of attempts to enumerate them rely on point-in-time or shelter counts, which can be costly and inaccurate. We use electronic health data from the Vancouver Island Health Authority from 2013 to 2022 to identify homeless adults based on their self reported housing status and their patterns of service utilization. We then estimate the total abundance of homeless adults each year using a capture-recapture model and compare our estimates with point-in-time counts.

3 Influence of Emotions, Topics, Appeal and Linguistic Style on Awareness and Engagement of Patients and Stakeholders on Online Healthcare Platforms: Online Field Experiment

Myrthe Kuipers[1], Umut Konus[2], [1]University of Amsterdam, Amsterdam, Netherlands; [2]University of Amsterdam, Amsterdam, Netherlands. Contact: m.f.kuipers@uva.nl

Providing 'beyond the pill' value, reaching, engaging and activating patients, their family circles and healthcare professionals are considered among the most substantial challenges within the health industry. This study investigates the causal impact of the content-elements of healthcare communication campaigns (emotions, topics, appeal and linguistic style) on awareness and engagement of heart patients and their caregivers on online platforms, while controlling for situational and temporal factors. Online user behavior is analyzed by estimating multiple regression models, resulting in practical guidelines on how to reach and engage patient audiences most in need.

4 A Predictive Learning Model for Healthcare Resources Forecasting During Infectious Disease Outbreaks

Niloofar Gilani Larimi[1], Adel Guitouni[1], Yakine Bahri[1], Slim Ibrahim[1], Andrew Park[1], Oussama Chakroun[2], [1]University of Victoria, Victoria, BC, Canada; [2]BCI (British Columbia Investment Management Corporation), Victoria, BC, Canada. Contact: niloofargilanilarimi@uvic.ca

Outbreaks of infectious diseases have disrupted healthcare systems, making it challenging to forecast surges in demand for acute care and allocate resources effectively. To address this issue, we propose a predictive learning model that uses a differential equation model with delays and a multi-objective learning genetic algorithm to forecast the surge in demand for healthcare resources. This model is a significant contribution to the field and provides healthcare managers and decision-makers with a valuable tool to plan resources during epidemics and major disasters.

TD16

Richmond
Healthcare Operations Management 3
Contributed Session

Session Chair

Pardis Seyedi, University of Toronto, Toronto, ON, Canada.

1 Continuity of Care in Home Health Care Scheduling

Yoram Clapper, Vrije Universiteit Amsterdam, Amsterdam, Netherlands. Contact: y.clapper@vu.nl

In home health care (operational) efficiency and continuity (of care) are critical in the planning design. Efficiency concerns the quality of the schedules in terms of travel time, waiting time and shift costs. A novel method is introduced that combines both optimization of short- (efficiency) and long-term (continuity) planning by exploiting recurring patterns of home health care jobs via blueprint schedules. The method is tested against several benchmarks, including dynamic planning methods, and is used to investigate the trade-off between efficiency and continuity.

2 Rotation Optimization and Automation in Providence Health Care

Fatih Bilen, Providence Health Care, Vancouver, BC, Canada.

The Nurse Rostering Problem (NRP) involves scheduling nurses while meeting constraints and minimizing costs. Challenges remain in this field, such as adding new constraints, developing efficient algorithms, and considering human factors. We present a real-life NRP at Providence Health Care, with a web app integrating the optimization model into the cloud. The model includes union rules, regulations, and nurse requests, with a recommender system suggesting relaxed solutions if infeasible. This project showcases the practical relevance of NRP and provides tools for optimizing nurse scheduling while considering constraints and human factors.

3 Empowering Attended Home Healthcare: A Robust Strategy to Mitigate Cascading Delays and Ensure Seamless Care Delivery

Mingda Liu[1], Yanlu Zhao[2], Xiaolei Xie[3], [1]Tsinghua University, Beijing, China; [2]Duham University Business School, Durham, United Kingdom; [3]Tsinghua University, Beijing, China. Contact: ydtmingda16@163.com

We consider an attended home healthcare problem with uncertain travel and service times, which is formulated as a robust heterogeneous site-dependent capacitated vehicle routing problem with time windows. We propose a distributionally robust model to jointly handle uncertainties and capture their characteristics, and integrate probability and magnitude assessment of schedule resiliency by analyzing the worst-case compound set reliability index (CSRI) regarding delays. To solve the problem, we develop an exact branch-and-price-and-cut approach where the CSRI is embedded as a resource and the corresponding constraints are ensured through resource extension functions.

4 An Integrated Online Booking System for Healthcare: A Decentralized Optimization Approach for Real Large-Scale Data

Pardis Seyedi[1], Michael W. Carter[1], Kourosh Eshghi[2], [1]University of Toronto, Toronto, ON, Canada; [2]Sharif University of Technology, Tehran, Iran, Islamic Republic of. Contact: pardis.seyedi@mail.utoronto.ca

We propose an Integrated Online Booking System (IOBS) to tackle healthcare variability and long wait times by enabling clients to select their preferred center and optimize scheduling based on priority level, patients' preferences, and resources. IOBS better responds to demand fluctuations and alleviates excessive wait times. To handle region-wide requests efficiently, we use a decentralized ADMM approach that is computationally reliable. Our focus is on analyzing the optimization aspects of IOBS with real-size data. The result is a simple and executable algorithm that can be applied in real situations and brings added value to the healthcare market.

Friday, 8–9:30AM

FA01

Carmichael

Mathematical Modeling to Inform Infectious Disease Prevention and Control

General Session

Session Chair

Lauren N. Steimle, Georgia Tech ISyE, Atlanta, GA

1 A New Mixed Agent-Based Network and Compartmental Simulation Framework for Joint Modeling of Related Infectious Diseases-Application to Sexually Transmitted Infections

Chaitra Gopalappa[1], Hari Balasubramanian[1], Peter J. Haas[2], [1]University of Massachusetts, Amherst, Amherst, MA, [2]UMass Amherst, Amherst, MA, Contact: chaitrag@umass.edu

A model that jointly simulates infectious diseases with common modes of transmission can serve as a decision-analytic tool to identify synergistic intervention combinations for overall disease prevention. In the US, sexually transmitted infections (STIs) are a huge economic burden. Data also show interactions between STIs, such as higher risk of acquisition and progression of a secondary STI among persons with HIV compared to persons without. However, given the widely varying epidemiological features across the STIs, current compartmental or agent-based network simulation methods

alone are insufficient or computationally burdensome. We present a new mixed agent-based compartmental (MAC) framework for joint modeling STIs. It uses network modeling for simulating persons with at least one slower-spreading disease and compartmental modeling for simulating all other persons including those with only faster-spreading diseases, and an evolving contact network algorithm maintaining the contact dynamics between the two populations.

2 A Model-Based Study to Inform Prevention and Outbreak Response Strategies to Eliminate Circulating Vaccine-Derived Poliovirus Type 2

Lauren N. Steimle[1], Yuming Sun[2], Pinar Keskinocak[3], [1]Georgia Tech ISyE, Atlanta, GA, [2]Georgia Institute of Technology, ATLANTA, GA, [3]ISyE Georgia Tech, Atlanta, GA

Despite the progress made by the Global Polio Eradication Initiative, there remain challenges in achieving a polio-free world. A major challenge in preventing and controlling poliovirus transmission is that the oral poliovirus vaccine (OPV), commonly used in low-income settings, can sometimes mutate to regain virulence and cause outbreaks of poliomyelitis. The polio program continues to respond to circulating vaccine-derived poliovirus type 2 (cVDPV2) outbreaks through supplementary immunization activities using monovalent OPV type 2 (mOPV2). In our study, we build a compartmental model to capture the dynamics of poliovirus transmission involving OPV virus reversion and evaluate the effectiveness of different prevention and outbreak response strategies. We focus on Northern Nigeria in our study given its ongoing cVDPV2 transmission.

3 Preventing Tuberculosis with Community-Based Care in an HIV Endemic Setting - A Modeling Analysis

Chelsea Greene[1], Zelda Zabinsky[1], Jennifer Ross[2], [1]University of Washington, Seattle, WA, [2]University of Washington, Seattle, WA, Contact: cgreene3@uw.edu

Antiretroviral therapy (ART) and isoniazid preventive therapy (IPT) both prevent tuberculosis (TB) disease and deaths among people living with HIV. We developed a dynamic compartmental model of TB and HIV transmission and disease progression that tests the impact of increased uptake of ART and IPT on TB health outcomes with community-based care. We simulate the impacts on TB deaths and incident TB cases averted relative to standard, clinic-based care in a high TB/HIV burden country.

Jackson

Organ Allocation Modeling and Policy

General Session

Session Chair

Grace Guan, Stanford University, Stanford, CA

1 Simulating and Evaluating a Joint International Kidney Exchange Program

Itai Ashlagi[1], José Correa[2], Felipe Subiabre[2], [1]Stanford University, Stanford, CA, [2]Universidad de Chile, Santiago, Chile.

In a kidney exchange program (KEP), willing but incompatible patient-donor pairs associate to form exchange cycles. We develop a simulator to analyze a hypothetical joint KEP between countries, where the diversity in pool compositions could potentially prove beneficial.

This software generates realistic time-based instances by using historical data from the participating countries and simulates periodic matching runs according to either a sequential or fully joint policy.

By running the simulator using real and recent data from two countries we gauge the effectiveness of the joint program in comparison with the individual ones, to be evaluated against the potential implementation costs.

2 Incentives in Outcome-Based Regulation for Lung Transplantation

David Mildebrath[1], Saumya Sinha[2], Taewoo Lee[3], Andrew J. Schaefer[4], Howard J. Huang[5], Ahmed O. Gaber[5], [1]Amazon, Seattle, WA, [2]University of Minnesota, Minneapolis, MN, [3]University of Pittsburgh, Pittsburgh, PA, [4]Rice University, Houston, TX, [5]Houston Methodist Hospital, Houston, TX, Contact: saumya@umn.edu

Federal agencies evaluate transplant programs in the United States by means of outcome-based regulations, which assess programs on the basis of their patients' post-transplantation survival. Clinical evidence indicates that these regulations induced some programs to engage in adverse patient selection, wherein they may reject high-risk but medically suitable transplant candidates to avoid penalization. We present a game-theoretic model of individual transplant programs to study the incentives created by these outcome-based regulations. We demonstrate that harsh penalization, more than other factors, incentivizes programs to engage in adverse patient selection. We then propose a pay-for-performance reimbursement scheme that penalizes programs with below-average post-transplant outcomes, and pays a bonus to programs with above-average post-transplant

outcomes. We demonstrate that our proposed scheme can incentivize programs to improve post-transplant outcomes, without inducing adverse patient selection.

3 Structural Estimation of Kidney Transplant Candidates' Quality of Life Scores

Baris Ata[1], Yue Hu[2], Cem Randa[3], [1]University of Chicago, Chicago, IL, [2]Stanford University, Stanford, CA, [3]Uber Marketplace, San Francisco, CA, Contact: yh2987@columbia.edu

We develop a framework for assessing the impact of changes to the deceased-donor kidney allocation policy taking into account transplant candidates' endogenous organ acceptance behavior. To be specific, we construct a dynamic structural model of transplant candidates' acceptance and rejection decisions for organ offers, and perform various counterfactual studies to assess policy changes.

4 Using Machine Learning Predictions to Improve Utilization and Reduce Discards in Deceased Donor Organ Allocation

Nikhil Agarwal[1], Itai Ashlagi[2], Grace Guan[2], Paulo Somaini[3], Jiacheng Zou[2], [1]Massachusetts Institute of Technology, Cambridge, MA, [2]Stanford University, Stanford, CA, [3]Stanford Graduate School of Business, Stanford, CA, Contact: gzguan@stanford.edu

While there are over 100,000 patients waiting for a kidney transplant in the U.S., over 20% of procured deceased donor kidneys are discarded. It is important to identify when a kidney is at risk of being discarded, because organ procurement organizations (OPOs) can expedite the organ to a more accepting transplant center lower down on the waiting list to avoid discard. We develop a machine learning model to predict whether a donor will be at risk of being discarded, and we estimate the causal effects of this mechanism in a field experiment with OPOs.

