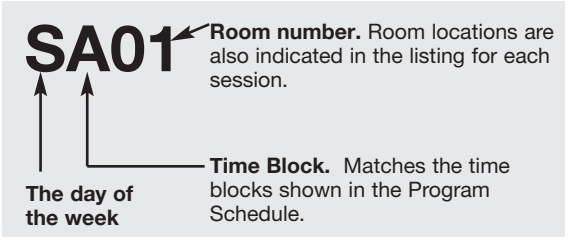
How to Navigate the Technical Sessions

There are four primary resources to help you understand and navigate the Technical Sessions:

- This Conference Session listing, which provides the most detailed information. The listing is presented chronologically by day/time, showing each session and the papers/abstracts/authors within each session.
- The Author and Session indices provide cross-reference assistance.
- The "Master Track Schedule" is on the back cover. This is an overview of the tracks (general topic areas) and where/when they are scheduled.

The Session Codes



Time Blocks

Wednesday

Welcome	10:00am - 10:10am
Keynote	10:40am - 11:00am
WA	11:10am - 12:40pm
WB	2:00pm - 3:30pm
WC	3:40pm - 5:10pm

Thursday

HAS	10:00am - 10:10am
Keynote	10:10am - 11:00am
TA	11:10am - 12:40pm
Tutorial	1:00pm - 1:50pm
WB	2:00pm - 3:30 pm
WC	3:40pm - 5:10pm

Friday

Keynote	10:00am - 10:50am
FA	11:00am - 12:30pm
FB	12:40pm - 2:10pm
FC	2:20pm - 3:50pm

Wednesday, 10:00AM - 10:10AM

■ Wednesday Welcome

Virtual Room 01

Welcome Remarks

Keynote Session

Introducers

Paul Griffin, Pennsylvania State University, University Park, PA, United States, Robert Dittus, Vanderbilt University, Brentwood, TN, United States

Chair: Nan Kong, Purdue University, Biomedical Eng., West Lafayette, IN, 47907-2032, United States

Wednesday, 10:10AM - 11:00AM

■ Keynote Wednesday

Virtual Room 01

Keynote: How Computational Approaches Can Have Helped the Response to COVID-19 and Other Pandemics and Epidemics

Keynote Session

1 - How Computational Approaches Can Have Helped the Response to COVID-19 and Other Pandemics and Epidemics

Bruce Y Lee, City University of New York, New York, NY, United States

Since 2007 our PHICOR Team has developed and used computational models and analytics and systems approach to help with the global, national, state, and local responses for many major infectious disease threats. This has included being embedded in HHS during the 2009 H1N1 influenza pandemic to help with the national response and working with the CDC to control the spread of antibiotic-resistant bacteria. Other examples have included the Zika outbreak and the current COVID-19 coronavirus pandemic

Wednesday, 11:10AM - 12:40PM

■ WA01

Virtual Room 01

Models to Inform Disease Control and Public Health

General Session

Chair: Sze-Chuan Suen, University of Southern California, Los Angeles, CA, 90089-0193, United States

1 - Reducing HIV Incidence and Racial Disparities Among Men Who Have Sex with Men in Los Angeles County

Anthony Nguyen, University of Southern California, Los Angeles, CA, United States, Sze-Chuan Suen

Los Angeles County (LAC) has the dual objectives of reducing HIV incidence and disparities in HIV burden, as currently, Blacks and Hispanics have incidence rates roughly 4.5x and 2x as that for Whites, respectively. Using a microsimulation with race-stratified parameters and transition probabilities for men who have sex with men (MSM) in LAC, we find that although the number of annual infections is decreasing over time, disparities across race/ethnicity remain substantial. We show that policies prioritizing PrEP allocation to the Black community over the next 15 years result in both a higher level of cumulative infections averted and a reduction in disparities based on incidence rate.

2 - Conditions Under Which Raw Case Count May Not be a Good Metric of Intervention Effectiveness

Peng Dai, Industrial and System Engineering University of Southern California, Los Angeles, CA, United States, Sze-Chuan Suen

While increasing clearance rates of infectious disease may be an intuitive disease control measure, we find that doing so under certain population dynamics may result in counter-intuitive case count outcomes. We identify properties of a classic compartmental model (the susceptible-infected-susceptible, or SIS) where this occurs. To validate the universality and adaptability of these properties, we additionally explore conditions for occurrence of these properties in generic and quadratic compartmental disease models.

3 - Optimal Chronic Kidney Disease Screening Frequency Among Diabetics

Chou-Chun Wu, University of Southern California, Los Angeles, CA, United States, Sze-Chuan Suen

US CDC estimates that the undiagnosed rate for chronic kidney disease can be as high as 90%, resulting in 30+ million unmanaged cases. To encourage timely diagnosis of at-risk patients, we develop screening guidelines stratified by age, proteinuria status, and prior test history for diabetics by race and gender. To do this, we adopt a Partially Observed Markov Decision Process framework to identify the optimal action (screen or wait) every three months from ages 30-85 that maximizes a patient's discounted lifetime net monetary benefit. We find that the optimal policy suggests more frequent screening in all race and gender groups compared with annual screening recommended in the status quo.

4 - Optimal Timing of Liver Transplantation for ACLF3 Patients

Suyanpeng Zhang, University of Southern California, Los Angeles, CA, United States, Sze-Chuan Suen, Vinay Sundaram, Cynthia Gong, Jessica Pham

Patients with acute-on-chronic liver failure grade 3 (ACLF-3) may require urgent liver transplantation (LT) but may be offered suboptimal organs. But how many days should a patient wait for an optimal liver before accepting a marginal liver to maximize survival? We create a Markov decision process to identify the ideal timing to start accepting a suboptimal organ. We show the existence of a threshold policy over time and perform sensitivity analysis by varying the likelihood of receiving an optimal liver and relative risk of a suboptimal organ. Moreover, we test the robustness of our results by considering the impact of chronic kidney disease and improvements to ACLF-2.

■ WA02

Virtual Room 02

COVID-19 Planning Using Simulation Models

General Session

Chair: Feryal Erhun, University of Cambridge, Cambridge, CB22 5GB, United Kingdom

Co-Chair: Stefan Scholtes, University of Cambridge, Cambridge, CB2 1AG, United Kingdom

1 - An Adaptive Research Approach to COVID-19 Forecasting for Regional Health Systems in England

Houyuan Jiang, University of Cambridge, Judge Business School Old Addenbrookes Site Trumpi, Cambridge, CB2 1AG, United Kingdom, Lidia Betcheva, Feryal Erhun, Antoine Feylessoufi, Peter Fryers, Paulo Goncalves, Paul Kattuman, Tom Pape, Anees Pari, Stefan Scholtes, Carina Tyrrell

Since March 2020, we have been studying research questions to address the pandemic's rapidly evolving current and near-future epidemiological state, as well as short-term and medium-term bed capacity demand. We apply dynamic data-driven approaches using time series modeling and system dynamics modeling. We thus obtain a broad view of the evolving situation and present the model outcomes and insights during weekly joint meetings among the regional leadership team in the EoE, contributing to the discussion of the COVID-19 response and issues beyond immediate COVID-19 planning. Our regional and local focus enables us to better understand the pandemic's progression and to help decision makers make more informed short- and medium-term capacity plans in different localities in the EoE.

2 - Evaluating Intensive Care Triage Strategies During the COVID-19 Pandemic

Christos Vasilakis, University of Bath, Bath, United Kingdom, , Richard M. Wood

During the pandemic many intensive care units (ICU) have been overwhelmed by unprecedented levels of demand. Notwithstanding ethical considerations, the prioritization of patients with better prognoses may support a more effective use of available capacity in maximizing aggregate outcomes. We constructed an open-source computer simulation model for approximating the intensive care admission and discharge dynamics under triage. The model was calibrated from observational data for 9505 patient admissions to UK ICUs. We used the model to explore likely triage outcomes under various conditions using a range of demand trajectories corresponding to different non-pharmaceutical interventions.

3 - Behavioral Responses to Risk Promote Vaccinating High-contact Individuals First

Hazhir Rahmandad, Massachusetts Institute of Technology, Cambridge, MA, 2142, United States

If COVID-19's reproduction number was constant, vaccinating elderly first minimized deaths. However, incorporating risk-driven behavior/policy changes enhances fit to data and prioritizes vaccinating high-contact individuals. Deaths grow exponentially until people are compelled to reduce contacts, stabilizing at levels obliging higher-contact groups to sufficiently cut interactions. Vaccinating those groups out of transmission saves lives and speeds everybody's return to normal life.

4 - Informing Hospital Capacity and Social Distancing Policies During the COVID-19 Pandemic

Paulo Goncalves, University of Italian Switzerland, Lugano, 6900, Switzerland, Paolo Ferrari, Luca Crivelli, Emiliano Albanese

At the start of the COVID-19 pandemic, health authorities in Ticino, Switzerland, needed to increase healthcare capacity (e.g., ICU beds, medical staff, oxygen supply) to meet the surge in patient demand. Using principles of healthcare operations management and system dynamics modeling, we were able to inform hospital system policies, including (a) designating one hospital as a COVID-19 focused facility, (b) informing ICU and ventilated bed capacity required to achieve volume flexibility, and (c) reallocating medical and nursing staff across units. Through "what-if" scenarios, we assessed that a second wave of infections were likely to occur if authorities lifted social distancing policies.

■ WA03

Virtual Room 03

HAS Student Paper Competition

Sponsored: Healthcare Applications Society (HAS)

Sponsored Session

Chair: Ebru Korular Bish, University of Alabama, Blacksburg, VA, 24061-2000, United States

Co-Chair: Tinglong Dai, Johns Hopkins University, Baltimore, MD, 21212-1708, United States

1 - Nonprofit vs. For-Profit: Allocation of Beds and Access to Care in U.S. Nursing Homes

Yangzi Jiang, Northwestern University, Evanston, IL, 60201, United States, Lauren Xiaoyuan Lu, Jan A. Van Mieghem

Motivated by empirical observations of U.S. nursing homes, we formulate a queueing network model to study nursing homes' bed allocation decisions and the resulting access to care for economically disadvantaged populations. To distinguish nonprofit from for-profit nursing homes, we incorporate altruism into a nonprofit nursing home's objective function to capture resident welfare including the blocking cost of high-margin Medicare residents and the waiting cost of low-margin Medicaid residents. Nursing homes can allocate a fixed number of beds among Medicare-dedicated, Medicaid-dedicated, and flexible beds. Our theoretical and empirical findings inform the public that the growth of the for-profit nursing home segment does not necessarily hurt the access to care for the Medicaid population, and surprisingly, under high Medicaid demand, for-profit nursing homes might provide higher access to care than their nonprofit counterparts.

2 - Contextual Learning with Online Convex Optimization: Theory and Applications to Chronic Diseases

Esmaeil Keyvanshokooh, University of Michigan, Ann Arbor, MI, 48108-1020, United States, Mohammad Zhalechian, Cong Shi, Mark P. Van Oyen, Pooyan Kazemian

Chronic diseases are the leading cause of mortality and disability worldwide, requiring the surveillance and monitoring of each patient to assess disease progression and determine if an appropriate intervention for that individual is warranted. In many cases, it is a challenge to determine the most effective treatment for an individual. Even when a suitable treatment is identified, dosing it optimally remains a significant challenge. Making these two nested decisions involves adaptively learning a personalized disease progression control model. We formulate this as a new contextual multi-armed bandit under a two-dimensional control with a nested structure. We then develop a joint contextual learning and optimization algorithm. We demonstrate the efficacy and practicality of our methodology using clinical trial data on high blood pressure patients with type 2 diabetes. Our framework could be widely used in many other applications with two-dimensional nested decision-making.

3 - Structural Estimation of Intertemporal Externalities on ICU Admission Decisions

Yiwen Shen, Columbia University, Columbia Business School, New York, NY, 10027-8385, United States, Carrie W. Chan, Fanyin Zheng, Gabriel Escobar

Service systems' behavior can be affected by multiple factors. In the case of intensive care units (ICUs), which admit patients from four primary loci (the emergency department (ED), scheduled patients, planned transfers from other ICUs, and unplanned transfers), it is known that admission rates of some patients decrease as occupancy increases. It is also known that, for at least some conditions, ICU admission is not just a function of patients' illness, and that a significant proportion of the variation in ICU admission rates is due to hospital, not patient, factors. In this paper, we employ two years of data from patients admitted to 21 Kaiser Permanente Northern California ICUs from the ED. We quantify the variation in ICU admission from the ED under varying degrees of ICU and ED occupancy. We find that substantial heterogeneity in admission rates is present, and that it cannot be explained either by patient factors or occupancy levelsalone. We use a structural model to understand the extent that intertemporal externalities could account for some of this variation.

4 - An Inverse Optimization Approach to Measuring Clinical Pathway Concordance

Nasrin Yousefi, University of Toronto, Toronto, ON, M4Y1R5, Canada, Timothy C. Chan, Katharina Forster, Maria Eberg, Claire Holloway, Luciano Ieraci

Clinical pathways outline standardized processes in the delivery of care for a specific disease. Patient journeys through the healthcare system, though, can deviate substantially from these pathways. Given the positive benefits of clinical pathways, it is important to measure the concordance of patient pathways so that variations in health system performance or bottlenecks in the delivery of care can be detected, monitored, and acted upon. This paper proposes the first data-driven inverse optimization approach to measuring pathway concordance in any problem context. Our specific application considers clinical pathway concordance for stage III colon cancer. We develop a novel concordance metric and demonstrate using real patient data from Ontario, Canada that it has a statistically significant association with survival. Our methodological approach considers a patient's journey as a walk in a directed graph, where the costs on the arcs are derived by solving an inverse shortest path problem. The inverse optimization model uses two sources of information to find the arc costs: reference pathways developed by a provincial cancer agency (primary) and data from real world patient-related activity from patients with both positive and negative clinical outcomes (secondary).

■ WA04

Virtual Room 04

Advances in Empirical Healthcare Operations

General Session

Chair: Hummy Song, University of Pennsylvania, Philadelphia, PA, 19104, United States

1 - The Variance Learning Curve

Jónas Jónasson, MIT. Sloan, Cambridge, MA, United States, Hessam Bavafa

The expansive Learning-Curve literature in Operations Management has explored how various facets of prior experience improve average performance. We show that cumulate experience also results in improved performance consistency. Since variability is a key driver of performance in most service systems, our results have implications for capacity planning.

2 - Searching for the Best Yardstick: Cost of Quality Improvements in the U.S. Hospital Industry

Jong Myeong Lim, The Wharton School, Philadelphia, PA, United States, Kenneth Moon, Sergei Savin

The Hospital Value-Based Purchasing (VBP) Program is Medicare's implementation of yardstick incentives applied to hospitals in the U.S. Under the VBP Program, 2% of all Medicare payments, estimated to be US$1.9B in FY2021, are withheld and redistributed based on relative performance in the quality of delivered care. We develop a dynamic equilibrium model in which hospitals are engaged in a repeated competition under yardstick incentives. Using structural estimation methods, we recover key parameters that govern hospitals' decisions to invest in quality improvement, including the financial and non-financial costs and uncertain outcomes of investment. Our counterfactual analyses explore the benefits, on the one hand, of modifying the overall size of the yardstick incentives and, on the other hand, of implementing a more focused program tailored to hospital type.

3 - A Field Experiment on Wait Time Information Provision

Danqi Luo, Stanford Graduate School of Business, Stanford, CA, 94305-7216, United States, Mohsen Bayati, Erica Plambeck

In an ongoing field experiment, we trial three different wait time information provision schemes to low-acuity patients (LAP), patients with ESI level 3, 4, and 5. Through an incentivized text-based survey, patients can electronically self-report their real-time satisfaction on wait time and pain level throughout their stay in the ED. Matching patients' responses with their electronic medical records (EMR) and the NRC health data (a survey collected by SMMC), we can measure the impact of different wait time information on patients' waiting satisfaction, outcomes concerning the behavior of left-without-being-seen by a physician, length of the stay in the ED, and pain level. In the first stage of results, we identified that LAPs are less likely to leave the ED without being seen by a physician compared to the baseline when no information is provided.

4 - Nudging Patients: Evidence from the Field and the Lab

Joy Liu, Emory University, Atlanta, GA, United States, Diwas S. Kc

To examine the drivers of patient no-shows at outpatient clinics, we conduct a series of field experiments where the messaging regarding their upcoming appointment is randomly assigned. We find that the type of messaging has a significant effect on the queuing behavior of individuals, most notably their no-show behavior.

■ WA05

Virtual Room 05

COVID-19 Research

General Session

Chair: Mohammad Delasay, Stony Brook University, East Setauket, NY, 11733, United States

1 - Controlling Epidemic Spread: Reducing Economic Losses with Targeted Closures

John R. Birge, University of Chicago, Booth School of Business Chicago, IL, 60637-1656, United States, Ozan Candogan, Yiding Feng

Data on population movements can be helpful in designing targeted policy responses to curb epidemic spread. We study a spatial epidemic model, which explicitly accounts for population movements, and propose an optimization framework for obtaining targeted policies that restrict economic activity in different neighborhoods of a city at different levels.We focus on COVID-19 and calibrate our model using the mobile phone data that capture individuals' movements within New York City (NYC). We show that appropriate targeting achieves a reduction in infections in all neighborhoods while resuming 23.1%-42.4% of the baseline non-teleworkable employment in NYC. By contrast, uniform (citywide) restriction policies that achieve the same policy goal lead to a factor of 3.92-6.25 reduction in permitted non-teleworkable employment. Ourtargeting framework gives policy makers an approach for curbing the spread of epidemics while limiting unemployment

2 - Retail Store Customer Flow and COVID-19 Transmission

Robert Shumsky, Professor, Tuck School of Business at Dartmouth, Hanover, NH, 03755-9000, United States, Laurens G. Debo, Rebecca Lebeaux, Quang Nguyen, Anne Hoen

To reduce the transmission of COVID-19, many retail stores use one-way aisles, occupancy limits, and 'safe shopping' times for vulnerable groups. To assess the value of these interventions, we formulate and analyze a mathematical model of customer flow and COVID-19 transmission. We find that the value of specific operational changes depends on how the virus is transmitted, through close contact or suspended aerosols. If transmission is primarily due to close contact then restricting customers to one-way movement can dramatically reduce transmission. We show that throughput (or occupancy) limits are always effective and assess the trade-off between infection rates and customer flow.

3 - A Queueing-theoretic Framework for Evaluating Transmission Risks in Service Facilities During a Pandemic
Kang Kang, University of Minnesota, Minneapolis, MN, United States, Sherwin Doroudi, Mohammad Delasay, Alexander Wickeham

We propose a new modeling framework for evaluating the risk of disease transmission during a pandemic in small-scale settings driven by stochasticity. We propose a novel metric inspired by the basic reproduction number from epidemiology and derive it for various queueing models of service facilities by leveraging a novel notion: sojourn time overlaps. We showcase how our metric can be used to explore the efficacy of a variety of common interventions aimed at curbing the spread of disease inside service facilities during the COVID-19 pandemic. We also discuss several directions for adapting our model to incorporate more nuanced features of disease transmission.

4 - Allocating Covid Vaccines: Save One for the Second Dose?
James E. Smith, Tuck School at Dartmouth, Hanover, NH, 03755-9000, United States, Robert Shumsky, Anne G. Hoen, Michael Gilbert

The two main COVID-19 vaccines in the U.S. are administered in two doses, with a prescribed number of weeks separating the two doses. Because of uncertainty in vaccine supply, many vaccination centers are saving doses in inventory to ensure on-time second doses. However, saving doses slows the administration of first doses and potentially delays completing the vaccination of the target population. In this paper, we use a mathematical model to explore the performance of policies to manage the administration of first and second doses in the face of supply uncertainty. The structure of the model suggests simple "set-aside" policies that reserve doses for second doses that are due in the coming weeks. Our experiments suggest that vaccine centers should set aside supply for second doses due in the next zero to two weeks, depending on the degree of uncertainty in the supply.

■ WA06

Virtual Room 06

Changes in Healthcare Operations in the Wake of COVID-19 Pandemic

General Session

Chair: Nurul (Ann) Suhaimi, Northeastern University, Boston, MA, 02115, United States

Co-Chair: Jacqueline Griffin, Northeastern University, Boston, MA, 02115, United States

1 - Analytical Study of the Effects of Drug Shortages on Hospital Pharmacy Operations During COVID-19
Noah Chicoine, Northeastern University, Boston, MA, United States, Min Gong, Jacqueline Griffin

The impact of COVID-19 has been well documented in the press, yet there remains a limited understanding of how these drug shortages were managed at the hospital level and the multitude of effects it had on operational decision making. We present our findings from an analysis of the operations of a top hospital pharmacy throughout the COVID-19 pandemic, with an emphasis on the results from analytics applied to data about inventories, information, and demand.

2 - Facility and Operations Design for a COVID-19 Community Vaccination Clinic
Jacqueline Griffin, Northeastern University, Boston, MA, 02115, United States, Ann Suhaimi

The COVID-19 pandemic onset in 2020 required quick changes by communities and organizations, particularly as it related to creating new testing and vaccination clinics. In this presentation we present simulation models, developed to inform decision making for the design of a community vaccination clinic - spanning decisions about scheduling, facility design, and operations. Finally, we discuss how the results of the analysis informed real world decision making.

3 - Use of Simulation Model to Help Outpatient Clinics Minimize Contact Time During the COVID-19 Pandemic
Ann Suhaimi, Northeastern University, Boston, MA, 02145, United States, Jacqueline Griffin

COVID-19 pandemic brings a new challenge to outpatient clinics. Other than the requirements to optimize telemedicine, in-person visits need to adhere to social distancing guidelines. Using a validated simulation model for a dermatology outpatient clinic with COVID-19 schedules, we identify the percentage of patients who wait with one or more patients and the average time they wait. Our goal is to determine the optimal number of clinic resources to minimize contact time between patients during their visits.

4 - Proactive Planning for Hospitals Operations in Anticipation of a Disruption
Mahsa Ghanbarpour, Northeastern University, Boston, MA, 02116, United States, Ozlem Ergun

The emergencies like a pandemic or extreme weather events impact hospitals' operations and capacities. This study introduces a decision-making framework that optimizes the level and timing of proactive actions in healthcare by analyzing the trade-offs between making more accurate decisions with better forecasts vs. increasing cost of action as the event approaches. We develop this framework by incorporating: (i) a pattern recognition method for determining the impact of emergency events on hospital operations and (ii) developing a stochastic dynamic programming model that captures the trade-offs. We aim to apply this framework to cancel elective surgeries proactively and dynamically in anticipation of an emergency to reduce the negative impact.

■ WA07

Virtual Room 07

COVID-19 Pandemic Modeling and Analysis 1

Contributed Session

Chair: Miao Bai, University of Connecticut, Storrs, CT, 06269-1041, United States

1 - Factors Associated with COVID-19 Cases Spread in Texas
Eduardo Pérez, Associate Professor, Texas State University, San Marcos, TX, United States, Francis Méndez Mediavilla, Samuel Greer, Kenneth Skidmore, Mary Van

County demographics, pre-existing disparities in healthcare, and restriction policies implemented at the county level may be intersecting with the observed number of COVID-19 outcomes. The goal of this research is to explore the relationship between county-level data and COVID-19 cases in the state of Texas and determine whether county-level factors explain this relationship. A multivariable cluster analysis is used to map the different infection trends observed in the state until December 2020. A multinomial logistic regression is used to determine factors that common in the clusters and insights are provided based on the results.

2 - A Study of Factors that Impact SARS-CoV-2 Progression at the County Level
Brittany Segundo, TAMU, College Station, TX, United States, Natarajan Gautam

In the throes of the novel SARS-CoV-2 pandemic, the factors that most greatly influence its progression are still unclear. In this work, we combine multiple datasets which capture sociological, political, and epidemiological characteristics of each county in the U.S. in order to build a data-driven model. By comparing the disease progression of disparate counties through a series of epidemiological metrics, we isolate which factors are most likely to impact transmission and thus inform appropriate public health measures to mitigate disease spread. Additionally, we use the fitted model to predict the disease trajectory for a subset of counties based on the characteristics of their populations.

3 - A Novel Data-driven Approach to Evaluate the Risk of Post-traumatic Stress Disorder in the U.S. Physicians During COVID-19 Pandemic
Sayanti Mukherjee, Assistant Professor, University at Buffalo - The State University of New York, Buffalo, NY, United States, Lance Rintamaki, Janet Shucard, Zhiyuan Wei, Lindsey Carlasare, Christine Sinsky

The traumatic nature of COVID-19-induced stressors makes post-traumatic stress disorder (PTSD) of special consequence for frontline physicians. Here, we propose a novel data-driven framework to assess the key PTSD risk factors in frontline physicians, leveraging statistical learning. This study identifies the prevalence and predictors of PTSD-risk among US frontline physicians during COVID-19, including stressors and support factors. The findings underscore the value of nonparametric modeling in uncovering nonlinear relationships between PTSD-risk and key variables for informed interventions, helping to better-prepare the US healthcare system for future epidemics/pandemics.

4 - No Panic in Pandemic: The Impact of Individual Choice on Public Health Policy and Vaccine Priority
Miao Bai, University of Connecticut, Storrs, CT, United States, Ying Cui, Guangwen (Crystal) Kong, Zhenhuan Zhang

We study strategic planning of public health interventions (social distancing and lockdown) in pandemics by considering individual response. We derive structural properties of optimal interventions and conduct numerical studies based on Minnesota COVID-19 data. We find that the individual equilibrium activity level is higher than the socially optimal activity level due to an individual's ignorance of the negative externality. As a result, lockdowns and social distancing policies are more effective when the disease prevalence is not at its peak level. Moreover, vaccination priority strategy needs to consider the trade-off between mortality rate and negative externality of different groups.

■ WA08

Virtual Room 08

Global COVID-19 Challenges

General Session

Chair: Hui Yang, Penn State, United States

1 - Shield-Net: Matching Supply with Demand for Face Shields During the COVID-19 Pandemic

Rebecca Alcock, University of Wisconsin, Madison, WI, United States, Justin J. Boutilier, Auyon Siddiq

The COVID-19 pandemic was marked by widespread shortages of personal protective equipment. Many domestic suppliers pivoted to producing PPE, but a key challenge that remained was the lack of an established marketplace to connect non-traditional suppliers to healthcare facilities. In response, we created an optimization model, Shield-Net, to match face shield requests with suppliers. Between March and September 2020, Shield-Net produced 390 matches, resulting in the shipment of 50,000+ face shields. This work contributed to the development of local PPE production initiatives in Guatemala with Engineers Without Borders and around the world with the United Nations Development Programme.

2 - Network Simulation of Epidemic Dynamics

Marta Ventura, Pennsylvania State University, University Park, PA, United States, Siqi Zhang, Hui Yang

With the recent pandemic outbreak of COVID19, there is an urgent need to develop epidemic simulations and design computer experiments. System dynamic models lack the ability to capture the complexity of the virus spread. To overcome this challenge, discrete event simulation (DES) is proposed. However, DES models are hampered by the complexity of modeling individuals' activities. Hence, this paper presents a novel framework to model the networked interaction of human activities and spread dynamics of diseases. Experimental results show that the proposed framework effectively characterizes the behaviors of individuals in the spatial environment and can help evaluate health policies.

3 - Simulation Optimization of COVID-19 Interventions

Siqi Zhang, The Pennsylvania State University, State College, PA, United States, Marta Ventura, Hui Yang

The existing preparedness plans by the Center for Disease Control and Health and Human Services strongly underscores the need for efficient COVID-19 interventions. However, computer models of COVID-19 interventions involve a greater level of complexity and traditional optimization techniques tend to be limited to calibrate such a complex epidemic system. Hence, this paper proposes a metamodeling approach to perform efficient epidemic simulations and optimize the strategies for COVID-19 interventions. Experimental results show that the proposed framework shows superior performance to capture the spatiotemporal dynamics of COVID-19 and aid the design of COVID-19 interventions.

4 - Performance Analysis of Sequence-to-sequence Deep Learning Framework for Hospital Census Predictions

Mihir Mehta, Graduate Research Assistant, Pennsylvania State University, State College, PA, United States, Biplab Sudhin Bhattacharya, Eric Reich, Soundar Kumara

Data-driven hospital census forecasting provides critical insights to health care operations and clinical leadership for developing effective resource allocation and scheduling policies while trying to meet the unique challenges of the evolving COVID-19 pandemic. We develop a sequence-to-sequence deep learning framework to forecast COVID-19 hospital census for a multi-hospital health care system and enhance its performance through a series of strategies. The framework demonstrates encouraging and actionable prediction capabilities. We derive insights about the role of each strategy toward performance improvement.

■ WA09

Virtual Room 09

Healthcare Analytics and Machine Learning 1

Contributed Session

Chair: Ilbin Lee, University of Alberta, School of Business, Edmonton, AB, T6G 2R6, Canada

1 - Benchmarking a Novel Scatter Search Algorithm for Markov Blanket Attribute Selection and Classification for Healthcare Data

John Threlfall, Cardiff University, Cardiff, United Kingdom, Daniel Gartner, Paul Harper, Rema Padman

Datasets with many discrete variables and relatively few observations are fairly common in the healthcare setting, particularly in clinical care. Finding which variables are relevant and non-redundant effectively and efficiently and achieving high prediction accuracy with them for critical patient outcomes are significant challenges. In this paper we develop a novel Scatter Search heuristic to efficiently learn which variables are relevant and non-redundant in a probabilistic graphical model. These probabilistic graphical model can then be easily interpreted by clinical staff.

2 - Healthcare Impact of COVID-19 Pandemic on Non-infected U.S. Population

Kristian Singh, Benefits Science Technology, Needham, MA, United States, Omid Nohadani

The progression of the COVID-19 pandemic has not only impacted those infected severely, but the entire US healthcare system as a whole. For the non-infected population, we study the impact to healthcare visitation, overall drug usage, and surgical deferments. Using machine learning and optimization on claims data from a large fraction of the US population, we developed insights that can be used to create more informed surgical deferral strategies for the healthcare system, creating better outcomes for patients and providers. Clinicians can employ a personalized decision support tool through our immersive web-based application.

3 - Predicting 30-Day Readmission Using Longitudinal Health Data

Ilbin Lee, University of Alberta, School of Business, Edmonton, AB, Canada, Sarah Davis, Jin Zhang, Mostafa Rezaei, Russ Greiner, Raj Padwal, Finlay McAlister

30-day readmission is an important operational measure of hospitals and has gained much attention in the research community. However, most existing prediction models fail to predict readmission well. We build prediction models using extensive data of more than 468k patients over seven years. The data contain detailed records of hospitalizations, outpatient visits, prescriptions, physician office visits, and lab results. We use deep learning methods and skip-gram to construct features from the longitudinal data. Our findings show that combining these features with other conventional ones improves the performance of various prediction models substantially.

■ WA10

Virtual Room 10

Actionable Analytics: AI/ML in Healthcare Decision Making

General Session

Chair: Yonatan Mintz, UW Madison, Madison, WI, United States

Co-Chair: Toyya Pujol, Purdue University, West Lafayette, IN, United States

1 - Optimal Local Explainer Aggregation for Interpretable Prediction

Qiaomei Li, UW. Madison, Madison, WI, United States, Yonatan Mintz, Rachel Cummings

In precision medicine, machine learning techniques have been commonly proposed to aid physicians in early screening of chronic diseases. However, the methods which typically achieve the highest level of accuracy are complex black box models. In this paper, we propose a local explainer aggregation method for explaining black box model predictions and evaluate the framework on two healthcare datasets. We use an integer optimization framework to combine local explainers into a near-global aggregate explainer, and we also propose a novel local explainer algorithm based on information filtering.

2 - Predictive Analytics for Hypertension Related Postpartum Readmission

Jinxin Tao, University of Wisconsin Madison, Madison, WI, United States, Ramsey Larson, Yonatan Mintz, Kara Hoppe

Hypertensive disorders of pregnancy, including chronic hypertension, gestational hypertension, and preeclampsia with or without severe features, account for the majority of postpartum readmissions. Postpartum readmission is costly both in financial terms and in quality of life measures for mothers and new families. However, using a predictive model to help predict postpartum readmission due to hypertension has not been proposed yet. In this study, we used a cost-sensitive random forest method to predict which patients would experience a hypertension-related postpartum readmission. Cost ratio is taken into account to tackle this highly imbalanced binary classification problem by penalizing a false negative error significantly higher than a false positive error. Our model can achieve a sensitivity of 85%, specificity of 79% and a balanced accuracy of 82% in predicting readmission. Some most important clinical variables are identified and compared between the readmitted group and non-readmitted group.

3 - An Optimization Approach to Plan a Community Health Worker Intervention for Diabetes Care

Katherine B. Adams, UW-Madison, Madison, WI, United States, Justin J. Boutilier, Yonatan Mintz

Diabetes is a global health priority, especially in lower-middle-income countries, where over 50% of premature deaths are attributed to high blood glucose. 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 select personalized CHW visit schedules to maximize glycemic control at a community-level. Our model incorporates the tradeoff between screening and follow-up visits, as well as patient decisions to enroll, stay enrolled or drop out based on disease progression, social stigma, and cognitive burden.

4 - Link Weight Prediction for Social Networks in Healthcare
Larissa Kawano Mori, Purdue University

Social networks can be a useful tool in healthcare to measure the impact of social influence on health outcomes. The link weight measures the strength of relationships within a network and provides additional insight into the effects of social influence on behavior (e.g., physicians, patients). In a healthcare setting, exogenous features of the nodes (i.e., metadata) can contain essential information that is pertinent to node behavior. Thus, we attempt to predict link weight using statistical learning methods by incorporating network features (adjusted for a weighted network) and metadata. We present the results of our approach and compare its performance to other commonly used methods.

■ WA11

Virtual Room 11

Healthcare Equity, Access, and Outcomes

General Session

Chair: Lina Song, University College London School of Management, London,United Kingdom

1 - Reverse Cross Subsidization in Healthcare Capitation Programs: Evidence from Medicare Advantage
Zhaowei She, Georgia Institute of Technology, Atlanta, GA, 30067-7980, United States, Turgay Ayer, Bilal Gokpinar, Danny Hughes

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.

2 - Does Competition Improve Service Quality? The Case of Nursing Homes Where Public and Private Payers Coexist
Bingxiao Wu, Rutgers University, New Brunswick, NJ, United States, Susan F. Lu, Konstantinos Serfes, Gerard Wedig

Competition plays an ambiguous role in nursing home markets where public and private payers coexist. Using U.S. nursing home data with a wide range of market structures, we find a U-shaped relationship between competition and service quality when nursing homes serve a mix of public and private segments, and a monotonically increasing relationship when nursing homes mostly serve the public, price-regulated, segment. The outcomes can be explained by the interplay of two opposing effects of competition: the reputation building effect whereby competing firms choose high quality to build a good reputation and the rent extraction effect whereby competition hinders investment for quality improvements by eliminating price premia. These observations are consistent with a repeated game model that incorporates public and private payer segments.

3 - The Allocation of Funds in Healthcare: Which Hospital to Support?
Lina Song, University College London School of Management, London, United Kingdom, Soroush Saghafian

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 2.1 million Medicare inpatient visits to over 1.3 million patients to U.S. hospitals, we analyze the performances of our heuristics in comparison to various hospital financing policies such as the Disproportional Share Hospital payment and Critical Access Hospital program. We find that our heuristics, as well as the allocations of investment based on quality, can improve the effectiveness and cost-effectiveness of current policies.

4 - Structural Estimation of Load Balancing Behavior in Inpatient Ward Network
Jing Dong, Columbia University, New York, NY, 10027-6945, United States, Pengyi Shi, Fanyin Zheng

In managing inpatient ward beds, decision-makers often face high levels of bed utilization and large variability in demand. Load balancing via off-service placement is one of the primary operational levers to alleviate congestion, yet this practice is associated with considerable costs. Therefore, it is imperative to understand how decision-makers exercise load balancing in practice and its implications on system performance. In this work, we take the structural estimation approach and empirically quantify the causal effect of inpatient wards' occupancy on patient routing decisions. We leverage the control function method to overcome the endogeneity problem of occupancy in estimation. Our results reveal a significant load balancing effect and a large difference between the load-balancing behavior during the day and the night. Based on the estimated routing policy, we further study how the load-balancing behavior affects system performance. Our findings provide new perspectives to manage congestion in the inpatient ward network.

■ WA12

Virtual Room 12

Data-Driven Research in Global Health and Wellbeing

General Session

Chair: Jonas Oddur Jonasson, MIT Sloan School of Management, Cambridge, MA, 02142-1347, United States

1 - The Use of Drones for Vaccine Delivery in Resource-limited Settings
Kim De Boeck, KU Leuven, Leuven, Belgium, Jónas Jónasson, Nico Vandaele

Among emerging technologies, the use of drones is increasingly put forward as a game-changing technology to improve the distribution of medical supplies in low- and middle-income countries. However, to date, little analysis has been done on the success factors that determine a sustainable implementation of drones in the public health supply chain, and more specifically in the vaccine supply chain. In this research, we assess the use of drones for vaccine delivery in resource-limited settings by applying a combination of research techniques including semi-structured interviews, spatial modeling, simulation, and optimization.

2 - Designing Data-driven Price Subsidies to Curb Malnutrition in Emerging Markets
Alp Sungu, London Business School, London, United Kingdom, Kamalini Ramdas, Ali Aouad

This research aims to shed light on the food choices of emerging market consumers and leverage data-driven frameworks to develop a nutritionally optimized food subsidy program against malnutrition. We develop a multi-purchase choice model to predict households' shopping baskets and then formulate an optimization model to prescribe a food subsidy policy that maximizes nutrient intake according to the fitted choice model. We empirically investigate the nutritional implications of alternative food subsidy policies by using scanner data collected from local groceries in low- and middle-income Indian neighborhoods.

3 - Optimal Prioritization and Discharge Policies for Medicaid Waiver Services
Can Zhang, Duke University, Durham, NC, 27708-9972, United States, Qiushi Chen

We study the management of waitlists for Medicaid waiver programs that provide critical services for individuals with developmental disabilities like autism. Unlike other typical waitlists management problems in healthcare settings such as for organ transplant where the service process is usually exogenous, a unique feature of Medicaid waiver waitlists is that patients may remain on the waiver slots for extended periods until being discharged, which renders systematic decisions for both prioritization and discharge relevant in this context. In this paper, we formulate a Markov decision process model to effectively prioritize the allocation of waiver slots with possible early discharge of individuals being served on the waiver, and characterize the structure of the jointly optimal prioritization and discharge policies.

4 - Unmasking Sex Trafficking Supply Chains with Machine Learning
Pia Ramchandani, Wharton, Philadelphia, PA, 19104, Canada, Hamsa Bastani

The covert nature of sex trafficking provides a significant barrier to generating large-scale, data-driven insights to inform law enforcement, policy and social work. We leverage massive deep web data in tandem with a novel machine learning framework to unmask recruitment-to-sales pathways, thereby providing the first global network view of sex trafficking supply chains. Key challenges to inferring supply chain relationships include extreme data imbalance and objective mismatch; our framework addresses these issues through natural language processing, active learning, and domain expertise.

■ WA13

Virtual Room 13

Topics in Opioids and Behavioral Health

General Session

Chair: Margret V. Bjarnadottir, University of Maryland, College Park, MD

Co-Chair: Katherine Bobroske, Cambridge Judge Business School, Cambridge, CB2 1AG, United Kingdom

1 - Learning Optimal Sequential Treatments from Clinical Data

Mohammed Amine Bennouna, PhD Student, MIT, Cambridge, MA, United States, Dessislava Pachamanova, Georgia Perakis, Omar Skali Lami

We propose a new, interpretable approach to learn personalized optimal sequential treatments from historic data. Our approach uses the data to partition the patient's feature space into region constituting treatment groups. It then constructs from these groups a finite state space Markov Decision Process modeling patient's treatment. Using the constructed interpretable model, we can derive optimal treatment policies as well as predict the outcome of different policies. Our algorithm is fully data-driven, and unlike traditional reinforcement learning algorithms, it can efficiently learn from a fixed batch of historic medical data without the need for exploration, a key advantage in healthcare settings. We prove that our approach learns the most concise MDP representation of the problem with provable guarantees and discuss its performance in numerical experiments.

2 - Visualizing Addiction Treatment Impact

Zlatana Nenova, University of Denver, Denver, CO, 80210-4711, United States, Margret Bjarnadottir

Patient monitoring across chronic diseases is increasingly touted as a promising approach to slow down disease progression. We examine the treatment trajectory of patients with substance abuse disorder through the examination of notes collected by their therapists during intensive group treatment sessions. Our goals are to (1) visualize patients' treatment progression and (2) quantify individuals' baseline state. This information is important when determining if a patient is improving and ready to discharge, as well as deteriorating and at a high risk of relapse.

3 - The Importance of Care Delivery in the Early Stages of Opioid Use

Katherine Bobroske, PhD Student, University of Cambridge, Cambridge, United Kingdom, Michael Freeman, Lawrence Huan, Anita Cattrell, Stefan Scholtes

As most opioid-related research is focused on chronic opioid users, little is known about the impact of care delivery interventions shortly after opioid initiation. We combine medical and pharmaceutical claims to investigate opioid initiation in the primary care setting. Of the patients who return for a follow-up appointment, what is the impact of provider discordance (i.e., seeing a clinician other than the original prescriber) on long-term opioid use? A series of controlled logistic regressions, instrumental variable analyses, and propensity score matching techniques suggest that provider discordance during opioid initiation could be promising intervention to curb the opioid epidemic.

4 - Optimal Geographic Access to Methadone Clinics

Anthony Bonifonte, Denison University, Granville, OH, 43023-9469, United States, Erin Garcia

This work studies the problem of identifying locations to open new methadone clinics to combat opioid addiction and prevent overdoses. We estimate unsatisfied methadone demand at a census tract level and model a modified facility location problem. Our objectives are to (1) offer access to individuals with unmet methadone demand due to geographic limitations and (2) improve the travel time of individuals currently attending a clinic. The results demonstrate the large unserved methadone demand in the United States, the significant improvement in methadone access for new and existing clients by opening new clinics, and the important role state-specific geography plays in these decisions.

■ WA14

Virtual Room 14

Healthcare Operations Management I

Contributed Session

Chair: Tianjian Guo, McCombs School of Business, The University of Texas at Austin, United States

1 - Deep Reinforcement Learning Supported Intensive Care Unit Decision Making

Jens Brunner, University of Augsburg, Augsburg, Germany, Jie Bai

Congestion in the intensive care unit leads to notable negative effects on patients' health.This talk develops and implements a decision support framework, which combines prediction and decision-making. In the supervised learning supported prediction module, we define a cost to balance the tradeoff between individual- and system-level cost, as well as myopic and future cost (readmission risk). In the deep reinforcement learning (DRL) supported decision-making module, a large-scale infinite discrete-time Markov decision process (MDP) is developed. In the numerical study, both systematic (model-based DRL) and personalized (model-free DRL) policies are investigated.

2 - Predicting ICU Length of Stay Using Recurrent Neural Network: A Comprehensive and Multimodal Approach

Tianjian Guo, McCombs School of Business, The University of Texas at Austin, Austin, TX, United States, Indranil R. Bardhan, Ying Ding

Intensive care units (ICUs) consume a substantial portion of hospital resources. As a step towards cost reduction, resource management is of significant interest for hospitals across the globe. Towards this end, we propose a novel multimodal model that predicts ICU length of stay for patients admitted to the ICU. We test the model on a dataset that contains clinical data for more than 60,000 ICU patients admitted to a large hospital in the US. Our results indicate that the addition of several types of clinical data resulted in a significant boost to the predictive capability. The model can be easily implemented using EHR data, to develop a more accurate prediction of ICU utilization at hospitals.

3 - A Distributionally Robust Optimization Approach for Elective Surgery Scheduling with Limited Intensive Care Unit Capacity

Karmel S. Shehadeh, Lehigh University, Bethlehem, PA, United States, Rema Padman

We address the distributional ambiguity in surgery duration and postoperative length-of-stay in the downstream intensive care unit (ICU). We present a distributionally robust downstream-constrained surgery scheduling model in multiple ORs. We propose an efficient column-and-constraint generation algorithm to solve DRESS and derive symmetry-breaking inequalities that improve solvability. We present extensive experiments that demonstrate our approach's superior computational and operational performance over the stochastic programming approach and provide insights into DRESS.

Wednesday, 2:00PM - 3:30PM

■ WB01

Virtual Room 01

Analytics in Healthcare: Impact and Challenges

General Session

Chair: Jean Pauphilet, London Business School, London, NW14SA, United Kingdom,

1 - Delivery Care in the Time of Uncertainty: Real-time Analytic Approaches to COVID-19 Forecasting for a Hospital System

Jennifer P. Stevens, MD, Beth Israel Deaconess Medical Center, Boston, MA, United States

Coronavirus-19 disrupted healthcare delivery for health systems. We will describe how one healthcare network of 13 hospitals in New England made use of three different healthcare analytic strategies using real-time data to guide hospital decision making: (1) a machine-learning approach to predict COVID-19 hospitalizations; (2) a quantification of high-risk business use by the public in the healthcare service area; and (3) a syndromic surveillance strategy using employee symptom attestations to create an early warning sign for community outbreaks.

2 - Assessing Primary Care Performance using ED Data
Nicos Savva, London Business School, London, NW14SA, United Kingdom, Sandra Sulz

This paper develops a data-driven methodology to objectively measure the performance of Primary Care Practices (PCPs) using routinely collected Emergency Department data from a major UK-based hospital. The measure is based on a random effect variance decomposition model that controls for observed and unobserved heterogeneity. We validate the measure using patient satisfaction surveys and quantify the savings associated with helping the worst-performing PCPs perform better.

3 - Improving Tuberculosis Treatment Adherence Support: The Case for Targeted Behavioral Interventions
Justin J. Boutilier, University of Wisconsin - Madison, Madison, WI, 53706-1603, United States, Jónas Oddur Jónasson, Erez Yoeli

Tuberculosis (TB) is a global health priority and lack of patient adherence to treatment protocols is a main barrier to reducing the global disease burden of tuberculosis. In this talk, we will study the operational design of a treatment adherence support (TAS) platform that requires patients to verify their treatment adherence on a daily basis. To do this, we partner with a TB TAS provider in Kenya and use data from a completed randomized controlled trial. Our analysis establishes that patient engagement can be increased by personal sponsor outreach and that patient behavior data can be used to identify at-risk patients for targeted outreach.

4 - Hospital Inpatient Flow Optimization
Jean Pauphilet, London Business School, London, United Kingdom, Dimitris Bertsimas

We propose a multi-stage adaptive robust optimization approach combined with machine learning techniques to dynamically allocate beds across the entire hospital in real-time. Informed by data and predictions, our framework accounts for present and future inpatient flows, discharges as well as bed requests - from the emergency department, scheduled surgeries and admissions, and outside transfers. On simulations, our algorithm solves in seconds and reduces both off-service placements (by 23%) and delays in the ED and PACU (by 52% and 24% resp.).

5 - Optimization in Hospital Resources
Liangyuan Na, Massachusetts Institute of Technology, Cambridge, MA, United States, Dimitris Bertsimas, Jean Pauphilet

We propose frameworks to optimize hospital resources. We first develop a robust optimization model to allocate staffing levels given historical uncertain demand patterns. Given the staffing levels, we then schedule individual work shifts to prioritize a variety of staff preferences as well as training opportunities. The framework is operationalized in a major hospital's emergency department to schedule the nurse staffing every 6 weeks. The implementation results in less costly staffing with more sufficient patient coverages and higher nurse satisfaction. We further discuss extensions to integrate this model into a broader hospital-level optimization in resources and patient flows.

■ WB02

Virtual Room 02

Large-Scale Simulation Models in COVID-19

General Session

Chair: Hawre Jalal, MD, MSc, PhD, University of Pittsburgh, Pittsburgh, PA, United States

1 - Dependence of COVID-19 Policies on End-of-Year Holiday Contacts in Mexico City Metropolitan Area: A Modeling Study
Fernando Alarid-Escudero, Center for Research and Teaching in Economics (CIDE), Aguascalientes, Mexico, Valeria Gracia, Andrea Luviano, Yadira Peralta, Marissa B. Reitsma, Anneke Claypool, Joshua A. Salomon, David M. Studdert, Jason R. Andrews, Jeremy D. Goldhaber-Fiebert

Mexico City Metropolitan Area (MCMA) has the largest number of COVID-19 cases in Mexico and was at risk of exceeding its hospital capacity in early 2021. We used the Stanford-CIDE Coronavirus Simulation Model (SC-COSMO) to evaluate the effect of policies considering increased contacts during the end-of-year holidays, intensification of social distancing, and school reopening on projected confirmed cases and deaths, hospital demand, and hospital capacity exceedance. MCMA must increase COVID-19 hospital capacity under all scenarios considered. MCMA's ability to reopen schools in early 2021 depended on sustaining social distancing and controlling contacts during the end-of-year holiday.

2 - Modeling the Evolving COVID-19 Pandemic in Minnesota
Eva A. Enns, University of Minnesota, Minneapolis, MN, 55455, United States, Shannon McKearnan, Zongbo Li, Erinn Sanstead, Szu-Yu Kao, Pamela Mink, Alisha Simon, Stefan Gildemeister, Karen Kuntz

We developed a dynamic compartmental model to reflect the transmission of the SARS-CoV-2 virus and associated COVID-19 outcomes for the state of Minnesota. The model was calibrated to state-level hospitalization and mortality data and was re-calibrated several times as more data became available. We used the model to evaluate and compare different hypothetical policy and vaccination scenarios. We will describe key insights obtained from our modeling work and how the use and focus of the model changed since the start of the epidemic in the context of evolving local COVID-19 conditions.

3 - Context-specific Contact Matrices for Community-tailored Modelling of COVID-19 Transmission
Lauren E. Cipriano, Associate Professor, Ivey Business School, London, ON, Canada, Erica Yarmol-Matusiak, Oladapo Folami, Farzaneh Daneshzand, Wael Haddara, Eva A. Enns

Existing age-structured dynamic compartmental models of COVID-19 are unable to fully capture the employment-based structure of contacts, or the employment-based ability to modify work to reduce the frequency or riskiness of those contacts. We developed a set of customizable age- and employment-stratified contact matrices for use in COVID-19 models designed around the context of contacts (e.g., schools, workplaces, homes) and the purpose of contacts (e.g., transportation, caregiving). We parameterized the matrices using national and regional data from secondary sources. The matrices can be tailored to the employment-distribution and risk profile of individual communities. Within a dynamic compartmental model, these matrices facilitate the evaluation of community-tailored interventions.

4 - Simulation of COVID-19 Vaccine Strategies in Realistic Human Populations Using a Flexible Agent Based Modeling Platform
Donald S. Burke, President, Epistemix, Inc., Epistemix, Inc., PIttsburgh, PA, PA, United States

We developed a flexible, modular, extensible, and easy to use agent-based We developed a flexible, modular, and easy to use agent-based modeling platform FRED (Framework for Reconstructing Epidemiological Dynamics), and used the platform to create a COVID-19 model that includes sub-models for natural history and contagion, newly emergent virus strains, behavioral change, vaccines and vaccine hesitancy, multiple vaccines with different properties, and other detailed features of SARS-CoV-2 dynamics. We calibrated the model to real-world epidemiological data from USA counties, and modeled the likely epidemic trajectories with a range of COVID-19 vaccine strategies. We will present our FRED COVID-19 modeling results on control of vaccine escape viruses.

5 - Safe Reopening of Colleges in the United States: An Analysis of 823 Colleges using COVID-19 Simulator
Jagpreet Chhatwal, Harvard Medical School, Mass General Hospital, Boston, MA, 2114, United States, Trisha Dwivedi, Jade Xiao, Turgay Ayer, Madeline Adee, Ozden Dalgic, Peter Mueller, Benjamin Linas

We estimated the seroprevalence of SARS-CoV-2 in 823 U.S. colleges and universities to inform their safe opening. We estimated the flow of students moving from one state to another state to attend college, based on college attendance data, state population sizes, and state locations. We then estimated active COVID-19 cases in each college using this data and the COVID-19 Simulator, an online compartmental model that simulates the trajectory of COVID-19 in each state. We found that almost all colleges can safely open in August—with 100% in-person classes. The daily case count is expected to remain less than 1 on the day of the opening. We also found that many colleges could start in-person classes in the Summer semester.

■ WB03

Virtual Room 03

Large-Scale Healthcare Decision-Making and Analysis

General Session

Chair: Dionne Aleman, University of Toronto, Toronto, ON, M5S 3G8, Canada

1 - How Effective was Newfoundland & Labrador's Travel Ban to Prevent the Spread of COVID-19? An Agent-based Analysis

Dionne Aleman, University of Toronto, Toronto, ON, M5S. 3G8, Canada, Benjamin Z. Tham, Sean J. Wagner, Justin Semelhago, Asghar Mohammadi, Paul Price, Randy Giffen, Proton Rahman, Proton Rahman

To prevent the spread of COVID in Newfoundland & Labrador (NL), NL implemented a wide travel ban in May 2020. We estimate the effectiveness of this travel ban using a customized, highly granular agent-based simulation (ABS), and find that infected travelers increased COVID cases by 2-52x (8-96x) times and hospitalizations by 2-49x (8-94x), with (without) contact tracing. Although contact tracing was highly effective at reducing spread, it was insufficient to stop travel-related outbreaks in the best-case scenario, and the likelihood of exceeding contact tracing capacity was a concern in most scenarios. Quarantine compliance had only a small impact; travel volume and infection rate drove spread.

2 - Mining Social Contact Networks for COVID-19 Vaccination Strategies

Mario Ventresca, Purdue University, West Lafayette, IN, United States, Dionne Aleman, Randy Giffen, Proton Rahman

We present a social contact-based analysis to evaluate the impact of COVID19 vaccination strategies on disease spread in Newfoundland & Labrador, Canada. Contact networks are derived from a high-resolution agent-based simulation that is based on census, demographic, and COVID19 data. We consider typical epidemiologically relevant metrics under probabilistic compliance and vaccine efficacy. Individuals' characteristics and whether they were identified for vaccination is used as input to construct decision trees to define implementable vaccination strategies. We find that topological measures for prioritization result in better reduction of transmission than age-based strategies.

3 - Big Data Insights Into MRI Demand and Wait Times

Suting Yang, University of Toronto, Toronto, ON, Canada, Saba Vahid, Dionne Aleman, Michael W. Carter, Ali Vahit Esensoy, Benjamine Fine

This big data study links multiple administrative data sets to characterize and explore drivers of growth in MRI imaging in Ontario (2008-2017). Our study shows an increasing trend in MRI use, outpacing capacity. Demand increased the greatest amongst family physicians, and there were also wide variations in MRI referral rates among the group. Multiple physician characteristics, including years of practice and physician demographics, also impacted the use of MRIs. 8% family physicians contributed to 25% of MRI tests. Reduction in family physician high-frequency user utilization could avoid 10-17% of all MRIs.These findings help better target interventions to reduce variations in care.

4 - Machine Learning to Predict Clinical Outcomes of Psoriasis Patients

Fereshteh Navabzadeh, University of Toronto, Toronto, ON, Canada, Faraz Khoshbakhtian, Dionne M. Aleman, Randy Giffen, Proton Rahman

We examine the application of machine learning in clinical decision-making for psoriasis patients. Our data includes medical records of 91K individuals with a 1:5 ratio for positive cases. The data attributes include several clinical outcomes, but few patient demographics details. Logistic regression, random forest, and Naive Bayes predicted clinical outcomes with high accuracy, yet none accurately predicted psoriasis diagnosis. Psoriasis showed significance only for mental health hospitalization and coronary angiogram. We observed a relationship between mental health problems and age. Further analysis and more patient details are required to relate psoriasis to clinical outcomes.

■ WB04

Virtual Room 04

Data Driven Decision-Making in Healthcare Services

General Session

Chair: Yuqian Xu, University of Illinois at Urbana-Champaign, Champaign, IL, 61820-6915, United States

1 - Treatment Planning of Victims with Heterogeneous Time-sensitivities in Mass Casualty Incidents

Nan Liu, Boston College, MA, 02467-3800, United States, Yunting Shi, Guohua Wan

Mass casualty incidents lead to a sudden jump in demand for care, making the rationing of medical resources inevitable. Informed by a unique timestamps dataset of surgeries operated in a field hospital set up in response to a large-scale earthquake, we develop scheduling models to aid treatment planning for patients with heterogeneous time-sensitivities in such a resource-scarce environment in order to do the greatest good for the greatest number of people.

2 - Does Algorithm Aversion Exist in the Field? Examining Human-Algorithm Interactions in Diabetes Self-Management

Wilson Lin, University of Southern California, Los Angeles, CA, United States, Song-Hee Kim, Jordan D. Tong

Advancements in technology and algorithms promise to improve operations by localizing decisions to non-expert users. However, researchers have argued that humans exhibit so-called ``algorithm aversion,'' which would be a key barrier to achieving such improvements — though these claims are based overwhelmingly on laboratory experiment findings. Using the decision-support algorithm behavior in over 170,000 bolus insulin dosing decisions from diabetes self-management, we contribute analysis of field evidence to test algorithm aversion. We precisely define dynamic algorithm aversion — an asymmetric usage response to performance feedback that favors humans over algorithms — as one key hypothesis from the experimental literature. We then reject this hypothesis, instead finding that patients respond to performance feedback asymmetrically, but in favor of the algorithm.

3 - Your Preferred Doctor Will See You Now: Relational Continuity of Care Increases the Productivity of Primary Care Physicians

Harshita Kajaria-Montag, University of Cambridge, Cambridge, United Kingdom, Michael Freeman, Stefan Scholtes

Service continuity in primary care is in decline as practices increase in scale and standardize their services to improve productivity. Is there a trade-off between care continuity and the productivity of primary care physicians (PCPs) or does continuity in fact improve the productivity of PCPs? Using appointment-level data from UK primary care practices over 11 years and 2 million patients, the study shows that continuity improves productivity by increasing the revisit intervals of patients by 15%, on average. This novel finding shows that interventions that reduce continuity may be counter-productive from a productivity perspective and lead to an increase in demand for future appointments.

4 - Ed Triage: An Empirical Study of Fast Track Routing

Shuai Hao, University of Illinois at Urbana–Champaign, Champaign, IL, United States, Yuqian Xu, Zhankun Sun

As an effective way to improve emergency department throughput efficiencies, many hospitals have opened a separated fast-track service line that is dedicated to low acuity patients. However, these hospitals don't have consistent routing policies and systematic routing criteria. This largely due to the fact that the impact of fast-track routing decisions on patient outcomes for heterogeneous patients hasn't been well determined. Although the fast track routing decision won't influence patients revisit probability for medium-severity patient group, low-severity patient group as well as all three patients severity groups combined (high medium low). We find that fast track routing decisions would increase patient 48-hour and 72-hour revisit probability by 22\% and 18\% correspondingly for the high-severity patient group. Based on these cost estimates, we proposed a parsimonious queuing model to compare different routing policies' performance and derived an optimal routing policy.

■ WB05

Virtual Room 05

Data Analytics in Healthcare

General Session

Chair: Yichuan Ding, McGill University, Montréal, QC, H3B9A9, Canada

Co-Chair: Yiwen Jin, UBC, Sauder School of Business, Vancouver, BC, V6T 1V8, Canada

1 - A Cost-effectiveness Analysis of Lethal Ovitraps for the Prevention of Dengue Fever

Huijun Yvonne Zhu, National University of Singapore, Singapore, Singapore, Joel Aik, Joel Goh

Dengue fever affects 390 million people yearly around the world, and the number has an upward trend. One of the control strategies that the World Health Organization has recommended for dengue fever is the systemic use of ovitraps. These refer to devices that attract, trap, and kill female egg-laying mosquitos. Units of such devices are typically cheap to manufacture, but require substantial investments of labor for frequent maintenance. In this study, we undertake the first system-level cost-effectiveness analysis of such a strategy for dengue control incorporating such labor cost drivers in the context of Singapore, a tropical country where the disease is endemic. The disease dynamics are modeled using a standard compartmental model, and benefits from the ovitrap strategy are measured in disability-adjusted life years. Labor costs are estimated by modeling the workload needed for periodic maintenance of the units through traveling salesmen problems (TSPs), and other costs are estimated using a combination of public and proprietary data.

2 - Structural Estimation of Prioritization Decisions for Admission to Rehabilitation Care

Berk Gorgulu, PhD Student, University of Toronto, Toronto, ON, M5J 1B7, Canada, Vahid Sarhangian, Jing Dong

Rehabilitation care is an essential stage of treatment to improve the physical ability of patients after their acute care is completed. Due to limited capacity and growing demand, long waiting times for admission to rehab facilities are frequently encountered. These delayed admissions not only affect the quality of care, but also ``block" beds in acute care, creating additional congestion upstream. In this work, we develop a new structural model of prioritization decisions for admission to rehab and estimate it using data from a large hospital. Our model provides important insights into various tradeoffs affecting rehab admission decisions and highlights the complexity of admission decisions in practice in contrast to those typically assumed in the OM/OR literature. In addition, the model accurately captures these complex decisions, allowing for analysis of counterfactual scenarios such as adjusting capacity to meet service levels and evaluating alternative system designs to reduce waiting times and ensure equitable care.

3 - Dynamic Patient Prioritization in Hospital Emergency Departments

Zhankun Sun, City University of Hong Kong, Kowloon, Hong Kong, Wenhao Li, Jeff Hong

Motivated by our empirical findings on patient prioritization decisions in emergency departments (EDs), we investigate how a patient's disposition affects the prioritization decisions for patients of the same triage level by a stylized MDP model, which captures the dual resource constraints on ED's capability of treating patients. We show that the optimal policy, which depends on the number of boarding patients, is of threshold type. Motivated by the structure of the optimal policy, we propose heuristic policies and demonstrate that they can reduce ED patient waiting times and length of stay through simulation.

4 - The Cost of Task Switching: Evidence from the Emergency Department

Yiwen Jin, UBC, Vancouver, BC, V6T. 1V8, Canada, Yige Duan, Yichuan Ding, Mahesh Nagarajan, Garth Hunte

Emergency department (ED) physicians treat patients with different symptoms that require constant switching of tasks. Using a comprehensive data set of patient visits to four EDs, we investigate the impact of task switching on physician productivity. Our instrumental variable estimation, which exploits the exogenous composition of waiting patients, indicates that switching between patients of different types increases the average pick-to-pick time by 4.9 to 14.7 percent, which is 1.1 to 3.1 minutes per patient. The switch cost reflects both a reconfiguration process and interference between tasks. Task switching also affects how physicians route patients, although we find little impact on healthcare quality. Our counterfactual analysis further reveals that the switch cost may have increased the average waiting time per patient by 14 minutes and the average waiting census by 1.6 patients. Our research has important managerial implications for how switch costs can be addressed to improve workplace efficiency.

5 - Who, if Anyone, Should be Screened for Diabetes in the Emergency Department?

M. Gabriela Sava, Clemson University, Wilbur O. and Ann Powers College, Clemson, SC, 29634, United States, Jerrold H. May, Ronald G. Pirrallo, Jingyuan Tian

Diabetic screening of ED patients can proactively improve health outcomes, but it is uneconomic to screen all such patients. We present a modeling approach for identifying patients who have a negligible risk of diabetes, so that available resources can be used to screen those with a non-negligible risk.

■ WB06

Virtual Room 06

Demand Management for Healthcare Networks

General Session

Chair: Shrutivandana Sharma, Singapore University of Technology and Design, Singapore, 138682, Singapore

1 - Patient-controlled: An Alternative Approach to the Utilization of Non-physician Providers

Enayon Sunday Taiwo, City University of Hong Kong, Kowloon, Hong Kong, Sergei Savin, Frank Y. Chen, Kwai S. Chin

We introduce a patient-controlled approach for appointment scheduling in an outpatient care setting with physician and non-physician providers and compare it to widely used "ice-breaker" and "standalone" arrangements. Our approach introduces a model that incorporates the patient's decision to join the queue for her non-preferred provider if her preferred provider's current wait exceeds a certain threshold. We find that the patient-controlled use of non-physician care capacity is more beneficial to patients and to clinical practices in a wide range of settings.

2 - Cents of Urgency: How Opening an Urgent Care Center Affects Emergency Department Arrivals?

Simin Li, Tulane University, New Orleans, LA, United States, Achal Bassamboo, Martin A. Lariviere

In this paper, we partner with a major medical system and utilize a natural experiment setting to investigate the impact of a UCC opening on an ED. The UCC, located adjacent to and operated by the same medical systems the ED, serves low-acuity conditions only. We use a difference-in-difference framework to tease out the impact of UCC. Compare patient arrivals pre- and post-UCC opening at the ED with a paired UCC to the EDs without one, we find the volume of low-acuity patient visits to the ED decreases by 13.7%. Low-acuity patients are diverted to the UCC. We further show that the proportion of hospitalized low-acuity patient visits to the ED increases by 7.5%. The patients effectively self-route to the right facility to get the care they need. Subsequently, we see the high-acuity encounters' door-to-doctor time decrease by 11.3%, which suggests that ED resources are freed up for more severe cases. The ED use becomes more efficient.

3 - Reducing Non-urgent Visits and Emergency Department Congestion: Perception-Improvement and Pricing

Shrutivandana Sharma, Singapore University of Technology and Design, Singapore, 138682, Singapore, Ying Xu, Manu Kumar Gupta, Costas Courcoubetis

We present a queueing games framework to investigate how patients' choice between an expensive/congested emergency department (ED) and general practitioners (GP), who refer urgent patients to the ED, are influenced by patients' imperfect perception of urgency. We then investigate how perception-improvement measures (e.g. tele-advice) and financial incentives may impact non-urgent ED visits and social cost. We find that exclusive perception-improvement may worsen these, but this limitation can be overcome by inducing optimum patient flows at equilibrium. To achieve this, we design a novel differential pricing mechanism (leveraging GP-referral feature), and discuss its benefits over traditional pricing mechanisms.

4 - Mining Service Models from Event Data

Arik Senderovich, University of Toronto, Toronto, ON, Canada, Opher Baron, Dmitry Krass

Analytical and simulation models have been used extensively to analyze service systems. These models always require substantial manual effort: one must hire an outside expert or develop in-house capabilities for modeling the system. The process of modeling is time-consuming and demanding. Moreover, human-constructed models are inherently subjective - two experts looking at the same system may well come up with very different representations. With the availability of ample event data, the field of queue mining has been attempting to automate the process of modelling systems. Specifically, the idea was to replace the modeler, or at least assist the modeler by converting the modelling process into a semi-automated procedure.In this work, we present ServiceMiner, a queue mining approach and tool that constructs queueing models automatically from event data.

■ WB07

Virtual Room 07

COVID-19 Pandemic Modeling and Analysis II

Contributed Session

Chair: Nazlican Arslan, Northwestern University, Evanston, IL, United States

1 - Buying Vaccines Through a Single Payment as a Proxy for Procuring Vaccines via Formularies

Bruno Alves Maciel, Rochester Institute of Technology, Rochester, NY, United States, Ruben Proano

In this study we evaluate the possibility of making vaccines more affordable without impacting profits by exploring the effects of selling vaccines as formularies, or baskets of vaccines bundled in the same sale. Assuming that countries are grouped into market segments for tiered pricing purposes, and are coordinated by a single decision maker, we propose selling vaccines as formularies by changing the pricing scheme so that each buyer makes a single lump-sum payment to each vaccine producer for the vaccines purchased. Results show that changing the pricing scheme can improve affordability.

2 - Respond to Current and Future Pandemics: A Healthcare-energy-environment Nexus Thinking

Peng Jiang, A/Prof., Sichuan University, Chengdu, China, Ji í Jaromír Klemeš, Yee Van Fan, Xiuju Fu, Li Luo

COVID-19 pandemics have caused profound impacts on various industries around the epicentre—namely, the healthcare sector. Many lessons and observations have been summarised to explain the local impact on a single sector or region, while the systematic impacts are rarely investigated in a short time window. As a pilot and pioneer work from a systems science perspective, this study analyses the worldwide spatial heterogeneities and structural changes in healthcare, energy and environment, and provides an in-depth understanding of the cross-sections of them. A new framework with a healthcare-energy-environment nexus thinking is proposed and discussed to respond to current and future pandemics.

3 - COVID-19 Vaccine Allocation Optimization by Age and Risk Groups

Nazlican Arslan, Northwestern University, Evanston, IL, United States, Ozge Surer, David Morton, Lauren Meyers

Vaccines are the primary means for mitigating a pandemic, but mass vaccination does not typically begin until a pandemic is well underway. As various types of COVID-19 vaccines become available in the US, it is crucial to decide on a vaccine prioritization strategy. We present an age and risk structured epidemiological model that incorporates vaccine allocation. We apply a derivative-free optimization algorithm as well as a greedy heuristic into our SEIR-type simulation model to determine an optimal vaccine rollout to minimize an objective, which can incorporate expected mortality, infections, and hospitalizations, accounting for both general ward and ICU beds.

■ WB08

Virtual Room 08

Modeling COVID-19 Interventions and Resource Allocation

General Session

Chair: Julie L. Swann, North Carolina State University, Raleigh, NC, 27695, United States

Co-Chair: Erik Rosenstrom, North Carolina State University, Raleigh, NC, United States

1 - Resource Allocation for Different Types of Vaccines Against COVID-19: Tradeoffs and Synergies Between Efficacy and Reach

Daniel Kim, ISyE Georgia Tech, Atlanta, GA, United States, Pelin Pekgun, Inci Yildirim, Pinar Keskinocak

During the COVID-19 pandemic, multiple vaccine candidates were developed in record time. The primary decision becomes how to allocate limited resources between different types of vaccines. If a high efficacy vaccine consumes more resources than a vaccine with lower efficacy due to distributional challenges, the decision is no longer trivial as a widespread vaccination is necessary to reach herd immunity. We adapt a Susceptible-Infected-Recovered-Deceased (SIR-D) model with vaccination and simulate the level of infection attack rate (IAR) under different resource consumption ratios between two vaccine types with different resource allocation decisions. We find that the reach of a vaccine to be distributed widely is a key factor to achieve low IAR levels, even though the vaccine may be of higher efficacy and may become earlier than others. We also explore the role of distribution speed as a balancing factor against the drop in vaccine efficacy as variants emerge.

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2 - The Impact of Testing Availabilities and Compliance with Self-isolation on COVID-19: A Mathematical Modeling Study

Zhuoting Yu, Georgia Institute of Technology, Atlanta, GA, United States, Lauren Steimle, Pinar Keskinocak

While COVID-19 diagnostic testing reveals whether an individual is infected, compliance with isolation is the key to cut off the transmission if the testing result is positive. In this work, we developed an extended SIR model and investigated how compliance with different isolation types impacts the progression of the disease under various availabilities of testing resources. Results show that high compliance with post-testing isolation can effectively contain the disease if there is an early introduction of testing programs; when the starting of mass testing is delayed, it is crucial to emphasize the importance of public health messaging and advocate symptomatic isolation.