FA03

Varley

Opioid Crisis

General Session

Session Chair

Jingyuan Hu, UCLA Anderson School of Management, Los Angeles, CA

1 Preventing Opioid Overdose: From Prediction to Operationalization

Jónas Oddur Jónasson[1], Neal Kaw[2], Deeksha Sinha[3], Nikolaos Trichakis[1], Anyi Chen[4], Joseph Conte[4], Ashley Restaino[4], Salvatore Volpe[4], [1]MIT Sloan School of Management, Cambridge, MA, [2]Unity Health Toronto, Toronto, ON, Canada; [3]Meta Platforms, Inc., Menlo Park, CA, [4]Staten Island Performing Provider System, New York, NY

A potential catalyst for reducing the incidence of opioid-related harm is the development and operationalization of risk stratification models. We partner with Staten Island Performing Provider System to access claims data and electronic health records for the patient population on Staten Island. For this population, we develop a single machine learning model that predicts a full range of adverse opioid-related events, and achieve an area under the receiver operating characteristic curve of 0.95, 0.87, 0.83 for the outcomes of any adverse opioid event, opioid overdose, and fatal opioid overdose, respectively. We find that the model can be used to identify a small intervention cohort (1% of the highest-risk patients) which includes the majority (69%) of adverse opioid events, allowing for targeted interventions with limited intervention capacity. Finally, we find that that predictive performance does not need to be sacrificed to satisfy implementation concerns, such as interpretability, delay in data feeds, and prediction window length.

2 A Locally Operating Spatio-Temporal Mutually Exciting Point Process with Dynamic Network for Improving Opioid Overdose Death Prediction

Che-Yi Liao[1], Gian-Gabriel P. Garcia[2], Kamran Paynabar[3], Zheng Dong[1], Yao Xie[1], Mohammad Jalali[4], [1]Georgia Institute of Technology, Atlanta, GA, [2]Georgia Institute of Technology, Atlanta, GA, [3]ISyE Georgia Tech, Atlanta, GA, [4]Harvard Medical School, Boston, MA, Contact: giangarcia@gatech.edu

Prediction of opioid overdose deaths (OODs) is challenging for public health officials due to fast-changing spatio-temporal trends in opioid use patterns. In this research, we design a Spatio-TEMporal Mutually Exciting point process with Dynamic network (STEMMED), i.e., a point process network wherein each node models a unique community-drug event stream with a dynamic mutually-exciting structure, accounting for influences from other nodes. Using individual-level OOD data and county-level demographics in Massachusetts to parameterize STEMMED, we find that STEMMED can accurately forecast local OOD trends and highlight complex interactions between OODs across communities and drug types.

3 Opioid-Related Treatment Disparities Among Medicaid Enrollees in Indiana

Carolina Vivas-Valencia[1], Nan Kong[2], Nicole Adams[2], Paul Griffin[3], [1]The University of Texas at San Antonio, San Antonio, TX, [2]Purdue University, West Lafayette, IN, [3]The Pennsylvania State University, University Park, PA, Contact: carolina.vivasvalencia@utsa.edu

Health care disparities based on race/ethnicity and sex can be found in a variety of settings. We aim to determine if there are disparities in treatment provided to Indiana Medicaid enrollees who have medically documented problematic opioid use (POU). We used deidentified medical and pharmacy Medicaid claims data from January 1, 2014, through December 31, 2019, from the Indiana Family and Social Services Administration. We first test if there is a difference between subgroups in the proportion that received POU treatment. Second, we used multilevel logistic regression models to analyze the influence of individual data and aggregate data on the diagnosis and treatment of POU with individuals residing across different counties in Indiana. Given the national concern on health care disparities among different race/ethnicity and sex groups, the need for conducting a detailed and comprehensive examination of treatment patterns is pressing.

4 Predicting Long-Term Opioid use via Interpretable Machine Learning

Jingyuan Hu, UCLA Anderson School of Management, Los Angeles, CA

Long-term opioid use can lead to opioid abuse, addiction, and other severe outcome. We obtain deidentified prescription-level data for opioid prescriptions dispensed in California and aim to create an interpretable scoring table that helps predict the risks of being a long-term opioid user at the early stage based on an optimization-based model named riskSLIM. Our findings suggest that the current opioid alert system are not effective as the thresholds are set too high, and propose different versions of the scoring table to cater to healthcare practitioners for different scenarios.

FA05

Toronto Ballroom II

Innovative Models in Healthcare

General Session

Session Chair

Alan Scheller-Wolf, Tepper School of Business, Pittsburgh, PA

Session Chair

Yanhan (Savannah) Tang, Carnegie Mellon University, Pittsburgh, PA

1 Proactive Patient Treatment in Sepsis

Chia-Hao Chang, Vineet Goyal, Carri Chan, Columbia University, New York, NY

Sepsis is an emergent medical condition in which body's immunological responses causes end-stage organ dysfunction and death. In a typical year, around three hundred and fifty thousand people died of sepsis in the United States. Its high mortality renders the timeliness of detection and treatment crucial. Some recent evidence has shown that providing early treatment to patients before they develop sepsis may lower their mortality. Due to the scarcity of the medical resources, such early treatment may cause congestion and block the urgent need from the patients developing sepsis. Hence, effective management of the medical resources is paramount. In this work, we consider a discrete-time Markov model where a central planner decides the number of patients to be proactively treated. Motivated by the structural insights from fluid approximation, we propose a state-dependent threshold policy. We justify our policy by showing its asymptotic optimality.

2 Split Liver Transplantation: An Analytical Decision Support Model

Yanhan (Savannah) Tang[1], Alan Scheller-Wolf[2], Sridhar R. Tayur[1], Emily R. Perito[3], John P. Roberts[3], [1]Carnegie Mellon University, Pittsburgh, PA, [2]Tepper School of Business, Pittsburgh, PA, [3]University of California, San Francisco, San Francisco, CA, Contact: yanhanta@andrew.cmu.edu

Split liver transplantation (SLT) is a procedure that saves two lives using one liver, increasing the total benefit derived from the limited number of donated livers available. SLT also improves equity by giving transplant candidates who are physically smaller (including children) increased access to liver transplants. However, SLT is rarely used in the US. To help quantify the benefits of increased SLT utilization and provide decision support tools, we introduce a deceased-donor liver allocation model with both efficiency and fairness objectives. We formulate our model as a multi-queue fluid system, incorporating donor-recipient size matching and patients' dynamically changing health conditions. Leveraging a novel decomposition result, we find the exact optimal matching procedure, enabling us to benchmark the performance of different allocation policies against the theoretical optimal. Numerical results show that increased utilization of SLT can significantly improve important transplant objectives and fairness.

3 A Fluid-Diffusion Hybrid Approximation for Priority Systems with Fast and Slow Customers

Lun Yu[1], Seyed Iravani[2], Ohad Perry[2], [1]Chinese University

of Hong Kong, Shenzhen, Shenzhen, China; [2]Northwestern University, Evanston, IL

Motivated by emergency departments, we consider a priority queueing system with two customer classes; the first class (of "high acuity") requires long service times and receives priority over the second class ("low acuity"), whose average service times are substantially shorter. Unfortunately, the dynamics of such a system are intractable, and existing heavy-traffic regimes cannot capture the fact that, in practice, a non-negligible proportion of the arrivals from either class must wait for service. We propose a Fluid-Diffusion Hybrid limit to approximate the two queues, and demonstrate how it can be employed to study the benefits of de-pooling (namely, of having a "fast-track").

4 Approximate Dynamic Programming for Multiclass Scheduling Under Slowdown

Jing Dong[1], Berk Gorgulu[2], Vahid Sarhangian[2], [1]Columbia University, New York, NY, [2]University of Toronto, Toronto, ON, Canada.

We consider a multiclass scheduling problem where customers' service ties depends on the workload of the system. We propose an approximate dynamic programming (ADP) approach to find approximately optimal scheduling policies. We illustrate the benefits of implementing the ADP policy in a case study related to prioritizing admissions to rehabilitation from acute care.

FA07

Toronto Ballroom 4: MacDonald

Establishing a Working Group on Health Disparities in ORMS Modeling

Panel Session

Session Chair
Julie Simmons Ivy, Guest, Cary, NC

Session Chair
Maria Esther Mayorga, North Carolina State University, Raleigh, NC

Moderator
Julie Simmons Ivy, Guest, Cary, NC

Panelist
Karen T. Hicklin, University of Florida, Gainesville, FL

Panelist
Shannon Harris, Virginia Commonwealth University, Richmond, VA

Panelist
Maria Esther Mayorga, North Carolina State University, Raleigh, NC

Panelist
Jennifer Mason Lobo, University of Virginia, Charlottesville, VA, Contact: jem4yb@virginia.edu

FA08

Toronto Ballroom 5: Lismer

Telemedicine

General Session

Session Chair
Hessam Bavafa, Wisconsin School of Business, Madison, WI

1 Impact of Telemedicine on Patient Flow

Diwas S. Kc[1], Sokol Tushe[1], Hao Ding[2], [1]Emory University, Atlanta, GA, [2]Emory University, Decatur, GA

We collaborated with the Veterans Healthcare Administration (VHA) to examine how their early adoption of telemedicine impacted patient flow and overall systemwide performance. During the study period, the VHA introduced a multi-channel healthcare system consisting of both in-person and telemedicine channels. We find that the introduction of the telemedicine channel led to a patient sorting process: patient complexity in the in-person channel increased, both in terms of treatment time and resource utilization. However, the advent of telemedicine also increased overall system-wide throughput and reduced waiting times. We believe that the introduction of the telemedicine channel facilitated more effecting matching of patient needs to treatment modality, resulting in the increased efficiency gains.

2 Telehealth in Acute Care: Pay Parity and Patient Access

Ozden Engin Cakici[1], Alex Mills[2], [1]American University, Washington, DC, [2]Baruch College, City University of New York, New York, NY, Contact: ozdengin@gmail.com

Telehealth pay-parity policy requires payers to reimburse healthcare providers equally for telehealth and office visits. Using a three-stage game, we study the impact of telehealth reimbursement on provider's operational decisions, where patients choose between telehealth and office. We find that pay parity can decrease patient access and discuss its implications.

3 Waiting Online Versus In-Person in Outpatient Clinics: An Empirical Study on Visit Incompletion

Jimmy Qin[1], Carri Chan[1], Jing Dong[2], Shunichi Homma[3], Siqin Ye[3], [1]Columbia Business School, New York, NY, [2]Columbia University, New York, NY, [3]Columbia University Irving Medical Center, New York, NY, Contact: qqin23@gsb.columbia.edu

The use of telemedicine has increased rapidly over the last few years. To better manage telemedicine visits and effectively integrate them with in-person visits, we need to better understand patient behaviors under the two modalities of visits. Utilizing data from two large outpatient clinics, we take an empirical approach to study service incompletion for in-person versus telemedicine appointments. We focus on estimating the causal effect of physician availability on service incompletion. Our estimation results show that intra-day delay increases the telemedicine service incompletion rate by 7.40%, but it does not have a significant effect on the in-person service incompletion rate. We conduct counterfactual experiments to optimize the intra-day sequencing rule when having both telemedicine and in-person patients. Our analysis indicates that not correctly differentiating the types of incompletions due to intra-day delays from no-show can lead to highly suboptimal patient sequencing decisions.

4 Does Reginal Health Information Exchange Improve Long-Term Care Service Quality?

Fang Wan[1], Huiwen Xu[2], Abraham Seidmann[3], [1]Harvard University, Boston, MA, [2]University of Texas Medical Branch, Galveston, TX, [3]Boston University, Newton, MA, Contact: fwan@hbs.edu

This research examines the impact of health information exchange (HIE) on the service quality of long-term care (LTC) facilities. Our results show that the readmission rate of an LTC facility with an operational HIE is reduced by 2% on average. We also estimate the heterogeneous effect of HIE by two innovative healthcare ITs (EHR and Telemedicine). We find that the applications of EHR and Telemedicine in LTC facilities are still at a very early stage. Our findings empirically demonstrate the importance of promoting effective data exchange in LTC facilities and improving the use of EHR and Telemedicine to increase the value that HIE can create.

FA09

Johnston

Decision-Making with Machine Learning for Personalized Medicine

General Session

Session Chair

Haiyan Yu, Chongqing University of Posts and Telecommunications, Chongqing, China.

1 Machine Learning for Optimal Test Admission in the Presenceof Resource Constraints

Dmitry Krass[1], Ramy Elitzur[1], Eyal Zimlichman[2], [1]Rotman School of Management, University of Toronto, Toronto, ON, Canada; [2]Tel Aviv University, Tel Aviv, Israel. Contact: krass@rotman.utoronto.ca

We combine predictive analytics methods using machine learning algorithms with optimal pre-test screening mechanisms, to achieve greatly increased test efficiency (i.e., rate of true positives identified per test), as well as allowing doctors to initiate early treatment. Our optimal test admission policies account for imperfect accuracy of both the medical test and the model prediction mechanism. We show how our policies can be extended to re-testing high-risk patients, as well as combined with pool testing approaches. We illustrate our techniques by applying them to a large data reported by the Israeli Ministry of Health for RT-PCR.

2 Decision Rules for Personalized Statin Treatment Prescriptions over Multi-Objectives

Pui Ying Yew, University of Minnesota, Minneapolis, MN, Contact: yew00003@umn.edu

The feasibility to produce a proactive statin prescription strategy was demonstrated in a previous study using neural networks with big data. However, its non-transparency limited clinical usability. To improve the transparency of the previous approach with minimal compromise to the maximal statin treatment benefits and minimal risks, a five-step pipeline approach called the Decision Rules for Statin Treatment is proposed in this study. The decision rules were generated by minimizing an impurity function based on the treatment simulation and multi-objective optimization results. Then, a clinical trial simulation was conducted to evaluate and compare with the other treatment strategies.

3 Extubation Decision Making for Mechanically Ventilated Patient in Intensive Care Units Using Reinforcement Learning with Safety Constraints

Maotong Sun[1], Jingui Xie[2], [1]Technical University of Munich, Heilbronn, Germany; [2]Technical University of Munich, Heilbronn, Germany. Contact: maotong.sun@tum.de

Extubation decision-making is critical in ICUs management, affecting patient outcomes and the throughput of ICUs. In this study, we develop a decision support tool that can utilize patient information to predict readiness for extubation and to have a more personalized extubation

strategy for patients in the ICU. We propose a Deep Offline Constrained Reinforcement Learning-based decision support tool to help clinicians determine the best action at a given patient state from sub-optimal historical ICU data. We perform experiments on a real dataset and show that our model enables substantial improvements in expected health outcomes and consistency with relevant practice and safety guidelines.

4 Providing Multi-Level Decision Support for Skilled Nursing Facilities: A Discrete-Time Simulation Approach

Caroline Strickland, University of Western Ontario, London, ON, Canada. Contact: cstrick4@uwo.ca

Staff in Skilled Nursing Facilities (SNFs) make decisions where uncertainty is high but optimal decision-making is critical to short- and long-term success. We introduce a SNF admission and staffing simulator to investigate the effects of patient- and facility-level actions at different timescales with multi-dimensional outcomes, calibrated using a dataset describing operations at many SNFs over several years. The simulator enables the development and evaluation of Reinforcement Learning-based sequential decision support methodology in this challenging setting.

5 Optimal Genetic Testing of Families

Kanix Wang[1], Daniel Adelman[2], [1]University of Cincinnati, Cincinnati, OH, [2]University of Chicago, Booth School of Business, Chicago, IL, Contact: wang2xk@ucmail.uc.edu

Genetic status informs familial risk, but tests focus on one person only. We develop an MDP framework that maximizes the net benefits of genetic testing by integrating a Bayesian network of family genetic statuses and a functional representation of cost-effectiveness. Our model provides a contingent sequence of family members to test one at a time, dynamically incorporating new results to decide who to test next. The optimal stopping follows a structure with double thresholds, and in the special case of sibling testing, the optimal sequence can be identified *a priori*. Our study on BRCA1/2 testing shows significant improvement of an optimal policy over even the most cost-effective existing protocols.

6 Constrained Optimization for Stratified Treatment Rules in Reducing Hospital Readmission Rates

Haiyan Yu, Chongqing University of Posts and Telecommunications, Chongqing, China. Contact: yhy188@tju.edu.cn

Diabetic patients can receive multiple/different treatments. However, there is no universal solution for all patients. Therefore, if we can stratify those patients into several sub-classes, the patients in each sub-class can receive the optimal treatment. There are two main challenges: (1) counterfactual inference when a patient can only take one treatment at a time; (2) the confounding effects of covariates on the treatment. Thus, we propose a method entitled constrained optimization for stratified treatment rules (COSTAR). The experiment results suggest that our results perform better than the related methods in reducing the hospital readmission rate within 30 days.

FA10

Casson

Short and Long-term Planning in Health Systems

General Session

Session Chair

Kimia Ghobadi, Johns Hopkins University, Baltimore, MD

Session Chair

Houra Mahmoudzadeh, University of Waterloo, Waterloo, ON, Canada.

1 Home Healthcare Routing and Scheduling with Consistency Considerations in a Stochastic Environment

Seyede Saeede Hosseini[1], Louis-Martin Rousseau[2], Yossiri Adulyasak[3], [1]Polytechnique Montreal, Montreal, QC, Canada; [2]Polythechnique Montreal, Montreal, QC, Canada; [3]HEC Montreal, Montreal, QC, Canada. Contact: saeedehosseini994@gmail.com

We study the integration of multi-period assignment, routing, and scheduling of care workers for home health care services in which each patient is visited with the same care worker at almost the same time on each day they require any services (person and visit time consistency). Also, given the importance of visit time consistency in service quality, we incorporate stochastic travel and service times into the model to improve solutions robustness. To address the uncertainty, we use the chance-constraint approach. In modeling, to check the feasibility of the scheduling despite travel and service time variations, first, we sample them by using multiple scenarios. Second, we try to replace scenarios with an estimation of start-service time and arrival time distributions for each patient. We aim to compare these two models with each other and with a deterministic

model in terms of both solving time and visit time stability. To solve this problem, we use an exact optimization method, branch and check.

2 Data-Driven Comprehensive OR-to-Downstream Elective Surgery Planning Under Uncertainty

Karmel S. Shehadeh[1], Man Yiu Tsang[1], Rema Padman[2], Arman Kilic[3], [1]Lehigh University, Bethlehem, PA, [2]Carnegie Mellon University, Pittsburgh, PA, [3]Medical University of South Carolina, Charleston, SC, Contact: karmelshehadeh@gmail.com

We propose novel stochastic optimization methodologies for an integrated elective surgery assignment, sequencing, and scheduling problem, involving multiple ORs and downstream recovery units. Numerical experiments based on real surgery data are used to compare the proposed methodologies and illustrate the potential for impact in practice. Our results show the benefits of our integrated approach compared to the traditional non-integrated approaches. Notably, implementing solutions obtained from our models can significantly reduce congestion in recovery units, delays in the ORs, and costs.

3 Long-term Capacity Planning for Healthcare Services

Eduardo Redondo[1], Angel Ruiz[2], Valérie Bélanger[3], [1]Université Laval, Québec, QC, Canada; [2]Université Laval, Québec, QC, Canada; [3]HEC Montreal, Montreal, QC, Canada. Contact: eduardo.redondo-ruiz-diaz.1@ulaval.ca

This study explores the effectiveness of a decision support tool for long-term capacity planning in healthcare services. The tool uses optimal modeling and stochastic techniques as the sample average approximation to account for uncertain and heterogeneous demand. By comparing it to a basic deterministic method, the study shows that the proposed approach is more effective and reliable. Accounting for uncertainty in demand allows for more comprehensive and robust capacity planning, which leads to better outcomes. Ultimately, the research provides evidence that taking uncertain demand into account in long-term planning can improve human resource management in healthcare services.

4 Distributionally Robust Master Surgery Scheduling

Hayo Bos, Richard J. Boucherie, Erwin Hans, Anne Leeftink, University of Twente, Enschede, Netherlands. Contact: h.bos-1@utwente.nl

We introduce the discrete-time Stochastic Knapsack with Periodic Scheduled Arrivals (SKPSA) to approach the Master Surgery Scheduling Problem (MSSP) with downstream resource constraints. We approximate this model by Distributionally Robust Optimization with Wasserstein Ambiguity. Using recent tractability results, we reformulate our approximation to a solvable model, which we apply to a real life case study of a medium-sized Dutch hospital.

5 Data-Driven Patient Scheduling for Speech and Language Therapy Considering Cancellations and No-Shows

Sina Hoveida[1], Parmida Mirhashemi[1], Hossein Abouee Mehrizi[1], Brandan Wylie-Toal[2], [1]University of Waterloo, Waterloo, ON, Canada; [2]KidsAbility, Waterloo, ON, Canada. Contact: Shoveida@uwaterloo.ca

We present a data-driven approach for patient scheduling in a speech and language program to reduce patient wait times and improve program efficiency. Using historical data, we first develop prediction models for cancellations, no-shows, and the number of sessions required for each patient. We then propose a model for patient scheduling that takes into account cancelations and no-shows. Using data from a large healthcare provider, we demonstrate the significant impact of patient scheduling on system utilization.

FA11

Tom Thomson

Holistic Machine Learning in Healthcare

General Session

Session Chair

Yu Ma, MIT, Cambridge, MA

1 Holistic Artificial Intelligence in Medicine

Yu Ma, MIT, Cambridge, MA

Artificial intelligence (AI) systems hold great promise to improve healthcare over the next decades. In this work, we propose and evaluate a unified Holistic AI in Medicine (HAIM) framework to facilitate the generation and testing of AI systems that leverage multimodal inputs. We show that this framework can consistently and robustly produce models that outperform similar single-source approaches across various healthcare demonstrations (by 6-33%), including 10 distinct chest pathology diagnoses, along with length-of-stay and 48 h mortality predictions. We also quantify the contribution of each modality and data source using Shapley values, which demonstrates the heterogeneity in data modality importance and the necessity of multimodal inputs across different healthcare-relevant tasks. The generalizable properties and flexibility of our Holistic AI in Medicine

(HAIM) framework could offer a promising pathway for future multimodal predictive systems in clinical and operational healthcare settings.

2 Prescriptive Neural Networks (PNNs): Structured Data Sources

Lisa Everest[1], Vasiliki Stoumpou[2], [1]Massachusetts Institute of Technology, Cambridge, MA, [2]Massachusetts Instiute of Technology, Cambridge, MA, Contact: leverest@mit.edu

We present a novel method that trains feedforward neural networks for prescriptive problems. Given an observational dataset with covariate features, treatments prescribed for each observation, and the corresponding outcome, we aim to prescribe the treatment that optimizes the outcome for a given observation. Our method involves three steps: 1) performing a counterfactual estimation step, 2) training a feedforward neural network with an appropriate prescriptive objective, and 3) training a corresponding classification tree that ensures interpretability of prescriptions without compromising performance. We apply this methodology in structured data experiments, both synthetic and real-world, and find that our Prescriptive Neural Network (PNN) outperforms other prescriptive methods on nearly all real world experiments. Therefore, we demonstrate that PNNs can handle complex data structures and present a tractable, flexible, and strongly-performing prescriptive model.

3 Prescriptive Neural Networks (PNNs): Unstructured Data Sources

Vasiliki Stoumpou, Lisa Everest, Massachusetts Institute of Technology, Cambridge, MA, Contact: vasstou@mit.edu

Our work aims to solve the prescriptive optimization problem, when the data source is unstructured, like image and language data. The prescriptive problem setting involves covariate features, treatments prescribed for each observation, and the corresponding outcome. The goal of a PNN is to prescribe the treatment for a given observation that optimizes its outcome. To handle unstructured data types, we experimented with two different approaches: 1) employing pretrained networks to extract features from the unstructured data and then use these features in our prescriptive pipeline, and 2) training specialized networks with an added Feedforward Network at the output, to simultaneously extract features and learn the prescriptive task. This novel pipeline leverages Deep Learning to solve prescriptive problems, regardless of the data source, thus expanding its applicability in a plethora of real life settings and paving the path to a holistic methodology that can combine both structured and unstructured data in one generalized framework.