3 - Evaluation of Different Types of Face Masks to Limit the Spread of SARS-CoV-2- A Modeling Study

Pragati V. Prasad, Centers for Disease Control and Prevention, Atlanta, GA, United States, Brian Gurbaxani, Andrew N. Hill, Rachel Slayton, Prabasaj Paul

We updated a published mathematical, compartmental model of SARS-CoV-2 transmission given face mask use in the general population, and used CDC laboratory-derived source and wearer protection efficacy estimates for a variety of face masks to estimate their impact on COVID-19 incidence and related mortality in the United States1. The model accurately accounts for the effects of various combinations of those who are asymptomatic and symptomatic, masked and unmasked, and detected and undetected transmitting the virus (yielding 8 total possible combinations, each with a different rate of mask wearing and other characteristics). When used at already-observed population rates of 80% for those ≥65 years and 60% for those <65 years, face masks are associated with 69% (cloth) to 78% (medical procedure mask) reductions in cumulative COVID-19 infections and 82% (cloth) to 87% (medical procedure mask) reductions in related deaths over a 6-month timeline in the model. If either cloth or medical procedure masks' source control and wearer protection efficacies are boosted to 84% and 60% (vs. ~50% and ~25% when unaided) by wearing a cloth mask over a medical procedure mask, or fitters or braces over either type of mask, the model found that the COVID-19 basic reproductive number of 2.5 could decrease to an effective reproductive number < 1.0, and from 4.0 to ≈ 1.6 for the B.1.1.7 SARS-CoV-2 variant2. 1 Worby, C.J. and H.H. Chang, Face mask use in the general population and optimal resource allocation during the COVID-19 pandemic. Nat Commun, 2020. 11(1): p. 4049.2 https://www.medrxiv.org/content/10.1101/2021.04.21.21255889v1.

4 - The Joint Impact of COVID-19 Vaccination and Non-pharmaceutical Interventions on Infections, Hospitalizations, and Mortality: An Agent-based Simulation

Erik Rosenstrom, North Carolina State University, Raleigh, NC, United States, Julie L. Swann, Julie Simmons Ivy, Maria Esther Mayorga, Mehul Patel

Vaccination against SARS-CoV-2 can significantly reduce transmission, morbidity and mortality due to COVID-19. This modeling study employed an agent-based simulation model for the State of North Carolina to understand the comparative and joint impact of COVID-19 vaccine efficacy and coverage with and without non-pharmaceutical interventions (NPIs) on total infections, hospitalizations, and deaths. Simulation results suggest that premature lifting of NPIs while vaccines are distributed may substantially increase infections, hospitalizations, and deaths. Furthermore, as NPIs are removed, higher vaccination coverage with less efficacious vaccines can contribute to a larger reduction in risk of SARS-CoV-2 infection compared to more efficacious vaccines at lower coverage. Our findings highlight the need for well-resourced and coordinated efforts to achieve high vaccine coverage and continued adherence to NPIs before many pre-pandemic activities can be resumed.

5 - A Multicountry, Multicommodity Stochastic Game Theory Network Model of Competition for Medical Supplies Inspired by the COVID-19 Pandemic

Mojtaba Salarpour, University of Massachusetts - Amherst, Amherst, MA, United States, Anna Nagurney

In this paper, we construct the first stochastic Generalized Nash Equilibrium model for the study of competition among countries for limited supplies of medical items (PPEs, ventilators, etc.) in the disaster preparedness and response phases in the COVID-19 pandemic. The government of each country is faced with a two-stage stochastic optimization problem in which the first stage is prior to the pandemic declaration and the second stage is post the pandemic declaration. Both illustrative examples are presented as well as algorithmically solved numerical examples, inspired by the need for N95 masks and ventilators. The results reveal that, in addition to the preparedness of countries before the pandemic declaration, their ability to adapt to the conditions in different scenarios has a significant impact on their overall success in the management of the pandemic crisis. The framework can capture competition for other medical supplies, including COVID-19 vaccines and possible treatments, with modifications to handle perishability.

■ WB09

Virtual Room 09

Healthcare Analytics and Machine Learning II

Contributed Session

Chair: Holly Mika Wiberg, Massachusetts Institute of Technology, Somerville, MA, 02144-2603, United States

1 - Smart Contact Tracing: Using Statistical ML to Identify Asymptomatic Epidemic Carriers

Yaniv Ravid, Cornell University, New York City, NY, United States, Abraham Seidmann

The prevalence of asymptomatic infected individuals has been mostly ignored by many classic public health measures to public viral outbreaks. We present a novel extension to the classic epidemiological models that accounts for the existence of individuals who propagate the spread without leaving the system for isolation, and therefore, are typically more infectious than the common symptomatic carriers. Our initial results clearly define when our statistical ML model can be used to derive a better identification of the key components of any ongoing outbreak. These results should direct public health officials who try to contain pandemic spreads in the most effective way.

2 - Study of Health Outcomes in a Technology Enabled Virtual Setting

Maxim Terekhov, University of Florida, Gainesville, FL, United States

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. These findings provide insight on the value of telemedicine and have important implications for stakeholders in healthcare field.

3 - Achieving Data-informed Healthcare with Analytics Capability

Ce (Jacky) Mo, Lecturer, The University of New South Wales, UNSW. Sydney, Australia, Oscar Perez Concha, Ting Yu, Tania Bucic

Strengthening analytics capability among health professionals is key for enabling them to extract value from varied data sources to provide relevant, personalized, and efficient patient care. Findings from our qualitative study comprising in-depth personal interviews with frontline healthcare professionals call attention to the important individual - (e.g., motivation, technical skills, learning orientation) and functional unit - (e.g., team support, leadership, process) level factors necessary for analytics capability.

4 - From Data to Prescriptions: An Optimization Framework for Treatment Personalization

Holly Mika Wiberg, Massachusetts Institute of Technology, Cambridge, MA, United States, Dimitris Bertsimas

Personalized treatment involves several complex decisions, particularly in the presence of multiple treatment options and continuous dosages. We propose a joint machine learning and optimization framework for treatment prescriptions, in which we leverage ML to learn treatment effects from data and formulate a mixed-integer programming model to identify promising regimens from the ML models. The approach generalizes to multiple treatment objectives and risk tolerances, as well as additional clinically-derived constraints. We demonstrate the method in chemotherapy as well as chronic disease management.

■ WB10

Virtual Room 10

Data-Driven Approaches for High-Dimensional Learning

General Session

Chair: Zhengyuan Zhou, Stern School of Business, New York University, New York, NY, 10012, United States

Co-Chair: Divya Singhvi, MIT, Cambridge, MA, United States

1 - Conformal Inference of Counterfactuals and Individual Treatment Effects

Lihua Lei, Stanford University, Palo Alto, CA, United States, Emmanuel Candès

Evaluating treatment effect heterogeneity widely informs treatment decision making. In this work, we propose a conformal inference-based approach that can produce reliable interval estimates for counterfactuals and individual treatment effects. For randomized experiments with perfect compliance, the intervals have guaranteed average coverage in finite samples regardless of the unknown data generating mechanism. For randomized experiments with ignorable compliance and general observational studies obeying the strong ignorability assumption, the intervals satisfy a doubly robust property which states the following: the average coverage is approximately controlled if either the propensity score or the conditional quantiles of potential outcomes can be estimated accurately. Numerical studies on both synthetic and real datasets empirically demonstrate that existing methods suffer from a significant coverage deficit even in simple models. In contrast, our methods achieve the desired coverage with reasonably short intervals.

2 - Hyper: Flexible and Effective Pooled Testing via Hypergraph Factorization

Edgar Dobriban, University of Pennsylvania, Philadelphia, PA, United States

Large scale screening is a critical tool in the life sciences, but is often limited by reagents, samples, or cost. An important challenge is to achieve widespread testing of individuals with SARS-CoV-2 infection in the face of substantial resource constraints. Group testing methods utilize constrained testing resources more efficiently by pooling specimens together. A. key challenge is to design an effective pooling strategy. The global nature of the ongoing pandemic calls for something simple and flexible (to tailor for settings with differing needs) that remains efficient. We propose HYPER, a new group testing method based on hypergraph factorizations. We provide characterizations under a general theoretical model, and exhaustively evaluate HYPER and proposed alternatives for SARS-CoV-2 screening under realistic simulations of epidemic spread and within-host viral kinetics. We demonstrate that HYPER performs at least as well as other methods in many scenarios. This is joint work with David Hong, Rounak Dey, Xihong Lin, and Brian Cleary.

3 - Dynamic Batch Learning in High-Dimensional Sparse Linear Contextual Bandits

Zhimei Ren, Stanford University, Stanford, CA, United States, Zhengyuan Zhou

We study the problem of dynamic batch learning in high-dimensional sparse linear contextual bandits, where a decision maker, under a given maximum-number-of-batch constraint and only able to observe rewards at the end of each batch, can dynamically decide how many individuals to include in the next batch (at the end of the current batch) and what personalized action-selection scheme to adopt within each batch. Such batch constraints are ubiquitous in a variety of practical contexts, including personalized product offerings in marketing and medical treatment selection in clinical trials. We characterize the fundamental learning limit in this problem via a regret lower bound and provide a matching upper bound (up to log factors), thus prescribing an optimal scheme for this problem. To the best of our knowledge, our work provides the first inroad into a theoretical understanding of dynamic batch learning in high-dimensional sparse linear contextual bandits.

4 - Adaptive Transfer Learning for Healthcare Operations: From Surrogates to Bandits

Arielle Elissa Anderer, The Wharton School, Wynnewood, PA, 19096-2455, United States, Divya Singhvi, Hamsa Sridhar Bastani

How do we adaptively learn from incoming and limited data sources in order to make more efficient decisions in a healthcare setting? This presentation outlines new, adaptive methods that medical professionals can use to determine efficacy or necessity of treatment. In designing these methods we leverage information as it becomes available to continually update predictions, to ensure that medical professionals can better balance providing effective healthcare with using available resources efficiently. We also focus on identifying the conditions under which it is most economically beneficial to use these strategies. This presentation will focus on two policy areas: clinical trial design and disease pre-screening algorithms.

■ WB11

Virtual Room 11

OR Strategies for Health Equity

General Session

Chair: Karen T. Hicklin, University of Florida, Gainesville, FL, 27599-7411, United States

Co-Chair: Toyya Pujol, Purdue University, West Lafayette, IN, United States

1 - Using Multilevel Logistic Regression to Identify Health Disparities for Women with Gestational Diabetes Mellitus

Carolina Gonzalez-Canas, Purdue University

Gestational Diabetes Mellitus (GDM) is a type of diabetes that is developed during pregnancy in women without a previous history of diabetes. The risk of developing GDM can be influenced by many social and demographic factors poverty level, rural percentage, and food security situation. We determine which factors are associated with higher rates of GDM and those variables based on the geographic region that influences detection and prevention of the disease. We develop and analyze a multilevel logistic regression model using Indiana Medicaid claims data for the years 2017 to 2020.

2 - Addressing Data Heterogeneity Through Robust Estimation
Amy L. Cochran, University of Wisconsin - Madison, Madison, WI, United States, Kenneth J. Nieser, Zachary Stowe

Data in healthcare research is largely collected from white individuals from middle to upper socioeconomic classes. When overlooked in data analysis, overrepresentation can lead to inferences that do not generalize across racial, ethnic, or socioeconomic groups. Existing methods for handling data heterogeneity require careful model crafting, which may explain their underutilization. We present a robust estimation approach for automatic detection of data heterogeneity and show its utility in simulation and for a study of maternal mental health. The approach can be used during the model-building process to improve inferences and identify population subsets that demand further attention.

3 - What Would it Take to Reach National Screening Targets for Colorectal Cancer Screening—A Simulation Study
Karen Theodora Hicklin, University of Florida, Gainesville, FL, 27599-7411, United States, Meghan O'Leary, Siddhartha Nambiar, Maria Esther Mayorga, Stephanie B. Wheeler, Melinda Davis, Kristen Hassmiller

Healthy People 2020 and the National Colorectal Cancer Roundtable established national colorectal cancer (CRC) screening targets of 70.5% and 80%, respectively. While evidence-based interventions (EBIs) have increased CRC screening, the ability to achieve these targets at the population level remains uncertain. We simulated the impact of four multicomponent interventions in North Carolina over a 5-year period. Each intervention was simulated with and without Medicaid expansion and at different levels of reach (percent of targeted population reached by the EBI). Outcomes included the percent up-to-date overall and by sociodemographic subgroups and the number of CRC cases and deaths averted. This study clarifies the potential for multicomponent EBIs to reach national CRC screening targets, but decision-makers also could consider tradeoffs in cost, reach, and ability to reduce disparities when selecting interventions.

4 - Understanding the Impact of Social Determinants on Opioid Use Disorder Diagnosis
Carolina Vivas Valencia, Purdue University, West Lafayette, IN, United States, Paul Griffin, Nan Kong

Over the last decade, the United States has experienced increasing rates of opioid use, and overdose deaths. This study aims to understand the impact of social determinants (sex, race or ethnicity) on the diagnosis of opioid use disorder (OUD). 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 extracted the information on the proportions of patients with an OUD diagnosis from the total opioid prescription. We developed regression models to ascertain the association of the independent variable (sex, race or ethnicity, opioid prescription) with the dependent variable, OUD.

■ WB12

Virtual Room 12

Refugee Crises and Migration

General Session

Chair: Shima Azizi, Worcester Polytechnic Institute, Worcester, MA, 01609, United States

1 - Refugee Camp System Aid Allocation with Uncertain Demand and Replenishment Cycles
Shima Azizi, Worcester Polytechnic Institute, Worcester, MA, 01545-4285, United States, Cem Deniz Caglar Bozkir, Andrew C. Trapp, Erhun Kundakcioglu, Ali Kaan Kurbanzade

Camp-based refugees seek shelter in camps, and urban refugees in nearby areas. Aid distribution to camps should prioritize camp-based refugees, yet share excess inventory with urban refugees when able. Amid uncertainty in demands and replenishments, we derive an inventory policy to govern a camp's aidsharing with urban refugees. We use the policy to construct expected costs of referring urban refugees elsewhere, depriving camp-based refugees, and holding, and embed them in a cost-minimizing aid allocation problem. Our study reveals insights into humanitarian aid allocation amid uncertainty.

2 - Risk-averse Placement Optimization in Refugee Resettlement
Narges Ahani, Worcester Polytechnic Institute, MA, Worcester, MA, 01609, United States, Alexander Teytelboym, Andrew C. Trapp

Refugees are resettled into communities in many ways, and of late with the well-designed use of analytical approaches. The refugee placement optimization software Annie™ MOORE estimates refugee-locality match quality scores using predictive modeling of past refugee placement and outcomes data to generate the likelihood of employment. While estimated scores are used for offline optimal matching of arriving refugees in subsequent placement periods, inherent uncertainty exists with respect to the quality score estimation, to which the optimized outcome may be sensitive. We study the uncertainty in refugee outcome optimization and propose methods to better stabilize the outcomes, so as to reduce this sensitivity.

3 - Modeling the United States Asylum Process via Data Science and Simulation
Geri Dimas, Worcester Polytechnic Institute, Worcester, MA, 01602-1915, United States, Renata Alexandra Konrad, Andrew C. Trapp

We explore the intricacies of the United States immigration court system, specifically looking at the defensive asylum process. Through the application of data science methodologies and discrete event simulation we determine key factors related to the defensive asylum process and create a simulation model to explore ways to improve an asylees' journey through this complex system.

4 - Estimating Effectiveness of Identifying Human Trafficking via Data Envelopment Analysis
Malak El Khalkhali, Worcester Polytechnic Institute, Worcester, MA, United States, Alex Bender, Geri Dimas, Kayse Lee Maass, Renata Alexandra Konrad, Jeffrey Blom, Joe Zhu, Andrew C. Trapp

Transit monitoring is a preventative approach used to identify possible cases of human trafficking while an individual is in transit or before one crosses a border. Transit monitoring is often conducted by non-governmental organizations (NGOs) who train staff to identify and intercept suspicious activity. Love Justice International (LJI) is one such NGO that has been conducting transit monitoring for 14 years along the Nepal-India border. In partnership with LJI, we developed a system that uses data envelopment analysis (DEA) to help LJI decision-makers evaluate the performance of these stations and make specific operational improvement recommendations.

■ WB13

Virtual Room 13

Modeling and Data Analysis – Opioids

General Session

Chair: Mohammad Jalali, Harvard University, Cambridge, MA, 2114, United States

1 - Analyzing Access to Opioid Overdose Reversal Medication Using a System Dynamics Model of the U.S. Opioid Epidemic
W. Alton Russell, Postdoctoral fellow, Harvard Medical School, Boston, MA, United States, Tse Yang Lim, Erin Stringfellow, Fatma Melike Yildirim, Elizabeth Beaulieu, Jaden Wood, Mohammad Jalali

Naloxone, an opioid agonist medication, is responsible for preventing thousands of overdose deaths in the United States. Expanding access to naloxone for community members who may witness an overdose is widely regarded as a critical strategy for reducing harms from the opioid epidemic. We extend a nationally representative system dynamics simulation model of the development and treatment of prescription opioid and heroin use disorder. Using this model, we analyze how policies impacting the availability and distribution of naloxone impact overdose deaths and health-economic outcomes.

2 - A Multi-state Analysis of Opioid Overdose Death Trends Since the Onset of COVID-19
Gian-Gabriel P. Garcia, Harvard Medical School, Boston, MA, 48103, United States, Catherine DiGennaro, Erin Stringfellow, Jaden Wood, Nicole Poellinger, Mohammad Jalali

Since the onset of COVID-19, studies have shown increasing rates of opioid overdose across the United States. Yet, little is known about how state-level opioid overdose trends and decedent characteristics have varied throughout the country. We analyze vital statistics data from several states and investigate the changes in decedent demographics and substances involved in these deaths. We find that the daily opioid overdose death rate has only significantly increased in a few states. Shifting decedent demographics also indicate increasing rates of opioid overdose deaths among males and racial minorities. Our analysis also reveals a simultaneous increase in the presence of synthetic opioids and decrease in heroin among overdose deaths across most states. These results highlight state-level differences in changing opioid overdose dynamics, which can inform targeted public health interventions that address state-specific needs.

3 - Reducing Opioid use Disorder and Overdose in the United States: A Systems Modeling Analysis of Intervention Strategies
Erin Stringfellow, Massachusetts General Hospital, Boston, MA, United States, Tse Yang Lim, Celia Stafford, Catherine DiGennaro, Mohammad Jalali

The exponential rise in opioid overdose deaths is among the most pressing public health issues in the U.S. We developed a system dynamics simulation model that incorporates feedback loops to replicate trends in the opioid-using population, encompassing prescription opioid misuse, nondisordered heroin use, opioid use disorder (OUD), and remission; treatment with medications for OUD (MOUD); and nonfatal and fatal overdose. We estimate the effect on OUD and fatal overdose after implementing several intervention strategies, spanning primary prevention, MOUD capacity, harm reduction, and recovery, from 2021-2031.

4 - Changes in Substance use Following Initiation of Opioid Agonist Therapy Among People Who Use Drugs in a Canadian Setting: A Segmented Regression Analysis
Huiru Dong, University of British Columbia, Vancouver, BC, Canada, Huiru Dong, British Columbia Centre on Substance Use, Vancouver, BC, Canada, Kanna Hayashi, M-J Milloy, Kora DeBeck, Joel Singer, Hubert Wong, Evan Wood, Thomas Kerr

Although previous studies have shown that opioid agonist therapy (OAT) is linked to reductions in illicit opioid use, less is known about how OAT impacts the use of other psychoactive substances. We aimed to examine the changes in the use of different substances by comparing patterns before and after initiating OAT. The study included 1107 people who use drugs in Vancouver, Canada, from 1996 to 2018. With segmented regression, we observed a decreasing trend for heroin (adjusted odds ratio (AOR): 0.80, 95% confidence interval (CI): 0.77, 0.83), illicit prescription opioid (AOR: 0.87, 95% CI: 0.83, 0.90), and benzodiazepines (AOR: 0.73, 95 % CI: 0.67, 0.80) after OAT engagement. There was no significant difference comparing the pre-treatment and post-treatment trends for stimulants and cannabis. However, a higher growth slope was noted during the post-treatment period for daily alcohol use (P = 0.016). Therefore, the development of comprehensive and tailored treatment strategies is needed for polysubstance users accessing OAT.

5 - Factors Related to Premature Exit from Opioid use Disorder Treatment - A Multiyear Machine Learning Analysis
Celia Stafford, Harvard Medical School, Boston, MA, United States, Becky Naumann, Kristen Hassmiller, Mohammad Jalali, Wesley Javier Marrero Colon

The steady rise in opioid overdose deaths has been punctuated by a plethora of use disorder treatment roadblocks from low capacity to ineffective methods, and importantly, low retention which often leads to relapse. We developed a machine learning model predicting premature exit from opioid use disorder treatment using socio-demographics, substance use and substance use treatment history, and legal system involvement, among others. We explore the implications of the most influential variables in this predictive model such as treatment setting and source of payment for treatment.

■ WB14

Virtual Room 14

Healthcare Operations Management II

Contributed Session

Chair: Aaron Bonnett, Texas A&M University, College Station, TX, United States

1 - Identification of Institutional Characteristics that May Drive (avoidable) Hospitalization of Nursing Home Residents
Zhe Hong, University of Rochester, Simon Business School, Rochester, NY, United States, Abraham Seidmann

Avoidable hospital transfers increase the risk of negative outcomes for patients and cause substantial waste in medical resources. While reducing emergency department (ED) transfer and hospitalization rates has been widely discussed, most research focuses on policy impacts and patient characteristics. This paper, rooted in the context of nursing homes, provides a a comprehensive review of the concept, identification, and contributing factors. In addition, empirical evidence is presented to complement the study. Using a nationwide panel data, we document the effect of occupancy rate, staffing level, competition pressure, and compliance to regulations.

2 - The Role of Advertising on High-tech Medical Procedures: Evidence from Robotic Surgeries
Tae Jung (TJ) Yoon, KAIST, Seoul, Korea, Republic of, Tongil (TI) Kim

Hospital advertising often promotes expensive high-tech procedures without disclosing risks or alternatives. This study brings a customer-centric view to this trend by investigating the role of hospital TV advertising in patients' choice of robotic surgery using FL's individual patient data. We find that advertising high-tech procedures induces more choices of robotic surgery over laparoscopic surgery, and patients are sophisticated by only responding to the relevant ad content. However, the advertised medical benefits of robotic surgery become statistically insignificant, after controlling for surgeon-level factors, calling the value of robotic surgery advertising into a question.

3 - Cross-regions Collaborative Scheduling Problem for Scarce Equipment of HHC
Gang Du, East China Normal University, Shanghai, 200241, China

This paper initially considers the cross-regions collaborative scheduling of scarce medical equipment in HHC, and take stochastic factors into account. To deal with uncertain issues, this paper puts forward a Stochastic Programming model with Recourse (SPR model) with the objection of minimizing the total dispatching cost considering the cross-regions profits. Furthermore, the improved Tabu Search Algorithm is proposed to solve the model. A series of numerical experiments demonstrate the effectiveness of the proposed model and algorithm. This research will provide reference for the improvement of equipment collaborative scheduling scheme, and be applied in the actual HHC to promote community support.

4 - Effects of Midlevel Providers on Hospital Performance
Aaron Bonnett, Texas A&M University, College Station, TX, United States

We analyze whether the extent of midlevel provider employment used by a hospital is associated with hospital operational outcomes, as reflected by the Triple Aim Performance metrics. We use multi-year panel data from the American Hospital Association (AHA), the Centers for Medicare and Medicaid Services (CMS), and the Healthcare Information and Management Systems Society (HIMSS) to perform the analyses. Our findings suggest that midlevel providers positively influence hospital technical efficiency and patient satisfaction while negatively influencing hospital costs and clinical quality.

Wednesday, 3:40PM - 5:10PM

■ WC01

Virtual Room 01

Applied Modeling in Health Care Applications

General Session

Chair: Ramesh Johari, Stanford University, Stanford, CA, 94305-4121, United States

1 - Empirical Analysis of Many-armed Bandits with High-dimensional Covariates
Jacqueline J. Vallon, Stanford University, Stanford, CA, United States, Nima Hamidi, Mohsen Bayati

Online experimentation is a common tool for optimizing decisions in various domains, and multi-armed bandits (MAB) provide a framework to reduce the opportunity cost of these experiments. However, even MABs have a high cost when the experiment involves personalizing many decisions to users with high-dimensional features. An example is a wellness application strategically choosing a message from dozens of candidates to display to a user with a large feature set to maximize user engagement in creating healthy habits. We show how the REAL bandit algorithm, a new algorithm that leverages ideas from low-rank matrix estimation, performs against existing benchmarks for the above family of problems.

2 - Relative-risk and the Assessment of School Safety in the COVID-19 Pandemic: Schools May Offer Students Shelter from the Storm

Yeganeh Alimohammadi, Stanford University, Stanford, CA, United States, Kirankumar Shiragur, Ramesh Johari, Amin Saberi, David Scheinker, Kevin Schulman, Kristan Staudenmayer

The debate around school closures has focused on the question of whether schools are safe in the midst of the pandemic. Most studies look at this issue from the perspective of absolute risk. We consider the perspective of relative risk: in other words, whether children are safer at school or at home.Our model shows, under a reasonable and robust set of assumptions about testing strategies and compliance with CDC guidance on countermeasures, in-person learning can be safer for children than being at home. Interestingly, our results suggest that the benefit of school reopening increases with rates of community spread. We use a network-based SEIR model to capture cohort structure and predict the risk of an outbreak under different levels of adherence to compliance measures.

3 - Population-level Management of Type 1 Diabetes via Continuous Glucose Monitoring and Algorithm-enabled Patient Prioritization

Johannes O. Ferstad, PhD Student, Stanford University, Stanford, CA, United States

In recent years, continuous glucose monitors (CGM) and data-driven care tools have been demonstrated to improve diabetes outcomes. With the rapid expansion of telemedicine, CGM-based remote patient monitoring could expand specialized type 1 diabetes (T1D) care to underserved areas. To facilitate efficient care delivery for T1D patients using CGM, we developed and deployed a data-driven dashboard in a pediatric endocrinology clinic at a large academic hospital; the dashboard identifies interpretable clinical criteria to prioritize patients for weekly provider review. We describe the tool, its deployment, and the resulting efficiency gains and improvements in patient outcomes.

4 - A Model for Hospital-level COVID-19 Associated Patient Demand Intervals from Consistent Estimators (DICE)

Teng Zhang, Stanford University, Stanford, CA, United States, Linying Yang, Peter Glynn, David Scheinker

Hospitals commonly project demand for their services by combining their historical share of regional demand with forecasts of total regional demand. Regional forecasts of patient demand are commonly available as a Poisson random variable, e.g., for the number of people requiring hospitalization due to an epidemic such as COVID-19. However, even in this common setting, no probabilistic, consistent, computationally tractable forecast is available for the fraction of patients in a region that a particular institution should expect. We introduce such a forecast, DICE (Demand Intervals from Consistent Estimators). We describe its development and deployment at an academic medical center in California during the `second wave' of COVID-19 in the United States. We show that DICE is consistent under mild assumptions and suitable for use with perfect, biased and unbiased regional forecasts. We evaluate its performance on empirical data from a large academic medical center as well as on synthetic data.

■ WC02

Virtual Room 02

Analytics in COVID-19 Modeling

General Session

Chair: Zelda B. Zabinsky, University of Washington, Seattle, WA, 98195-2650, United States

1 - Modeling the Dynamics of COVID-19 in Los Angeles using Traffic Information

Suyanpeng Zhang, University of Southern California, Los Angeles, CA, United States, Sze-Chuan Suen

Predicting COVID-19 prevalence is critical for effectively targeting diagnosis and vaccination efforts. However, prevalence is driven by a complex set of factors, including transmission patterns and quarantine orders. We construct a dynamic disease model of Los Angeles county with data from surveillance reports and traffic flow data to approximate regional flows. This road sensor network data was collected continuously over the last few years, allowing pre- and post-Covid comparisons. Our dynamic model allows us to create geographically specific prevalence predictions and is a critical first step for future targeted disease control efforts.

2 - Managing Queues During Infectious Disease Outbreaks

Kurtis Konrad, North Carolina State University, Raleigh, NC, United States, Yunan Liu, Xu Sun

As an aid to making capacity planning and resource allocation decisions in health systems treating infectious diseases, we develop a novel analytical framework that integrates the classical susceptible-exposed-infectious-recovered (SEIS) model with a multi-server queue. Unlike most compartmental models of infectious disease where researchers' primary goal is to develop new forecasting tools for future trajectories of the compartments, our focus is on how to optimally design the service capacity (beds, staffs, protection gears, etc.) with the objective of achieving acceptable quality of service. Also, our study distinguishes from conventional queueing models in that prolonged customer delay not only translates into low quality of service but also leads to significant increase in future arrivals, as a waiting customer (representing an unhospitalized infectious individual) can "invite" new future arrivals (by turning susceptible individuals into exposed ones).

3 - Using Agent-based Simulation to Analyze How to Achieve Herd Immunity to Sars-CoV-2 with Vaccination and Non-pharmaceutical Interventions

Serin Lee, University of Washington, Seattle, WA, 98195-2650, United States, Zelda Zabinsky, Shan Liu

While vaccines for the novel coronavirus (COVID-19) are being rolled out in 2021, concerns remain on whether herd immunity can be achieved with emergent new variants and immunity loss. Using an agent-based simulation that is calibrated to the greater Seattle, we simulate the feasibility of achieving herd immunity to SARS-CoV-2 through vaccination, natural immunity, and non-pharmaceutical interventions. Several factors, including vaccination coverage, average immunity duration, vaccine effectiveness against variants, and non-pharmaceutical interventions are considered.

4 - On the Effects of Hospital-acquired Conditions on Patient Outcomes

Bogdan C. Bichescu, University of Tennessee, Knoxville, TN, 37996-4515, United States, Haileab Hilafu

We examine the understudied effect of hospital acquired conditions (HACs) on 30-day readmission risk (ReAd) and hospital length of stay (LOS). Using econometric modeling and a patient-visit level secondary dataset for Florida patients treated for acute myocardial infarction between 2011 and 2014, we find the expected excess LOS and ReAd attributable to HACs to be 3.248 days and 11.8%, respectively. LOS mediates the relationship between HACs and ReAd, such that the longer LOS associated with HACs reduces the risk of readmission. In a post-hoc analysis, we quantify the excess cost attributable to a HAC incident. Our study contributes to the existing literature on the implications of HACs.

5 - Optimal Control of COVID-19 via Non-pharmaceutical Interventions and Vaccination Policies

Zelda B. Zabinsky, University of Washington, Industrial and Systems Engineering, Seattle, WA, 98195-2650, United States, Aaron Z. Palmer, Shan Liu

We present an optimal disease control model for COVID-19 where disease propagation is influenced by degree of non-pharmaceutical interventions (NPIs) and vaccination policies. The objective function includes deaths, hospitalizations, and simple social and economic costs. Before vaccination, we discover two locally optimal control strategies that we categorize as suppression and mitigation strategies. With vaccination, we find a delay-mitigation strategy for NPIs as vaccines roll-out. We also analyze optimal allocation of vaccines to different populations (i.e., those with high mortality rates versus those with high contact rates) depending on transmissibility and prevalence.

■ WC03

Virtual Room 03

Models of Multiple Conditions and Adverse Events

General Session

Chair: Hari Balasubramanian, University of Massachusetts - Amherst, Amherst, MA, 01003-9265, United States

1 - Analyzing Adverse Events Following Durable LVAD Implantation: A Sequence Clustering Approach

Rema Padman, Trustees Professor of Mgmt. Sci & Healthcare IS, Carnegie Mellon University, H. John Heinz III College, Mgmt Sci & Healthcare In, Pittsburgh, PA, 15213, United States, J. Macickova, L. Duan, F. Movahedi, L. Seese, Y. Zhang, M. Jacoski, A. Kilic

Left ventricular assist devices (LVADs) are being implanted with increasing frequency in the advanced heart failure population but adverse events (AE) following implantation are a major concern. We employ machine learning algorithms with sequence clustering to visualize and assess AE sequences following implantation using data from a randomized clinical trial with 568 patients who experienced 3,590 AEs such as bleeding, infection and stroke. Five distinct clusters of patients were generated, each with different patterns of time intervals between AEs, transition rates between AEs, and clinical outcomes, providing insights for early intervention.

2 - Predicting Unscheduled Emergency Department Revisits Leading to Acute Hospital Admissions among Older Adults

Yiye Zhang, Weill Cornell Medicine, New York, NY, 10065, United States, Peter A. Steel

Unscheduled emergency department (ED) revisits leading to acute hospital admission (RVA) are tantamount to a failed discharge. We developed and validated a machine learning model to predict individual patient risk of RVA within 72 hours and 9 days of index ED visits. A machine learning model was applied to retrospective electronic health record (EHR) data of patients presenting to 2 geographically and demographically divergent urban EDs in 2019. Multiple machine learning algorithms were constructed; models were compared against a pre-existing adult ED-RVA risk score as a baseline. A total of 62,154 patients were included in the analysis, with 508 (0.82%) and 889 (1.4%) having 72-hour and 9-day RVA. The best-performing model, combining deep significance clustering (DICE) and regularized logistic regression, achieved AUC of 0.86 and 0.79 for 72-hour and 9-day ED-RVA for older adult patients, respectively, outperforming the pre-existing RVA risk score (0.704 and 0.694). Machine learning may be useful in reducing adverse events post-ED.

3 - Network Simulation Algorithm for Integrated Modeling of Diseases

Chaitra Gopalappa, University of Massachusetts, Amherst, MA, 01003-9265, United States

Research in social epidemiology has shown that social determinants are the root cause of several preventable diseases. Recognizing this, instead of just disease-specific interventions, the national public health strategic plan, HealthyPeople2020, aims for structural interventions that address social determinants and reduce health disparities. However, it is difficult to predict the overall effectiveness of structural interventions through individual disease models as diseases are syndemic by nature, i.e., the presence of one disease can amplify another. Subsidized housing, for example, is shown to decrease HIV infections, even in communities of concentrated poverty. However, this figure underestimates the benefit of subsidized housing because preventing HIV decreases human papillomavirus, hepatitis B, and hepatitis C . We develop a network modeling framework for integrated modeling of diseases for evaluation of structural interventions.

4 - Estimating the Prevalence of Multiple Chronic Diseases via Maximum Entropy

Pracheta Amaranath, University of Massachusetts - Amherst, Amherst, MA, United States, Ninad Khargonkar, Roshan Thaikkat, Prasanna Srinivasan, Hari Balasubramanian, Peter J. Haas

The prevalence of multiple chronic conditions among the United States population accounts for a large portion of healthcare expenditures. A baseline predictive model for the probabilities of co-occurring conditions is essential for planning interventions and organizing healthcare delivery systems. Because the number of individuals in a disease dataset is usually small compared to the number of possible disease combinations, simple maximum-likelihood estimates of disease co-occurrence will erroneously assign zero probabilities to disease combinations that are missing from the dataset but occur in the larger population. We combine maximum-entropy, data-mining, and machine learning techniques to create an algorithm, called MaxEnt-MCC, for estimating the prevalence of chronic diseases in a population in the face of sparse data. In a case study using Medical Expenditure Panel Survey (MEPS) data, we show how MaxEnt-MCC can be used to predict previously unobserved disease combinations and estimate healthcare costs in a principled manner.

■ WC04

Virtual Room 04

Healthcare Decision Making and Analytics

General Session

Chair: Kimia Ghobadi, Johns Hopkins University, Baltimore, MD, 21218-2625, United States

1 - Optimal Resource and Demand Redistribution for Healthcare Systems

Felix Parker, Johns Hopkins University, Baltimore, MD, United States, Fardin Ganjkhanloo, Farzin Ahmadi, Kimia Ghobadi

Managing COVID-19 surges has been challenging for many health systems. Increasing hospitals' COVID-19 capacity to match demand can overburden staff and adversely impact patient outcomes. Patient transfers can relieve much of this burden and improve outcomes, if done correctly. We propose a data-driven optimization model to redistribute patients and resources between hospitals to minimize the amount of capacity hospitals have to create. This model is robust against uncertainty and incorporates operational constraints and preferences, so it is practical for real-world adoption. We have also developed an interactive tool to demonstrate its potential impact in over 4,800 US hospitals.