4 Improving Predictions of Cardiovascular Diseases Using Language-Encoding of Tabular Data

Jiayi Gu[1], Matthew Peroni[2], [1]MIT, Cambridge, MA, [2]MIT, Cambridge, MA, Contact: jgu321@mit.edu

Tabular data, like electronic health records (EHRs), is commonly used in healthcare systems to record patient information. However, there are challenges to using tabular data in Machine Learning models for healthcare due to data sparsity, and missing values, and some healthcare data not being tabular in nature. This work utilizes TabText, a method for encoding different data structures as natural language, to improve the prediction accuracy of cardiovascular diseases studied in the Framingham Heart Study. We demonstrate that enhancing tabular data with medical language context outperforms models with tabular data only. Furthermore, we analyze the sensitivity of our approach against different choices for language representations and different patterns of data missingness and provide insights into when this approach brings about significant performance improvement.

FA12

Osgood West

Incentives and Coordination in Healthcare

General Session

Session Chair

Kraig Delana, University of Oregon, Eugene, OR

Session Chair

Jong Myeong Lim, Tuck School of Business at Dartmouth, Hanover, NH

1 Unintended Consequences of Hospital Regulation: The Case of the Hospital Readmissions Reduction Program

Christopher J. Chen[1], Nicos Savva[2], [1]Indiana University Kelley School of Business, Bloomington, IN, [2]London Business School, London, United Kingdom.

We examine the impact of the Hospital Readmissions Reduction Program (HRRP) on hospitals' admission behavior. We exploit variation in hospitals' financial exposure to HRRP due to i) readmission performance before HRRP was implemented and ii) financial constraints, to show that hospitals tried to reduce readmission rates by increasing the number of patients that were classified as admitted for observation. Despite this substantial increase, preliminary analysis suggests that the impact of observation bed usage on readmissions was limited - we estimate that only

1.3% of the recorded post-HRRP decrease in readmissions of penalized hospitals can be attributed to increased observation bed usage.

2 Reverse Cross Subsidization in Healthcare Capitation Programs: Evidence from Medicare Advantage

Zhaowei She[1], Bilal Gokpinar[2], Turgay Ayer[3], Danny R. Hughes[4], [1]Singapore Management University, Singapore, Singapore; [2]UCL School of Management, London, United Kingdom; [3]Georgia Tech, Atlanta, GA, [4]Georgia Institute of Technology, Atlanta, GA

Capitation payment models have been increasingly adopted by payers in the U.S. healthcare market during the past decade. However, early study shows that Medicare Advantage (MA), the largest capitation program in the U.S., tends to under-provide healthcare services to the old and the sick but over-provide to the relatively younger and healthier patients. This paper empirically shows that MA unintentionally incentivizes providers (MA health plans) to reallocate parts of the capitation payments from the old and the sick to cross subsidize the young and the healthy. By exploiting a policy induced exogenous shock on MA capitation payments, we identify this reverse cross subsidization incentive through a difference-in-difference (DID) design. Furthermore, we empirically demonstrate that this reverse cross subsidization incentive causes risk selection in MA.

3 From Black to Grey: Improving Access to Antimalarial Drugs in the Presence of Conterfeits

Jiatao Ding[1], Michael Freeman[1], Sasa Zorc[2], [1]INSEAD, Singapore, Singapore; [2]University of Virginia, Darden School of Business, Charlottesville, VA, Contact: zorcs@darden.virginia.edu

In malaria-endemic countries, the high demand for and low accessibility of antimalarial drugs has fostered the prevalence of counterfeits. We study how donors should allocate limited budgets to subsidies in markets where counterfeits are present. A game-theoretic model is developed , where the retailer has a strategic choice to source either legitimate or counterfeit drugs, or both. Different from the extant literature, we show that in the presence of counterfeits, a purchase subsidy only may no longer be optimal. We also evaluate five strategies that have been employed to combat counterfeits (improving consumer awareness of counterfeits, increasing the penalty for sourcing counterfeits, adopting traceability technology, cracking down on the supply of counterfeits, and imposing price controls) and identify the conditions under which these approaches can either improve or worsen outcomes. Finally, we perform an extensive numerical analysis where the models are calibrated to malaria data from Mozambique.

4 The More Monitoring, the Better Quality? Empirical Evidence from the Generic Drug Industry

Anqi Wu[1], Yixin Iris Wang[2], [1]Florida International University, Miami, FL, [2]University of Illinois at Urbana-Champaign, Champaign, IL, Contact: anwu@fiu.edu

In response to the growing concern regarding drug safety issues, the U.S. Food and Drug Administration (FDA) has allocated more inspection resources to high-risk manufacturing facilities. The actions of this government agency implicitly assume that inspection frequency can serve as an effective lever to improve compliance, yet the efficacy of inspection can be undermined if facilities do not react and respond to inspections for strategic reasons. This study directly examines and tests the relationship between inspection frequency and manufacturing quality. We employ a fixed effects model with instrumental variables to identify the impact of past inspection count on the subsequent product recall rates. Overall, we observe a significantly negative impact of inspections on recalls, although this impact is subject to diminishing returns. When we focus on high-risk facilities, however, no evidence is found that supports the negative link between inspections and recalls. Our findings provide important implications for regime improvement.

FA13

Osgood East

Empirical Research in Healthcare Operations: II

General Session

Session Chair

Nazli Sönmez,

1 Small Area Estimation of Case Growths for Timely COVID-19 Outbreak Detection

Zhaowei She[1], Zilong Wang[2], Turgay Ayer[3], Jagpreet Chhatwal[4], [1]Singapore Management University, Singapore, Singapore; [2]Georgia Institute of Technology, Industrial Systems and Engineering, Atlanta, GA, [3]Georgia Tech, Atlanta, GA, [4]Harvard Medical School, Mass General Hospital, Boston, MA

Rapid and accurate detection of local outbreaks is critical to tackling resurgent waves of COVID-19. A fundamental challenge in case growth rate estimation, a key epidemiological parameter, is balancing the accuracy

vs. speed tradeoff for small sample sizes of counties. We develop an algorithm, Transfer Learning Generalized Random Forest (TLGRF), that balances this tradeoff. Through transfer learning, TLGRF can accurately estimate case growth rates for counties with small sample sizes based on relevant day and county-level features affecting the disease spread. TLGRF outperforms established growth rate estimation methods and demonstrated that it can greatly improve the timely detection of outbreaks. We thus developed a open-source tool for timely detection of COVID-19 outbreaks in each U.S. county, which received substantial attention from policymakers.

2 Worker Experience and Donor Heterogeneity: The Impact of Charitable Workers on Donors' Blood Donation Decisions

Wilson Lin[1], Susan F. Lu[2], Tianshu Sun[3], [1]Santa Clara University, Santa Clara, CA, [2]Purdue University, West Lafayette, IN, [3]University of Southern California, Los Angeles, CA

We ask whether and how a charitable organization's front-line staff members can be effectively positioned to encourage donors to donate more (in compliance with the eligibility rules) during their in-person interactions. We find that the effect of the charitable worker on charitable productivity strongly depends on the worker's experiences which entail sharing knowledge about a donor's donation options, rather than the worker's experiences that are primarily focused on collecting donations. Moreover, worker experience can encourage donors that have lower self-efficacy over performing their donation to choose higher donation volumes. A worker's experience with donors with lower self-efficacy furthermore benefits charitable productivity when interacting with those donors. Higher donations induced by an experienced worker from the previous session are correlated with higher donation volumes in the focal session if the donor returns to donate.

3 Does Quality Matter? Prediction of U.S. Hospital Closures Using Hospital Quality

Lina Song, University College London School of Management, London, United Kingdom.

Hospital closures can have a negative impact on the community and the healthcare system1,2. Knowing hospital closures in advance is important for policymakers to mitigate its potentially negative consequences It is, however, challenging to do so with the limitation of the currently available data. We propose a machine learning algorithm method to predict the U.S. hospital closure, focusing on the potential of using quality variables for prediction.

4 Improving Group Testing in a Pandemic

Tong Wang, Kamalini Ramdas, Song Yang, London Business School, London, United Kingdom.

In a pandemic, we rely on accurate tests to identify positive cases and reduce infection, yet large-scale tests can be costly to run and subject to capacity constraints. Group testing can efficiently test populations and significantly save testing capacities. In a group test, samples are first pooled and tested. If the result is negative, every individual in the group is healthy. Otherwise, individual tests are conducted to detect the infected individuals. The appropriate group size depends on the underlying risk level of individuals. In this study, we examine different approaches that health policymakers or administrators can use to improve group formation for the pooling stage of the testing procedure in the presence of heterogeneous risk levels among individuals.

5 Wheels on the Bus: Impact of Vaccine Rollouts on Demand for Public Transportation

Huaiyang Zhong[1], Guihua Wang[2], Tinglong Dai[3], [1]Harvard University, Revere, MA, [2]University of Texas at Dallas, RICHARDSON, TX, [3]Johns Hopkins University, Baltimore, MD, Contact: guihua.wang@utdallas.edu

The COVID-19 pandemic led to a significant decline in public transit ridership in the United States, resulting in large budget deficits and service cuts that could disproportionately affect vulnerable riders. This paper examines the relationship between COVID-19 vaccination progress and demand for public transportation. To address challenges in empirical estimation, we employ an instrumental variable approach that exploits unique features of the vaccination process. By analyzing vaccination rates and transportation data, we find that increased vaccination rates lead to increased mobility at public transit centers. The effect is particularly pronounced in counties with a high proportion of uninsured people and people without a college degree. These findings underscore the importance of restoring and revitalizing public transit infrastructure in anticipation of vaccine-induced demand recovery.

FA14

Fitzgerald
eHealth and Telemedicine
Contributed Session

Session Chair
Renee Pratt, Auburn University, Auburn, AL

1 Telemedicine Physician Staffing in the Face of Multi-Type Reentrant Patients

Xu Dai, Xiaolei Xie, Tsinghua University, Beijing, China.

Contact: dx21@mails.tsinghua.edu.cn
This manuscript considers that patients may abandon the queue when waiting for remote treatment, and those abandoned patients have the behavior of random retrial. Besides, patients who complete the service have random feedback behavior. However, few papers have been found on the operations management of telemedicine physician staffing with different reentrant patients. Therefore, we propose a fluid analytical approximation of dynamic physician staffing based on the time-varying queueing model, which can ensure the quality of service for patients while maintaining high utilization. The effectiveness of the proposed solution is validated by discrete event simulation in the numerical study.

2 Operational Efficiency and Patient Satisfaction in the Online Healthcare Service Delivery

Liping Liang, Lingnan University, Tuen Mun, N.T., Hong Kong.
Using consultation service data from a large online healthcare platform, we investigate the relationship between online operational efficiency and patient satisfaction. We show that operational inefficiency before or during the online healthcare service delivery process negatively affects patient satisfaction. Drawing on the psychological distance theory, we examine the effects of geographical distance and information gap between patients and physicians on the relationship. Our findings reveal the value of psychological distance and dynamic quality signals in the online healthcare service.

3 What's Missing? Interoperability: A Gap Analysis

Renee Pratt[1], Cindi T. Smatt[2], Anthony Thomas[1], [1]Auburn University, Auburn, AL, [2]University of North Georgia, Dahlonega, GA, Contact: rpratt@auburn.edu
The demand for health information exchange over recent years has encouraged organizations to become more interoperable for greater coordination and value within facilities. With the increased global changes in a post-pandemic era, there is a critical need to merge data from diverse and disparate systems to quickly access relevant information, evaluate across clinical and care-giving practices, and expand inclusion of interoperability. We perform a literature review among the top information systems (IS) and health information system (HIS) journals to produce an analysis of the significant topics to coordinate and connect various partners.

FA15

University

Decision Support

Contributed Session

Session Chair

Tahera Yesmin, University of Toronto, Toronto, ON, Canada.

1 Optimizing Healthcare Network Design and Logistics Outsourcing: A Decision-Support Tool for Policy Makers

Asmae El Mokrini[1], Tarik Aouam[2], [1]International University of Rabat, Rabat, Morocco; [2]Ghent University, Ghent, Belgium.
This paper presents a decision-support tool for healthcare policymakers to design efficient supply chain networks with outsourcing options and risks in mind. It utilizes a multiphase approach that factors in logistics, product importance, and market regions to create optimized network designs and outsourcing strategies. The tool is tested on the Moroccan pharmaceutical supply chain, a large-scale healthcare project where network design with outsourcing is crucial. The proposed tool helps policymakers evaluate options for network design and outsourcing functions to deliver high-quality healthcare products and services across regions.