2 - A Prescriptive Approach to Surgical Inpatient Discharges

Taghi Khaniyev, MIT. Sloan School of Management, Cambridge, MA, 02142-1508, United States, Safavi Kyan, Martin Copenhaver, Ana Cecilia Zenteno Langle, Bethany Daily, Peter Dunn, Retsef Levi

As hospitals continue to experience frequent capacity crises, what is often needed beyond predicting discharges is identifying a small number of potentially actionable patients to be able to manage the level of disruption to hospital operations. We propose a prescriptive approach to identify such a list of actionable patients and prescribe associated interventions for their timely transition out of the hospital. The proposed approach starts with representing patients' clinical and administrative barriers to discharge in a clinically interpretable way, followed by building a neural network model to predict the discharge likelihood of a given patient within 24 hours. Finally, we employ a mixed integer programming model to identify the minimal subset of barriers that need to be resolved, i.e., prescribed interventions, in order to lift a patient's discharge likelihood above a given threshold. We show the effectiveness of the proposed approach in a series of retrospective analyses conducted at the Massachusetts General Hospital.

3 - Data-driven Inverse Optimization for Standardizing Cancer Care Guidelines

Houra Mahmoudzadeh, University of Waterloo, Sciences Univ. Of Department of Man. Waterloo, ON, N2 L. 3G1, Canada, Kimia Ghobadi

Radiation therapy treatment is a time-consuming process in cancer care that often involves iterative manual planning by a planner and feedback/approval by an oncologist. There are clinical guidelines on radiation dose thresholds, but these guidelines are not universally agreed upon and differ per institution and oncologist. In this paper, we demonstrate that by considering the historically approved plans as feasible points to an LP, we can employ an inverse optimization framework to find the underlying agreed-upon constraints. Finding such constraints enables us to better understand the implicit logic of oncologists in approving or rejecting treatment plans. In doing so, we help standardize the guidelines and care practices, generate more realistic plans based on past observations, improve the quality of the initial plans, and reduce the number of iterations between planners and oncologists, and improve the quality of the final plans by preventing low-quality solutions that otherwise satisfy the acceptability thresholds.

4 - The Effect of Visibility on Forecast and Inventory Management Performance During the COVID-19 Pandemic

Martin Cousineau, HEC Montréal, Montreal, QC, H3T. 2A7, Canada, Kaveh Dehkhoda, Valérie Bélanger

During the COVID-19 pandemic, healthcare organizations suffered a shortage of essential medical supplies such as personal protective equipment, which resulted in severe consequences. The goal of this study is to assess the impact of one potential factor for this shortage, i.e., the lack of visibility over the inventory and consumption. To do so, different forecasting and inventory management methods are tested with real and simulated data. This talk presents preliminary results for this study.

■ WC05

Virtual Room 05

Healthcare Delivery in the Care Continuum

General Session

Chair: Yingchao Lan, University of Nebraska-Lincoln, Lincoln, NE, 68506, United States

1 - A Million Small Experiments: An Examination of Two Hospitals and the Response to the First Wave of COVID-19

Soh Hyun Chu, Ohio State University, Columbus, OH, United States

The COVID-19 presented serious challenges to hospitals, whose standard processes and stored supplies were inadequate to treat a deluge of critically ill patients. This paper takes an inductive approach while adopting a longitudinal retrospective design to observe the early reactions and transitions to COVID-19 at two hospitals, Regional NJ, and Manhattan Health, over the first six months of 2020. We interviewed 20 subjects, each with senior leadership, medical, and purchasing roles in the two hospitals located in the greater New York metropolitan region. Our study reveals that the empowerment of frontline workers and involvement of government are essential when reacting to such disruptions.

2 - Ancillary Cost Implications of Physicians Multisiting and Organizational Boundary Spanning During Healthcare Delivery
Yingchao Lan, Assistant Professor, University of Nebraska-Lincoln, Lincoln, NE, 68506, United States, Deepa Wani, Aravind Chandrasekaran

In this research, we examine the role of individual boundary spanners, namely multisiting physicians, who practice at more than one hospital, in reducing ancillary cost. We also look at how organizational boundary spanning abilities measured by the hospital's affiliation in an accountable care organization (ACO) model affect this relationship.

3 - Examining the Role of Physicians in Efficiency and Quality of Care
Deepa Wani, Georgia State University, Atlanta, GA, United States, Aravind Chandrasekaran

Healthcare researchers have long studied how to improve patient care when admitted to hospitals. While the role of nurses, hospitalists, and health information technologies in coordinating care has been investigated extensively, the role of physicians has been relatively understudied. In this study, we investigate the role of physicians in the continuity of care and its impact on efficiency and quality outcomes. Using patient-level data, we find support for our hypotheses.

4 - The Opioid Crisis: How Disruptive Interventions in the Prescription Opioid Supply Chain Make the Crisis Deadlier
Eunseok Kim, PhD Candidate, Rutgers University, Newark, NJ, United States, Alok Baveja

The opioid crisis's adverse impact on our society has worsened during COVID. In the last decade, many states have adopted prescription monitoring programs to control the supply of prescription opioids. However, zip code level analysis on secondary data from New Jersey shows that as the number of pharmacy shoppers decreases, the number of opioid-related hospitalizations and overdose deaths increase. The results suggest the curbed supply of prescription opioids displaces its demand to illicit drugs with implications for opioid-related hospitalizations and deaths. This work emphasizes the need for both supply and demand management planning to control unintended adverse consequences.

■ WC06

Virtual Room 06

Data-driven Decision Support for COVID-19 Response and Beyond

General Session

Chair: Pengyi Shi, Purdue University, West Lafayette, 47907, United States

1 - Data-driven Adaptive Robust Optimization for Resource Sharing During a Pandemic
Esmaeil Keyvanshokooh, University of Michigan, Ann Arbor, MI, 48108-1020, United States, Mohammad Fattahi, Maryam Zokaeinikoo, Mark P. Van Oyen, Kenneth A. Freedberg, Pooyan Kazemian

Amid local outbreaks of COVID-19, many US hospitals canceled elective procedures to preserve ventilator capacity for COVID-19 patients. The virus spreads at varying rates across different regions, so 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 states and regions within them to satisfy demand with fewer total ventilators. We use real data and disease prevalence simulation models for regions in Ohio and Michigan during the first pandemic's peak in 2020. Demand could be satisfied using 22%-65% fewer ventilators with ventilator sharing compared to no sharing (status quo), thereby allowing hospitals to preserve more elective procedures.

2 - Operations (Management) Warp Speed, Rapid Deployment of a Hospital Prediction and Decision Support Framework for COVID-19
Jonathan Eugene Helm, Indiana University, Kelley School of Bus. Bloomington, IN, 47405-5308, United States, Pengyi Shi, Chris Chen, Jeff Lim, Rodney Parker

We develop a multi-method prediction model integrating disease transmission models with a stochastic queueing network of patient flow in hospitals enhanced with adaptive tuning methods to overcome scarce data and partially-observable parameters, and adjust to time-varying dynamics. We implement our framework at IU Health, with 18 hospitals serving >1million patients.

3 - Deploying an Artificial Intelligence System for COVID-19 Testing at the Greek Border
Hamsa Sridhar Bastani, Wharton School, Philadelphia, PA, 19104, United States, Drakopoulos Kimon, Vishal Gupta, Jon Vlachogiannis, Christos Hadjicristodoulou, Pagona Lagiou, Gkikas Magiorkinis, Dimitrios Paraskevis, Sotirios Tsiodras

On July 1st, 2020, members of the European Union gradually lifted earlier COVID-19 restrictions on non-essential travel. In response, we designed and deployed "EVA" - a novel, self-learning artificial intelligence system - across all Greek borders to identify asymptomatic travelers infected with SARS-CoV-2 based on demographic characteristics and results from previously tested travelers. EVA allocates Greece's limited testing resources to (i) limit the importation of new cases and (ii) provide real-time estimates of COVID-19 prevalence to inform border policies. Counterfactual analysis shows that our system identified on average 1.85x as many asymptomatic, infected travelers as random surveillance testing, and up to 2-4x as many during peak travel. Moreover, for most countries, EVA identified atypically high prevalence 9 days earlier than machine learning systems based on publicly reported data. By adaptively adjusting border policies 9 days earlier, EVA prevented additional infected travelers from arriving.

4 - To Catch a Killer: A Data-Driven Personalized and Compliance-Aware Sepsis Alert System
Zahra Mobini, University of Texas at Dallas, Richardson, TX, 75252, United States, Mehmet Ayvaci, Ozalp Ozer

In this study, we develop an alert system for early detection of sepsis. Our system personalizes alerts to individual patients and accounts for caregivers' compliance behavior. Integrating predictive approaches with prescriptive ones in a Markov decision process framework, our system determines when a sepsis alert should be triggered. We find that personalized alerts are essential for capturing the heterogeneity of sepsis risk among patients, while compliance-aware alerts are necessary when caregivers' compliance varies during a patient's hospital stay. Using data from a large hospital system in the U.S., we back test and validate our alert policy by evaluating its performance against that of the hospital system. On average, our system detects 22% more sepsis cases. In cases for which both the existing system and ours triggered an alert, our system alerts, on average, 39 hours earlier (ranges 29-53 hours). This time difference matters, as every hour of delay in providing proper sepsis treatment can increase mortality by up to 8%.

■ WC07

Virtual Room 07

COVID-19 Pandemic Modeling and Analysis III

Contributed Session

Chair: Leann Thayaparan, Massachusetts Institute of Technology, Somerville, MA, 02144-1805, United States

1 - Forecasting COVID-19 and Analyzing the Effect of Government Interventions
Michael Lingzhi Li, PhD Candidate, Massachusetts Institute of Technology, Cambridge, MA, United States, Hamza Tazi Bouardi, Omar Skali Lami, Thomas Trikalinos, Nikolaos Trichakis, Dimitris Bertsimas

To help combat the COVID-19 pandemic and understand the impact of government interventions, we develop DELPHI, a novel epidemiological model. We applied DELPHI across >200 regions since early April 2020 with consistent high predictive power. DELPHI compares favorably with other models and predicted large-scale epidemics in areas such as South Africa and Russia weeks before realization. Furthermore, using DELPHI, we can quantify the impact of interventions and provide insights on future virus incidence under different policies. Such analysis was utilized by Janssen Pharmaceuticals to determine locations of its Phase III trial for the first single-dose vaccine Ad26.Cov2.S.

2 - Epidemic Forecasting: Why Did Most COVID-19 Models Fail
Navid Ghaffarzadegan, Virginia Tech, Blacksburg, VA, United States, Hazhir Rahmandad, Ran Xu

What determines the accuracy of predictive models of COVID-19? We assess the predictive power of models contributing to CDC repository of COVID-19 death projections, finding that better long-term predictions correlate with (1) capturing the physics of transmission (in contrast to black-box models); (2) capturing human reactions to an evolving pandemic; and (3) resetting state variables to account for unobserved shocks before starting projection. We build a very simple model that incorporates these features. The model endogenously creates the multi-wave trajectory and provides more accurate long-term forecasts than more than sixty models included in a CDC supported covid-19 forecast hub.

3 - COVID-19: A Multipeak SIR Based Model for Learning Waves and Optimizing Testing

Leann Thayaparan, Massachusetts Institute of Technology, Cambridge, MA, United States, Georgia Perakis, Divya Singhvi, Omar Skali Lami

The COVID-19 pandemic has been marked by behaviour-driven waves, which traditional epidemiology models are not equipped to handle. We propose a novel multipeak SIR model, which can systematically detect and model the waves of the disease using the SIR model's compartmental structure and a change-point detection martingale process. We create a dynamic process where new waves can be flagged and learned in real time (less than a week). We show that the multipeak model improves MAPE by 10%-15% for the United States, and by 25%-40% in the specific regions that were hit by the multiple waves.

■ WC08

Virtual Room 08

Bonder Scholar Applied Research

General Session

Chair: Gian-Gabriel P. Garcia, Harvard University, Ann Arbor, MI, 48103, United States

1 - An Analysis of Structured Optimal Policies for Hypertension Treatment Planning

Gian-Gabriel P. Garcia, Harvard Medical School, Boston, MA, 48103, United States, Lauren N. Steimle, Wesley Marrero Colon

Markov Decision Processes (MDPs) are commonly used for optimizing sequential decisions under uncertainty in medical decision making. If an MDP's parameters satisfy several assumptions, then the optimal policy is guaranteed to be monotone, which provides an appealing interpretable structure for practitioners. Unfortunately, these assumptions are not always satisfied. In this research, we define the Price of Interpretability (PI) which measures the gap between the optimal policy and an interpretable policy. To this end, we assess the PI for the Best-performing Monotone Policy (BMP) and the novel Class-ordered Monotone Policy (CMP), which preserves interpretability along user-defined state and action classes. For hypertension treatment planning, we demonstrate that the CMP can be computed more quickly and achieves greater total QALYs across a large patient population compared to the BMP. We conclude that the CMP is a practically appealing approach to mitigating the tradeoff between optimality and interpretability.

2 - Optimizing Drone Delivered Defibrillators

Justin J. Boutilier, University of Wisconsin - Madison, Madison, WI, 53706-1603, United States, Timothy Chan

OHCA claims over 400,000 lives each year in North America and is one of the most time-sensitive medical emergencies. Drone-delivered automated external defibrillators (AEDs) have the potential to be a transformative innovation in the provision of emergency care for OHCA. In this talk, we design a defibrillator-enabled drone network that augments the existing EMS system to rapidly respond to out-of-hospital cardiac arrest (OHCA). Using real data from an area covering 26,000 square kilometers around Toronto, Canada, we find that a modest number of drones are required to significantly reduce response times in all regions. We estimate that the response time reductions achieved by the drone network are associated with between a 42% to 76% higher survival rate, and up to 144 additional lives saved each year.

3 - Adaptive Transfer Learning for Healthcare Operations: From Surrogates to Bandits

Arielle Elissa Anderer, The Wharton School, Wynnewood, PA, 19096-2455, United States

How do we adaptively learn from incoming and limited data sources in order to make more efficient decisions in a healthcare setting? This presentation outlines new, adaptive methods that medical professionals can use to determine efficacy or necessity of treatment. In designing these methods we leverage information as it becomes available to continually update predictions, to ensure that medical professionals can better balance providing effective healthcare with using available resources efficiently. We also focus on identifying the conditions under which it is most economically beneficial to use these strategies. This presentation will focus on two policy areas: clinical trial design and disease pre-screening algorithms.

4 - Redesigning Sample Transportation in Malawi through Improved Data Sharing and Daily Route Optimization

Emma Gibson, MIT, Cambridge, MA, 02142-1307, United States, Jonas Oddur Jonasson, Sarang Deo, Kara Palamountain, Mphatso Kachule

Sample transportation (ST) systems move medical samples (e.g. blood, sputum) between health centers and laboratories in many developing countries. In partnership with Riders for Health Malawi, we implemented an optimized ST algorithm to deploy motorcycle couriers on a daily basis and maximize the efficiency of the Malawian ST system.

■ WC09

Virtual Room 09

Healthcare Analytics and Machine Learning III

Contributed Session

Chair: Meghan Howell, Patient Access Business Manager, Stanford Children's Health, Palo Alto, CA, United States

1 - Evaluating Value-based Care by Collecting Patient Data using Wearables

Charlotte Köhler, Freie Universität, Berlin, Germany, Daniel Furstenau

Through the continuous measurement of vital parameters, wearables promise high potential for use in medicine. An analysis of the collected data enables an understanding of the patient's history and holds the potential to, for example, detect COVID cases or prevent future diseases. Although the use of wearables seems promising, they are not yet integrated into standard care. We present a value-based care approach to evaluate the benefits with the challenges of collecting data using wearables to help accelerate their adoption.

2 - Using Analytics to Improve Patient Access in Specialty Care: Data Architecture and Visualizations That Drive Change

Meghan E. Howell, Patient Access Business Manager, Stanford Children's Health, Palo Alto, CA, United States, Rachel Weber, Natasa Tekic, Laissa Lai

Patient access improvement is primarily solving a delay problem, and at the heart, balancing capacity with demand. Stanford Children's Analytics has developed a suite of comprehensive dashboards to compare recent demand (appointments booked) and activity (appointments completed) against prospective capacity (appointments offered) and delay (third next available appointment). Innovative data architecture supports functionality across specialties. Visualizations and forward-looking data equip operational users with insights to anticipate and minimize delays via proactive system adjustments.

■ WC10

Virtual Room 10

Data, Learning, and Decision-Making in Healthcare Management

General Session

Chair: Mohsen Bayati, Stanford University, Stanford, CA, 94305-7216, United States

1 - Discovering Causal Models with Optimization: Confounders, Cycles, and Feature Selection

Nur Kaynar, University of California - Los Angeles, Los Angeles, CA, United States, Auyon Siddiq, Frederick Eberhardt

Causal inference is important for developing effective public health interventions. The recent advancements in graphical approaches to causality have opened new opportunities to learn the underlying causal relations systematically from observational data. In this work, we propose an efficient optimization-based framework for learning causal graphs from observational data. Our approach accommodates the presence of feedback loops and latent variables, which are essential to adequately represent many real-world settings. We also propose a causality-based feature selection method for improving interpretability. Our numerical results show that the proposed framework compares favorably with the current state-of-the-art discovery methods.

2 - Optimal Experimental Design for Staggered Rollouts
Ruoxuan Xiong, Stanford University, Stanford, CA, 94305-4121, United States, Susan Athey, Mohsen Bayati, Guido Imbens

Multi-period experiments have been widely used in healthcare to study the effect of treatments or decisions that can impact outcomes for multiple periods. We focus on the setting with multiple units, such as geographical locations, where all units start in the control state at the initial period. The experiment designer chooses a particular point in time for each unit to allocate the treatment of interest. Then the unit remains exposed to this treatment in subsequent time periods. We study the optimal allocation of treatments to units in order to maximize the experiment's statistical power. We study a general data model and provide the optimal treatment schedules that minimize the variance, where the corresponding fraction of treated units takes an S-shaped curve in time. In addition, we propose a data-driven local search algorithm that allows the experiment designer to leverage historical data to improve the treatment schedule. We demonstrate the relevance of our solution by using synthetic experiments on real datasets.

3 - Physicians' Ordering Behavior for Diagnostic Tests in the ED
Danqi Luo, Stanford University, Stanford, CA, 94305-7216, United States

Using patients' electronic medical data from an emergency department n (ED), we identified high variances in the number of diagnostic tests that physicians ordered for the same type of patients. We wish to identify the root causes of such variation. We find that when the ED is busy, physicians tend to order fewer diagnostic tests for patients. Leveraging a field experiment on providing wait time information, we developed an IV and established this causal claim.

4 - Machine Learning Methods Applied to Cancer Treatment Planning
Jacqueline J. Vallon, Stanford University, Stanford, CA, United States, Neil Panjwani, Xi Ling, Sush Vij, Mark Buyyounouski, Mohsen Bayati

Cancer treatment planning is complex, requiring the integration of many parts. Traditional analyses to guide cancer treatment decisions have several shortcomings: 1) Models often only incorporate covariates readily available in the EMR. However, texts such as biopsy reports include rich covariates used in clinical practice but missed in analyses because of their unstructured nature. 2) Advanced machine learning (ML) models trade off variance by injecting bias to increase estimation accuracy, potentially recommending decisions inconsistent with clinical intuition. We study these challenges by applying recent ML and causal inference methods to prostate cancer treatment planning.

■ WC11

Virtual Room 11

Exploration of Disease-Related Racial Disparities using ORMS Methods

General Session

Chair: Jennifer Mason Lobo, University of Virginia, Charlottesville, VA, 22908-0717, United States

1 - Diabetes Management at Community Health Centers: Examining Associations with Patient and Regional Characteristics, Efficiency, and Staffing Patterns
Ronald McGarvey, University of Missouri, Columbia, MO, United States, Maggie Thorsen, Andreas Thorsen

A major source of primary health care for millions of Americans, community health centers (CHCs) act as a key point of access for diabetes care. This study examines how patient and regional characteristics, staffing patterns and efficiency were associated with diabetes management at CHCs. Latent class analysis identified seven underlying staffing patterns at CHCs. Data envelopment analysis was performed to evaluate the efficiency of CHCs, relative to centers with similar staffing patterns. Finally, generalized linear models were used to examine the association between staffing patterns, efficiency, and patient and regional-level characteristics. Findings from this study suggest that (1) diabetes control appears to be worse at CHCs serving racial minorities living in predominantly White areas; (2) CHCs that incorporate more behavioral health care into their staffing mix have lower rates of uncontrolled diabetes among their patients; and (3) greater efficiency in CHC operations is associated with better diabetes control among patients.

2 - Racial Disparities and Geography in Colorectal Cancer Outcomes
Nirup M. Menon, Associate Dean and Professor, George Mason University, Fairfax, VA, United States, Cara Frankenfeld, Timothy Leslie

This presentation will cover our work on racial disparities in colorectal cancer as well as some ongoing work on racial disparities in length of stay and respiration intubation for COVID-19 patients.

3 - Accounting for Racial Differences in Optimizing Lung Cancer Screening Schedules
Iakovos Toumazis, The University of Texas MD Anderson Cancer Center, Houston, TX, 77030, United States

Lung cancer screening recommendations that determine eligibility based on age, lifetime cumulative smoking exposure and years since smoking cessation, have been shown to exaggerate racial disparities especially in non-Hispanic Blacks (NHB). To address this issue, the US Preventive Services Task Force have updated their recommendations by lowering the minimum age and smoking exposure eligibility criteria. Lung cancer risk prediction models have been developed accounting for racial differences. We adapted the individualized lung cancer screening decisions (ENGAGE) framework such that it incorporates race to derive race-specific screening schedules. We compare the ENGAGE-derived policies for NHB against policies for non-Hispanic Whites (NHW) with similar smoking histories and assess the effectiveness of an individualized lung cancer screening program against the updated guidelines.

4 - Racial Disparities Revealed by Models Predicting COVID-19 Outcomes
Ioannis (Yannis) Paschalidis, Boston University, Department Of Electrical & Computer Eng., Boston, MA, 02215-2421, United States

We develop distributionally robust predictive models to predict level-of-care requirements for patients who tested positive for COVID-19 at a large safety-net hospital system. We analyze data for more than 7,000 patients and develop models to predict who is likely to be hospitalized, require ICU treatment, intubation, and succumb to the disease. Our analysis reveals that social determinants of health and race are important predictive variables. In particular, the model learns that being black implies higher hospitalization risk and is more eager to make that prediction for black patients. (Joint work with Boran Hao, Shahabeddin Sotudian, Yang Hu, Zahra Zad, William Adams, Rebecca Mishuris, Sabrina Assoumou, Heather Hsu).

■ WC12

Virtual Room 12

Pharmaceutical and Vaccine Logistics

General Session

Chair: Jacqueline Griffin, Northeastern University, Boston, MA, 02115, United States

1 - A Centralized Ebola Vaccine Safety Stock for Sub-Saharan Africa
Ruben Proano, Rochester Institute of Technology, Kate Gleason College Of Engineering, Rochester, NY, 14623-5602, United States

We present a simulation study to determine the optimal number of Ebola vaccine doses necessary to effectively support a ring-immunization strategy against potential Ebola outbreaks in 25 Africa countries. A proposed framework integrates a network of compartmentalized epidemiological models, a continuous review inventory model, and a gravitational demographic model. The study evaluates the effect of three controllable- and seven- noncontrollable factors on the safety stock's ability to help control potential outbreaks with fewer vaccine doses. Results show that modulating vaccine replenishing lead times and increasing contact tracing effectiveness can decrease the number of doses needed to mitigate outbreaks.

2 - Designing Systematic Information Sharing to Influence the Intent to Get Vaccinated
Ann Suhaimi, Northeastern University, Somerville, MA, 02145, United States, Jacqueline Griffin

Information supply related to COVID-19 vaccines is abundant and increasing over time. Still, the intent to get vaccinated among populations continue to become a barrier in achieving herd immunity in the country. Using unique survey data, we analyze the relationship between frequency and type of information received and the intent to get vaccinated amongst adults living in Georgia and Massachusetts. Based on this understanding, we aim to guide public health officials to systematically disseminate vaccine information that varies among demographic groups.

■ WC13

Virtual Room 13

Mental Health and Substance Use

Contributed Session

Chair: Jinha Lee, Bowling Green State University, Bowling Green, OH, 43403-0154, United States

1 - A Geospatial Analysis of Overdose Emergencies
Hyojung Kang, University of Illinois at Urbana-Champaign, Champaign, IL, United States, Jinha Lee, Bai-Yau Yeh, Jung Im Choi, Qizhen Lan

The epidemic of opioids is a serious public health issue in the U.S. The number of overdose deaths involving prescription opioids and illicit drugs has continuously increased over the last years. The objective of this study is to develop a geospatial model that identifies hot zones where rates of overdose emergencies are high. Then, we analyze socioeconomic characteristics and levels of health resources available in the areas. Findings of this study may inform policy makers about strategies to mitigate opioid crisis.

2 - Enabling Mental Healthcare Delivery to Underserved Populations: An Empirical Analysis of the Equity Advancing Effect of Mobile Apps
Yi Tang, Carlson School of Management, Minneapolis, MN, United States, Adam Moen, Kingshuk K. Sinha

The gap between the supply and demand for mental health care is raising alarms in the U.S. and around the world. Certain populations are suffering more by having significantly less-than-average treatment rates and treatment efficacy. Mobile health technologies such as mobile apps are believed to have the potential to reduce the disparities by breaking the geographical and temporal barriers and by reducing stigma through a psychologically safe environment for people in need. In this study, we document empirical evidences that mobile apps can create capacity in a mental healthcare supply chain so as to reduce the disparities associated with gender, sexual orientation, and race-ethnicity.

3 - Predictive Model on Drug Overdoses Incidents
Jinha Lee, Bowling Green State University, Bowling Green, OH, United States, Arthur Yeh, Qizhen Lan, Jung Im Choi, Hyojung Kang

Drug-related mortality and morbidity have increased significantly in the past decade, largely due to increases in the number of fatal and non-fatal overdoses in the United States. Understanding drug abuse and overdose patterns from a geo-spatial framework can empower communities to develop strategy for responding to the drug abuse based on where incidents take place. This research intends to provide the knowledge and tools necessary for curbing regional suspected drug-related overdoses problem. The essential idea is to harness the potential of data analytics to identify the geo-spatial and socioeconomic factors that affect the overdose risk.

■ WC14

Virtual Room 14

Healthcare Operations Management III

Contributed Session

Chair: Olga Bountali, University of Toronto, Toronto, ON, M5V0K3, Canada

1 - Managing the Intake of New Patients into a Physician Panel over Time
Anne Zander, Karlsruhe Institute of Technology, Karlsruhe, Germany, Stefan Nickel, Peter Vanberkel

We focus on balancing supply and demand for physicians and panel patients on a tactical level to ensure a manageable workload for the physicians and access to care for patients. We propose deterministic integer linear programs that decide on the intake of new patients into panels over time, taking into account the future panel development. The main objective is to minimize the deviation between the expected panel workload and the physician's capacity over time. We conduct experiments based on real-world data where we significantly reduce the expected differences, considering several future periods instead of one. Classification of new patients decreases the expected differences further.

2 - Long-Term Blended Workforce Planning in Healthcare
Saha Malaki, City, University of London, London, United Kingdom, Navid Izady, Oben Ceryan, Lilian M. de Menezes

There has been a significant increase in the demand for temporary workers in healthcare systems. They provide short-term volume flexibility but are generally more expensive. This raises the important question that, given uncertain demand, how many permanent and subsequently temporary workers should be recruited each year. We attempt to answer this question by developing a dynamic programming model that captures the main trade-offs between recruiting permanent and temporary workers.

3 - A Multiclass Fluid Model of the Liver Allocation System: Theory and Numerical Results
Zachary Leung, City University of Hong Kong, Hong Kong, Mustafa Akan, Sridhar R. Tayur, Huan Zhao

We build a multiclass fluid model of the United States liver allocation system. We formulate a linear program for the problem of how to allocate livers to maximize the transplant benefit. We develop structural results for the optimal liver allocation policy. We also build a computer simulation model. Using real-world data, we estimate the parameters of our model, and compare the predictions of our two models with the observed real-world values.

4 - The Impact of Treatment Restrictions for the Indigent Suffering From a Chronic Disease: The Case of Compassionate Dialysis
Olga Bountali, University of Toronto, Toronto, ON, Canada, Sila Cetinkaya, Vishal Ahuja

We analyze a congested healthcare setting due to emergency treatment of a chronic disease. A prominent example is ER congestion due to arrivals of uninsured end-stage renal disease patients (a.k.a., compassionate dialysis). Unfortunately, this is the only option for these patients and is available only when their clinical condition is deemed as life-threatening after a screening assessment. That is, treatment restrictions are in place and a percentage of patients is denied treatment. To develop a deeper understanding of the unintended consequences of this policy, we model the problem as a queueing network and obtain expressions of metrics indicative of patient welfare deterioration.

Thursday, 10:00AM - 10:10AM

■ HAS Competition

Virtual Room 01

HAS Student Competition Announcement

Keynote Session

Chair: Tinglong Dai, Johns Hopkins University, Baltimore, MD, 21212-1708, United States

Thursday, 10:10AM - 11:00AM

■ Keynote Thursday

Virtual Room 01

Keynote Ensuring Equity Beyond the Pandemic

Keynote Session

Introducer: Robert Dittus, Vanderbilt University, Nashville, TN, United States

1 - Ensuring Equity Beyond the Pandemic
Giselle Corbi-Smith, University of North Carolina at Chapel Hill, Chapel Hill, NC, United States

The COVID-19 pandemic has revealed not only long standing racial and ethnic disparities but also the fault lines in our systems of care. How can we rebuild after this pandemic in a way that ensures equity? How can we think about the relationships between systems of care to ensure the most vulnerable in our society have the opportunity for a healthy life?

Thursday, 11:10AM - 12:40PM

■ TA01

Virtual Room 01

The Design and Deployment of Analytics in Healthcare; The C-Suite Perspective

Panel Session

Moderator: David Scheinker, Stanford - Lucile Packard Children's Hospital, Stanford, CA, 94305, United States

Moderator: Jing Dong, Columbia University, New York, NY, 10027-6945, United States

1 - The Design and Deployment of Analytics in Healthcare; The C-Suite Perspective

David Scheinker, Stanford University, Huang Engineering Center, Stanford, CA, 94305, United States

David Scheinker is the Director and Founder of SURF Stanford Medicine, a collaboration between the Stanford Hospitals, School of Engineering, and School of Medicine. He has led the design, implementation, and publication of dozens of analytics-based projects on quality and efficiency of care. He will facilitate a discussion about the practical, technical, and operational factors that healthcare executives look for in a project.

Chief Strategy Officer

Panelist: Kristin Petersen, Robert Wood Johnson Barnaby, NJ, United States

Associate Chief Informatics Officer

Panelist: Nigam Shah, PhD, Stanford Health Care, CA, United States

Chief Executive Officer

Panelist: Matt Hollingsworth, Carta Healthcare

■ TA02

Virtual Room 02

Operations Research in Support of the National COVID-19 Response

General Session

Chair: Paul Nicholas, Johns Hopkins University, Applied Physics Laboratory, Baltimore, MD

1 - The National Syndromic Surveillance Program: A Collaborative Approach to Detecting and Characterizing Emerging Health Threats

Loren Rodgers, National Syndromic Surveillance Program Lead, Centers for Disease Control and Prevention, Atlanta, GA, United States

The National Syndromic Surveillance Program (NSSP) is a collaboration between the US Centers for Disease Control and Prevention, local and state health departments, independent clinical laboratories, and a university-affiliated research center. NSSP collects, analyzes, and shares de-identified records from emergency departments, clinical laboratories, and other healthcare settings. By tracking symptoms and diagnoses in near-real time, users can detect unusual levels of illness in communities to better respond to emerging health threats. NSSP was among the earliest sources of COVID-19 situational awareness and provides timely understanding of how COVID-19 is affecting communities.

2 - Open-Source Data Operations in Support of Public Awareness and the National COVID-19 Response

Aaron Katz, Johns Hopkins University Applied Physics Laboratory

JHU/APL provides data to the Centers for Disease Control and Prevention (CDC) and the broader US Department of Health and Human Services (HHS), generating an aggregated view of COVID-19 cases and deaths from domestic sources. Built from the foundations of the open-source data pipeline that powers the JHU Coronavirus Resource Center and the JHU Centers for Systems Science and Engineering (CSSE) COVID-19 Dashboard, this system collects and curates open public health surveillance data to help inform federal situational awareness and analysis efforts. We will discuss the path to building this capability, including the challenges we faced as well as observations for improvement.

3 - Epidemiological Forecasting Models in Support of the National COVID-19 Response

Kaitlin Lovett, Johns Hopkins University Applied Physics Laboratory

The Johns Hopkins Applied Physics Laboratory provided epidemic modeling, simulation, and model evaluation capabilities to estimate disease outcome trajectories. In addition to cataloguing and comparing many of the COVID-19 models that were publicly released early in the pandemic, we developed and employed multiple action-oriented forecasting models, leveraged modeling expertise from Johns Hopkins University, and informed downstream resource allocation estimates. We now seek to strengthen the Nation's forecasting capabilities by further orienting models towards decision-making and public health response.

4 - Health Resource Modeling in Support of the National COVID-19 Response

Jonathan Thornhill, Johns Hopkins University Applied Physics Laboratory

JHU/APL developed multiple resource usage models to inform operational healthcare resourcing decisions, ranging from Personal Protective Equipment (PPE) and hand sanitizer to ventilator drug medication and healthcare staffing. Developed using a combination of clinical subject matter expertise and available data, these models projected resource demands by locale based on factors such as projected COVID hospitalizations, population, historical healthcare utilization, and other supporting assumptions. Similar models and tools can support improved situational awareness and decision making for future health response efforts.

5 - Operational Analytics in Support of the National COVID-19 Response

Elisha Peterson, Johns Hopkins University Applied Physics Laboratory

In support of the National COVID-19 Response, JHU/APL provided an operations analysis capability for data-driven decision making, supporting both persistent needs and urgent inquiries. Ad hoc analyses answered requests for information from across the federal government, while recurring analysis products provided sustained awareness of the outbreak. Both were enabled by the development of an analytic pipeline centered on the dynamic, fast-paced environment, enabling rapid deployment of visual analytics customized for the need, audience, timeline, and available data. We will discuss the evolution of this pipeline, along with lessons learned and implications for future response efforts.

■ TA03

Virtual Room 03

Risk and Prediction Modeling in Healthcare

General Session

Chair: Joseph Agor, PhD, Oregon State University, Corvallis, OR, 97331, United States

1 - A Mixed-Integer Programming Approach to Determine Cutoff Values for Scoring Systems Used to Predict Adverse Outcomes in Healthcare

James E. McKenna, Oregon State University, Corvallis, OR, United States, Joseph Kapena Agor

Electronic Health Record data can be used to quantify the relationship between patient attributes and the progression of acute medical conditions. Risk scoring systems can dynamically assess the status of a patient and their risk of further degeneration. We present a Mixed Integer Linear Programming formulation for the development of a risk scoring system to identify potential of a specific adverse outcome. We compare our results to existing classification algorithms. We find value in our approach and discuss the need to develop a solution algorithm for scalability to large datasets.

2 - Knowledge-enhanced Risk Prediction Modeling in Healthcare

Fenglong Ma, PhD, The Pennsylvania State University, University Park, PA, United States

Recent advances in deep learning-based methods provide unprecedented ability to predict patients' future health status (i.e., risk prediction), but they still suffer from the sparsity issue of electronic health records (EHRs). In this talk, HI. will present our recent work on improving predictive performance and interpretability by incorporating medical knowledge graph into state-of-the-art risk prediction models. The proposed method is general and model-agnostic, which enables any existing risk prediction models to work with both EHR data and personalized knowledge graphs simultaneously, for providing personalized prediction and explicit reasoning.

3 - Using Clinical Narratives to Identify Physician Inertia in Hypertension Management
Mohammad Samie Tootooni, Assistant Professor, Loyola University Chicago, Maywood, IL, United States, Ranit Sengupta, Talar Markossian, Siddharth Bhayani, Majid Afshar, Holly Kramer

Hypertension is among critical risk factors for cardiovascular and kidney disease and related mortality. Here, we use machine learning to combine the latent variables from Natural Language Processing tools applied on clinical narratives, with demographic, medication and comorbidity patient data to identify key barriers to hypertension control among elderly patients undergoing hypertension treatment.