2 Machine Learning Integrated Patient Flow Simulation: Why and How?

Tesfamariam M. Abuhay[1,2], Vedat Verter[1], Lomi Eyachew Adane[2], Bilen Yitages Eshete[2], Birhanu Motbaynor Alemu[3], Stewart Robinson[4], Adane Mamuye[2], Sergey V. Kovalchuk[5], [1]Queen's University, Kingston, ON, Canada; [2]University of Gondar, Gondar, Ethiopia; [3]Bahir Dar University, Bahir Dar, Ethiopia; [4]Newcastle University, Newcastle upon Tyne, United Kingdom; [5]ITMO University, Saint Petersburg, Russian Federation. Contact: tesfamariam.abuhay@queensu.ca
Stochastic distribution methods were used to construct patient flow simulation sub-models such as patient inflow, length of stay, cost of treatment and clinical pathway models. However, patient inflow exhibits seasonality, trend and variation over time and is affected by natural and/or human-made factors. LoS, CoT and CPs are also highly associated with patients' attributes, clinical and laboratory test results, and availability of resources. This study, hence, describes why coupling machine learning with patient flow simulation is important, proposes a conceptual architecture for machine learning integrated patient flow simulation and demonstrates its implementation with examples.

3 A Simulation-Based Optimization Model for Non-Acute Patients Re-Allocation in Multi Hospital Networks

Mattia Cattaneo, Sebastian Birolini, Stefano Paleari, University of Bergamo, Dalmine, Italy. Contact: mattia.cattaneo@unibg.it

Non-acute patients have been acknowledged to play a major role in congesting emergency departments, being responsible of more than 80% of accesses. As an effective strategy to alleviate ED overcrowding, we investigate non-acute patients' re-allocation decisions towards other EDs belonging to the same multi hospital network. We applied a simulation-optimization approach that leverages an extensive dataset comprising 4 EDs and 1.4 million patient accesses in the period 2010-2022. We observed that under specific conditions (e.g., time of the day) the re-allocation of non-acute patients can be a valid strategy to improve the efficiency of emergency care services within a multi hospital network.

4 Forecasting Number of Beds to Clean and Identifying Staff Requirements at Emergency Department Using Machine Learning Algorithms and Discrete Event Simulation Modeling

Tahera Yesmin, Michael Carter, University of Toronto, Toronto, ON, Canada. Contact: tahera.yesmin@mail.utoronto.ca

We aim to predict the number of beds to clean within the next four hours at a hospital emergency department applying machine learning algorithms and identify the staff requirements to clean those beds using discrete event simulation. We aim to provide a means to inform decision-making about staffing and resource allocation by creating a decision support system (DSS) tool.

FA16

Richmond

Logistics and Supply Chain Management

Contributed Session

Session Chair

Sabrina Casucci, University at Buffalo-SUNY, Amherst, NY

1 Leveraging Smart Lockers with City Buses for Enhanced Healthcare Logistics in Urban Environments

Si Liu, McMaster University, Hamilton, ON, Canada. Contact: lius278@mcmaster.ca

The growing demand for efficient and sustainable urban logistics solutions has led to the development of innovative delivery methods, such as integrating smart lockers with city buses. This study investigates the feasibility of implementing smart lockers with city buses for healthcare logistics in urban settings. We formulated and solved the problem by utilizing smart lockers with city buses for transporting medical samples. Our findings suggest that integrating smart lockers with city buses can significantly improve healthcare logistics efficiency, reduce transportation costs, and enhance patient access to essential medical supplies and medications.

2 Geopolitical Risk and Global Access to Medications

Emily L. Tucker, Martha Sabogal De La Pava, Clemson University, Clemson, SC, Contact: etucke3@clemson.edu

Pharmaceutical supply chains have experienced on-going struggles to meet the domestic and global demand for drugs for decades. Shortages are caused by supply-demand mismatches and supply strain, including disruptions due to quality and natural disasters. A recent strain - export bans - has emerged as a result of recent geopolitical instability and persistent shortages. In this work, we present a stochastic integer programming approach to optimize a company's global supply chain under geopolitical strain, endogenous pricing, strategic alliances, and global demand. We evaluate effects on countries by income level and analyze policies to improve global access.

3 What Happens when We Actually Keep Track of Surgical Devices: Exploring Integrated Supply and Clinical Workflows in the O.R.

Benjamin Neve[1], James Tcheng[2], [1]Weber State University, Ogden, UT, [2]Duke University School of Medicine, Durham, NC, Contact: benjaminneve@weber.edu

The vast majority of surgery operating room (OR) processes for documenting product usage (including medical device implants) rely on manual recording and transcription of product data after the products have already been opened and used on patients. Lacking are point of care workflows with integrated technologies to scan, check, and prevent recalled items from being implanted. By using an innovative technology that enables point of care scanning in the OR, hospitals can see a wide variety of benefits. This research presentation explores the potential benefits to supply chains, operating rooms, patients and staff as more accurate scanning and UDI tracking becomes feasible.

4 Improving Blood Supply Chain Management in a Regional Network

Rishabh Bhandawat[1], Jose L. Walteros[2], Sabrina Casucci[3], [1]University at Buffalo, Atlanta, GA, [2]University at Buffalo, Buffalo, NY, [3]University at Buffalo-SUNY, Amherst, NY
Blood products are managed through a highly complex multi-echelon supply chain, with uncertain demands, limited and perishable supplies. System inefficiencies lead to significant losses from both wastage and shortages. With declining donations and lack of a synthetic substitute we need systems that can more effectively manage this critical shared resource, reduce losses, and improve outcomes. This research introduces a new system framework that provides a multi-echelon approach to optimizing blood product management from collection to transfusion. The potential for this system to improve patient and agency outcomes across a regional network of competing agencies is also discussed.

Friday, 10–11AM

P03

Toronto Ballroom I

Plenary - The Application of Artificial Intelligence in Healthcare

Plenary Session

1 The Application of Artificial Intelligence in Healthcare

Muhammad Mamdani, Unity Health Toronto, Toronto, ON, Canada.
While the application of artificial intelligence (AI) has transformed numerous sectors, including retail, transportation, and hospitality, its application to health has been limited. The Toronto community is well positioned to advance AI research and application given its strengths in relevant disciplines such as medicine, allied health, computer science, mathematics, engineering, and statistics. This talk will provide an overview of the newly established Temerty Centre for Artificial Intelligence Research and Education in Medicine (T-CAIREM) of the University of Toronto and present examples of applied AI research and translation. A particular focus on AI translation will be provide attendees with a deeper appreciation of the complexity of AI applications in health.

Friday, 11:15AM–12:45PM

FB01

Carmichael

Data-driven Decision-making in Response to a Pandemic

General Session

Session Chair

Shibshankar Dey, Northwestern University, Evanston, IL

1 Mapping Agent-Based Infectious Disease Models to Compartmental Models Using Equation Learning

Osman Ozaltin, Xin Li, NC State University, Raleigh, NC, Contact: oyozalti@ncsu.edu
The COVID-19 pandemic has highlighted the need for accurate mathematical models to inform decision-making and policy evaluation. Agent-based models (ABMs) are useful for capturing complex agent interactions and heterogeneity, while compartmental models are computationally efficient but lack the ability to capture such complexity. However, there is a lack of methodology to link these two types of models. We propose a novel approach to link ABMs with compartmental models using equation learning. We modify the open-source ABM Covasim for data generation and propose a new compartmental. Neural networks are used to approximate the unknown terms in the differential equations of the compartmental model, and physical constraints are added to the loss function for model training. The results demonstrate the potential of this approach for building accurate matching between ABM and compartmental models.

2 Vaccination for Endemic Diseases: Optimal Allocation of Initial and Booster Vaccine Doses

Isabelle J. Rao, Management Science and Engineering, Stanford University, Stanford, CA, Contact: isarao@stanford.edu
For some communicable diseases such as COVID-19, vaccination is an effective means of control but must be augmented with booster doses due to waning immunity from vaccination. We consider an SEIS model with interacting population groups, an allocation over time of limited vaccines (initial and booster doses), and four objectives: minimize new infections, deaths, life years lost and quality-adjusted life years lost due to death. We derive intuitive analytical conditions characterizing the optimal solution. Numerical simulations calibrated to COVID-19 in New York show that our method achieves near-optimal results. Our unique model provides interpretability while still being accurate.

3 Modeling Peer Influence for Public Health Decisions

Amin Rahimian, Industrial Engineering, University of

Pittsburgh, PA

I will discuss recent results addressing peer influence in public health outcomes. In "Interdependence and the cost of uncoordinated responses to COVID-19" (PNAS), we present a case for how different state policies spillover across borders geographically and socially, and can lead to suboptimal outcomes without coordination. In "Providing normative information increases intentions to accept a COVID-19 vaccine" (Nat Comm), we present results from a large, pre-registered, randomized experiment (N=484,239) embedded in an international survey that show messaging with accurate descriptive norms can substantially increase intentions to accept a vaccine for COVID-19. Finally, I will discuss recent attempts using Facebook's social connectedness index (SCI) to measure the effect of social networks on the spread of the opioid epidemic in the U.S. We identify comparable social and spatial effects for opioid incidents in alter locations on egos, consistently in several modeling variations after controlling for social determinants of health.

4 Utility And Herd-immunity Driven Vaccination Center Location Decision During A Pandemic

Shibshankar Dey[1], Sanjay Mehrotra[2], [1]Industrial Engineering and Management Sciences, Northwestern University, Evanston, IL, [2]Northwestern University, Evanston, IL

This study presents an optimization model for deciding the location of vaccination centers accounting maximum level of utility, herd immunity and equity. The utility function considered is assumed to be increasing with respect to its determining factors, and both linear and concave utility functions are investigated. However, the data related to these determining factors (e.g., distance) toward a location choice is very limited and sometimes inaccessible. Additionally, epidemiological parameters defining herd immunity function are quite volatile in spatiotemporal sense as experienced from COVID-19. Considering the imprecise estimate to the parameters of utility function and spatiotemporal epidemic parameter uncertainties, we focus distributionally robust version of the two-stage stochastic location problem. We interpret how location decision changes with respect to anticipated herd-immunity level, equity threshold, and robustness consideration and the resulting implications for pandemic containment.

FB02

Jackson

Unleashing the Power of Data in Healthcare

General Session

Session Chair

Hrayer Aprahamian, Texas A&M University, College Station, TX

1 Identifying Motivations and Barriers of Health Coaching Program Enrollment with Topic Modeling

Annisa Marlin Rus[1], Maria Esther Mayorga[2], Julie Simmons Ivy[1], Min Chi[3], [1]North Carolina State University, Raleigh, NC, [2]North Carolina State University, Raleigh, NC, [3]North Carolina State University, Raleigh, NC, Contact: amasbar@ncsu.edu

Diabetic retinopathy (DR) is a complication of diabetes that can become vision-threatening (VTDR) and cause blindness. VTDR is difficult to catch due to the slow progression and dependence on patients' care-seeking behavior. One of the ways to ensure that patients receive timely care is by enrolling them in a care coordination (CC) program. This program helps educate and assist patients in making appointments and seeking care through phone call coaching. However, little is known about why some patients are more likely to enroll in the program. Therefore, this study tries to identify factors that lead to enrollment in the CC program based on call transcripts by identifying crucial keywords using structural topic modeling (STM). We convert topic proportion from the STM into features to represent the call transcript. Then, we compare the performance of different classification models used to predict enrollment.

2 Improving Equity in Healthcare Access Through Network Design: A Case Study of Specialist Cancer Care in Rwanda

Abel Sapirstein, Georgia Institute of Technology, Baltimore, MD

Cancer is a growing cause of death in Rwanda. Addressing inequity in access to cancer care requires policy solutions that consider cost, demand for care, provider availability, and barriers to healthcare access. In this talk, we consider an important barrier to access - poor road conditions that lead to long travel times to access specialist cancer care in Rwanda. We formulate a network design problem that considers road improvements and facility expansion simultaneously. We parameterize the model using publicly available data and propose solutions that align with the objectives of government and NGO partners.