4 - Personalized Treatment Selection in Chronic Depression via Model-based and Model-free Approaches
Mutita Siriruchatanon, University of Washington, Seattle, WA, United States, Shan Liu

With heterogeneity in the chronic depression population and uncertainty in treatment response, personalized treatment plans that are tailored to individual characteristics and treatment history are essential to improve health outcomes. We formulate a treatment selection problem as a Markov Decision Process and estimate the individual treatment effect to create optimized treatment plans. Using simulated patient trajectories, we evaluate a model-free approach (a variations of one-step look-ahead) and a model-based approach (Fitted Q-Iteration) against a guideline-based policy. Results show that the model-based approach provides the best health outcome.

5 - A Machine Learning Approach for Prediction in Bed Cleaning and Staff Requirements in the Emergency Department
Tahera Yesmin, PhD Candidate, University of Toronto, Toronto, ON, M4C 5L7, Canada, Michael W. Carter

Excess wait times in the emergency department (ED) is a global issue, which can be seriously impacted by the delay in bed cleaning at the ED. Therefore, knowing the number of beds to clean will help reduce the bed turnover time and consequently will help to reduce the ED crowding. Machine learning algorithms have been widely used to predict various aspects of ED. However, a few studies have addressed this issue. Therefore, this research applied machine learning algorithms to predict the number of beds requiring cleaning in the next four hours. Later, the predicted number of beds was used to determine the bed cleaning staff requirements of the ED. The results from this research will enable the hospitals to proactively plan their resources rather than being reactive during crisis moments.

■ TA04

Virtual Room 04

Healthcare Operations

General Session

Chair: Burhaneddin Sandikci, University of Chicago, Chicago, IL, 60637-1656, United States

Co-Chair: Sait Tunc, Virginia Tech, Blacksburg, VA, 24061, United States

1 - Gaming the Waiting List to Receive a Heart
Sait Tunc, Virginia Tech, Blacksburg, VA, 24061, United States, Burhaneddin Sandikci, Philipp Afeche

Organ scarcity is a pervasive problem for all major organ transplant systems, however, the US heart transplantation system has the following important distinctive feature: Transplant candidates are prioritized according to the severity of their pre-transplant medical therapy - the more severe the therapy, the higher the priority. It is, however, constantly debated that therapy-based prioritization opens up room for gaming the system. Manipulation of the waitlist priority is acknowledged by the medical community as well as the policy makers and there is an active debate on the issue. We propose a novel framework to analytically study the gaming decisions of heart transplant centers, understand when strategic gaming emerges under different competition types, and how it can be prevented within the confines of the current system.

2 - Remotely Executed Questionnaires to Accurately Prescribe Opioids
Abdullah Gokcinar, PhD Candidate, The University of Texas at Dallas, Richardson, TX, 75206, United States, Metin Cakanyildirim

Opioid drugs are prescribed for effective management of chronic pain. However, their inappropriate use leads to dependence, overdose, or even death. Medical guidelines stress the importance of clinical evaluation of patients prior to prescribing decisions. This evaluation is currently based on questionnaires administered at the point-of-care. Telehealth solutions such as a health app allows for a remotely executed questionnaire (req) as well choosing a req dynamically (req-d). This refined and up-to-date data can be input into a decision support model to improve prescription decisions.

3 - Screening Multi Dimensional Heterogeneous Populations for Infectious Diseases Under Scarce Testing Resources, with Application to COVID-19
Hrayer Aprahamian, Texas A&M University, College Station, TX, 77840, United States, Hussein El Hajj, Douglas Bish, Ebru Bish

Testing provides essential information for managing infectious disease outbreaks, such as the COVID-19 pandemic. When testing resources are scarce, an important decision is who to test. This decision is compounded by the fact that potential testing subjects are heterogeneous in multiple dimensions, including their likelihood of being disease-positive, and how much potential harm would be averted through testing. To increase coverage, pooled testing can be utilized, but this comes at a cost of increased false-negatives. The decision problem is to partition the population into three mutually exclusive sets: those to be individually tested, those to be pool tested, and those not to be tested. The objectives include the minimization of harm or maximization of testing coverage. We develop data-driven optimization models to design testing strategies, and show, via a COVID-19 case study, that the proposed strategies can substantially outperform the current practice while considering population heterogeneity.

4 - Testing and Vaccination Location Decisions using Decision Dependent Utilities
Sanjay Mehrotra, Northwestern University, Dept. of IE Tech Inst., Evanston, IL, 60208-0834, United States, Fengqiao Luo

We present a novel model for deciding locations of facilities that can be opened for testing and vaccination in a resource-constrained situation. The model allows implicit generation of demand to locations that are to be decided when we have limited information on resident preferences. A novel solution technique based on cut generation of the union of two convex functions is proposed. Computational performance of this technique is demonstrated, and the use of the model is illustrated using demand data available during the earlier months of the Covid pandemic from San Diego county.

■ TA05

Virtual Room 05

Empirical Research in Healthcare Operations

General Session

Chair: Ujjal Kumar Mukherjee, University of Illinois, Urbana-Champaign, Champaign, IL, 61820-6915, United States

Co-Chair: Han Ye, University of Illinois at Urbana-Champaign, Champaign, IL, 61820-6915, United States

1 - Developing the Capability for Robot-assisted Surgeries
Ujjal Kumar Mukherjee, University of Illinois, Urbana-Champaign, Champaign, IL, 61820-6915, United States, Kingshuk K. Sinha

In this paper, we study factors associated with successful adoption of robot assisted surgical technology at a large multispecialty hospital. Specifically, we identify factors associated with surgeon and team learning. We used data from four different surgical procedures from two disciplines, namely hysterectomy and sacrocolpopexy from OB/GYN and prostatectomy and pelviscopy from Urology, to empirically identify significant factors that lead to learning. We comment on the implications of the empirical findings for hospital level policies of surgical team formation and usage of robotic procedures.

2 - Personalizing Encounters for Diabetes Care
Han Ye, University of Illinois at Urbana-Champaign, Champaign, IL, 61820-6915, United States, Ujjal Kumar Mukherjee, Dilip Chhajed

We consider a data-driven approach to personalize encounters for diabetes patients. We first use machine learning models to predict future diabetes risks for individual patients, with patient-level clinical, demographic, and encounter data, as well as zip-code level socioeconomic information. We then use the predicted risks as inputs to build a decision model to optimally allocate encounters to individual patients.

3 - How and in What Ways Does Colocation of Services Matter? Empirical Evidence from a Large Healthcare Setting
Vishal Ahuja, Southern Methodist University, Dallas, TX, 75240-3623, United States, Carlos Alvarez, Bradley R. Staats

We examine how colocation of mental and behavioral health services with primary and specialty care services impacts patient outcomes: MBH hospitalizations; average length of stay; total number of 30-day readmissions; and suicidal ideations/attempts by a patient. We hypothesize that colocation improves outcomes. In addition, we study the impact of two moderators on the relationship between colocation and outcomes: continuity of care, known to be linked with improved outcomes and variability and patient's severity of mental illness, as measured by past hospitalizations. We also investigate two mechanisms through which colocation impacts outcomes. Specifically, we study the mediating role of a patient's no-show rate to their primary care appointment; and their adherence to MBH medications.

4 - What Explains India's Second Wave of COVID-19 Infections?
Sebastian Souyris, Postdoc, University of Illinois Urbana-Champaign, Urbana, IL, 61801-4860, United States, Subhonmesh Bose, Shuai Hao, Albert England, Anton Ivanov, Ujjal Kumar Mukherjee, Sridhar Seshadri

India experienced a rapid surge in COVID-19 infections during March-April 2021 that overwhelmed the healthcare system. This second wave of infections emerged almost simultaneously across the nation, following steady growth in Maharashtra since January 2021. In this paper, we employ a combination of data analysis and epidemiological modeling to explain the reason behind the second wave. The spread in the second wave does not resemble a typical spatio-temporal diffusion pattern. Instead, we posit that this wave is likely a result of the circulation of the highly virulent B.1.617 variant, amplified by super-spreader event(s) that allowed it to impact large parts of the country concurrently. India's experience serves as a cautionary tale that calls for close monitoring of epidemic data, increased genomic sequencing to identify potent variants, and regulating possible super-spreader events. Lock-downs in the short run, and vaccination, in the long run, can complement these efforts to mitigate emergent mutant variants of the SARS-CoV-2 virus.

■ TA06

Virtual Room 06

Novel Approaches in Organ Transplantation

General Session

Chair: Alan Scheller-Wolf, Tepper School of Business, Pittsburgh, PA, 15213-3815, United States

1 - Continuous Distribution: Re-designing Organ Transplant Allocation in The U.S.
Nikolaos Trichakis, MIT, Cambridge, MA, 02143, United States, Dimitris Bertsimas, Theodore Papalexopoulos

We present a novel multi-objective optimization methodology for the design of continuous allocation policies in deceased donor lung transplantation. We use machine learning and optimization to approximate the traditional simulation tools that are used by policy makers to project outcomes. These approximations provide a unified view of the Pareto frontier for several efficiency/fairness outcomes of interest to stakeholders, including waitlist mortality rates, post-transplant outcomes, transportation costs and more. The approximations are designed as to be MIP-representable, allowing for quick iteration in the design of points schedules that achieve any set of desired outcomes.

2 - Size-Based Exception Points for Fair Liver Allocation
Musa Celdir, Tepper School of Business, Pittsburgh, PA, 15213, United States, Mustafa Akan, Sridhar R. Tayur

We consider the problem of achieving a fairer liver allocation system where there are size-based disparities in organ access. Shorter patients in liver transplant waitlists have higher average waiting times and mortality rates while waiting for a transplant compared to taller patients. We model the transplant waiting list as a multiclass fluid model of overcrowded queues. We focus on equalizing the likelihood of receiving a transplant objective for three different patient classes based on height. The optimal policy ranks patients according to their patient classes and dropout probabilities to allocate deceased-donor livers. In addition, we propose exception points to short patients' Model of End-Stage Liver Disease (MELD) scores to artificially move them to higher positions in the transplant waitlist. Our numerical results show that the short patients' average waiting time until receiving a transplant and number of dropouts while waiting for a transplant can decrease drastically with the implementation of our proposed policy.

3 - Designing Composite Allocation Scores with Simulation Optimization
Sommer Elizabeth Gentry, Professor, US. Naval Academy, Mathematics Dept., Annapolis, MD, 21402-5026, United States, Michal Mankowski, Nicholas L. Wood, Dorry Segev

Geographic boundaries also implement other priorities (e.g. for pediatric and O blood type candidates). With geographic boundaries being eliminated, transplant candidates will instead get a composite allocation score (CAS); CAS is a weighted sum of medical priority and distance. Using simulation optimization, we designed CAS score weights and tested them with a three-year simulation. Our CAS decreased deaths from 7771.2 to 7666.0, with a similar travel burden of average (272.66 NM vs. 277.28 NM) and median (201.14 NM vs. 196.32 NM) distance. We use an objective and constraints for racial and other equity limits, offering policymakers an alternative to ad hoc guesses in designing the CAS.

4 - Generalized Bandits with Learning and Queueing in Split Liver Transplantation
Savannah Tang, Carnegie Mellon University, Pittsburgh, PA, United States, Alan Scheller-Wolf, Sridhar R. Tayur, Andrew A. Li

We study liver allocation where surgeons with different abilities learn split liver transplantation. We formulate a multi-armed bandit with embedded learning curves to address the trade-off between discovering talents (exploration) and strengthening extant surgeons' skills (exploitation). Our QFL-UCB algorithm, enhanced with queueing dynamics, and fairness, has O(log t) regret. Our algorithm could be applied to help evaluate strategies to increase the use of SLT and other technically-difficult procedures that require practice. Methodologically, our proposed MAB model and algorithm are generic and have broad applications.

■ TA07

Virtual Room 07

COVID-19 Pandemic Modeling and Analysis IV

Contributed Session

Chair: Victoria C. P. Chen, The University of Texas at Arlington, Industrial, Manufacturing, & Systems Engr., Campus, Arlington, TX, 76019-0017, United States

1 - Optimal Medical Supplies Allocation During Epidemic Outbreaks
Yuqing Pan, The Hong Kong Polytechnic University, Kowloon, Hong Kong, Edwin Cheng, Chi To Daniel NG, Suresh P. Sethi

COVID-19 has affected the entire world and led to critical shortages of medical resources in many countries. To balance the demand and supply for medical resources, we develop top-down and bottom-up medical supply allocation models for central and local governments, respectively, to cope with a large-scale epidemic outbreak. We consider the limited capacity of the central government and the self-interest behaviors of the local governments. Our results provide useful managerial implications for governments' decision-making on medical resource allocation in response to epidemic outbreaks.

2 - Balancing the Protection of COVID-19 At-risk Populations while Reopening Communities
Victoria C. Chen, Professor, University of Texas at Arlington, Arlington, TX, United States, Yuan Zhou, Alireza Fallahi, Amith Viswanatha, Jingmei Yang, Feng Liu, Nilabh Ohol, Yasaman Ghasemi, Ashkan Farahani, Jay M. Rosenberger, Jeffrey B. Guild

As communities reopen during the COVID-19 pandemic, they are facing two conflicting objectives. The first is to minimize cases of severe illness leading to potential fatalities. The second is to revive the U.S. economy. This research presents a linear program that optimizes the allocation of interventions, namely social precautions, personal protective equipment, COVID-19 testing, and vaccination, so as to study the delicate balance between the expected fatality rate and the level of normalcy in the community.

3 - An Integrated Agent-based Simulation and Linear Programming Approach for Mitigation COVID-19 Infections and Fatalities
Yuan Zhou, The University of Texas at Arlington, Arlington, TX, United States, Victoria C. P. Chen, Amith Viswanatha, Jingmei Yang, Alireza Fallahi, Yasaman Ghasemi, Nilabh Ohol, Ashkan Farahani, Jay Michael Rosenberger, Jeff B. Guild

In this talk, we will present an integrated agent-based simulation (ABS) and linear programming (LP) approach to develop mitigation strategies for minimizing COVID-19 infections and fatalities. ABS is built based on an epidemic SEIR (susceptible, exposed, infectious, and recovery) framework to mimic the transmission dynamics, and the LP problem is formulated to search for optimal allocation solutions of resources, including testing kits, PPE, and vaccines. ABS and LP are interplaying via an iterative process towards achieving the best disease control outcomes. A case study will be discussed to demonstrate the use of the proposed approach and the efficacy of the recommended solutions.

■ TA08

Virtual Room 08

Data-driven Assessment in Healthcare

General Session

Chair: Turgay Ayer, Georgia Institute of Technology, Atlanta, GA, 30332, United States

Co-Chair: Andrew ElHabr, Georgia Tech, Atlanta, GA, 30318-8272, United States

1 - Effect of Imaging Prior to Endovascular Intervention on the Mortality Rate of Emergency Pelvic Trauma Patients

Andrew ElHabr, Georgia Tech., Atlanta, GA, 30318-8272, United States, Turgay Ayer, Judy Gichoya

In stable patients with pelvic-related trauma, imaging is recommended to diagnose the need for endovascular intervention, a minimally invasive procedure, based on the presence of internal bleeding and vascular injury. In practice, imaging can be skipped based on the level of emergency and clinical discretion and bias. We used observational data from the National Trauma Data Bank (NTDB) from 2007-2016 to estimate the average effect of imaging prior to endovascular intervention on the mortality rate of pelvic trauma patients.

2 - Impact of a Community-policing Initiative Promoting Substance Use Disorder Treatment Over Criminal Charges on Arrest Recidivism

Gabriel Zayas-Caban, University of Wisconsin - Madison, Mechanical Engineering Bldg, Madison, WI, 53706-1539, United States

We evaluate whether the Madison (WI) Addiction Recovery Initiative (MARI), a community policing program implemented by the City of Madison Police Department (MPD) that diverts low-level adults who committed drug-related victimless crimes from the criminal justice system to addiction treatment, reduces the risk of recidivism following the index crime. Using observational crime data collected by the MPD, we estimate average effects of MARI on the risk of 6-month recidivism using an intention-to-treat analysis, a per-protocol analysis, and a complier average causal effects analysis.

3 - Rationing Scarce Healthcare Capacity: A Study of the Ventilator Allocation Guidelines During the COVID-19 Pandemic in the United States

Margret V. Bjarnadottir, University of Maryland, College Park, MD, United States, David Anderson, Tolga Aydinliyim, Eren Basar Cil

In the United States, 26 states have specific ventilator allocation guidelines to be invoked in case of a shortage. The objective of this study is to assess the existing procedures and priority rules in place for allocating/rationing scarce ventilator capacity and propose alternative priority schemes. We first build machine learning models to predict survival probabilities as well as ventilator length-of-use. Then, we use the resulting point estimators and their uncertainties as inputs for a multi-class priority queueing model with abandonments to assess three priority schemes. We find that our proposed priority scheme, achieves a demonstrable improvement over the other two alternatives; the expected number of survivals increases and death risk while waiting for ventilator use decreases. We also illustrate how priority schemes with sole focus on acute-phase survival odds may be discriminatory with respect to certain demographics, and highlight how the proposed policy allocates scarce healthcare capacity in a more equitable way.

4 - Evaluation of a Split Flow Model for the Emergency Department

Juan Camilo David, University of Wisconsin-Madison, Madison, WI, 53703, United States

Split flow models, in which an Advanced Practice Provider (APP) rather than a nurse performs triage, are increasingly being used in emergency departments (EDs). We present a regression discontinuity design to estimate the impact of a split flow model implemented in an ED at a large tertiary teaching hospital on 'standard' operational and clinical metrics. We estimate that the split flow model reduces average treatment times without significantly impacting admissions or revisits. Further, this reduction is mediated via the ability of APPs in split flow to start the ED work-up earlier.

■ TA09

Virtual Room 09

Healthcare Analytics and Machine Learning IV

Contributed Session

Chair: Hossein Piri, University of British Columbia - Sauder School of Business, Vancouver, BC, V6B 1X9, Canada

1 - Insights into the Community Mental Health-Built Environment Nexus: A Multi-level Scenario-based Predictive Analytics Framework

Sayanti Mukherjee, Assistant Professor, University at Buffalo - The State University of New York, Buffalo, NY, United States, Emmanuel Frimpong Boamah, Prasangsha Ganguly, Nisha Botchwey

Understanding the complex community mental health—built environment nexus remains vital to building healthy and sustainable cities; however, there are limited analytical/methodological frameworks to unpack these relationships. Here, we present a multilevel scenario based predictive analytics framework (MSPAF) to explore the relationship between community mental health and socio-economic/physical aspects of built environment across the US metropolitan areas, leveraging rigorously validated interpretable machine learning models and scenario based sensitivity analyses. Proposed MSPAF framework will aid in better understanding of these relationships for informed policy actions.

2 - Forecasting Emergency Department Length of Stay and Hospital Admissions during the Pandemic

Siddharth Arora, Departmental Lecturer, University of Oxford, Oxford, United Kingdom, James W. Taylor

This study investigates the impact of the pandemic on patient-flow in the emergency department (ED), focussing on attendances, emergency admissions to the hospital, length of stay (LOS), and the reason for attendance. Using machine learning, for each patient, we generate personalized and probabilistic estimates of their LOS and admission risk, as communicating these estimates can help reduce patient drop-out rates and improve patient satisfaction. We envisage the findings of this study could potentially help facilitate patient risk stratification and case management in the ED.

3 - A Hyperparameter Tuning Approach to Automated Inverse Planning in Radiotherapy

Minsun Kim, University of Washington, Seattle, WA, United States, Kelsey Maass, Aleksandr Aravkin

Inverse planning in radiotherapy requires treatment planners to modify multiple parameters in the objective function to produce clinically acceptable plans. Due to the manual steps in this process, the quality of plans could widely vary depending on planning time available and treatment planner's skills. We propose a hyperparameter tuning approach to automated inverse planning to reduce planning time and improve plan quality. We present numerical simulations using actual patient cases and demonstrate the benefit of our approach over clinical plans manually designed by certified medical dosimetrists.

4 - Individualized Dynamic Patient Monitoring under Alarm Fatigue

Hossein Piri, University of British Columbia-Sauder School of Business, Vancouver, BC, Canada, Woonghee Tim Huh, Steven Shechter, Darren Hudson

Hospitals are rife with alarms, leading to alarm fatigue. We develop a partially observable Markov decision process model for recommending dynamic, patient-specific alarms in which we incorporate the cry-wolf feedback-loop of repeated false alarms. Our model considers patient heterogeneity in safety limits and learns a patient's safety limit by performing Bayesian updates during a patient's hospital stay. We find that the optimal alarm policy may not be monotone in the vital sign measurement. However, we show that the optimal policy does have a threshold structure in the belief about the patient's safety limit. As a case study, we simulate patient monitoring in an intensive care unit (ICU).

■ TA10

Virtual Room 10

Causal Inference and Machine Learning Applied to Healthcare

General Session

Chair: Nathan Kallus, Cornell University, New York, NY, 10044-1501, United States

Co-Chair: Angela Zhou, Cornell University ORIE, Ithaca, NY, 14853-3801, United States

1 - Estimating the Effects of Continuous-valued Interventions using Generative Adversarial Networks

Ioana Bica, University of Oxford, Oxford, United Kingdom

While much attention has been given to the problem of estimating the effect of discrete interventions from observational data, relatively little work has been done in the setting of continuous-valued interventions, such as treatments associated with a dosage parameter. In this talk we will introduce SCIGAN, a method that builds on the framework of generative adversarial networks (GANs), and is capable of estimating counterfactual outcomes for continuous interventions. The key idea is to use a significantly modified GAN model to learn the distribution of the unobserved counterfactuals, which can then be used to learn an inference model, using standard supervised methods, capable of estimating these counterfactuals for a new sample. We provide theoretical results to support our use of the GAN framework. Moreover, we introduce a new semi-synthetic data simulation for use in the continuous intervention setting and demonstrate improvements over the existing benchmark models.

2 - Confounding-Robust Policy Evaluation in Infinite-Horizon Reinforcement Learning

Angela Zhou, Cornell University ORIE, Ithaca, NY, 14853-3801, United States, Nathan Kallus

Off-policy evaluation of sequential decision policies from observational data is necessary in applications of batch reinforcement learning such as education and healthcare. Unobserved variables confound observed actions, rendering exact evaluation of new policies impossible, i.e., unidentifiable. We develop a robust approach that estimates sharp bounds on the (unidentifiable) value of a given policy in an infinite-horizon problem given data from another policy with unobserved confounding, subject to a sensitivity model. We consider stationary or baseline unobserved confounding and compute bounds by optimizing over the set of all stationary state-occupancy ratios that agree with a new partially identified estimating equation and the sensitivity model. We prove convergence. Although checking set membership is a linear program, the support function is given by a difficult nonconvex optimization problem. We develop approximations based on nonconvex projected gradient descent and demonstrate the resulting bounds empirically.

3 - Evaluating Model Robustness and Stability to Dataset Shift

Adarsh Subbaswamy, Johns Hopkins University, Baltimore, MD, 21218-2608, United States, Roy Adams, Suchi Saria

As the use of machine learning in healthcare is becoming more common, the importance of proactively addressing sources of failure and evaluating model reliability has increased. Achieving this, however, can be difficult because the performance and reliability of machine learning models are vulnerable to being overly dependent on the "context" (i.e., artifacts specific to the training dataset) on which the model was trained. In this talk I will discuss how causal graphical models can be used to identify and express problematic shifts that can occur across datasets. Then, since evaluating model stability to these types of shifts in setting or population typically requires applying the model to a large number of independent datasets (which are often prohibitively costly to collect), I will describe a distributionally robust framework for evaluating this type of robustness using only the fixed, available evaluation data.

■ TA11

Virtual Room 11

DEI and Health Policy

General Session

Chair: Lu Shi, Clemson University, Clemson, South Carolina, United States

1 - A Cluster Analysis of Diabetes Self-management Behavior over Time and Predictive Factors among Low-income Primarily Latino Patients

Shinyi Wu, University of Southern California, Los Angeles, CA, United States, Olivia Leigh Evanson

Using a safety-net trial data (N=847) that tested three care-management models—usual care, team care, and technology— to improve outcomes among low-income patients with type 2 diabetes, this study conducted two-part analysis. First, a longitudinal clustering analysis identified 3 clusters of consistent (20.3%), moderate (67.7%), or struggling (12.0%) with self-management. Second, cluster prediction modeling found diabetes complications, depression, and economic stress are predictive of worse self-management, while providing team collaborative care improved odds of being in consistent cluster. Patients with higher education were likely in either consistent or struggling clusters.

2 - Using Causal Loop Diagramming to Elucidate Connections Between Individual, Environmental, and Structural Causes of Racial and Socioeconomic Disparities in Smoking

Kristen Hassmiller Lich, Associate Professor, University of North Carolina at Chapel Hill, Chapel Hill, NC, United States, Sarah D. Mills, Shelley Golden, Meghan C. O'Leary, Paige Logan

We developed a causal loop diagram (CLD) to elucidate connections between individual, environmental, and structural causes of racial and socioeconomic disparities in smoking. The CLD was informed by a literature review and 19 qualitative interviews. We used the qualitative CLD to examine the potential impacts of 3 tobacco control policies. The CLD includes 24 constructs encompassing individual (e.g. stress), environmental (e.g. norms), and structural (e.g. discrimination) factors associated with smoking. Evaluations of policies using the CLD identified potential unintended consequences that may maintain disparities. The CLD may be used to identify novel partners and approaches for tobacco control. We will discuss how such a qualitative CLD can serve as foundation for better simulation modeling to inform efforts to reduce tobacco use and observed disparities.

3 - The Relationship Between Menthol Cigarette Use and Smoking Cessation: Findings from Waves 1 to 4 of the Population Assessment of Tobacco and Health Study

Sarah D. Mills, Assistant Professor, University of North Carolina, Chapel Hill, NC, United States, Yajing Hao, Kurt M. Ribisl, Christopher A. Wiesen, Kristen Hassmiller Lich

We used generalized estimating equations to examine the relationship between menthol cigarette use and cessation in the United States, providing critical information for dynamic tobacco simulation models. Data come from the Population Assessment of Tobacco and Health Study. Despite finding no significant relationships among non-daily smokers, daily menthol cigarette smokers (n=13,710) were less likely to have quit compared to daily non-menthol smokers (OR=0.76 [0.63, 0.91]). Among Black daily smokers, menthol smokers had a 53% lower odds of quitting compared to non-menthol smokers. Menthol cigarette use is associated with lower odds of cessation, especially among Black daily smokers.

4 - Human Factors Considerations in the Design and Implementation of Telemedicine-integrated Ambulance-based Environments for Stroke Care

Kapil Chalil Madathil, Tiencken endowed Assistant Professor, Clemson University, Clemson, SC, United States

This presentation will focus on the AHRQ supported studies conducted to understand the human factors-related issues faced by a geographically distributed team of caregivers in a telemedicine-integrated ambulance-based setting for stroke care. The study identified such barriers to and facilitators for using telemedicine for ambulance-based stroke caregiving as training and experience, technical difficulty barriers, and patient care and efficiency improvement facilitators. The findings from this study resulted in design recommendations for supporting healthcare professionals during caregiving, especially ones that support their distributed cognition when using ambulance-based telemedicine for stroke care.

■ TA12

Virtual Room 12

Machine Learning and Optimization Approaches to COVID-19 Resources and Vaccination Allocation

General Session

Chair: Esra Buyuktahtakin Toy, New Jersey Institute of Technology, Newark, NJ, 07103-3918, United States

1 - Optimization of Scarce Vaccine during the COVID-19 Pandemic
Jessica A. Mele, North Carolina State University, Raleigh, NC, United States, Erik Rosenstrom, Nicole Colberg, Julie Simmons Ivy, Maria Esther Mayorga, Yiwei Zhang, Julie L. Swann, Paul Delamater, Kristen Hassmiller, Mehul Patel

Due to the limited supply of COVID-19 vaccinations, priority groups, determined by conditions such as older age, essential worker status, and high-risk medical conditions, were established to maximize impact. We explored whether an optimal vaccination strategy exists, which simultaneously reduces disease burden and inequities. We used an agent-based stochastic network to simulate various vaccination prioritization schemas for the state of North Carolina. Our resulting estimates of disease prevalence and COVID-19 related hospitalizations and deaths suggest that further work may be necessary to reduce the inequities caused by the COVID-19 pandemic.

2 - Healthcare Capacity and COVID-19 Mortality
Fardin Ganjkhanloo, Johns Hopkins University, Baltimore, MD, United States, Kimia Ghobadi, Farzin Ahmadi

We investigate the association of hospital capacity with the number of COVID-19 deaths in US counties. In each county, we consider the total number of hospitals, their level of care, and the number of beds, among other factors that are known to impact the spread of COVID-19. We analyze the correlation between healthcare capacity and the outbreak, particularly at the early stages of the outbreak in each county of the United States. Results show a positive correlation for indicators of healthcare capacity, especially among counties with a lower level of care and lower density, while large metropolitan cities show the opposite effect. We hypothesize that this difference could be a result of health care access that led to higher mortality.

3 - COVID-19: Data-driven Optimal Allocation of Ventilator Supply Under Uncertainty and Risk
Xuecheng Yin, New Jersey Institute of Technology, Newark, NJ, 07102, United States, Esra Buyuktahtakin Toy, Bhumi Pritesh Patel

This study presents a new risk-averse multi-stage stochastic epidemics-ventilator-logistics compartmental model to address the resource allocation challenges of mitigating COVID-19. This model involves the uncertainty of untested asymptomatic infections and incorporates short-term human migration as well as space and time-varying transmission rate with respect to various non-pharmaceutical interventions. The model minimizes the total expected number of newly infected and deceased people. We apply our model to the case of controlling the COVID-19 in highly impacted counties of New York and New Jersey. Our data-driven modeling framework can be adapted to study the disease transmission dynamics and logistics of other similar epidemics and pandemics.

4 - A Simulation – Deep Reinforcement Learning (SiRL) Optimization Approach to Controlling the COVID-19
Sabah Bushaj, New Jersey Institute of Technology, Newark, NJ, 07026-2594, United States, Esra Büyüktahtak n Toy, Xuecheng Yin

In our study, we present a Simulation-Reinforcement Learning (SiRL) optimization approach to model the spread of an epidemic and provide trained decision-making strategies to fight against the COVID-19. We incorporate an agent-based simulation model (ABM) into a reinforcement learning (RL) framework to mimic disease progression and impact of intervention strategies and help RL agents to learn. We use COVID-19 data to model the simulation and compare decisions implemented in practice with those suggested by the RL agent. We optimize decision-making in certain states of the pandemic and study vaccination strategies.

■ TA13

Virtual Room 13

Mathematical Modeling to Inform Decisions in Healthcare

Emerging Topic: Mental Health and Substance Use as Public Health Crisis

Emerging Topic Session

Chair: Isabelle Jueli Rao, Stanford University, Stanford, CA, 94305-7556, United States

1 - Machine Learning to Predict Misclassification of Overdoses in Emergency Medical Services Data
Suzan Iloglu, PhD, Yale University, CT, United States

About 24 percent of fatal overdose incidents in Cincinnati in 2017 are represented in the EMS data with an assigned incident type description as overdose-related. While these misclassifications are understandable as the incident type descriptions are based on the initial report of 911 incidents to dispatchers, EMS data is often used to understand the epidemiology of overdose in local settings and guide local programs and policies. We used extra-tree classification algorithms to recover misclassified fatal overdoses in the EMS record with a ROC curve score of 0.87. This approach can help improve the accuracy of reporting of fatal opioid overdoses by state and local public health departments.

2 - Empirical Characteristics of Affordable Care Act Risk-transfers
Grace Guan, Stanford University, Stanford, CA, 94305, United States, Mark Braverman

Under the Affordable Care Act (ACA), insurers cannot engage in medical underwriting. Under such conditions, insurers face perverse incentives to discourage high-cost patients from enrolling in their plans. To fix this problem, the ACA risk transfer program stipulates those insurers with less healthy enrollees receive risk-transfers from insurers with healthier enrollees. We demonstrate that it is very unlikely that risk-transfers are caused solely by random shocks that reflect health events of the population, raising important questions about the causes of heterogeneity in risk-transfers.

3 - Optimal COVID-19 Containment Strategies: Evidence Across Multiple Mathematical Models
John M. Silberholz, University of Michigan Ross School of Business, Ann Arbor, MI, 48103-2380, United States, Hyun-Soo Ahn, Xueze Song, Xiaoyu Wu

Policymakers rely on mathematical models to plan non-pharmaceutical interventions (NPIs) such as lockdowns to combat COVID-19, weighing health benefits against economic costs. Many such models have been created, but they vary in forecasts and recommendations. We find an NPI policy (how to change restrictions based on the current pandemic status) optimized with a single model can perform poorly (more than double the cost) when evaluated with a different model. We optimize across multiple models and find policies that all models find effective. The most effective policy varies significantly by state, due to differences in the NPIs selected by states and the response of citizens to those NPIs.

4 - Effectiveness of Policies for Addressing the U.S. Opioid Epidemic: A Model-based Analysis
Isabelle J. Rao, MS, Stanford University, Stanford, CA, United States, Keith Humphreys, Margaret L. Brandeau

The opioid epidemic causes significant morbidity and mortality in the United States, and has been exacerbated by COVID-19. We develop a dynamic model to assess the effectiveness of a range of interventions for controlling the U.S. opioid epidemic. We measure life years, quality-adjusted life years and opioid-related deaths over five and ten years. Our model predicts that a combination of expanded health services for addicted individuals and reduced opioid prescribing would moderately lessen the severity of the opioid crisis over the next decade. However, even with improved public policies, significant morbidity and mortality is inevitable.

5 - A Tool to Inform Global Hepatitis C Elimination in Developing Countries
Huaiyang Zhong, PhD, Massachusett General Hospital/Harvard Medical School, Boston, MA, United States, Madeline Adee, Lindsey Hiebert, John Ward, Jagpreet Chhatwal

The World Health Organization (WHO) recently launched a global campaign for eliminating hepatitis C virus (HCV) as a public health threat by the year 2030. However, most countries do not have a national strategy for HCV screening and treatment that can lead to HCV elimination. We developed a microsimulation model to assess various combinations of screening and treatment strategies, and built an online, publicly accessible tool to help policy makers identify a path to HCV elimination.

■ TA14

Virtual Room 14

Healthcare Operations Management IV

Contributed Session

Chair: Mahdi Shakeri, University of Calgary, Calgary, AB, T3A 2E6, Canada

1 - Dynamic Relocation Policies for Ambulance Using Self-Organizing Map

Rudramoorthi Thangaraj, Indian Institute of Technology Madras, Chennai, India, R. K. Amit

In Emergency medical service (EMS) management, determining the importance of each base station is essential to develop the dynamic relocation policies. In this study, we propose to use Kohonen self-organizing map (SOM) along with Cooperative game theory to study the interaction of base stations in the EMS network. We assumed that each neuron represents the base stations in the Emergency network. The model is trained using the demand data as input with travel time as the metric. The weights obtained for each neuron in the SOM represents the importance of the base stations in the network. The compliance table obtained based on the proposed method improved the coverage for EMS provider operating in Chennai.

2 - Scheduling of Inpatient Hospital Beds – A Case Study of Ebina General Hospital

Juan Ohara, Tokyo University of Science, Noda-shi, Japan, Mari Ito, Ryuta Takashima, Takamori Ukai, Masaki Koizumi, Akemi Yano, Shunsuke Matsushima, Sadaki Inokuchi

The bed management in hospitals is an important issue because it affects the response rate of emergency patients and community healthcare. The Ebina General Hospital in Japan has managed its beds by predicting the number of admissions based on actual bed occupancy and weather conditions. The bed management might be improved by optimizing the scheduling of beds. In this study, we propose an integer programming problem model for the bed scheduling at the Ebina General Hospital. In addition, the previous model is extended to a more realistic one by embedding the patient's department and surgery date.