3 Optimizing Real-Time Hospital Bed Matching for a Hospital Command Center

Arlen Dean[1], Mark P. Van Oyen[1], Mohammad Zhalechian[2], [1]University of Michigan, Ann Arbor, MI, [2]Harvard University, Cambridge, MA, Contact: ajdean@asu.edu

We report on our research with a large, highly utilized hospital to coordinate bed assignments. These decisions are complicated by patients' varying care needs and rooms/beds' distinct features. To overcome these challenges, we develop and implement an optimization model that leverages operational practices with real-time patient and system information

4 An Optimization-Based Scheduling Methodology for Multi-Service Appointment Systems with Non-Stationary Arrival Processes

Sohom Chatterjee, Youssef Hebaish, Hrayer Aprahamian, Lewis Ntaimo, Texas A&M University, College Station, TX, Contact: hrayer@tamu.edu

This paper analyzes multi-service appointment systems with non-stationary arrival processes to identify server schedules that improve system performance. A stylized optimization model is used, based on a pointwise stationary approximation, to emulate the original stochastic system. The resulting solution scheme is generalized to the case of multiple service types for two different formulations of the decision problem. The proposed framework is demonstrated through a case study on Texas A&M University's College and Psychological Services, which shows that optimal solutions substantially improve the system's performance and identifies easily implementable scheduling policies.

FB03

Varley

Predictive and Analytical Modeling for Informing Health Policy

General Session

Session Chair

Qiushi Chen, Penn State University, University Park, PA

Session Chair

Yu-Hsin Chen, Pennsylvania State University, University Park, PA

1 Optimizing Lung Cancer Screening Schedules at the Individual-Level Using an Expanded Version of Engage, a Personalized Screening Decision Tool

Utkarsh Verma[1], Seyyed Mostafa Mousavi Janbeh Sarayi[1], Martin Carl Tammemägi[2], Rafael Meza[3], Iakovos Toumazis[1], [1]The University of Texas MD Anderson Cancer Center, Houston, TX, [2]Brock University, St. Catharines, ON, Canada; [3]BC Cancer Research Institute, Vancouver, BC, Canada.

Current lung cancer screening eligibility is based solely on categorical age and smoking criteria. The ENGAGE framework provides individualized lung cancer screening schedules based on a partially observable Markov decision process that maximize the expected quality-adjusted life years of people. We expanded the ENGAGE framework to include in addition to sex, age, and smoking history, non-smoking related lung cancer risk factors and the disutility associated with screening. We compare the effectiveness and efficiency of the resulting optimal screening policies obtained from the expanded ENGAGE framework, to the original ENGAGE model and the existing lung cancer screening recommendations.

2 Quantifying the Benefits of More Frequent Decision Making Opportunities

Suyanpeng Zhang, Sze-chuan Suen, University of Southern California, Los Angeles, CA

Many decisions in healthcare have regular intervals at which decisions can be made, whether at regular checkups or at monthly, biyearly, or annual follow-up visits after a health event. However, the interval between these visits is often arbitrarily determined. In this work, we study a framework for quantifying the benefits to more frequent decision-making opportunities with the goal of understanding whether increasing the frequency would be worth any associated costs. We compare two otherwise equivalent MDP systems with different epoch lengths and provide structural insights on the difference between the optimal values of these systems. To demonstrate the applicability and generalizability of this framework, we provide an organ failure numerical example.

3 Optimizing Screening for Autism Under Limited Diagnostic Service Capacity

Yu-Hsin Chen, Qiushi Chen, Penn State University, University Park, PA

Early diagnosis is crucial to the treatment outcome of Autism Spectrum Disorder (ASD), a developmental disorder that affects 1 in 44 children in the US. The universal ASD screening guideline for children at 18 and 24 months old has been widely debated as it increases the diagnosis delay due to having extra false-positive cases. To improve the early diagnosis of ASD children, we develop a finite-horizon mixed integer program (MIP) that determines the optimal sequential risk threshold for screening at different ages. We solve the non-convex MIP with relaxation and branch and bound algorithm, and evaluate the performance with discrete event simulation.

FB05

Toronto Ballroom II

Healthcare Operations Management

General Session

Session Chair

Hossein Abouee Mehrizi, University of Waterloo, Waterloo, ON, Canada.

1 Multi-Class Advance Patient Scheduling: A Data-Driven Robust Approach

Hamid Arzani[1], Hossein Abouee-Mehrizi[2], Saeed Ghadimi[2], [1]University of Toronto, Toronto, ON, Canada; [2]University of Waterloo, Waterloo, ON, Canada. Contact: hamid.arzani@rotman.utoronto.ca

We study a multi-class advance patient scheduling problem where patients of different classes have different service times and incur different waiting costs to the system. It is known that dynamic advance patient scheduling is a challenging problem due to the high variability in the daily arrivals and high dimensionality of the problem. To overcome these challenges, we focus on analyzing the regret of any online scheduling policy relative to an offline controller. We develop a novel dynamic optimization framework where the problem can be approximately decomposed into multiple single-stage stochastic problems. We then extend the framework to a data-driven setting where the true distribution of demand in each period is unknown. We propose an algorithm to solve the robust model and examine its performance by leveraging the MRI data from hospitals in Ontario. We observe that the proposed approach schedules patients such that the system is efficiently protected against the high variability in the daily and performs well compared to an offline policy.

2 Asymptotic Analysis of Multi-Class Advance Patient Scheduling

Mohamad Sadegh Shirani Faradonbeh[1], Hossein Abouee-Mehrizi[2], Mohamad Kazem Shirani Faradonbeh[3], [1]Stanford University, Stanford, CA, [2]University of Waterloo, Waterloo, ON, Canada; [3]University of Georgia, Athens, GA

Advance patient scheduling is a daily task that health providers need to deal with to minimize patients' waiting times while trying to utilize the available resources efficiently. Despite its impact in practice, the structure of the optimal policy for multi-class settings is unknown. The main challenge is to dynamically assign patients to future appointment time slots in the booking horizon. This paper develops the first theoretical framework to characterize the optimal policy. We analyze the problem in an asymptotic regime and derive the diffusion-optimal policy, establishing that it follows a state-dependent threshold structure. Leveraging the theoretical analysis, we propose a practical scheduling policy that fully determines which patients to schedule and which time slots in the booking horizon to assign to them. Finally, empirical analysis of the proposed policy using data from two hospitals illustrates that it appropriately reserves capacity for future emergency patients and efficiently prioritizes the patient classes.

3 Dynamic Control of Service Systems with Returns

Timothy Chan[1], Simon Yuxuan Huang[2], Vahid Sarhangian[1], [1]University of Toronto, Toronto, ON, Canada; [2]University of Toronto, Richmond Hill, ON, Canada.

We study a queueing system with returns where at each service completion epoch, the decision maker can choose to reduce the probability of return for the departing customer at a cost that is convex increasing in the amount of reduction in the return probability. We characterize the structure of optimal long-run average and bias-optimal transient control policies for associated fluid control problems. Our results provide insights on the design of post-discharge intervention programs aimed at reducing hospital readmissions.

4 Share or Hide Emergency Department Queue-Lengths to Reduce Congestion?

Yufeng Zhang[1], Shrutivandana Sharma[2], [1]Singapore University of Technology and Design, Singapore, Singapore; [2]New York University, New York, NY, Contact: shrutivandana.sharma@nyu.edu

In recent years, emergency departments (EDs) have adopted different models for sharing information on ED waiting times. We present a queueing games framework to investigate how sharing of real-time queue-length or waiting time information at ED, where urgent patients receive priority of service over nonurgent patients, influences nonurgent patients' decision to enter or balk the ED queue, and how it affects the overall social welfare of patients who visit the ED. We show that under certain conditions, it may be better to partially reveal ED queue-length information rather than making ED queues completely transparent.

FB06

Toronto Ballroom 3: Harris

Emerging Trends and Innovations in Healthcare IT and Analytics

General Session

Session Chair

Muhammad Zia Hydari, University of Pittsburgh, Pittsburgh, PA

1 Heterogenous Patient Responses to Healthcare Data Breach

Junyuan Ke[1], Weiguang Wang[1], Natasha Zhang Foutz[2], [1]University of Rochester, Rochester, NY, [2]University of Virginia, Charlottesville, VA, Contact: junyuan.ke@simon.rochester.edu

While healthcare data breaches pose significant risks to organizations and society at large, patients also face irrevocable privacy violations, limited options, and high switching costs. This research aims to provide population-scale evidence of how patients respond heterogeneously to a healthcare data breach, highlighting the social disparities underlying such response heterogeneity. Using a major healthcare data breach as a natural shock, novel location big data, and various analytical methods, this research reveal that the impacts of the data breach on patients were profound, long-lasting, and heterogeneous. Furthermore, this research highlights the alarming impact of data breach on disadvantaged patients, hence calling for equitable policies towards healthcare cybersecurity.

2 Explainable Deep-Learning Model Reveals past Cardiovascular Disease in Patients with Diabetes Using Free-Form Visit Reports

Alessandro Guazzo[1,2], Enrico Longato[1], Gian Paolo Fadini[1], Mario Luca Morieri[1], Giovanni Sparacino[1], Barbara Di Camillo[1], [1]University of Padua, Padova, Italy; [2]Carnegie Mellon University, Pittsburgh, PA, Contact: alessandro.guazzo@studenti.unipd.it

Writing notes remains the most widespread method to record clinical events. As a result, a relevant portion of a patient's health status is recorded in the form of text. Natural language processing can enable the conversion of free-form text into structured data. We used electronic health records to develop a tool to automatically identify past cardiovascular disease hospitalizations using the free-form text of routine visits of diabetic patients. We also provided an interpretability framework that could be leveraged to understand the most relevant factors that influenced the model predictions, empowering the user to decide whether to follow up on the algorithm's suggestion or ignore it.

3 Telemedicine and Its Impact on Atrial Fibrillation Patients

Muhammad Zia Hydari[1], Eric Dueweke[2], Rahul Telang[3], Shalini Allam[2], [1]University of Pittsburgh, Pittsburgh, PA, [2]UPMC, Pittsburgh, PA, [3]Carnegie Mellon University, Pittsburgh, PA, Contact: hydari@alum.mit.edu

We analyzed the impact of telemedicine on the process and clinical outcomes of atrial fibrillation (AFib) patients in a large mid-Atlantic hospital system. The study found that telemedicine encounters resulted in a 4% lower likelihood of DOAC or anticoagulant prescriptions but did not significantly affect other clinical outcomes. The analysis suggests a potential increase in mortality risk for female patients, warranting further investigation. The findings suggest the importance of evaluating the efficacy of telemedicine to ensure its appropriate use and identify potential variations in its effectiveness among different patient populations.

4 Evaluating User Engagement with Digital Health Interventions

Bengisu Tulu, Lidan Zhang, Worcester Polytechnic Institute (WPI), Worcester, MA, Contact: bengisu@wpi.edu

Digital health interventions target various health outcomes. While evaluating user engagement, it is important to take these outcomes and the components of the intervention into account. We will demonstrate how to define target user engagement measures and how to interpret user behavior more meaningfully using these targets. Our case study is a digital weight loss intervention involving Habit app and a private social media group. Habit app was used by 20 participants over a 6-week intervention period to facilitate weight loss. We will discuss identified target user engagement that is relevant to the intervention design and how we analyzed user engagement using the click data from the app.

FB07

Toronto Ballroom 4: MacDonald

Chronic Diseases and Long-Term Care

Contributed Session

Session Chair

Quinten Carfagnini, Brock University, St. Catharines, ON, Canada.

1 Proposing A Methodology To Evaluate The Policy Impact Of Over-the-Counter Hearing Aids

Sarah E. Kruger, Thomas A. Mazzuchi, Shahram Sarkani, George Washington University, Washington, DC, Contact: sekruger@gwu.edu

With an aging U.S. population and concerns about health access, there is increased interest in hearing health due to the number of older adults with hearing loss. Despite the high prevalence, utilization of hearing healthcare is

limited. In response to the Over-the-Counter Hearing Aid Act of 2017, the FDA established a new category of over-the-counter (OTC) hearing aids. Effective October 2022, OTC hearing aids became available for adults with mild to moderate hearing loss and can be purchased directly without a prescription or hearing evaluation. Our research aims to establish a framework, using publicly accessible data, to evaluate the policy impact of OTC hearing aids in an evidence-based manner.