3 - Stochastic Programming Model for Two Surgery Types and Verification of Effectiveness

Ryota Akiyama, Tokyo University of Science, Noda, Japan, Mari Ito, Ryuta Takashima, Kinju Hoshino, Manabu Hashimoto, Hiroyuki Yamamoto, Hirofumi Fujii

This paper examines two surgery types as elective surgery and emergency surgery by using a stochastic programming model. We propose the model that decides the number of elective surgeries per day. Specifically, uncertain demands for emergency surgery are taken into account. In the numerical experiments, multiple durations of surgery by random sampling are generated. We compare the results obtained the proposed model to that of the previous model. In this presentation, the proposed model, numerical results, discussion, and future research prospects will be mentioned.

4 - Patient Selection by Emergency Physicians during their Shift

Mahdi Shakeri, University of Calgary, Calgary, AB, Canada, , Marco Bijvank

We study the patient selection decision-making of physicians in emergency departments (EDs) over the course of their shift when there are multiple types of patients in the waiting area. Current patient selection policies prioritize patients based on their severity score or waiting time, regardless of the time remaining in a physician's shift. In particular, when physicians get closer to the end of their shift, they need to be more mindful of which patient to select. We formulate the problem which patient to select as a finite horizon Markov decision process (MDP) and illustrate its application to a case study.

Thursday, 1:00PM - 1:50PM

■ Thursday Tutorial

Virtual Room 01

Technology Tutorial: Data Science Approaches to Confronting the COVID-19 Pandemic

Sponsored Session

1 - Data Science Approaches to Confronting the COVID-19 Pandemic

Qingpeng Zhang, City University of Hong Kong, Kowloon, 12180, Hong Kong

During the COVID-19 pandemic, for the first time ever in history, data science has become a powerful weapon in combating infectious disease epidemic and arguably any future infectious disease epidemic. In this tutorial, we review the newly-born data science approaches to confronting COVID-19, compare the new approaches with the conventional epidemiological studies, discuss lessons we learned from the COVID-19 pandemic, and highlight the opportunities and challenges of data science approaches to confronting future infectious disease epidemics.

Thursday, 2:00PM - 3:30PM

■ TB01

Virtual Room 01

ER Management

General Session

Chair: Fernanda Bravo, UCLA Anderson School of Management, Los Angeles, CA, 90024-5055, United States

1 - Waiting-Time Prediction with Invisible Customers

Yuting Yuan, University of Rochester, Rochester, NY, United States, Yoav Kerner, Ricky Roet-Green, Arik Senderovich, Yaron Shaposhnik

We study the problem of predicting customers' waiting time in queues when some customers are invisible. We derive closed-form expressions for this problem in a partially visible M/M/1 queue. Based on insights of this simple case, we design relevant features and demonstrate their effectiveness for prediction in more general queues.

2 - Low-acuity Patients Delay High-acuity Patients in EDs

Danqi Luo, Stanford University, Stanford, CA, United States, Mohsen Bayati, Erica Plambeck

This paper provides evidence that the arrival of an additional low-acuity patient (LAP) substantially increases the wait time to start of treatment for high-acuity patients (HAP), contradicting the long-standing prior conclusion in the medical literature that the effect is "negligible". Whereas the medical literature underestimates the effect by neglecting how delay propagates in a queuing system, this paper develops and validates a new estimation method based on queuing theory, machine learning, and causal inference. Wait time information displayed to LAPs provides a quasi-randomized instrumental variable. This paper shows that a LAP increases wait times for HAPs through: pre-triage delay; delay of lab tests ordered for HAPs; and transition delay when an ED interrupts treatment of a LAP in order to treat a HAP. Hence HAPs' wait times could be reduced by: reducing the standard deviation or mean of those transition delays, particularly in bed-changeover; providing vertical or "fast track" treatment for more LAPs.

3 - Optimizing Intra-hospital Patient Transport Services

Christopher Sun, Massachusetts Institute of Technology, Boston, MA, United States, Martin S. Copenhaver, Retsef Levi, A. Cecilia Zenteno

Intra-hospital patient transportation services are an integral part of daily logistic activities in a hospital, facilitating patient flow between inpatient units on stretchers, wheelchairs, and beds. Delays stemming from suboptimal transport practices can significantly impact operations of procedural areas and test sites, potentially compromising quality of care. In this project, we identified the primary drivers of patient transport delays at Massachusetts General Hospital, and propose analytical frameworks to address these issues.

■ TB02

Virtual Room 02

Matching Supply with Demand under Pandemic

General Session

Chair: Yong-Hong Kuo, The University of Hong Kong, Hong Kong

1 - Where to Locate COVID-19 Mass Vaccination Facilities?

Alexandre Jacquillat, MIT. Sloan School of Management, Cambridge, MA, 2142, United States, Michael Li, Vassilis Digalakis, Dimitris Bertsimas

In response to the COVID-19 outbreak, where to locate mass vaccination centers to maximize the effectiveness of the vaccination campaign, and how to subsequently distribute vaccines? This paper tackles this question with a novel data-driven approach to optimize COVID-19 vaccine distribution. We first augment a state-of-the-art epidemiological model to capture the effects of vaccinations and the variability in mortality rates across age groups. We then develop a prescriptive model to optimize the location of vaccination sites and vaccine allocation. The model is formulated as a bilinear, non-convex optimization model, and solved using a coordinate descent algorithm. As compared to several benchmarks, the proposed optimization approach increases the effectiveness of the vaccination campaign by an estimated 20\%, saving an extra 4,000 extra lives in the United States over a three-month period. The proposed solution achieves critical fairness objectives and is highly robust to uncertainties and forecast errors.

2 - A Multiclass, Multiproduct COVID-19 Convalescent Plasma Donor Equilibrium Model

Pritha Dutta, Pace University, Lubin School of Business, New York, NY, 10038-1502, United States, Anna Nagurney

In this paper, we develop a multiclass, multiproduct equilibrium model for convalescent plasma donations in the COVID-19 pandemic. The potential donors are situated at different locations and the donor population at each location can be separated into different classes based on their motivation and the product for which they provide donations at a collection site. The model captures the competition between nonprofit and for profit organizations seeking convalescent plasma donations, which is a characteristic of this new market. A variational inequality formulation of the equilibrium conditions and qualitative properties of the model are provided. We also present a capacitated version of the model. Numerical examples of increasing complexity are presented and solved using the modified projection method. The results reveal multiclass, multiproduct donor behavior under different scenarios which can inform policy makers during this pandemic and beyond.

3 - Outbreak Minimization vs Influence Maximization: An Optimization Framework

Yong-Hong Kuo, The University of Hong Kong, Dept. of Industrial and Manu. Sys. Eng., Hong Kong, Chun-Hung Cheng, Ziye Zhou

An effective approach to containing epidemic outbreaks (e.g., COVID-19) is targeted immunization, which involves identifying "super spreaders" who play a key role in spreading disease over human contact networks. The ultimate goal of targeted immunization and other disease control strategies is to minimize the impact of outbreaks. It shares similarity with the famous influence maximization problem studied in the field of social network analysis, whose objective is to identify a group of influential individuals to maximize the influence spread over social networks. This study aims to establish the equivalence of the two problems and develop an effective methodology for targeted immunization through the use of influence maximization.

4 - The Benefits and Consequences of Non-Pharmaceutical Intervention Strategies

Buse Eylul, ISyE Georgia Tech, Atlanta, GA, United States, Oruc Aglar, Arden Baxter, John Asplund, Pinar Keskinocak, Nicoleta Serban

This study evaluates the potential benefits (e.g., reduction in infection spread and deaths) of interventions for COVID19 and the consequences (i.e., refraining from community or workplace interactions) along with the impact of various school reopening scenarios (when, and how to return in-person instruction) on the spread of COVID19. An agent-based simulation model was adapted and used to project the number of infections and deaths in Georgia under various types and combinations of non-pharmaceutical interventions and multiple school reopening dates and scenarios.

■ TB03

Virtual Room 03

Operations Research for Vaccine Access, Allocation, and Delivery

General Session

Chair: Shakiba Enayati, University of Missouri-Saint Louis, St Louis, MO, 63101, United States

1 - Understanding the Factors Influencing COVID-19 Community Mitigation Practices: Evidence from Nigeria

Ekundayo Shittu, George Washington University, Washington, DC, United States, Chizoba Wonodi, Nikata Chuku, Nkemdilim Ene

We examine the factors influencing community adoption of non-pharmaceutical interventions to limit the spread of COVID-19. Using data from 990 respondents in communities across Nigeria, we examine the correlation of health behaviors and socioeconomic indicators to find that women are more likely to wear masks, wash or sanitize their hands or protect their cough with tissue than men. The provision of palliatives and access to family supplies enhance mask wearing. The implications for pandemic mitigation policy is that minimizing incidence rates requires putting in place responsive initiatives such as routine information updates on pandemic progression and the provision of relief supplies.

2 - An Integrated Simulation-Optimization Algorithmic Framework to Vaccine Distribution for Controlling the COVID-19

Xuecheng Yin, New Jersey Institute of Technology, Newark, NJ, 07102, United States, Sabah Bushaj, Esra Buyuktahtakin Toy

In this study, we introduce a simulation-optimization approach to addressing the vaccination facility location and allocation challenges of the COVID-19. We extend an agent-based model of the COVID-19 and incorporate it with a new vaccination center and vaccine-allocation optimization model. The proposed model simulates the disease transmission first and then minimizes the total number of infections over all the considered regions by choosing the optimal vaccine center locations and vaccine allocation to those centers.

3 - A Reinforcement Learning Approach to Optimize Vaccine Allocation

Osman Ozaltin, Associate Professor, North Carolina State University, Raleigh, NC, 27605, United States, Hossein Tohidi

The vaccine gradually becomes available throughout an infectious disease outbreak. We propose a model-free reinforcement learning approach to effectively allocate limited vaccines to a heterogeneous population to minimize the number of infected individuals. A six-stage compartmental model is formulated to simulate the transmission of the disease and assess vaccine allocation strategies. The proposed method utilizes deep neural networks which can handle large state and actions spaces. We run numerical experiments with different problem instances and compare the results with heuristic policies. The results show the high quality of the vaccine allocation policy obtained by the proposed approach.

4 - National Multi-modal Vaccine Supply Network Design with Drones

Deng Pan, PhD Candidate, University of Missouri - Saint Louis, St Louis, MO, 63121, United States, James Campbell, Haitao Li, Shakiba Enayati

Vaccine delivery in less-developed countries is challenging due to the remote populations, the lack of reliable and fast transportation, and the need to maintain the cold chain. This research develops an MILP model to optimize the multi-modal national vaccine supply network, where drones can also deliver vaccines to regional health distribution centers (DCs) to exploit drones' advantages in fast speed and low cost. The model optimizes vaccine flows and DC locations with multi-stop drone paths that allow drone recharging, and satisfy cold chain requirements. Our experiments study the value of using drones with both service- and cost- related performance measures for the island nation of Vanuatu.

■ TB04

Virtual Room 04

Frontiers in Empirical Healthcare Operations

General Session

Chair: Tinglong Dai, Johns Hopkins University, Baltimore, MD, 21212-1708, United States

1 - Going Beyond Adoption: The Effect of Telemedicine on Drug Prescriptions During the COVID-19 Pandemic

TI Tongil Kim, Assistant Professor, University of Texas at Dallas, Richardson, TX, 30322-1059, United States, Shujing Sun, Guihua Wang

The COVID-19 pandemic has spurred an unparalleled telemedicine adoption, and this study investigates how the shift toward virtual clinical settings affects providers' prescribing behaviors. Using encounter-level data between Oct. 2019 and Sept. 2020, we find significantly lower levels of prescriptions with telemedicine encounters relative to in-person settings. We observe greater divergence among senior patients (i.e., above 65) and patients with more comorbidities, reflecting providers' heightened concerns for potential drug interactions when prescribing via telemedicine. We do not find differential effects along with other social determinants, such as patient race and ethnicity.

2 - How Does Telemedicine Shape Physician's Practice in Mental Health?

Manqi Li, University of Michigan, Ann Arbor, MI, United States, Shima Nassiri, Xiang Liu, Chandy Ellimootil

In this work, we study whether telemedicine adoption has an impact on physicians' behavior in terms of scheduling related follow-up visits. To answer this question, we use a changes-in-changes (CIC) model to estimate the effect of telemedicine adoption on the length of the interval between two related visits, namely, the related visit interval (RVI). Our results show that physicians schedule related visits with shorter RVIs in the short term after adoption. Consequently, physicians can expand their panel size over time. Thus, in the long run, telemedicine adoption results in experiencing a heavier workload and scheduling related visits with longer RVIs. The adoption effect is also spilled over to the scheduling decision made during in-office visits with a decrease in RVI length in the short term and an increase in the long term. Furthermore, we show that physicians tend to schedule more frequent follow-up visits after a telemedicine visit due to the uncertainty in patients' health status in a remote visit.

3 - The Quality Spillover of Managed Care: An Empirical Investigation of Cancer and Racial Disparities

Lina Song, PhD, University College London, London, United Kingdom

Managed care health plans aim to improve quality while reducing spending and are increasingly becoming popular. Evidence shows that managed care plans encourage the use of high-value care such as cancer screening, but there is a limited understanding of their quality spillover. We empirically study the spillover effect of managed care activity on care quality and racial disparities, focusing on colorectal cancer screening and incidence. We find that greater managed care penetration improves cancer screening rates in the area by encouraging the use of less invasive, cheaper screening options. However, racial disparities are aggravated as the spillover effect fell mostly among white patients.

4 - Oh, The Places You'll Go! Estimating Effect of Vaccination on Demand for Public Transport

Huaiyang Zhong, Harvard Medical School, Boston, MA, United States, Guihua Wang, Tinglong Dai

Public transit ridership tumbled amid the COVID-19 pandemic, fueling enormous budget shortfalls and prompting slashed or eliminated services across the U.S. In this paper, we estimate the COVID-19 vaccination process on the demand for public transport. Despite well-documented empirical challenges related to causal inference of vaccination campaigns, we leverage unique features of the COVID-19 vaccine rollout to develop an instrumental variables (IV) approach. By merging the U.S. COVID-19 vaccination data with several sources of mobility and transportation data, we construct a sample connecting vaccination rates with the demand for public transport. Using our IV approach, we estimate a 1% increase in the fully vaccinated population led to a 2.6% increase in the relative mobility in public transit centers. Our findings demonstrate the significant effect of vaccination in accelerating the recovery of public transit and provides strong support for restoring and strengthening public transit infrastructure as vaccination progresses.

■ TB05

Virtual Room 05

Health Policy and Care Delivery

General Session

Chair: Luv Sharma, University of South Carolina, Columbia, SC, 29206, United States

1 - An Empirical investigation of Factors Influencing Opioid Prescription Rates

Justin Kistler, Assistant Professor, University of Tennessee, 200 Acton Ct, Knoxville, TN, 29212-8260, United States, Luv Sharma, Mark Ferguson

The opioid crisis has inflicted severe societal and financial consequences in the United States, with annual estimates projecting upwards of 40,000 overdose deaths annually and over $500 billion in annual economic impact. In this study, we aim to enhance our understanding of the drivers underlying opioid prescription behavior and provide prescriptive insights to reduce opioid prescribing, which serves as the principal gateway to opioid addiction. Our findings inform the discussion on key drivers contributing to the health and societal impacts of the opioid epidemic in the United States, while providing key implications to hospital managers, prescribers and policymakers about the influence of operational, legislative and competitive factors on opioid prescription rates.

2 - Legislative Action Driven Interorganizational Spillovers of Tacit Knowledge – Investigation of the Quality Payment Program

Mengyang Pan, Southwestern University of Finance and Economics, Chengdu, China, Luv Sharma, Yingchao Lan

This study looks at the efficacy of legislative actions in driving a broader change in the target sector through interorganizational spillovers of compliance related tacit knowledge by shared resources. We also investigate the existence of anticipatory spillover effects as well as heterogeneity in such spillovers based on types of performance metrics, and the affiliation strength of the shared resource. We investigate these relationships using the context of the Quality Payment Program (QPP).

3 - Does Your Insurance Type Impact Treatment Outcomes: An Investigation of Contributing Factors

Luv Sharma, University of South Carolina, Columbia, SC, 29206, United States, Deepa Wani

In this study we explore the relationship between patients' insurance, their treatment intensity and eventually their clinical quality. Using agency theory, we argue that underinsured patients (patients that have Medicaid insurance) will experience a lower treatment intensity compared to privately insured patients, which in turn will impact the clinical outcomes experienced by these patients. We also explore whether two hospital-level operational decisions-Health Information Technology (HIT) infrastructure and resource utilization, influence the relationship between insurance type and treatment intensity.

4 - Does Fresh Food Improve Health? Expanding the Care Delivery Boundary in Partnership Models of Care

John Lowrey, Ohio State University, Columbus, OH, United States, Aravind Chandrasekaran

We investigate the health quality and cost benefit of participating in the produce prescription program using difference in differences and patient health medical records. Our results show that participation confers a weight reduction benefit and preventative care cost savings.

■ TB06

Virtual Room 06

Liver Transplanation and Allocation

Contributed Session

Chair: Yanhan Tang, Carnegie Mellon University, Pittsburgh, PA, 15213, United States

1 - Be the Match: Optimizing Capacity Allocation for Allogeneic Stem Cell Transplantation

Sundara Natarajan Panchanatham, PhD Candidate, INSEAD, Singapore, Singapore, Michael Freeman, Harry Groenevelt, Sameer Hasija

Treating many blood-related diseases require transplantation of genetically compatible hematopoietic stem cells (HSCs) extracted from the bone marrow (BM) of live donors or the umbilical cord blood (CB) of babies. The two sources vary along dimensions like supply, costs, processing, matching requirements and effectiveness, thereby giving rise to important trade-offs such that neither is preferred exclusively to the other. We derive a simulation-based joint optimization model that estimates the temporal variation in the matching probabilities and provides the optimal capacity allocation. We find that 17.5 million BM donors and 335 thousand CB units are optimal for the U.S. population.

2 - A Continuous Scoring Model for Fair Liver Transplant Allocation

Shubham Akshat, University of Maryland, College Park, MD, United States, Subramanian Raghavan

The United States (U.S.) Department of Health and Human Services is interested in increasing geographical equity in access to liver transplant. We develop a novel analytical method to design heterogeneous scoring functions for continuous scoring policy in the deceased donor liver transplantation that equalizes supply to demand ratios across the transplant centers. The framework is general enough to be applied to other organs as well.

3 - Split Liver Transplantation: An Analytical Decision Support Model

Yanhan Tang, Carnegie Mellon University, Pittsburgh, PA, United States, Alan Scheller-Wolf, Sridhar R. Tayur

Split liver transplantation (SLT) is a procedure that saves two lives using one liver. Despite SLT's potential to relieve the acute shortage of donated livers, SLT is rarely used in the US. Barriers to increase SLT utilization include surgical expertise, geography, and the complexities of donor-recipient matching. We analytically model the deceased-donor liver allocation system incorporating both SLT and fairness concerns. We formulate a multi-queue fluid system, incorporating the donor-recipient size matching and dynamically changing patient health conditions. Our formulation enables us to find the optimal matching and evaluate the performance of different allocation policies.

■ TB07

Virtual Room 07

COVID-19 Pandemic Modeling and Analysis V

Contributed Session

Chair: Manuel Ignacio Hermosilla, Johns Hopkins University, Carey Business School, Baltimore, MD, 21202, United States

1 - Supply Chain Management During COVID-19 Pandemics: Experience of Bumrungrad International Hospital, Thailand

Krit Pongpirul, Research & Quality Counselor, Bumrungrad International Hospital, Bangkok, Thailand, Oraphan Buamuang, Vorasilp Srisornkompon, Kanjana Chinaramrungruang, Chulaluk Sungkaratana, Wichai Techasathit, Korpong Rookkapan

Objective: To share the supply chain management (SCM) experience of a large international hospital in Thailand during the COVID-19 pandemic. Approaches: (1) Proactive Situational Assessment was started by the infection control team. (2) Patient Safety First Policy permitted the acquisition of protective equipment and redesigned the service flow. The SCM department was empowered to approve manufacturers. The inventory threshold of medical supplies was reset. (3) Practical Supports for Hospital Staff were offered: medical supplies, insurance, accommodations, and a work-from-home policy. Conclusion: Effective healthcare SCM has been made possible by the hospital leadership.

2 - The Best of Two Worlds: Combining Country Medical and Stability Data to Provide a Clearer Picture of COVID-19 for Force Health Protection

Jose M Jimenez, Assistant Professor, US. Army, San Antonio, TX, United States, Douglas Hurst

Military missions worldwide must continue even during the current COVID-19 pandemic. Military commanders need to make decisions regarding the deployment of Service Members to countries severely affected by COVID-19 to conduct effective risk analysis. We developed a methodology utilizing epidemiological (quantitative) and country stability (qualitative) data to produce a Combined Risk Score (CRS), utilizing data from the United States Southern Command Area of Operations. The Combined Risk Score provided a more accurate picture of the situation in many of the countries that do not have the means or willingness to share pandemic data.

3 - A Simulation Study on Spread of Disease and Control Measures in Closed-population Using Agent Based Model

Youngmin Kim, Korea National Defense University, Captain in ROK Army, Nonsan, Korea, Republic of, Namsuk Cho, Jong Cheol Kim

Diseases such as COVID-19 can cause a detrimental effect to national security. A group such as the military, called a closed-population which is a subset of general population but has many distinct characteristics, must survive even under a pandemic. Hence, it requires their own distinct solution during pandemic. In this study, we investigate a simulation analysis for implementing Agent Based Model that reflects characteristics of agents and environment in closed-population and finding effective control measures for making closed-population functional in the course of diseases spreading.

4 - Healthcare Crowd-out and Resource Allocation: Evidence from COVID-19 Pandemic

Manuel Hermosilla, Johns Hopkins University, Baltimore, MD, United States

We study the COVID-19 healthcare crowd-out hypothesis using a large sample of online drug retailing transactions in Mainland China which covers the height of the pandemic. Since an interaction with healthcare providers is required to purchase prescription drugs (Rx) but not for over-the-counter drugs (OTC), crowd-out can be inferred based on relative Rx/OTC demand changes. Built on a triple-differences (DDD) identification framework, our results are consistent with the presence of crowd-out, estimating it equivalent to a 10% healthcare capacity decrease for non-COVID care at peak. Significant crowd-out reduction could be achieved with limited capacity reallocation.

■ TB08

Virtual Room 08

Data-driven Approaches for Combating Healthcare Challenges

General Session

Chair: Hrayer Aprahamian, Texas A&M University, College Station, TX, 77840, United States

1 - Optimal Unlabeled Set Partitioning with Application to Risk-based Quarantine Policies

Hrayer Aprahamian, Texas A&M University, College Station, TX, 77840, United States, Su Li, Jiayi Lin, Hadi El-Amine

We consider the problem of partitioning a set of items into unlabeled subsets so as to optimize an additive objective. Under an arbitrary objective function, this family of problems is known to be an NP-complete combinatorial optimization problem. We study this problem under a broad family of objective functions characterized by elementary symmetric polynomials. By analyzing a continuous relaxation of the problem, we identify conditions that enable the use of a reformulation technique in which the set partitioning problem is cast as a more tractable shortest path problem solvable in polynomial-time. We demonstrate the usefulness of the developed methodology through a novel and timely application of quarantining heterogeneous populations in an optimal manner. Our case study on real COVID-19 data reveals significant benefits over conventional measures in terms of both spread mitigation and economic impact, underscoring the importance of data-driven policies.

2 - A Collaboration Model to Improve Healthcare Access in Rural Communities

Amarnath Banerjee, Texas A&M University, College Station, TX, 77843-3131, United States, Sohom Chatterjee, Hrayer Aprahamian, Pouya Sharifi

Access to quality care is an important factor for all, but it is especially relevant for sparsely populated rural areas. Rural and critical access hospitals have a key role in serving this important need. Unfortunately, recent data reveals an alarming number of such hospitals closing nationwide due to economic factors and low utilization of expensive resources required to provide the services. Here, we present a data-driven quantitative model that explores potential collaboration between groups of nearby hospitals to achieve higher utilization of resources. By doing so, hospitals will be able to provide the most crucial, and popular, set of services which are based on their specific patient needs, thereby preserving access to local care with shorter distances and less travel. Data used in the model is publicly available and reduces the burden on the hospitals.

3 - The Impact of Early Large-scale Screening on the Evolution of Pandemics

Marwan Shams Eddin, George Mason University, Fairfax, VA, United States, Hadi El-Amine, Hrayer Aprahamian

We study the problem of large-scale screening in the early stages of a pandemic. In this setting, resources such as testing kits, budget, and hospital beds are scarce, and early-stage testing has the potential to alter the dynamics of disease spread. Thus, devising optimal screening strategies that operate within these constraints is crucial to saving lives and reducing healthcare costs. To address the issue of limited testing capacity, we study two models that focus on either individual or group (pooled) testing, and we determine conditions under which each scheme is superior. We calibrate our models using data on the ongoing COVID pandemic and demonstrate the benefits of our proposed methods.

4 - Machine Learning to Improve Kidney Discard Prediction for Reducing Discard Rate and Improving Disparity

Sanjay Mehrotra, Northwestern University, Evanston, IL, United States, Masoud Barah

Despite kidney supply shortage, 18%-20% deceased donor kidneys are discarded annually in the US. In 2018, 3569 of the diseased donor kidneys were discarded. We rigorously compared Machine Learning (ML) techniques to identify kidneys at risk of discard at the time of match-run, and after biopsy and machine perfusion results become available. The cohort consisted of adult deceased donor kidneys donated between 2014-12-04 and 2019-07-01. The studied ML models included Random Forests (RF), Adaptive Boosting (AdaBoost), among others and compared with Logistic Regression (LR). The performance of these models will be compared, and conclusions will be drawn towards improving the process.

5 - Early Detection of COVID-19 Outbreaks Based on Human Mobility Data

Grace Guan, Stanford University, Stanford, CA, United States, Yotam Dery, Matan Yechezkel, Yuval Foox, Irad Ben-Gal, Dan Yamin, Margaret L. Brandeau

Social distancing measures can reduce the spread of COVID-19. To target these measures to the most affected areas, we must first be able to predict when and where outbreaks will occur, and how severe they will be. Using anonymized health and cell phone mobility data, we develop predictive models for daily new cases of COVID-19 and the COVID-19 test positivity rate for many regions of Israel. We then use these predictions in a categorization system to predict the severity of COVID-19. We find that human mobility data can improve prediction of the timing, location, and severity of COVID-19.

■ TB09

Virtual Room 09

Healthcare Analytics and Machine Learning V

Contributed Session

Chair: Mihir Mehta, Penn State University, State College, PA, 16801-4585, United States

1 - A Value of Information Approach to Designing Sequential Clinical Trials for Precision Medicine

Andres Alban, INSEAD, Fontainebleau, France, Stephen E. Chick, Spyros Zoumpoulis

We formulate a model of a clinical trial in which predictive and prognostic patient characteristics are observed. Prognostic characteristics have an effect on patient outcomes but do not interact with treatments, while predictive characteristics do have treatment interaction. The goal of the trial is to determine the effectiveness of each treatment for any set of predictive characteristics. A trial observes patients arriving with random characteristics and sequentially determines the treatment assigned to each arriving patient. We develop an expected value of information policy that assigns patients to the treatment that maximizes the value of information gained.

2 - Performance Analysis of Sequence-to-sequence Deep Learning Framework for Hospital Census Predictions

Mihir Mehta, Penn State University, State College, PA, United States, Biplab Sudhin Bhattacharya, Eric Reich, Soundar Kumara

Data driven hospital census forecasting provides critical insights to health care operations and clinical leadership for developing effective resource allocation and scheduling policies while trying to meet the unique challenges of the evolving COVID-19 pandemic. We develop a sequence-to-sequence deep learning framework to forecast COVID-19 hospital census for a multi-hospital health care system and enhance its performance through a series of strategies. The framework demonstrates encouraging and actionable prediction capabilities. We derive insights about the role of each strategy toward performance improvement.

3 - Machine Learning Effect Evaluation of Unbalanced Data with Randomized Complete Block Design
Haiyan Yu, Chongqing University of Posts and Telecommunications, Chongqing, China, Hongxia Miao

Unbalanced data in class labels often causes critical loss for supervised machine learning (ML). A novel hybrid model of over-sampling and under-sampling with uniform design (SUUD) is proposed to balance the class labels in training during the data preprocessing. Uniform design is used to find the optimal parameters of sampling. The objective of the model is to minimize the area under the curve (AUC) with the CL2 criteria. Randomized Completely Block Design (RCBD) is implemented in the experiments. The results with the mixed model of RCBD systematically show that the machine learning effect of those algorithms on those blocks of data.

4 - Multi-site and Multi-service Modelling for Elderly and Frail Patients
Elizabeth Williams, PhD Student, Cardiff University, Cardiff, United Kingdom, Daniel Gartner, Paul Harper

Multi-site modelling allows the interactions of patients between hospitals to be analysed. Elderly patients with frailty often have longer recovery times compared to the general population, therefore, have a higher likelihood of hospital admittance with a longer stay in hospital. A two-stage stochastic model is being developed for capacity planning of hospital beds and staffing requirements in South East Wales, UK. This model incorporates patient demographics including; age, hospital ICD10 admission code and admission speciality, for both short and long term demands. Community avoidance model parameters can be implemented to determine the effect these schemes have on hospital admittance.

■ TB10

Virtual Room 10

Prediction of Healthcare Outcomes and Utilization using Machine Learning

General Session

Chair: Malini Mahendra, Stanford University, Stanford, CA , United States

Co-Chair: Anil Aswani, UC Berkeley, Berkeley, CA, 94720-1731, United States

1 - The Impact of Updating Clinical Machine Learning Models
Erkin Otles, University of Michigan, Ann Arbor, MI, 53593, United States, Brian T. Denton

Updating machine learning models regularly over time through periodic retraining provides an avenue to maintain high levels of predictive performance. However, these updates to models affect compatibility, the expectation users have of a model, affecting trust and joint performance. This has been demonstrated for single model updates but is not well characterized for a series of model updates that would occur with periodic retraining or other updating schemes. We aim to develop a framework to assess the performance and compatibility implications of various model updating policies. Additionally, we extend existing model compatibility measures to be compatible with ranking based performance measures (e.g., AUROC). This work is inspired by the problem of periodic updating of deployed infection risk prevention models.

2 - Optimization Hierarchy for Fair Statistical Decision Problems
Anil Aswani, UC Berkeley, Berkeley, CA, 94720-1731, United States, Matt Olfat

Data-driven decision-making has drawn scrutiny from policy makers due to fears of potential discrimination. This paper develops an optimization hierarchy for fair statistical decision problems, which provides a systematic approach for developing and studying fair versions of hypothesis testing, decision-making, estimation, regression, and classification. We use the insight that qualitative definitions of fairness are equivalent to statistical independence between the output of a statistical technique and a random variable that measures attributes for which fairness is desired. We use this insight to construct an optimization hierarchy that lends itself to numerical computation, and we prove that higher levels of this hierarchy lead to consistency in the sense that it asymptotically imposes this independence as a constraint in corresponding statistical decision problems. We demonstrate numerical effectiveness of our hierarchy using several data sets, and we use our hierarchy to fairly perform automated dosing of morphine.

3 - Low Information Loss Associated with Mapping Clinical Text to Concepts for Predictive Analytics
Adams Dudley,University of Minnesota, Minneapolis, MN, United States

Background: Conversion of clinical text to concepts (or Concept Unique Identifiers, CUIs) removes PHI, but the extent to which this conversion reduces the value of notes for predictive analytics is unknown.Methods: Models predicting intensive care unit (ICU) mortality were built on data from UCSF and tested at BIDMC and five community hospitals from the Midwest. Predictive performance for a bag of words (BOW) model was compared to a bag of CUIs (BOC) model.Results: At BIDMC, the c statistics for the BOW and BOC models were 0.871 and 0.880. At the community hospital system, the c statistics for the BOW and BOC models were 0.881 and 0.862.Conclusion: Conversion of text to CUIs did not result in significant loss of power to predict ICU mortality. This finding should be validated in other use cases.

4 - Using Machine Learning to Identify Electroencephalographic Markers of Arterialischemic Stroke in the Pediatric ICU: A Novel Quantitative EEG Approach
Mauro Caffarelli, UCFS, San Francisco, CA, United States

Arterial Ischemic Stroke (AIS) is rare in pediatrics, the diagnosis is often missed and can occur as a complication of high risk cardiac procedures. Quantitative Electroencephalography (QEEG) is a potential tool that may allow for more effective detection of AIS. in various clinical contexts. We describe a novel QEEG analytic technique with the hypothesis that it is superior to current analytic standards of Brain Symmetry Index (BSI) and Alpha-Delta Ratio (ADR). In our study, we will be employing unsupervised and supervised machine learning approaches to measure sensitivity and specificity in detecting AIS. We expect that our novel index will be superior to BSI and ADR in detecting AIS.

■ TB11

Virtual Room 11

Models for Evaluating Equitable Access to Services

General Session

Chair: Andreas Holger Thorsen, Montana State University, Bozeman, MT, 59718-6211, United States

1 - Identifying Service Gaps Between Patients and Providers in a Rural Native American Outpatient Clinic in Montana
David Claudio, Associate Professor, Montana State University, Bozeman, MT, United States, Robert Dorsey, Maria Velazquez, Polly Petersen

This research explored if the services provided at a Native American outpatient clinic were designed to care for the patient and meet the expectations patients anticipate. Staff and patient interviews and surveys allowed service expectations to be assessed according to the clinic's ability to meet those expectations. A total of 48 patients and ten staff members (83% of the staff in this specific clinic) participated in the study voluntarily. We found a disconnect between what patients anticipate for care and what staff think they are anticipating. The disconnect shown can lead to a gap in providers designing their services without patient input. These gaps combine to increase the breach between patient expectations and perceptions of the healthcare services. With better insight that captures what patients are looking for from a service, the potential to meet those needs increases. Instead of being reactive in the improvement process, the aim will be proactive to enhance the patient experience and meet their needs.

2 - Modeling Obstetric Bypassing in Montana from Both Patient and Facility Perspectives
Sean Harris, Montana State University, Bozeman, MT, United States, Maggie Thorsen, Ron McGarvey, Janelle Palacios, Andreas Thorsen

Obstetric bypassing occurs when a mother gives birth at a facility that is not the closest option and the distance to that facility exceeds a minimum threshold. Using a dataset that contains five years of birth records for the state of Montana, we examine sociodemographic factors such as location, insurance status, and race, that play a role in explaining patient bypassing behavior. We then look at bypassing from a facility perspective and develop metrics that capture to what extent a facility tends to repel or attract patients. Finally, we discuss how these results can help inform policy makers to reduce current obstetric access inequities.

3 - Evaluating Disparities in Access to Obstetric Services for American Indian Women Across Montana

Andreas Thorsen, Montana State University, Bozeman, MT, 59718-6211, United States, Maggie L. Thorsen, Sean Harris, Ronald McGarvey, Janelle Palacios

Pregnant women across the rural United States have increasingly limited access to obstetric care. Limited research focuses on access for rural American Indian/Alaskan Native women, a population warranting attention given persistent inequalities in birth outcomes. Using Montana birth certificate data (2014-2018), we examined variation in travel time to give birth and access to different levels of obstetric care, by rurality and race. Results point to pronounced rural and racial disparities in Montana. Finally, we describe policy implications of this work related to maternal care professional shortages.

4 - The Health and Economic Impact of Using a Sugar Sweetened Beverage Tax to Subsidize Fruit and Vegetable Purchase in New York City: A Modeling Study

Zhouyang Lou, Purdue University, West Lafayette, IN, United States, Heesun Eom, Junxiu Liu, Stella S. Yi, Rienna Russo, Brandon Bellows, Yiyi Zhang, Andrew Moran, Yan Li, Nan Kong

Both high sugar intake and low fruit and vegetable (FV) consumption increase coronary heart disease (CHD) risk. Sugar-sweetened beverage (SSB) taxes can reduce sugar intake, whereas FV subsidies increase FV consumption. To find the long-term health and economic impact of SSB tax and to subsidize FV policy in New York City (NYC) with a diverse population, we compared the cost and CHD outcomes of penny-per-ounce SSB tax and to subsidize FV policy with SSB tax, FV subsidy, and no policy using a validated microsimulation model of cardiovascular disease in NYC. Our model highlighted that SSB tax to subsidize FV policy would prevent 12209 CHD events per million NYC population with savings of $518 per person.

5 - Assessments of Latino Health in Montana Using PDCA Cycles: An Academic-community Partnership

David Claudio, Montana State University, Bozeman, MT, United States, Sally Moyce, Maria Velazquez

Engaging minorities in research, especially in Montana, where Latinos make up a small percentage of the population, can be challenging. We describe an effort to recruit Latinos into research studies through the development of an academic-community partnership. We first hosted a community health screening event where 150 Latinos were introduced to our project, and 29 volunteered to engage in future research. We invited five representative members to form a community advisory board (CAB). The CAB prioritized health issues affecting the community and determined that mental health and nutrition were the top two to address. A series of PDCA cycles were conducted to systematically uncover root causes concerning these two issues. The research team and CAB employed a SIPOC analysis and fishbone diagrams and determined that language barriers, costs, and stigma prevented people from seeking professional services. Countermeasures, such as peer support, community-building activities, and exercise programs were proposed and are currently ongoing.

■ TB12

Virtual Room 12

Healthcare Logistics and Supply Chain Management during the COVID-19 Pandemic and Beyond

General Session

Chair: Sandra D. Eksioglu, University of Arkansas, Fayetteville, AR, 72701, United States

1 - Hospital Beds and PPE Planning for COVID-19 Pandemic using a Hybrid Computer Simulation Approach

Xiang Zhong, University of Florida, Gainesville, FL, United States, Yiruo Lu, Yongpei Guan, Jennifer Fishe, Thanh Hogan

Hospital pandemic preparedness has been hampered by a lack of sufficiently specific planning guidelines. In this work, we developed a hybrid computer simulation approach, with a system dynamic model to predict COVID-19 cases and a discrete-event simulation to evaluate hospital bed utilization and subsequently determine bed allocation and personal protective equipment (PPE) needs. A data-driven SEIR model was developed to characterize the patient arrival process. The model was validated using historical patient census data from the University of Florida Health Jacksonville. PPE needs were calculated following the Assistant Secretary for Preparedness and Response (ASPR) protocol.

2 - Analysis of COVID-19 Spread in the Metropolitan Areas Within U.S via Integrating Multi-source Data

Bilal Majeed, PhD Candidate, University of Houston, Houston, TX, United States, Jiming Peng, Ang Li, Ying Lin

The COVID-19 has wreaked havoc upon the world with over 121 million confirmed cases and a death toll of over 2.68 million. It is alarming that the United States contributes to about a quarter of these confirmed cases and deaths. In this talk, we analyze major metropolitan areas (MSAs) in the U.S. and compare MSAs with similar demographic characteristics, to explore the association between some COVID-19 related measurements and the demographic characteristics in MSAs. Particularly, we explore possible reasons for the MSAs with high mortality rate (MR) and fatality rate (FR) and find that most large MSAs with high MR and FR implemented a common policy of sending COVID-19 patients back to nursing homes, which indicates that such a policy is a key factor leading to the high MR and FR in these MSAs, whilethe high MR and FR in small MSAs are closely related to the high percentage of poverty and lack of medical resources in these MSAs.

3 - Optimization of Vaccine Supply Chains in Low-and Middle-Income Countries Utilizing Drones

Maximilian Kolter, Master Student, University of Arkansas, Fayetteville, AR, United States, Ruben Proano, Sarah Nurre Pinkley, Sandra Eksioglu

Millions of children in developing countries are still excluded from the benefits of routine immunization. Thus, this study aims to improve vaccination rates by utilizing drones for vaccine delivery. We use a two-stage stochastic program to determine drone networks that maximizes vaccination rates. We use a pre-processing method to reduce the problem size and solve the model using the L-shaped method. Applying our model to Niger's supply chain, we found that using drones lessens the need for cold capacities through a high frequency of direct deliveries over several supply chain levels. A single drone hub could increase the average vaccine availability by 10.58% compared to the base case.

■ TB13

Virtual Room 13

Decision-Analytic Modeling in Mental Health and Substance Use Disorder

General Session

Chair: Shan Liu, University of Washington, Seattle, WA, 98195-2650, United States

1 - Cost-effectiveness of Treatments for Opioid Use Disorder: A Model-based Analysis

Margaret L. Brandeau, Stanford University, Management Science And Eng., Stanford, CA, 94305-4121, United States, Michael Fairley

Opioid use disorder (OUD) has become a public health crisis and is a significant cause of morbidity, mortality, lost productivity, and criminal justice system cost in the U.S. We developed a mathematical model to assess the effectiveness and cost-effectiveness of interventions to treat OUD. We considered possible combinations of medication-assisted treatment (with buprenorphine, methadone, or injectable extended release naltrexone) with add-on treatments (psychotherapy, overdose education and naloxone distribution). We evaluated costs and quality-adjusted life years (QALYs) for different treatment combinations. We conducted cost-effectiveness analyses from a healthcare sector perspective and from a broader perspective that also included criminal justice costs.

2 - Risk Prediction and Risk-based Screening for Autism Spectrum Disorder to Improve Early Diagnosis

Yu-Hsin Chen, Pennsylvania State University, University Park, PA, United States, Qiushi Chen, Guodong Liu

Autism Spectrum Disorder (ASD) is a life-long developmental disorder that affects every 1 in 54 children in the US. Early diagnosis is crucial for improving long-term outcomes in these children, but there exists a substantial delay in diagnosis due to insufficient screening accuracy and limited capacity of diagnostic services. In this study, we first developed risk prediction models of ASD in young children using a large real-world medical claims database, and then evaluated screening policies that targeted high-risk children using a simulation model. We found that the risk-based screening policies could effectively reduce the diagnosis delay and improve the early diagnosis of ASD.

3 - Efficient and Fair Gatekeeper Training via Robust Optimization
Aida Rahmattalabi, University of Southern California, Los Angeles, CA, United States, Phebe Vayanos, Anthony Fulginiti, Eric Rice, Bryan Wilder, Yadav Amulya, Milind Tambe

We study the problem of selecting gatekeepers, with uncertain availabilities, as monitors capable of recognizing warning signs of suicide among their peers in a social network. We show that, in the absence of fairness constraints, state-of-the-art algorithms for the robust graph covering problem result in biased node coverage: they tend to discriminate individuals (nodes) based on membership in traditionally marginalized groups. To mitigate this issue, we formulate the problem as a two-stage robust optimization problem with group fairness constraints and we propose a practically tractable approximation scheme based on the K-adaptability idea. Our method yields competitive node coverage while significantly improving group fairness relative to state-of-the-art methods.

4 - Cost-effectiveness Analysis of Remote Monitoring Technology for Chronic Depression Patients
Xiaonan Sun, University of Washington, Seattle, WA, 98195, United States, Shan Liu

Rapid development in mobile apps, remote sensing, and big data has enabled the use of remote technologies to monitor chronic depression treatment. Using electronic health record data, we built a decision-analytic Markov-cohort model to simulate chronic depression progression and treatment response. We evaluated the cost-effectiveness of a remote monitoring technology with various accuracies (i.e. sensitivity and specificity) to switch treatment optimally. Results showed that compared with fixed-frequency monitoring practice, remote monitoring technology is cost-effective under a range of accuracies and cost-saving under perfect accuracy.

5 - Gender Differences in Cost-effectiveness of Depression Screening
Melike Yildirim, Harvard Medical School, Boston, MA, 30332, United States, Bradley Gaynes, Pinar Keskinocak, Brian Pence, Julie Swann

Screening is an essential tool for preventive medicine. Screening increases the detection of patients early enough to manage the treatment, reduce treatment time, and prevent disease progression at a reasonable cost. Due to the high suicide rates, policymakers and healthcare agencies increased their interest in improving the detection of depression. We used a discrete-time nonstationary Markov model to simulate the progression of depression. We used time-sensitive transition probabilities and parameters from the literature. Annual transitions were dependent on patient histories, such as the number of previous episodes, treatment status, and time spent without treatment state based on the available data. We applied Monte Carlo techniques to simulate the stochastic model. Baseline and screening scenario models with screening frequencies of annual, 2-year, and 5-year were compared based on incremental cost-effectiveness ratio (ICER) for different age groups and genders for pre-COVID 19 and during the COVID-19 period parameters.

■ TB14

Virtual Room 14

Healthcare Operations Management 5

Contributed Session

Chair: Sam L. Savage, Stanford University, Palo Alto, CA, 94303-4446, United States

1 - Appointment Scheduling Under Patient Choices with Walk-in Behavior and Cancellations
Feray Tuncalp, Koc University, Istanbul, Turkey, Erhun Ozkan, E. Lerzan Ormeci

We consider an outpatient clinic with regular and walk-in patients. The clinic decides on the number of slots allocated for walk-in patients and the set of appointment days offered to a patient. Given the offered set, patients may select making an appointment for one of the offered days or walking in on a day that is not included in the set. Walk-in patients have a risk of not receiving service, which we call "blockage". Patients consider the blockage cost of walk-in option while making their choices. We first formulate the problem with a static model to maximize the expected net profit. We characterize the structure of the optimal solution under the static model and establish its asymptotic optimality.

2 - Descriptive and Predictive Analysis of Healthcare Cost and Resources for Economic Evaluation of Paid Treatment Units
Parminder Singh Kang, Mount Royal University, Edmonton, AB, Canada, Ibrahim Alrashed

This research will explore descriptive analysis to identify the criticality of various factors to cost and resources and generate the guidelines to increase the revenue through predictive analytics for King Saud Medical City's (KSMC) paid treatment units (PTUs). COVID-19, as an unknown-unknown, exponentially increased the cost and resource burden on the PTUs. At KSCM the COVID patients are eligible for treatment free of cost. This has affected the capacity and revenue streams for the PTUs. Preliminary analysis shows that PTU revenue has been decreased by 28%, even that the number of patients was very similar to 2019 and paid training administration revenue has been dropped by 34%.

3 - Binomial Entropy of Anesthesiologists' Ratings of Nurse Anesthetists Explains Information Loss when Adjusting Evaluations for Rater Leniency
Franklin Dexter, Professor, University of Iowa, Iowa City, IA, United States, Richard H. Epstein, John Öhrvik, Bradley J. Hindman

US hospital regulations require department heads to identify clinicians who performing significantly better or worse than peers. At the Univ. of Iowa, 74 faculty anesthesiologists (raters) working with nurse anesthetists (ratees) evaluate their clinical performance daily using a valid and reliable work habits scale; 40,027 ratings over 5.8 years. Because the evaluations are used for ongoing professional practice evaluation and performance reviews, mixed effects logistic regression is used to adjust for rater bias (leniency). Calculating binomial entropy, most of the resulting loss of information originated from raters who provided all ratees with the largest possible score for all items.

4 - Actionable Uncertainty in Hospital Bed Management
Sam L. Savage, Executive Director, ProbabilityManagement.org, Palo Alto, CA, United States, Eng-Wee E. Yeo

Managing hospitals under uncertain COVID-19 surges has been difficult, especially in small facilities. It is tempting to plan for the surge in demand based on the average or best guesses of the CDC forecast models, but this leads to systematic errors induced by the Flaw of Averages. We will show how the discipline of probability management can transform the uncertain CDC models into actionable data that hospital administrators can use in spreadsheets to make chance-informed decisions involving resource allocation for COVID patients and other hospital-based services such as elective surgeries.

Thursday, 3:40PM - 5:10PM

■ TC01

Virtual Room 01

Clinical Applications of Probabilistic Models

General Session

Chair: Andrew Shin, Stanford University Medical Center

Co-Chair: David Scheinker, Stanford - Lucile Packard Children's Hospital, Stanford, CA, 94305, United States

1 - Automating Clinical Targets to Reduce Variations in Care
Isabelle J. Rao, Stanford University, Stanford, CA, 94305-7556, United States, Andrew Shin, Claudia Algaze-Yojay, David Scheinker

Goal-directed care with specific clinical targets has been demonstrated to reduce variations in care at Lucile Packard Children's Hospital (LPCH). This has facilitated efforts to optimize outcomes and reduce costs. The process to derive clinical targets was manual and time intensive. To expand target-based care (TBC) to more patient cohorts, we created a theoretical framework for how TBC initiatives can be designed and evaluated. We developed a filtering algorithm using electronic health records to automate the process of generating targets for patients' intensive care unit and postoperative length of stay. In an application of our framework to LPCH, the automated targets matched in 86% of cases.

2 - Noninvasive Identification of Hypotension Using Convolutional-Deconvolutional Networks
Daniel Miller, Carta Healthcare, San Mateo, CA, United States, David Scheinker, Andrew Shin, Nicholas Bambos

High-frequency identification of a patient's hypotensive state allows for early notification of adverse events and long-term trends. Current methods are based on manually collected blood pressure cuff measurements or catheterized blood pressure sensors. We explore replacing the hypotensive state sensed by invasive arterial catheters with a high-frequency projection from a convolutional neural network using a fusion of multiple noninvasive sensors. Our results demonstrate that by using a single flexible model architecture, a patient's hypotensive state may be reconstructed from any combination of the input sensor channels, with fidelity increasing in the number of available inputs.

3 - Tailoring Minimum Blood Donation Intervals to Individual Risk for Iron-related Adverse Donation Outcomes

W. Alton Russell, Postdoctoral fellow, Harvard Medical School, Boston, MA, H3G2A9, United States, David Scheinker, Brian S. Custer

American blood donors must wait 8 weeks between donations, but some blood donors take longer to replenish iron stores. This can lead to iron-related adverse donation outcomes: low hemoglobin deferrals and collections from donors with low or absent iron stores. We develop machine learning models that estimate 'risk trajectories' for individual donors: how risk for adverse outcomes develops as a function of the time interval between donation attempts. We then develop a simple decision algorithm that assigns a minimum donation interval based on estimated risk trajectory. In simulation, we estimate that our tailored donation intervals would reduce more adverse events with a smaller reduction in blood collections as compared to non-tailored donation intervals.

■ TC02

Virtual Room 02

Healthcare Decision-Making with OR and Data

General Session

Chair: Behshad Lahijanian, University of Florida, Gainesville, FL, 32611-6595, United States

1 - A Stochastic Programming Model of Health Insurance Plans Selection

Behshad Lahijanian, University of Florida, Herbert Wertheim College of Engineering, Industria, Gainesville, FL, 32611-6595, United States, Michelle Alvarado

Selecting a health insurance plan can be complicated for individuals or families. It is due to lots of available plans in the marketplace and how they split the cost in a year. A stochastic program model is developed to determine the health insurance selection model by considering different network types that can help people to understand, compare, and choose the right health insurance plan to suit their individual needs. We present a solving algorithm and computational results to minimize the total costs including covered and uncovered expenses in a year.

2 - Matching Medical Staff to Long Term Care Facilities to Respond to COVID-19 Outbreak

Hamid Reza Zarei, PhD Candidate, Northeastern University, Boston, MA, United States, Mahsa Ghanbarpour Mamaghani, Ozlem Ergun

Since the COVID-19 outbreak, resources and medical staff shortages occurred in healthcare centers. The shortage issue has been more vivid in Long Term Care Facilities (LTCFs), where the most vulnerable population segment resides. To assist LTCFs in Massachusetts, the Commonwealth's Executive Office of Elder Affairs put together a team to collect demand and supply data for medical staff and allocate the supply to LTCFs' demand. In this work, we developed a matching framework to match medical workers, centrally and continuously, to an ever-changing list of facility staffing needs and analyzed the data to find the most salient features of successful matches that resulted in the matched staff being hired by the facility.

3 - University of Minnesota COVID-19 Hospitalization Tracking Project

Pinar Karaca-Mandic, University of Minnesota, Minneapolis, MN, 55455, United States

In March 2020, as COVID-19 was spreading across the United States, one of the most significant threats was overwhelming the capacity of the nation's hospital systems. To address the information gap, the University of Minnesota's Carlson School of Management launched the COVID-19 Hospitalization Tracking Project. Tracking daily hospitalization data is critically important in quantifying the current impact on local hospital systems, modeling and forecasting future utilization needs, and tracking the rate of change in the disease severity. This presentation will discuss major challenges associated with real-time data collection and dissemination along with several research insights generated from the project data.

4 - Using Longitudinal Health Records to Simulate the Impact of National Treatment Guidelines for Cardiovascular Disease

Daniel Felipe Otero-Leon, University of Michigan, Ann Arbor, MI, 48109, United States, Weiyu Li, Mariel Sofia Lavieri, Brian T. Denton, Jeremy Sussman, Rod Hayward

Continuous tracking of patient's health data through electronic health records (EHRs) has created an opportunity to predict the impact of healthcare policies. Despite the advances in EHRs, data can be missing or sparsely collected. We developed a simulation model to test treatment guidelines to prevent cardiovascular diseases. We study the treatment benefits and burden based on patients' medication exposure over time. Our framework consists of using EM algorithms to fit sparse data and a discrete-time simulation model to test guidelines. Our results suggest that the current American College of Cardiology guidelines reduces over-treatment without affecting the risk of having a disease.

■ TC03

Virtual Room 03

Healthcare Operations and Policy

Joint Session

Chair: Soroush Saghafian, Harvard University, Cambridge, MA, 02138-5806, United States

1 - Who Should See the Patient? On Deviations from Routine Patient-provider Assignments in Hospitals

Soroush Saghafian, Harvard University, Kennedy School of Gov., Cambridge, MA, 02138-5806, United States, Mariam Atkinson

We use evidence on the assignments of generalist and specialists to patients in a children's hospital and generate insights into whether and when hospital administrators should allow providers to deviate from routine assignments. To perform our analyses, we identify 73 top medical diagnoses and use detailed patient-level electronic medical record (EMR) data of more than 4,700 hospitalizations. In parallel, we conduct a carefully designed survey of physicians and utilize it to identify the routine provider type that should have been assigned to each patient. Using these two sources of data, we examine the consequence of deviations from routine provider assignments.

2 - The Impact of Vertical Integration on Healthcare Delivery: Evidence from Gastroenterology Practices

Lina (Dahye) Song, University College London School of Management, London, 02138-6314, United Kingdom, Soroush Saghafian, Joseph Newhouse, Mary Beth Landrum, John Hsu

The U.S. healthcare system is undergoing a period of substantial change, with hospitals purchasing many physician practices ("vertical integration"). In theory, integration could improve quality by promoting care coordination, but could also worsen it by impacting the care delivery patterns. We study the impact of vertical integration on quality and spending by examining 2.6 million Medicare patient visits across 5,488 gastroenterologists between 2008-2015. We find that integration resulted in increased spending and worse quality of care. In particular, physicians reduce recommended care processes (e.g., anesthesia with deep sedation) after they integrate, which results in a substantial increase in patients' post-procedure complications. Our results suggest that policymakers should carefully align the financial incentives of the integrated providers to prevent the unintended consequences on the quality that may result from the current integration trends.

3 - Preventing Opioid Overdose: From Prediction to Operationalization

Deeksha Sinha, Massachusetts Institute of Technology, Cambridge, MA, United States, Jónas Oddur Jónasson, Neal Kaw, Nikos Trichakis

We study the problem of stratifying patients by level of risk for opioid-related harm, and use the risk predictions to form a cohort for monitoring or intervention. Further, we compute statistics that inform the capacity an organization would require to achieve goals for harm reduction and quantify tradeoffs against predictive power that would arise from decisions made in implementation. We partner with Staten Island Performing Provider System to access health insurance claims and electronic health records. Our results indicate that highly accurate and interpretable predictive models of opioid-related harm can be developed without sacrificing accuracy to satisfy implementation concerns.

4 - The Impact of Sampling Error on Pay for Performance

Cem Aydin, London Business School, Sussex Place, London, NW14SA, United Kingdom, Nicos Savva, Tolga Tezcan

This paper investigates the impact of sampling error on pay for performance schemes. Typically, such schemes monitor provider performance on one or more dimensions of quality (e.g., readmission rate) and penalize providers that perform worse than an endogenous benchmark (e.g., the national average). We show that the statistical estimators used to measure performance have a profound impact on equilibrium outcomes. If the payer uses within estimators (e.g. sample means, fixed effects models) the first-best investment in quality can be sustained as a unique equilibrium outcome. Conversely, standard variance reduction techniques often used in practice (e.g., shrinking within-estimators, random effects models) leads to an asymmetric equilibrium outcome - providers exert less effort compared to first best and provider's quality becomes decreasing in sample size. We test and find support for our predictions using publicly available data on pay-for-performance schemes implemented in the United States, and discuss further implications.

5 - Surgical Case-mix and Discharge Decisions: Does Within-hospital Coordination Matter?

Vanitha Virudachalam, Gies College of Business, University of Illinois at Urbana-Champaign, Champaign, IL, United States, Hessam Bavafa, Lerzan Örmeci, Sergei Savin

We study the problem faced by a hospital that controls patient inflows by designing a case-mix of elective procedures and patient outflows via patient discharges. Our model analyzes the impact of patient flow decisions on the utilization of two classes of resources, front-end (e.g. operating rooms), and backroom (e.g. recovery beds). We introduce a new approach for modeling patient recovery process and use it to characterize the relationship between a patient's length of stay and probability of readmission. We assess the benefit from coordinated decision-making, where portfolio and discharge decisions are made in tandem, when compared to two decentralized approaches: front-end (both decisions are made based only on front-end costs) and siloed (discharge decisions are made based on backroom costs, and the case-mix is the optimal match for the discharge policy).

■ TC04

Virtual Room 04

Healthcare Analytics

General Session

Chair: Hessam Bavafa, Wisconsin School of Business, Madison, WI, 53706, United States

1 - Familiarity and Patient Pick-up: The Effects of Group Composition on Physician Behavior and Patient Outcomes in the Emergency Department

R. J. Niewoehner, UNC Kenan-Flagler Business School, Chapel Hill, NC, 27599, United States, K. C. Diwas, Bradley Staats

Background: Operations literature has a rich history of applying formal mathematical models to study queuing system performance. In the context of parallel servers, much of this literature has generally assumed server independence, such that servers have zero effect on each other's behavior. Aim: In an Emergency Department, we study how familiarity at the physician-level alters patient pick-up behavior and system-level outcomes. Methods: Using empirical methods and data from multiple Emergency Departments, we explore the impact of average familiarity and familiarity dispersion on patient wait time before service, patient pick-up likelihood, and patient length of visit. Results: We find that greater average familiarity leads to shorter patient wait time and greater pick-up likelihood, especially for urgent patients. Conclusion: Within more familiar groups, physicians seem willing to exert more effort. Our insights empower future research to model server behavior even more accurately.

2 - Evaluating the Efficacy of Connected Healthcare: An Empirical Examination of Patient Engagement Systems and Their Impact on Readmission

Tan (Suparerk) Lekwijit, University of Pennsylvania - Wharton School, Philadelphia, PA, 19104-6340, United States, Christian Terwiesch, David A. Asch, Kevin G. Volpp

We study a connected health system where patients received electronic pill bottles and medication adherence feedback. Our work aims to investigate its efficacy in promoting adherence, examine the relationship between medication adherence and readmission, and develop a dynamic readmission risk-scoring model that considers medication adherence and use it to better target patients. We find that (1) patients are more likely to be adherent when they receive personalized feedback and when the intervention is escalated quickly, (2) better adherence substantially reduces readmission risk, and (3) we can reduce readmissions by using an intervention strategy that prioritizes high-risk patients.

3 - Multi-channel Chronic Patient Care in a Performance-based Reimbursement Framework

A. Mete Ozbek, Koc University, Istanbul, Turkey, Hessam Bavafa, Evrim D. Gunes, E. Lerzan Ormeci

We model and analyze the Comprehensive Primary Care Plus (CPC+) reimbursement system that was recently introduced by the Centers for Medicare & Medicaid Services. Our model includes a primary care practice (PCP) as a profit-oriented service provider with limited capacity. PCP employs multiple channels of care in handling demand of patients with chronic conditions to maximize its revenue in the existence of additional financial incentives. We analyze the operational decisions of the PCP, in particular the panel size and time allocated to different channels, under CPC+ and investigate conditions under which CPC+ could encourage the PCP to improve the quality of care for chronic patients.

4 - Hospital Readmissions Reduction Program Does Not Provide the Right Incentives: Issues and Remedies

Kenan Arifoglu, University College London, Gower Street, London, United Kingdom, Hang Ren, Tolga Tezcan

The Hospital Readmissions Reduction Program (HRRP) reduces Medicare payments to hospitals with higher than expected readmission rates where the expected readmission rate for each hospital is determined based on the readmission levels at other hospitals. Although similar relative performance-based schemes are shown to lead to socially optimal outcomes in other settings (e.g., cost-cutting efforts), HRRP differs from these schemes in three respects: (i) deviation from the targets is adjusted using a multiplier; (ii) the total financial penalty for a hospital with higher than expected readmission rate is capped; and (iii) hospitals with lower than expected readmission rates do not receive bonus payments. We study three regulatory schemes derived from HRRP to determine the impact of each feature by using a principal-agent model.

■ TC05

Virtual Room 05

Studies of the Pharmaceutical Supply Chain

Sponsored: MSOM /Healthcare

Sponsored Session

Chair: Liang (Leon) Xu, University of Nebraska - Lincoln, Lincoln, NE, 68588-0491, United States

1 - Improving Access to Rare Disease Treatments: Subsidy, Pricing, and Payment Schemes

Tugce Martagan, Eindhoven University of Technology, Eindhoven, 5611AZ, Netherlands, Wendy Olsder, Christopher Tang

There are more than 7,000 known rare diseases, but pharmaceutical manufacturers developed treatments for only 500 of them. To improve the availability and accessibility of treatments for rare diseases, we analyze several programs including subsidies, exogenous pricing, and outcome-based payment schemes. We formulate a 4-stage Stackelberg game to determine whether it is optimal to subsidize the pharmaceutical manufacturer, the patients, or both. Our analysis formalizes our understanding of the interactions among different parties, and our results inform policymakers when developing programs for improving patient access to rare disease treatments.

2 - A Multi-treatment Forest Approach for Analyzing the Heterogeneous Effects of Team Familiarity

Minmin Zhang, The University of Texas at Dallas, Richardson, TX, 75252, United States, Wallace J. Hopp, Guihua Wang, Michael Mathis

We study the heterogeneous effects of team familiarity on surgery duration. We develop a multi-treatment forest model consisting of multiple tree models that divide patients into different subgroups based on their features and estimate the effects of familiarity within each subgroup. The results show that the effects of familiarity are different for different types of patients. Our results can help hospital administrators to improve operational efficiency by matching patients with surgery team members using patient-specific information.

3 - The Interactions of Crowding, Patient Severity, and Queue Rank at a Hospital Emergency Department

Lu Wang, Assistant Professor, Ball State University, Muncie, IN, United States, Mazhar Arikan, Suman Mallik

Utilizing the patient data from the ED of a large urban teaching hospital, we characterize the impacts of the change in patient queue rank on patient LOS. We study how arrivals of higher/lower severity patients influence patient LOS, and how changes in queue rank, severity, and crowding simultaneously affect LOS.

4 - Outcome-based Reimbursement: The Solution to High Drug Spending?

Liang (Leon) Xu, University of Nebraska - Lincoln, Lincoln, NE, 68588-0491, United States, Hongmin Li, Hui Zhao

The continuously soaring prices of new drugs and their uncertain effectiveness in clinical practices have put substantial risks on insurers/payers. To induce insurer coverage of their new drugs, manufacturers start to propose an innovative outcome-based reimbursement (OBR) scheme, under which manufacturers will refund insurers (and possibly patients) if the drugs fail to achieve the pre-specified treatment target. We evaluate the impact of OBR on the insurer, the manufacturer and patients. We find that OBR improves patients' access to the new drug which may otherwise not be covered or placed on a formulary position with high copay. However, OBR inflates the wholesale price of the drug as risk premium and thus the insurer spending will not decrease under OBR. We thus caution insurers/payers who are seeking OBR to reduce their spending.

■ TC06

Virtual Room 06

Data Driven Insights for Decision Making

General Session

Chair: Seokjun Youn, The University of Arizona, Tucson, AZ, 85721-0087, United States

1 - Post-discharge Units: How Keeping Patients at the Hospital Reduces Congestion and Costs

Maryam Khatami, PhD, Indiana University, Bloomington, IN, United States, Jon M. Stauffer, Mark Lawley

Up to 60% of inpatients are transferred to post-acute care facilities. They may experience non-medical inpatient stays until the hospital finds a facility that fits their needs, contributing to upstream units' overcrowding. We study the feasibility of creating a "post-discharge-unit" (PDU) for patients who are medically ready-for-discharge but experience transfer delays. We use a multistage stochastic program to address PDU capacity planning and cost-effectiveness issues. Our numerical analysis, using data from a large hospital in Texas, show that a PDU is cost-efficient and improves access to inpatient beds even for a small number of patients waiting for transfer to post-acute care facilities. Compared to current practice in this hospital, operating a PDU could increase access to inpatient beds by 10% and reduce patient recovery costs by up to 30%. Another finding is that PDU optimal capacity in hospitals with a larger number of discharged patients waiting for transfer is more sensitive to variation in PDU fixed and operational costs.

2 - Does Underuse Variation in Test-ordering Practice Relate to Higher Care-delivery Cost?

Seokjun Youn, PhD Student, University of Arizona, Tucson, AZ, 85721, United States, Gregory R. Heim

Recent studies estimate that a significant portion, approximately 25%, of total healthcare spending in the U.S. is waste, ranging from $690 billion to $935 billion every year. Naturally, there has been a sustained call for efforts to reduce such waste of healthcare resources. This study aims to empirically investigate how unwarranted clinical variation in healthcare relates to hospital resource usage. Specifically, we posit that hospitals with a higher underuse variation in test-ordering practice (e.g., radiology and lab tests) may face unexpected higher expenditures in subsequent care-delivery stages. We also consider the intervening effects of quality initiatives on the relationship. We discuss our findings and policy implications based on comprehensive six-year inpatient data from New York and Florida states.

3 - Cost and Quality Performance of Accountable Care Organizations: An Empirical Investigation

Mayukh Majumdar, Texas A& M. University, College Station, TX, 77840, United States, Anupam Agrawal, Arun Sen, Chelliah Sriskandarajah

Healthcare expenditure remains a significant challenge for policymakers in the US. Accountable care organizations (ACO), formed under the Affordable Care Act (2010), are touted as an attractive option for reducing healthcare costs and improving care coordination. In this study, we use the data on 255 Medicare ACOs to examine the impact of leadership diversity, care delivery, and experience on the cost and quality performance of ACOs. Our results suggest that (i) having diverse leadership in their governing board helps in better cost performance of ACOs, (ii) using specialists for providing primary care services increases cost and reduces quality performance, (iii) ACOs that are associated with community and rural health clinics exhibit better quality and cost performance; specifically, providing the majority of care services by primary care providers and nurse practitioners, and having affiliation with hospitals improve the cost performance of such ACOs.

■ TC07

Virtual Room 07

COVID-19 Pandemic Modeling and Analysis 6

Contributed Session

Chair: Omar Skali Lami, MIT, Cambridge, MA, 2139, United States

1 - A Flexible User-driven Agent-based JRE Package for Evaluating Vaccination Strategies in Epidemics with Immune Waning and Genetic Drift: The Case of COVID-19

Wayne M. Getz, Professor of the Graduate School, University of California, Berkeley, CA, United States, Richard Salter, James S. Koopman, Carl Simon

We present a stochastic, agent-based SEIR model to evaluate vaccine rollout programs for epidemics with strain drift. Our JRE platform allows users to modify: SEIR transition rates; adaptive, prevalence-dependent, contacts; strain-dependent transmission, virulence, immunological waning, infector shedding, environmental persistence, infectee invasion, within-host mutation and reproduction rates; and, competing rates strain transmission and drift probabilities. We demonstrate the platform's utilities (sliders, graphics, diagnostic panels, function entry windows) in the context of the COVID-19 pandemic and present results on contrasting vaccination rollout programs.

2 - Development of a COVID-19 Vaccination Plan Considering Vaccine Availability and Temporary Delivery Centers

Haya Alshayji, Pennsylvania State University, State College, PA, 16803-2824, United States, Marta Ventura, Adhithya Padmannabhan, Jose Antonio Ventura, Hui Yang

COVID-19 vaccines availability led to new distribution challenges. Recent contributions regarding vaccine distribution optimization are built upon expanding existing epidemiological models. This paper applies mixed integer linear programing to solve a cost-minimizing facility location and vaccine distribution problem. Ultimately, this model will aid in reaching herd immunity while minimizing associated vaccination costs, new temporary facilities, and patients' travel distance costs.

3 - Centers for Disease Control and Prevention as a Strategic Agent in Public Sector Vaccine Pricing: Case Studies of COVID-19 and DTaP

Kayla Spring Cummings, Massachusetts Institute of Technology, Cambridge, MA, United States, Susan E. Martonosi, Banafsheh Behzad

We model cost-effective procurement of pediatric and COVID-19 vaccines by the CDC. Our optimization model selects prices minimizing negotiated costs, requiring full vaccination, linking public and private sectors, and representing private sector competition. We show the CDC should re-balance a shortage with manufacturer-dependent strategies, supporting a shift from annual contracts to ongoing negotiations. Even with high supply chain costs, low public sector COVID-19 prices can still support all CDC goals. Predicted and true COVID-19 vaccine prices coincide at the time of writing.

4 - The Power of Analytics in Epidemiology for COVID-19: Prediction, Prevalence, and Vaccine Allocation

Omar Skali Lami, Massachusetts Institute of Technology, Cambridge, MA, 2139, United States, Mohammed Amine Bennouna, David Alexandre Nze Ndong, Georgia Perakis, Ioannis Spantidakis, Leann Thayaparan, Asterios Tsiourvas, Shane Weisberg

Mitigating the COVID19 pandemic poses many challenges. Those include predicting new cases and deaths, understanding true prevalence, and allocating vaccines. We present a novel predictive ML-based aggregation method (MIT-Cassandra) also used by the CDC that is consistently among the top 10 models in terms of accuracy. We then predict the true prevalence of COVID19 and incorporate it into an optimization model for fair vaccine allocation. We obtain interesting insights on how prevalence affects the vaccine distribution for a heterogeneous population. Our work has been part of a collaboration with MIT's Quest for Intelligence and as part of CDC's model ensemble.

■ TC08

Virtual Room 08

Health Care Operations 1

Contributed Session

1 - Personalized Unit Placement: Joint Online Learning and Control with Delayed Feedback

Arlen Dean, University of Michigan, Ann Arbor, MI, United States, Mohammad Zhalechian, Mark P. Van Oyen

We propose an online algorithm for allocating care unit beds to patients in real-time. The problem involves reusable resources and heterogeneous rewards that must be learned over time. The algorithm is personalized to each patient and integrates Thompson sampling with an inventory balancing algorithm for joint learning and decision making. In contrast to typical models, feedback is not immediate. Inverse propensity score weighting is used in our algorithm to minimize the potential risks of delayed feedback. We demonstrate the applicability of our proposed method using patient data from a collaborating hospital. We also prove a competitive ratio to guarantee worst-case performance.

2 - Does Broader Sharing Improve Patient Outcomes? Analysis of Share 35 Liver Allocation Policy

Shubham Akshat, University of Maryland, College Park, MD, United States, Liye Ma, Subramanian Raghavan

Broader sharing of organs is believed to mitigate geographic disparity in access to liver transplants. We build a structural model to study the impact of Share 35 policy, a variant of broader sharing introduced in 2013, on behavior changes and on patients' welfare. We find that Share 35 policy helped in reducing the geographic disparity. The sicker patients benefited from policy and became selective in accepting organs, however there was heterogeneity in behavior change across geographies in lesser sick patients. Collectively, not all geographies benefited from Share 35 policy. We conclude that the current acuity circles policy would result in lower patient welfare than the previous Share 35 policy.