2 Hospital Discharge Planning; Prediction of Time and Next Destination of ALC Patients

Mahsa Pahlevani[1], Majid Taghavi[2], Peter Vanberkel[3], [1]Dalhousie University, Halifax, NS, Canada; [2]Saint Mary's University, Halifax, NS, Canada; [3]Dahousie University, Halifax, NS, Canada.

Improved medical treatments for chronic conditions have allowed people to live longer, often requiring an Alternate level of care (ALC). Since structured discharge planning can reduce hospital length of stay (LOS) and readmission rates while enhancing patient satisfaction, this study seeks to utilize multiple Machine Learning (ML) algorithms to identify the most significant characteristics associated with patients requiring ALC. Also, it develops highly accurate prediction models that forecast the likelihood that an incoming patient will need ALC, the LOS, and the discharge destination of patients.

3 What Factors Increase Odds of Long-Stay Delayed Discharge in Alternate Level of Care Patients?

Quinten Carfagnini[1], Anteneh Ayanso[1], Madelyn Law[1], Elaina Orlando[2], Brent Faught[1], [1]Brock University, St. Catharines, ON, Canada; [2]Niagara Health, St. Catharines, ON, Canada. Contact: qc13kj@brocku.ca

Analyzed factors that increased the odds of long-stay delayed discharge (LSDD) in Alternate Level of Care (ALC) patients. Sample consisted of 16,429 ALC patients. 30 or more days was used as the threshold for a LSDD. Regression modelling analyzed sex, age, admission source, discharge destination and needs/barriers requirements to assess the likelihood of a LSDD. Long-stay ALC patients were more likely to be male and have a discharge destination of an LTC bed. Bariatric, behavioural, infection (isolation) and feeding barriers hindered discharge the most. Understanding the importance of specialized patient requirements can help hospitals become more prepared in preventing delayed discharges.

FB08

Toronto Ballroom 5: Lismer

Information Technology to Improve Access, Collaboration, and Safety

General Session

Session Chair
Saeede Eftekhari, Tulane University, NEW ORLEANS, LA

Session Chair
Yeongin Kim, Virginia Commonwealth University, Glen Allen

1 Cables for Bottles? The Role of Internet Access in Mitigating Post-Deregulation Resurgence of Risky Behavior

Fanruo Wang, University of Rochester, Rochester, NY

This research examines the role of Internet access in mitigating the post-deregulation resurgence of risky behaviors, specifically patronage to liquor stores. Leveraging the regulation and deregulation of all liquor stores in Pennsylvania as a natural experiment, and the newly available individual-level location big data, this research quantifies the relationship between Internet access and resurgence of liquor store patronage after deregulation. We find that greater Internet access is linked to reduced resurgence of liquor store patronage, hence diminishing crime. Further mechanism analyses reveal that Internet access potentially substitutes alcohol in addressing social expectancy.

2 Patient Flux at Primary Care- Impact of Health Information Exchanges

Saeede Eftekhari[1], Ramaswamy Ramesh[2], [1]Tulane University, NEW ORLEANS, LA, [2]SUNY Buffalo, East Amherst, NY, Contact: seftekhari@tulane.edu

Patient movement between service providers is an important phenomenon that occurs in the continuum of healthcare. Such movement arises in the form of either physicians' referrals and follow-ups or patients' visiting alternate service providers on their own volition. This movement constitutes a flux of patients among healthcare providers. We study patient flux at primary care and investigate how Health Information Exchanges (HIE) affect the flux. We study two forms of flux: *Random* and *Managed.* Random flux is the patient movement that is unintended by their physicians; managed flux is the patient movement that occurs in the cycle of referral and follow-up, which is physician intended. We show that HIE positively affects both flux types in the segment of HIE-member physicians. The increased random flux indicates that HIE leads to increased competition in this segment. The increase in managed flux implies HIE fosters collaboration between primary care providers and specialists. Our findings have important managerial and policy implications.

3 Using Information Technologies and Dynamic Flow Diversions to Improve Access to Medical Care

Opher Baron[1], Fanying Chen[2], Abraham Seidmann[3], [1]University of Toronto, Toronto, ON, Canada; [2]Boston University, Boston, MA, [3]Boston University, NEWTON, MA, MA, Contact: fanying@bu.edu

Our research of patients' care delivery is inspired by an extensive field project conducted with a large HMO that covers 2.5 million lives. We study how the combination of Artificial Intelligence and a novel waiting line control mechanism can potentially improve access to care and reduce regional inequities in primary and secondary care delivery. We present an innovative *'dynamic flow diversion' (DFD)* mechanism and mathematically analyze its performance in terms of overall capacity, service quality, and the cost of care delivery. Our initial theoretical, numerical, and empirical results show that this combined mechanism generates dramatic improvements in care delivery at a relatively low cost.

4 Humber River Health (HRH) Command Centre - A Digital Revolution for Delivering Care

Peter Voros, Susan Tory, Humber River Health, Toronto, ON, Canada.

HRH's Command Centre is a NASA-style 'Mission Control' room, located in the heart of the hospital, which works behind scenes to help make every patient's experience at the hospital better, faster and safer.

In addition to providing frontline staff with a bird's eye view of the entire hospital, the Command Centre also provides an early warning system to detect potential health risks, alerts to flag real-time incidents and allows informed decision-making.

The Command Centre is not just a technology or a tool. It is a manifestation of a personal and organizational commitment to transformation with a purpose of improving care and saving lives.

FB09

Johnston

Shared Decision Making - Experts in the Loop

General Session

Session Chair

Ming-Yen Lin, Kaohsiung Medical University Hospital, Kaohsiung, Taiwan.

Session Chair

Hsing Luh, National Cheng Chi University, Taipei, Taiwan.

1 Investigations on the Medication Errors Happened in Chemotherapy Drug Dispensing Using the Knowledge of Human Factors Engineering

Pei-yi Lin[1,2], Eric Kin-Lap Lee[3], Kuo-Wei Su[4], Chao-Hung Wang[4], [1]Kaohsiung Veterans General Hospital, Kaohsiung, Taiwan; [2]National Kaohsiung University of Science and Technology, Kaohsiung, Taiwan; [3]Tajen University, Pingtung, Taiwan; [4]National Kaohsiung University of Science and Technology, Kaohsiung, Taiwan. Contact: wangch@nkust.edu.tw

Human factor analysis was used to reveal the chemotherapy dispensing process related medical errors to improve patient safety of a 1500-bed Taiwan medical center. These errors are related to 3 factors: personnel, workflow and equipments. Results showed a negligence of personnel, unfamiliarity with environmental facilities, non-compliance to SOPs and excessive workload. Also, paper prescription labels have many potential problems such as low legibility, low identifiability, no active warning functions and misidentification of items in multiple-dosage or similar packaging. May apply new technology and human factors engineering perspective to improve operations that prone to human error.

2 The Risk Factors of Diabetic Kidney Disease

Yi-Ling Wu, Chih-Cheng Hsu, National Health Research Institutes, Miaoli, Taiwan.

Diabetic kidney disease (DKD) is a serious microvascular complication of both type 1 diabetes mellitus (T1DM) and type 2 diabetes mellitus (T2DM). According to a recent Taiwan Diabetes Atlas, about 18 percent of patients with T2DM developed DKD in 2014, and the number is still growing up. DKD is the main cause of end-stage kidney disease (ESKD) in developed countries. Therefore, to understand the risk factor of diabetic kidney disease is to help us develop a better kidney disease care model. The risk factors for DKD development can be divided into two categories: risk factors that cannot be changed, such as older age, male sex, ethnicity, and heredity, and risk factors that can be modified, including elevated glucose levels, high blood pressure, dyslipidemia, acute kidney injury, and lifestyles. This presentation summaries the important risk factors in the development and progression of DKD in order to rationalize and support our novel model and later to propose recommendations to improve national health policies in diabetes and renal care.

3 The Prevention and Care of Chronic Kidney Disease in Taiwan

JIA-SIN Liu, Kaohsiung, Taiwan.

Chronic kidney disease is a serious health condition that can progress to end-stage renal disease, which increases the risk of death and requires extensive medical resources for treatment such as dialysis or kidney transplantation. Taiwan has the highest incidence of end-stage renal disease in the world, but the prevalence of chronic kidney disease is not significantly higher than in other countries. While there is not enough evidence for Taiwan's unique factors in chronic kidney disease progression, Taiwan has implemented relevant care plans for the prevention and care of kidney disease based on existing theories.

4 Experts in the Care Model: Experiences from Taiwan's Chronic Kidney Disease Care

Ming-Yen Lin, Kaohsiung Medical University Hospital, Kaohsiung Medical University, Kaohsiung, Taiwan. Contact: mingyenlin3@gmail.com

Taiwan has ranked high in end-stage kidney disease (ESKD) incidence worldwide since 2001. Dialysis annually consumes nearly 7-8% total reimbursement of National Health Insurance (NHI). To avoid the rising trends of burdens, experts launched a multidisciplinary care model for patients with advanced chronic kidney disease (CKD) in 2002. In 2006, Taiwan NHI launched the Pre-ESRD care program to encourage nephrologists to organize care teams to deliver comprehensive care based on provided requirements for patients with advanced CKD. Another pay-for-performance care program, Early-CKD, was additionally reimbursed for early intervention in 2011. A recent study evaluated 15-year ESKD incidence trends and found substantial improvement in reducing trends of age-standardized incidence, causing 6.38 per million in 2016 compared with the counterfactual scenario. The care programs start to enroll highly CKD-risky populations through expert consensus and elevated care effectiveness.

FB10

Casson

Inverse Optimization for Learning Health Decisions

General Session

Session Chair

Kimia Ghobadi, Johns Hopkins University, Baltimore, MD

Session Chair

Houra Mahmoudzadeh, University of Waterloo, Waterloo, ON, Canada.

1 Understanding the Logic Behind Hospital Discharge Decisions Using Inverse Optimization

Sara Ebrahimkhani, Hossein Abouee Mehrizi, Houra Mahmoudzadeh, University of Waterloo, Waterloo, ON, Canada.

Hospitals make decisions on when to discharge patients and such decisions do not necessarily adhere to a certain set of known guidelines due to trade-offs between different implicit criteria. In this talk, we propose an inverse optimization method to infer the underlying criteria used for determining the severity of patients' illnesses. Using laboratory report data from a hospital's patients, the proposed model finds linear criteria based on which outpatients are identified.

2 Inverse Learning of Diet Recommendations

Farzin Ahmadi[1], Fardin Ganjkhanloo[2], Kimia Ghobadi[1], [1]Johns Hopkins University, Baltimore, MD, [2]Johns hopkins University, Towson, MD, Contact: kimia@jhu.edu

We use 'Inverse learning', an inverse optimization approach, to find personalized diets for patients who suffer from hypertension. This data-driven approach considers prior food intakes of patients and embeds that within dietary frameworks that are recommended by clinical providers. The results are diets that mimic patients' habits and behaviour while gradually moving them towards healthier diets.

3 Inverse Optimization for Inferring Clinical Criteria for Radiation Plans for Prostate Cancer Patients

Bradley Hallett[1], Ernest Osei[2], Johnson Darko[2], Houra Mahmoudzadeh[1], [1]University of Waterloo, Waterloo, ON, Canada; [2]Grand River Regional Cancer Centre, Waterloo, ON, Canada. Contact: btmhalle@uwaterloo.ca

Our research proposes using an inverse optimization technique to understand the implicit logic of the oncologist's approved treatment plans. We retrieved various features of successful historical plans from critical organs as well as the planning target volume (PTV) and critical target volume (CTV). Through inverse optimization, we can leverage past radiation plans to determine the updated clinical guidelines and any other unrecognized trade-offs utilized. Additionally, different loss functions were tested as the objective function in the inverse model.

4 Inverse Learning of Acceptability Criteria in Radiotherapy

Houra Mahmoudzadeh[1], Kimia Ghobadi[2], [1]University of Waterloo, Waterloo, ON, Canada; [2]Johns Hopkins University, Baltimore, MD, Contact: houra.mahmoudzadeh@uwaterloo.ca

In radiation therapy treatment planning for cancer patients, radiation oncologists make decisions on whether the quality of personalized plans generated through a treatment planning system is acceptable for each patient. The clinical guidelines for the acceptability of plans are neither explicitly known nor universally agreed upon. We use inverse optimization to learn the underlying clinical guidelines for the acceptability of plans in different patient populations. Inferring such guidelines can lead to more efficient treatment planning and improved quality of treatment.

FB11

Tom Thomson

Interpretable and Equitable Analytics for Healthcare

General Session

Session Chair
Gian-Gabriel Garcia,

Session Chair
Sun Ju Lee,

1 Estimating Chronic Kidney Disease Stages For Patients With Small Renal Masses Using The Expectation-maximization Algorithm

Wendy Qi[1], Jennifer Mason Lobo[2], Thomas Lidbetter[3], Emmett Kennady[4], Noah Schenkman[4], [1]University of Virginia, Charlottesville, VA, [2]University of Virginia, Charlottesville, VA, [3]University of Virginia, Newark, NJ, [4]University of Virginia, Charlottesville, VA, Contact: jem4yb@virginia.edu

Management of small renal masses involves cancer control and preservation of renal function. Estimation of renal function changes is challenging given that measurements are taken at uneven intervals. We employ the Expectation-Maximization algorithm to estimate the renal function transition probabilities. Results improve understanding and interpretation of renal function transitions for patients and clinicians, enhancing clinical decision-making and informing treatment planning.

2 Sequential Learning and Decision Making with Optimized Time Windows for Irregularly-Sampled Multivariate Time Series Health Data

Maryam Alimohammadi, Shengfan Zhang, University of Arkansas, Fayetteville, AR

Laboratory test results can help care providers monitor a patient's health condition and evaluate treatment options. However, excessive lab tests increase the chance of associated risk for patients and lead to elevated costs for patients and hospitals. The associated risk is even higher for patients under critical conditions, such as those mechanically ventilated in ICU. The most common and critical lab test for mechanically ventilated patients is the arterial blood gas (ABG) test. Limited clinical and data-driven guidelines are available for lab test timing to avoid unnecessary lab tests. We introduce sequential learning models to find the optimal timing of the ABG test for mechanically ventilated patients in the ICU. We also propose an optimization-based algorithm to prepare the irregularly-sampled electronic health records data to train the model. In this algorithm, a patient-specific optimal time window size is determined to avoid both high loss of information due to data aggregation and excessive time windows without any assigned value.

3 Toward Equitable Allocation Strategies for Opioid Settlements

Robert Newton, Penn State, University Park, PA

Recent settlements with opioid distributors and manufacturers lead directly to a discussion of how to equitably allocate funds. States, including Pennsylvania, have used weighted combinations of metrics agreed upon by stakeholders to allocate settlement funds across subdivisions, but these strategies do not necessarily consider equity directly. We present approaches that optimize allocations based on social welfare functions and use them to compute allocations and evaluate strategies alongside the actual formula-based strategy used in Pennsylvania. Specifically, we contrast Pennsylvania's strategy with strategies that 1) minimize total deviation, 2) minimize the worst-case (minimax) regret, and 3) balance efficiency with equity using alpha fairness. While the Pennsylvania allocation is noteworthy in that all parties agreed to it, we propose that stakeholders may perceive as more equitable an allocation based on relative regret---particularly using minimax regret or blending efficiency and equity using alpha fairness.

4 Clustered Multi-Task Learning for Prediction of Adverse Pregnancy Outcomes

Sun Ju Lee[1], Gian-Gabriel P. Garcia[2], [1]Georgia Institute of Technology, Atlanta, GA, [2]Georgia Institute of Technology, Atlanta, GA, Contact: julee@gatech.edu

In clinical prediction models, combining individual indicators into a composite outcome can help overcome issues associated with single outcomes such as low predictability and low prevalence. However, this may obscure relationships between predictors and single outcomes, and may limit the

clinical utility of the prediction model as diagnoses may have different etiologies addressed by different interventions. We aim to resolve this trade-off by developing an optimization framework to simultaneously cluster related outcomes and learn model parameters for each cluster. We apply our formulation to indicators comprising maternal and neonatal morbidity and demonstrate that our approach can aid interpretability by finding underlying groups of related tasks and deriving an interpretable set of predictors.

FB12

Osgood West

Empirical Healthcare Operations Management

General Session

Session Chair

Masoud Kamalahmadi, University of Miami

1 How Online Reviews Affect Patients' Trust to Choose a Primary Care Physician

Sina Ansari[1], Shabnam Azimi[2], [1]Driehaus College of Business, DePaul University, Chicago, IL, [2]Loyola University Chicago, Chicago, IL, Contact: sina.ansari@depaul.edu

Recent research suggests that more than two-thirds of people use online reviews as the first step in finding a new primary care physician (PCP). However, it is unclear what role review content plays when a patient uses online reviews to decide about a new PCP. The purpose of this research is to understand how the content of a review, related to competence (communication and technical skills), and benevolence (fidelity and fairness) impact patients' trusting intentions to select a PCP. We use two experimental studies to test our hypotheses and collect data through Prolific.co. We find that reviews about the communication skills of a PCP have strongest effects on trusting intentions than other types of reviews. We also find that positive reviews are perceived as more helpful for the readers than negative reviews, but negative reviews have a stronger impact on patients' trust intentions than positive ones.

2 Behavioral Responses to Kidney Allocation Priority: A Regression Discontinuity Analysis

Jiayi Liu[1], Diwas S. KC[2], [1]Virginia Tech, Blacksburg, VA, [2]Emory University, Atlanta, GA, Contact: jyliu@vt.edu

The severe shortage of deceased-donor kidneys has turned the allocation into a rationing problem. Previous research and policy guidance on the design of allocation system often makes restrictive assumptions about patient behavior. This study provides quasi-experimental evidence on how patients respond to allocation rules. We exploit a national kidney allocation policy that assigns priority based on an exogenous cutoff. Allocation priority produces a positive supply shock: prioritized patients receive more frequent kidney donors with generally higher quality. We find that prioritized patients become more selective; they are much less likely to accept an organ donor of a given quality, which can lead to an increasing number of organs being discarded, further exacerbating the organ shortage. These findings have implications for kidney allocation policy making.

3 When Does Collocation of Physical and Mental Health Services Matter?

Vishal Ahuja, Southern Methodist University, Dallas, TX

We examine how collocation, defined as sharing the same physical space, of mental and physical health providers impacts four important health outcomes: number of hospitalizations; associated length of stay and 30-day readmissions; and suicide ideation/attempts. Furthermore, we investigate factors that moderate the collocation-outcomes relationship. Using data on diabetic patients from the Veterans Administration over an 11-year period, we find that collocation is negatively associated with all four outcomes. Put simply, the more often the patient sees their collocated providers, the better their outcomes. In examining the moderators, we find that collocation benefits patients who identify as Black; whose mental health is severe; whose care is fragmented; or whose providers are not as familiar with each other. Our results offer insights into how healthcare organizations can develop targeted (collocation-based) interventions to yield the highest expected benefit.

FB14

Fitzgerald

Mental Health and Addictions

Contributed Session

Session Chair

Michaela Rikard, Atlanta, GA

1 Allocation of Persons with Severe Mental Illness to Group Homes

Rebekka Arntzen, Centrum Wiskunde & Informatica, Amsterdam, Netherlands. Contact: rebekka.arntzen@cwi.nl

Psychiatric care patients often encounter long waiting times for protected living facilities such as group homes. This problem worsens if patients have such a set of characteristics that they do not 'fit in' with already residing other patients in the facilities. In this research, a heuristic method is proposed that can allocate persons to group homes constrained by a

maximum allowed set of features, such as aggression and criminal history. In this way, the group homes can best be balanced. We test the performance of the heuristic against a Markov Decision Process.

2 Longitudinal Dose Patterns Among Patients Newly Initiated on Long-Term Opioid Therapy in the United States, 218-219

Michaela Rikard, Nisha Nataraj, Kun Zhang, Andrea Strahan, Christina Mikosz, Gery Guy, Centers for Disease Control and Prevention, Atlanta, GA, Contact: ruv4@cdc.gov

Time-series cluster analysis was utilized to characterize and visualize trends in prescribed opioid dosage among patients newly initiated on long-term opioid therapy using data from an all-payer pharmacy database. Patients were stratified into four categories based on mean daily opioid dosage during a 90-day baseline period. Cluster analysis identified nine unique clusters of dosage trajectories among these four baseline dosage categories and indicated multiple clusters of patients who experienced high rates of discontinuation and rapid tapering. These findings highlight opportunities for clinician training pertaining to evidence-based guideline-concordant opioid prescribing.

3 Causal Inference in Medical Records: Applications to Antihypertensive Drug Repurposing for Dementia Prevention

Marie-Laure Charpignon[1], Bella Vakulenko-Lagun[2], Colin Magdamo[3], [1]Massachusetts Institute of Technology, Cambridge, MA, [2]Haifa University, Haifa, Israel; [3]MGH, Boston, MA

Beyond age, type 2 diabetes and hypertension are two major risk factors for dementia onset. However, prior observational studies contrasting antihypertensive drug classes, including ACE inhibitors and Angiotensin Receptor Blockers (ARB), yielded mixed results. To evaluate the repurposing potential of drugs with distinct mechanisms of action, we deployed a causal inference approach accounting for competing risk of death in emulated clinical trials using two electronic health record systems. ARB initiation associated with lower hazard of all-cause mortality (HR=1.14 [95% CI: 1.09-1.20]) and of dementia onset (HR=1.37 [95% CI: 1.31-1.45]) in cause-specific Cox Proportional Hazards models.

FB16

Richmond

System and Process Modeling

Contributed Session

Session Chair

Murray J. Cote, Texas A&M University, College Station, TX

1 Balancing ICU Occupancy and Operating Room Efficiency: A Novel Genetic Algorithm with Simulation Solutions

Jiawen Tan[1,2], Fan Yang[2], Hui Li[2], Wanyi Tang[2], Ying Wang[1], Yonggang Zhang[1], Nian Li[1], [1]West China Hospital, Chengdu, China; [2]Tsinghua University, Beijing, China. Contact: wanyitang1029@gmail.com

Intensive Care Unit (ICU) bed scarcity poses serious challenges to healthcare systems, such as increased deaths, delayed surgeries, and lower satisfaction. We propose an integer programming (IP) model aiming to reduce blocking across the perioperative period by balancing ICU occupancy and minimizing idle- and over-time hours of operating rooms. A novel genetic algorithm approach that activates population iteration by inserting simulation solutions is introduced. We test our method using diverse sets of instances generated from real-world data and show that our method can obtain high performance and accelerates the convergence speed of the algorithm in large-scale scenarios.

2 Hospital Choice and Waiting: Queiing up or Opting Out - with a Case Study from Shanghai

J.J. Van De Klundert[1], Roberto Cominetti[2], Qingxia Kong[3], Yun Liu[4], [1]Universidad Adolfo Ibanez, Santiago, Chile; [2]Universidad Adolfo Ibanez, Santiago, Chile; [3]Erasmus University Rotterdam, Rotterdam, Netherlands; [4]Erasmus University Rotterdam, Rotterdam, Netherlands.

Policy studies use typically rely on DCE based preference models to analyse the effect of interventions to strengthen and direct patients towards primary care. The DCE models capture the direct effects of factors determining the attractiveness of primary care and the alternatives. For the factor waiting time, however, these studies ignore the interrelationship: waiting determines facility choice which determines waiting time. We integrate DCE based utility models for patient choice with queuing models to accurately capture these interrelationships. We prove that that the resulting model has a unique solution and can be solved to optimality. We present a case study from Shanghai, China.

3 "Truthiness" at the Doctor's Office: How Information Asymmetry Affects Outpatient Clinic Performance

Murray J. Cote[1], Jon M. Stauffer[2], Cynthia Weston[3], [1]Texas A&M University, College Station, TX, [2]Texas A&M University, College Station, TX, [3]Texas A&M University, College Station, TX, Contact: mjcote@tamu.edu

A perennial challenge in outpatient clinic management is efficient patient flow where patient healthcare concerns are fully disclosed in advance of their appointments. During the appointment, additional health concerns may be revealed with the expectation of them to be addressed as well. If accommodated, subsequent patients may be delayed as the appointment is extended beyond its expected duration. Similarly, the patient's provider may choose to end the appointment and request a new appointment to address these additional health concerns. We report results from a comprehensive survey of patients and their providers and offer strategies for addressing patient "truthiness."