■ TC09

Virtual Room 09

Healthcare Analytics and Machine Learning VI

Contributed Session

Chair: James Mansfield, Merck, Jersey City, NJ, 07306, United States

1 - Incorporation of American Hospital Association Annual Survey Data into a Health Services Research Data Warehouse

Bunyamin Ozaydin, Assistant Professor, University of Alabama at Birmingham, Birmingham, AL, United States, Nichole Samuy, Ferhat Zengul

American Hospital Association Annual Survey data could serve as a rich resource for health services research but must first undergo ETL processes that many researchers lack the technical proficiency to perform. To address this obstacle, we developed a semi-automated process to integrate and update AHA Annual Survey data into a research data warehouse supported by the University of Alabama School of Health Professions. This data can be used alone or linked with other datasets to generate and answer many research questions in a much more efficient manner.

2 - Automated Detection and Classification of Continuous Glucose Monitoring (CGM) Patterns: Comparison to Human Experts

Shiping Liu, University of Maryland, College Park, MD, United States, Mansur E. Shomali, Abhimanyu Kumbara, Anand K. Iyer, Michelle Dugas, Kenyon Crowley, Gordon Gao

CGM has become an indispensable tool for helping patients and clinicians improve diabetes management, but making sense of thousands of data points can be challenging. In this study, our goal was to examine the performance of an automated method for detecting and classifying CGM events of clinical interest compared to that of a group of diabetes experts. We found that the system detected and classified CGM events similarly to the diabetes experts. The severity scores from both groups were highly correlated (r=0.87). The detected events may thus be used by software to coach people with diabetes to improve self-management and may be useful for clinicians caring for those patients in person or remotely.

3 - Machine Intelligence for Parkinson Patient Churn Reduction in Home Care

Christopher W. Cala, Infusion Therapy Market Director, Air Liquide Santé International, Gentilly, France, François Meunier, Habiboulaye Amadou-Boubacar

People living with Advanced Parkinson's disease on Device-Assisted-Therapy have high treatment discontinuation rates. In telecommunications, machine learning models are used to predict customer churn. We leverage this idea by training a supervised machine learning classifier model to predict Parkinson patient churn. Home healthcare nurses are given a list of patients at risk of churn at 3 months to call or visit to alter the course of churn. French nurses are piloting this model to identify patients at risk of churn and make prescriptive actions based on explicability and recommendation methods to reduce churn for better patient outcomes. The pilot will then be extended to Nordic and German nurses.

4 - Life Science Machine Learning & Artificial Intelligence to Support Value-based-pricing of Therapies, Investments and Innovations Required to Save and Improve Lives

James E. Mansfield, Quantitative Science, Global Analytics, Merck, Jersey City, NJ, United States

Innovative technology growth in healthcare is paramount. However, healthcare providers, i.e. world health organizations, country ministries of health and systems are challenged to find a balance between innovation and healthcare cost savings. Conversely, healthcare innovators, i.e. industry, academia, need healthcare provider and private/public funding support to create these innovations. Machine Learning & Artificial Intelligence will prescribe ways to address the challenge. Disclaimer: These views are with the sole expression and innovation of presenter and not views of the organization or company HI. am employed.

■ TC10

Virtual Room 10

Causal Inference and Machine Learning in Healthcare Operations

General Session

Chair: Hamsa Sridhar Bastani, Wharton School, Philadelphia, PA, 19104, United States

Co-Chair: Arielle Anderer, Wharton School, Philadelphia, PA , United States

1 - Online Routing with Stochastic Anytime Constraints: An Application to Hospital Inpatient Flow Management

Pengyi Shi, Purdue University, West Lafayette, IN, 47907, United States, Xin Liu, Bin Li, Lei Ying

We develop a novel primal-dual algorithm to solve online routing problems with stochastic anytime constraints. The algorithm is computationally efficient, with similar complexity as the conventional multi-armed bandit problem. We prove this algorithm achieves zero constraint violation yet maintaining a sub-linear regret. We apply the algorithm to an online inpatient bed assignment problem with unknown delay and readmission cost.

2 - Does Transportation Mean Transplantation? Impact of New Airline Routes on Sharing of Cadaveric Kidneys

Tinglong Dai, Johns Hopkins University, Baltimore, MD, 21212-1708, United States, Guihua Wang, Ronghuo Zheng

Every year, nearly 5,000 patients die while waiting for kidney transplants, and yet an estimated 3,500 procured kidneys are discarded. Such a polarized co-existence of dire scarcity and massive wastefulness has been mainly driven by insufficient pooling of cadaveric kidneys across geographic regions. In this paper, we estimate the effect of the introduction of new airline routes on broader kidney sharing. By merging the U.S. airline transportation and kidney transplantation datasets, we create a unique sample tracking (1) the evolution of airline routes connecting all the U.S. airports and (2) kidney transplants between donors and recipients connected by these airports. We estimate the introduction of a new airline route increases the number of shared kidneys by 7.3%. We also find a net increase in the total number of kidney transplants and a decrease in the organ discard rate with the introduction of new routes.

3 - Mind the Gap: Safely Bridging Offline and Online Reinforcement Learning

Wanqiao Xu, University of Michigan, Ann Arbor, MI, United States, Kan Xu, Hamsa Sridhar Bastani, Osbert Bastani

Reinforcement learning is a promising approach to integrating predictive modeling with sequential decision-making. It can be used to help manage health conditions like sepsis and chronic illnesses, which require the clinician to make sequences of treatment decisions. However, unconstrained exploration can be unacceptably harmful to patients. We propose an algorithm that is guaranteed to maintain a minimum performance level specified by an offline (doctor's) policy, ensuring safety for all patients at all times. We prove that our algorithm achieves near-optimal regret guarantees for finite-state MDPs, thus showing that safety can be achieved with a negligible reduction in performance.

4 - Combining Pre-approval Clinical Trials and Post-approval Spontaneous Adverse Event Reporting for Improved Safety Signaling

Lawrence (Yunliang) Chen, UC Berkeley, Berkeley, CA, 90024-5055, United States, Fernanda Bravo, John M. Silberholz

We propose a methodology to enhance post-approval safety surveillance of pharmaceuticals. Clinical trials typically do not provide sufficient evidence for flagging rare safety issues. Our approach combines pre-approval clinical trial results with post-approval surveillance information for common and rare adverse effects to decide whether to flag the rare reaction in the drug label, weighing type I and type II error costs. We analytically establish when our approach will be most valuable and numerically demonstrate its effectiveness.

■ TC11

Virtual Room 11

Diversity, Equity, and Inclusion

Contributed Session

Chair: Robert Hill, George Washington University SEAS, Pinecrest, FL, 33156, United States

1 - Disparities in Patient-Generated Health Data Sharing with U.S. Hospitals

William Olivera, Georgia State University, Atlanta, GA, United States, Aaron Baird, Yichen Cheng, Yusen Xia

There has been limited research on the adoption and distribution of systems that support Patient-Generated Health Data (PGHD) data sharing, especially in areas of higher deprivation. We consider U.S. hospital adoption of systems that generate or use PGHD (e.g., remote patient monitoring). Through analysis of American Hospital Association (AHA), Twitter, and related data, we evaluate differences in U.S. populations that do or do not have access to PGHD information sharing. We further analyze differences in consumer perceptions of such systems. Implications for health policy are discussed.

2 - A Percolation-based Framework for Analyzing Network Resilience and Diversity with Application to Post-Covid Reopening Strategies

Robert Hill, George Washington University SEAS, Washington, DC, United States

Research in network science and mathematical epidemiology has noted the positive correlations between epidemic spreading and both the robustness of a social network, as measured by its percolation threshold, and its degree correlation, or assortativity. Drawing on analytical, simulation and empirical results, this work extends previous research, showing how more diverse networks are more degree assortative networks and thus more susceptible to contagion. This suggests that post-Covid reopening strategies to inhibit infectious disease spread may have unintended negative effects on organizational diversity and inclusion that must be mitigated.

■ TC12

Virtual Room 12

Logistics to Improve Public Health

General Session

Chair: Emily L. Tucker, Clemson University, Clemson, SC, 29634, United States

1 - COVID-19 Response: Campus Hand-Sanitizer Deployment

Tyler O'Brien, Clemson University, Clemson, SC, United States, Steven Foster, Emily Tucker, Sudeep Hegde

The COVID-19 has forced universities to find different alternatives and strategies to reduce the spread amongst their student bodies, as well as the surrounding communities. Clemson University has deployed hand-sanitizing stations across campus to mitigate the transmission of the virus amongst students and to support students in following the CDC health guidelines. The current study takes an interdisciplinary approach to integrate optimization models and human factors methods to maximize the usage of these hand-sanitizing stations. We present a facility location model that uses campus door access control data to determine optimal locations for the hand-sanitizing dispensers. To better understand facilities' decision-making process and student behavior around hand-sanitizer use, we also use data gathered from interviews and questionnaires with facilities management, and Clemson students. We will partner with campus facilities to redeploy hand-sanitizer stations this summer in preparation for the Fall 2021 semester.

2 - Using Simulation to Reduce ED Boarding of Psychiatric Patients

Nathan Adeyemi, Northeastern University, Boston, MA, United States, Nasibeh Zanjirani Farahani, Kalyan Pasupathy, Amanda Graham, Kayse Maass

Hospital emergency departments (ED) are often heavily backlogged by patients in need of psychiatric care but awaiting placement in an inpatient bed (IP) either at their current hospital or transfer to another facility. This is known as ED boarding. Using discrete event simulation to model this system of IP bed assignment and patient transfer, we aim to reduce patient boarding time due to lack of available IP beds, distance-related transfer restrictions, and patient-characteristic related inclusion and exclusion criteria. Our goal is to find novel alternatives to the current system that are both effective in reducing ED boarding and implementable without requiring substantial capacity increases.

3 - Reducing Risks of Human Trafficking: Improving Access to Housing and Supportive Services for Runaway and Homeless Youth in NYC

Yaren Bilge Kaya, PhD Candidate, Northeastern University, Boston, MA, 02130-0000, United States, Geri Dimas, Andrew Trapp, Renata Konrad, Kayse Maass

Exposure to trauma, violence, and substance use, coupled with a lack of community support services, puts runaway and homeless youth at high risk of being trafficked. Access to safe housing and supportive services such as physical and mental healthcare is known to be the most effective answer to youth's vulnerability towards exploitation. In this study a survivor-informed, data-driven, systematic approach is undertaken to disrupt the supply side of human trafficking networks. This approach involves primary data collection and an integer linear optimization model to project the collective capacity required by service providers to adequately meet the needs of these vulnerable youth.

■ TC13

Virtual Room 13

Analytics in Opioid Therapy and Major Depression

General Session

Chair: Nan Kong, Purdue University, West Lafayette, IN, 47907-2032, United States

1 - Association of Opioid Prescription Dose and Discontinuation with Risk of Substance-related Morbidity in Long-term Opioid Therapy

Patrick D. Quinn, PhD, Indiana University School of Public Health, Bloomington, IN, United States, Zheng Chang, Matthew J. Bair, Martin E. Rickert, Robert D. Gibbons, Kurt Kroenke, Brian M. D'Onofrio

Efforts to reduce opioid-related harms have provoked concerns about unintended consequences, underscoring the need for research on the adverse effects of long-term opioid therapy (LtOT) and its discontinuation. Using 2010-2018 commercial insurance claims data on 194,839 LtOT recipients, we examined change in substance-related morbidity from opioid therapy initiation through dose changes and discontinuations. Compared with risk during initial treatment, risk of substance-related morbidity was up to 48% (95% CI, 25%-76%) relatively greater within individual during subsequent LtOT in a dose-dependent manner. In contrast, we found less support for increased risk due to discontinuation.

2 - Systematic Investigation of Parameters and Calibrations to Adapt the Natural History Model of Major Depression to the Current U.S. Adult Population

Melike Yildirim, PhD, Harvard Medical School, Boston, MA, United States, Bradley Gaynes, Pinar Keskinocak, Brian Pence, Julie Swann

Optimistic assumptions about the prevalence of major depression have significant consequences for underestimating the burden of disease and the benefit of preventive care. We describe a natural history model of major depression with incidence and prevalence. We utilize a discrete-time Markov chain with gender-specific transition probabilities and parameters from secondary data that was collected from laptop computer-assisted personal interviews and a national telephone survey of adults in the US. We solve differential equations and test the parameters empirically. We focus on the reported values of the annual incidence of major depression and lifetime prevalence for females and males in the US and the calibrated parameters of the measures that are simultaneously feasible for a cohort. We conclude that the reported lifetime prevalence for both females and males and incidence rates for males are underestimated.

3 - Institution Response to the Opioid Epidemic

Marie N. Hanna, MD, MEHP, Johns Hopkins University, Baltimore, MD, United States

Addressing The Opioids Crisis during COVID Pandemic The use of opioid analgesics for pain management has increased drastically over the past two decades and worsen during COVID Pandemic. At the Johns Hopkins Hospital, the Personalized Pain Program (PPP) developed as an institutional response to the opioid crisis. The organization recognized an opportunity to provide more thorough and multi-faceted care for surgical patients on chronic opioid therapy by helping with opioid tapering, tailoring anesthetic plans to incorporate multimodal non-opioid interventions, and providing long-term postoperative follow-up. A telemedicine approach of the PPP was sustainable during COVID Pandemic

■ TC14

Virtual Room 14

Healthcare Operations Management 6

Contributed Session

Chair: Bingnan Lu, University of Minnesota, Dept. of ISYE, Minneapolis, MN, 55455-0150, United States

1 - Simulating Bed Cleaning Logistics Considering Operators' Behaviour

Gaspard Hosteins, Technical University of Denmark, Kgs. Lyngby, Denmark, Allan Larsen, Dario Pacino, Christian Sørup

Beds are a crucial resource, which must be adequately managed both in use with the patient and after for a well-performing hospital. The staff ensures that sterile beds are always available for patients performing, transport, and storage under high pressure, reacting to uncertain patient arrival.We work jointly with Rigshospitalet, a public hospital in Denmark, building a simulation tool for the bed flow with a tension level indicator modeling the stress on the cleaning unit and the induced behavioral change of the workers. Using this simulation tool, we propose adaptations of the cleaning unit to increase efficiency and robustness.

2 - Appointment-driven Queueing Systems with Non-punctual Customers

Bingnan Lu, University of Minnesota, Minneapolis, MN, United States, Oualid Jouini, Saif Benjaafar, Siqiao Li, Benjamin Legros

We consider a single server queueing system where a finite number of customers arrive over time. Arrivals are driven by appointments, but customers are not necessarily punctual or may not show up at all. Customers are also not homogeneous in their punctuality and show up behavior. Service times are assumed to be random with a -Cox distribution. We develop both exact and approximate approaches for characterizing the distribution of waiting time. We prove that the approximation provides an upper bound for the expected customer waiting time. We also examine the impact of non-punctuality on system performance and illustrate how our approach can be used to support individualized appointment scheduling.

Friday, 10:00AM - 10:50AM

■ Keynote Friday

Virtual Room 01

Keynote: Vaccination During a Pandemic: When Planning and Scale-up Must Coincide

Keynote Session

Introducer: Paul Griffin, Pennsylvania State University, Regenstrief Center for Healthcare Engineering, West Lafayette, IN, 47907-1971, United States

1 - Vaccination During a Pandemic: When Planning and Scale-up Must Coincide

Anne Schuchat, Center for Disease Control and Prevention, Atlanta, GA, United States

Pandemics and other emerging infectious diseases involve uncertainty and dynamic circumstances. Responses must be speedy but thoughtful; caring and cultural sensitivity are as important as efficiency. Dr. Schuchat will share her experiences responding to public health emergencies.

Friday, 11:00AM - 12:30PM

■ FA01

Virtual Room 01

Data-Driven Modeling and Optimization in Healthcare

General Session

Chair: Cong Shi, University of Michigan, Ann Arbor, MI, 48105-3000, United States

Co-Chair: Esmaeil Keyvanshokooh, University of Michigan, Ann Arbor, Ann Arbor, MI, 48108-1020, United States

1 - Prediction-driven Surge Planning with Application in the Emergency Department

Yue Hu, Columbia University, New York, NY, United States, Carri Chan, Jing Dong

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. High fidelity ED simulation experiments demonstrate that the proposed framework can reduce staffing costs by 8% - 17% while guaranteeing timely access to care.

2 - Data-pooling for Personalized Intervention in Healthcare

Pengyi Shi, Purdue University, West Lafayette, IN, 47907, United States, Xinyun Chen, Xiuwen Wang

Personalized intervention management in healthcare has received a rapidly growing interest in the big-data era yet still is a burgeoning field. The small sample issue makes conventional learning methods hard to learn the right policy and suffer from large variances. In this research, we extend the data-pooling technique from the bandit setting to the reinforcement learning context. We develop a novel data-pooling estimator and establish theoretical performance guarantee.

3 - Organ Procurement and Information Process Optimization

Paola Martin, University of Texas, Austin, TX, United States, Diwakar Gupta

The widespread use of electronic medical record systems by hospitals, and electronic capture of referrals data by Organ Procurement Organizations (OPOs) makes it possible to harness large amounts of data to augment human decision-making and ask whether this can increase the supply of organs. This talk will focus on describing efforts to improve the speed and accuracy of case coordinators' donor-disposition decisions by exploiting data from two OPOs. In particular, this study will examine both clinical and operations factors that affect the evaluation of each referral.

4 - Optimizing Nurse Assignments to High-performance Surgical Teams

Cagla Keceli, The University of Chicago Booth School of Business

We consider the daily assignment of nurses to operating rooms to maximize team performance in a high-volume academic medical center. Our approach considers not only familiarity between nurses and surgeons, but also nurse experience across surgical specialties. We report on results from a pilot implementing our approach in a real hospital setting.

5 - Contextual Learning with Online Convex Optimization: Theory and Applications to Chronic Diseases

Esmaeil Keyvanshokooh, University of Michigan, Ann Arbor, MI, 48108-1020, United States, Mohammad Zhalechian, Cong Shi, Mark P. Van Oyen, Pooyan Kazemian

We formulate a new contextual multi-armed bandit problem under a two-dimensional control with a nested structure, where each arm (treatment) has a control (dosage) that affects the arm's performance. Reward (disease progression) is binary and is modeled as the outcome of a logistic random variable that depends on the chosen arm and a convex function of the corresponding control. We develop a joint contextual bandit learning and stochastic gradient descent algorithm, that integrates the strength of contextual bandit learning with online convex optimization. We prove a sub-linear regret, which is provably tight up to a logarithmic factor. We illustrate the effectiveness of our methodology by using case data on patients with type 2 diabetes.

■ FA02

Virtual Room 02

Data-driven Modeling

Contributed Session

Chair: Anna Svirsko, United States Naval Academy, Annapolis, MD, 21401, United States

1 - Structural Estimation of the Cost of Flexible Capacity in the Emergency Department

Arshya Feizi, PhD Candidate, Boston University, Boston, MA, United States, William Baker

A common practice in busy emergency departments (EDs) is to room patients in hallways to mitigate long wait times. However, it is well known that patients in hallway beds experience lower satisfaction and quality of care. We model a forward-looking, cost-minimizing decision-maker who rooms patients on either hallway or non-hallway beds. Using this model and two years of ED data, we structurally estimate the costs associated with patient wait times and lower quality of care from hallway placement, as perceived by the decision-maker.

2 - Analysis of the Yearly Transition Function in Measles Disease Modeling

Carlo Davila-Payan, Prevention Effectiveness Fellow, Centers for Disease Control and Prevention, Atlanta, GA, United States, Andrew Hill, Xi Li, Michael Lynch, Sarah W. Pallas

Globally, an estimated 9.8 million measles cases and 207,500 measles deaths occurred in 2019. This study presents a novel approach to use a yearly transition function to account for: 1) the effects of measles vaccination timing among different age groups and 2) the effects of disease seasonality on the number of measles cases in a country. Our methodology adds to and expands on an existing modeling framework by developing explicit functional expressions for each underlying component of the transition function to adjust for the temporal interaction between vaccination and exposure to disease.

3 - Optimizing ED Physician Staffing Levels

Anna C. Svirsko, Assistant Professor, United States Naval Academy, Annapolis, MD, United States, Richard Saladino

Scheduling physicians for emergency departments can be extremely difficult due to the uncertainty that exists in patient demand. This uncertainty results in ad-hoc staffing methods based on speculation or feelings regarding "busy-ness". We propose a data-driven staffing plan that uses patient arrival rates and discharge rates. This method provides the opportunity to develop a robust staffing plan by accounting for uncertainty in patient volume. A linear program is used to create an optimal physician schedule that aligns with the staffing plan determined in the data-driven model. This model was used to determine the allocation of additional physician capacity and a new schedule at a local ED.

■ FA03

Virtual Room 03

Modeling and Assessing Opioid Use Interventions

General Session

Chair: Nisha Nataraj, Centers for Disease Control and Prevention, Atlanta, GA, 30319-2801, United States

1 - The FRED Simulator for Opioid Use Disorder and Overdose

Mark S. Roberts, University of Pittsburgh, Pittsburgh, PA, 15261-3100, United States, Hawre Jalal, Mary Kraulland, Donald Burke

The Framework for Reconstructing Epidemiological Dynamics (FRED) is an agent-based modeling (ABM) system with a census-based synthetic population that is statistically equivalent to the US population. The opioid overdose epidemic is a complex and dynamic public health emergency - ABMs can help better understand these dynamics and predict effectiveness of intervention strategies. We developed a publicly-available FRED ABM tool of opioid use disorder (OUD) and overdose that tracks disease progression in individuals and prevalence at the county-level under the conditions of two key strategies for preventing opioid overdose deaths - provision of naloxone and availability of medication for OUD.

2 - A Systems Dynamics Model to Assess the Impacts of CDC Efforts in Preventing Opioid Overdoses

Nisha Nataraj, Centers for Disease Control and Prevention, Atlanta, GA, 30319-2801, United States, Kun Zhang, Gery Guy, Ketra Rice, Jan Losby, Matthew Gladden, Desiree Mustaquim, Christine Mattson, Noonan Rita, Puja Seth

The opioid overdose epidemic is a complex, evolving public health emergency involving clinicians, persons who misuse prescription or illicit opioids, those with opioid use disorder (OUD), first responders, and federal, state, and community partners. Efforts to address the epidemic span a range of diverse interventions, such as improving opioid prescribing, access to medication for OUD, and harm reduction. Systems dynamics (SD) models can provide insights into the most effective levers for preventing overdoses and help identify data gaps. We present an SD model to estimate opioid overdoses averted through the prevention efforts of the Centers for Disease Control and Prevention from 2016-2019.

3 - Bayesian Calibration of a Complex Agent-based Model of Opioid Use Disorder Using Deep Machine Learning

Hawre Jalal, University of Pittsburgh, Pittsburgh, PA, United States Mary Kraulandm Kun Zhang, Nisha Nataraj, Mark S. Roberts, Donald Burke

Calibration can be used to fine-tune simulation model parameters so that its output matches observed trends. Bayesian calibration is often superior to traditional approaches, but it requires programming the simulation model in specialized software and are computationally expensive. We used our newly developed method Bayesian Calibration via Artificial Neural Network (BayCANN) to overcome both limitations and calibrate our complex agent-based model, the Framework for Reconstructing Epidemiologic Dynamics (FRED), to simulate the dynamics of opioid use disorder in the United States. BayCANN uses advances in deep learning to calibrate FRED only using a set of model inputs and outputs from FRED. Implementing BayCANN did not require reprogramming FRED in a probabilistic language capable of Bayesian calibration. Using BayCANN, we successfully calibrated FRED to trends in overdose mortality, illicit drug seizures, and prescribing patterns in 14 counties across the US.

4 - Modeling the Long-term Impact and Cost-effectiveness of Buprenorphine-naloxone Treatment at Syringe Service Programs

Joella W. Adams, PhD Student, Boston Medical Center, Boston, MA, United States, Alexandra Savinkina, Aaron Fox, Czarina Behrends, Avik Chatterjee, Alexander Walley, Joshua Barocas, Benjamin Linas

We employed a state-transition model of the natural history of opioid use disorder and treatment provision to estimate population-level outcomes of offering on-site buprenorphine treatment in Massachusetts syringe service programs (SSPs). We compared an intervention scenario where 30% of SSP clients started treatment to the status quo. The modeled intervention resulted in 117576 (+7.8%) additional treatment initiations and averted 5015 (-21.8%) fatal overdoses. The intervention provided additional quality-adjusted life-expectancy (0.2 QALY per-person) at lower cost (-$3600 per person), due largely to decreased healthcare utilization among patients on buprenorphine.

■ FA04

Virtual Room 04

Contracts and Incentive Alignment in Health Technology Innovation Pipeline

General Session

Chair: Ozge Yapar, Indiana University, Kelley School of Business, Indiana University, Kelley School of Business, Bloomington, IN, 47405-5308, United States

1 - Incentives for Project In-Licensing

Jochen Schlapp, Frankfurt School of Finance & Management gGmbH, Adickesallee 32-34, Frankfurt Am Main, 60322, Germany, Nektarios Oraiopoulos

Pharmaceutical companies frequently acquire new drug candidates from external sources—such as, e.g., biotech companies, university labs, venture capitalists, or other pharmaceutical companies—in order to strengthen their R&D portfolios. But how can pharma companies reliably discover promising drug candidates? We present a simple but effective incentive mechanism that allows firms to steer the search behaviour of their scouting agents and thus to improve search outcomes.

2 - Conditional Approval vs. Discount Schemes for New Medical Treatments

Ozge Yapar, Assistant Professor, Indiana University, Kelley School of Business, Bloomington, IN, United States, Stephen E. Chick, Noah Gans

Healthcare payers have been implementing conditional approval schemes in which a treatment's reimbursement is conditional on the successful demonstration of the health-economic value through post-marketing data captured after the treatment has entered the market. Payers also allow companies to apply for discount schemes which lead to a reduction in the price of the treatment. As a result, companies can choose between applying for a discount, which decreases the budget impact, and applying for conditional approval, which decreases the uncertainty. Using a game-theoretic model, we investigate whether there is a systematic difference between treatments that enter these two types of schemes.

3 - Regulations for Substitutable Medical Devices

Fan Zhou, University of Michigan, Ross Annex, Ann Arbor, MI, 48109-1234, United States, Shima Nassiri, Ravi Anupindi

It is common practice for healthcare providers to offer several treatment choices to patients and make recommendations based on patients' characteristics. In this study, we consider the stent, a medical device used in percutaneous coronary intervention (PCI). There are two kinds of stents available in the market, and the high-price option shows higher quality only for high-risk patients. Without regulations, profit-maximizing providers can misuse these devices and limit patients' access to care by setting high prices. We are interested in regulation policies that help avoid such adverse effects.

4 - The Benefits-Value-Advisor Program for Shoppable Medical Services

Jingyao Huang, The University of Texas at Austin, Austin, TX, United States, Diwakar Gupta

There is often a great deal of variation in prices charged by providers of non-urgent and routine medical procedures such as MRI and CT Scan. Some insurers have recently introduced the Benefits-Value-Adviser (BVA) program to help improve the quality and reduce the cost of such services. In this paper, we ask and answer the following question: can the BVA program add value? Value is defined as the cost of all services normalized by quality. We incorporate the characteristics of healthcare markets in a game-theoretic model of provider competition to derive the providers' decisions in price-only and comprehensive equilibrium settings. We find that in the price-only equilibrium, the BVA program is guaranteed to add value in a market where the differences in providers' pre-existing quality and marketing activity levels are both simultaneously low. Additionally, in the comprehensive model, the BVA program adds more value when it can affect a large increase in quality sensitivity relative to the change in price sensitivity.

■ FA05

Virtual Room 05

COVID-19 Modelling in Support of Canadian Military and Government Decision-makers

Sponsored: Military and Security (MAS)

Sponsored Session

Chair: Matthew R. MacLeod, DRDC CORA, Ottawa, ON, K1Y 4P7, Canada

1 - The Impact of Age Demographics on Interpreting and Applying Population-wide Infection Fatality Rates for COVID-19

Matthew R. MacLeod, Defense Research and Development Canada, Ottawa, ON, K1Y. 4P7, Canada, Gregory Hunter

The coronavirus disease 2019 (COVID-19) pandemic affects the Canadian Armed Forces (CAF) and its members in multiple ways. The CAF must maintain situational awareness of the pandemic for impacts on its healthcare operations, its operational effectiveness, and for where it may be asked to respond. We will focus on how we established estimates of COVID-19 infection fatality rates (IFRs) for the CAF and to the Canadian public. Age-dependent effects of COVID-19 must be considered when comparing estimates based on countries with very different age profiles, such as China and Italy. Conversely, one must consider the age structure of the population to which an estimate is being applied.

2 - Likelihood of Undetected COVID-19 Infection in a Group

Steve Guillouzic, Defense Research and Development Canada, Ottawa, ON, Canada, Ramzi Mirshak, Steven Horn, Andrew Sirjoosingh

In order to help the Canadian Armed Forces (CAF) manage the risk of coronavirus disease 2019 (COVID-19) outbreaks, we developed an online calculator to estimate how much sequestration and testing is required to reduce the likelihood of having an undetected infection in a group to a level with which commanders are comfortable. We will discuss the genesis of the tool and how it evolved to consider ideal and imperfect sequestration, people travelling from multiple locations, PCR or antigen testing, and vaccination. We will also discuss how we use Bayesian inference with probabilistic programming to estimate the point prevalence in the various health regions, a key parameter of the calculator.

■ FA06

Virtual Room 06

Medical Decision Making 1

Contributed Session

Chair: Breanna Swan, North Carolina State University, Raleigh, NC, 20740, United States

1 - What Causes Disagreement Among Physicians? An Exploration of Customers' Perception and Physicians' Experiential Learning Dynamics

Hesam Mahmoudi, Virginia Tech, Blacksburg, VA, United States, Navid Ghaffarzadegan

Over-utilization bias and practice variation are two major contributors to suboptimal medical decisions. We do not seek to reject the common static explanations for bias and variation; instead, we offer an alternative and dynamic one. Our case is obstetricians' decision between C-section and natural deliveries. Simulation results show that skill accumulation together with conditional feedback availability are enough to endogenously cause bias and variation. The dynamics of patients' matching their preferences with the obstetricians' reputation interacts with the experiential learning dynamics, exacerbates the bias, and pushes the physicians to settle in their preferred delivery method.

2 - Disregarding, Modifying, and Adopting: How Medical Experts Incorporate AI Recommendations Into Patient Care Decisions

Jeffrey Clement, PhD Candidate, University of Minnesota, Minneapolis, MN, United States, Yuqing Ren, Shawn P. Curley

AI Clinical Decision Support Systems can generate recommendations to improve patient care, but it is unclear how healthcare professionals incorporate recommendations into decisions. We combined semi-structured interviews with two lab experiments with experienced clinicians to examine factors influencing the use of AI recommendations, and find that incorporating AI recommendations into clinical decisions seems to differ from other domains. Contrary to predictions, providing explanations did not increase trust in and adoption of AI recommendations. Instead, explanations increased adoption of low-quality AI recommendations while decreasing adoption of high-quality recommendations.

3 - The Smart Framework: Selection of Machine Learning Algorithms with Replications - A Case Study on the Microvascular Complications of Diabetes

Breanna P. Swan, North Carolina State University, Raleigh, NC, United States, Maria Esther Mayorga, Julie Simmons Ivy

Selecting the 'best' prediction model for a given disease, population, and clinical application is challenging due to the many health-related ML models in the literature and the increasing availability of ML methodologies. To support this decision, we developed the SMART Framework that integrates building and selecting ML models with decision theory. We estimate model performance for multiple future populations, ranking them by simulating decision-maker priorities using a range of accuracy measures and robustness metrics from decision theory (e.g., minimax Regret). We present our framework through a case study on the microvascular complications of diabetes, using the ACCORD clinical trial.

■ FA07

Virtual Room 07

COVID-19 Pandemic Modeling and Analysis VII

Contributed Session

Chair: Himanshu Kharkwal,University of Minnesota, Minneapolis, MN, United States

1 - Application of a Hybrid Simulation Framework in Modelling COVID-19 Transmission Across Care Homes

Le Khanh Ngan Nguyen, University of Strathclyde, Glasgow, United Kingdom, Itamar Megiddo, Susan Howick

Single simulation modelling methods have widely been used to study the dynamics of infectious diseases and help evaluate the impact of infection control interventions. However, some problems can benefit from the complementary view and deeper insight gained from combining multiple simulation methods. The use of hybrid simulation models requires modelers to specify model components, selection of modelling method for each component, and connection between components. The process of developing a conceptual hybrid model is explained using a case study of a hybrid SD-AB model simulating the transmission of COVID-19 via temporary staff working across several facilities in a network of care homes.

2 - Online Prediction of Hospital and Intensive Care Unit Bed Occupancy of COVID-19 Patients. Application to the Autonomous Regions in Spain

Daniel Garcia-Vicuña, Public University of Navarre, Pamplona, Spain, Fermin Mallor, Laida Esparza

Simulation models are suitable tools to represent the complexity and randomness of hospital systems. In this work, the construction of a simulation model has been used to support the decision-making concerned with the short-term planning of the necessary hospital beds to face the COVID-19 in all regions of Spain. Every day during the pandemic waves, the research team sends the national government detailed reports on the forecasted occupancy of both hospital and ICU beds. These reports are received by the logistic teams in charge of planning the health resources in each region. Based on these predictions the authorities plan the necessary resources.

3 - Long Term Care Facility (LTCF) Operations: Agent Based Modeling(ABM) for COVID-19 Forecasting and Planning During a Pandemic

Himanshu Kharkwal, University of Minnesota, Minneapolis, MN, United States, Ankur Mani, Eva A. Enns, Jaideep Srivastava

Given their age and comorbidities, LTCF residents have a significant risk of COVID-19 mortality. Risk reduction can be achieved by focusing on minimizing infection exposure for the residents. Our system, an agent-based model combined with a stochastic network, models multiple LTCFs and interactions between them. This will enable administrators to assess and optimize their COVID-19 LTCF management policies based on testing decisions, including frequency, turnaround time, and false +ve/false -ve rates; and staff management policies, including staff rotation schedules, quarantine, and cohorting policies, and masking/distancing protocols. We apply it to the Minnesota LTCF network.

■ FA08

Virtual Room 08

Health Care Operations 2

Contributed Session

Chair: Jorge Andrés Acuña, University of South Florida, Tampa, FL, 33613-2992, United States

1 - Returning to Normal: Dynamic Surgical Capacity Management for Deferred Surgeries

Eojin Han, Southern Methodist University, Dallas, TX, United States, Kartikey Sharma, Kristian Singh, Omid Nohadani

The COVID-19 pandemic necessitated sweeping deferrals of elective surgeries. These deferrals led to deterioration of patients' conditions due to delayed procedures and potential departures. Current policies are ad-hoc, i.e., either all surgeries are deferred or capacities are extended by pre-determined factors. We develop an optimization framework to optimally manage the expansion of surgical capacity under uncertain backlog. Given that the model contains nonlinear products of uncertainties, we provide tractable policies for realistic problems. Numerical experiments on claims data from a large fraction of US hernia patients demonstrate sizable improvements over competing methods.

2 - To Extend or Not to Extend? Dynamic Shift Lengths in Emergency Departments

Negar Ganjouhaghighi, University of Calgary, Calgary, AB, Canada, Marco Bijvank, Alireza Sabouri

In Emergency Departments (EDs), it is difficult to predict patient arrivals, whereas physicians are usually scheduled a long time in advance. To ensure that enough physicians are available to provide service in a timely fashion, we consider shift lengths to be dynamic: two hours before the end of a shift, the extension decision is made. The objective is to find an optimal policy for shift extensions such that patients' wait times are minimized. We formulate this problem as an infinite horizon MDP and use stochastic dynamic programming to solve it. A case study from an ED is used to illustrate solution procedure.

3 - Mergers and Competition in Healthcare Markets: A Key to Affordable Care

Jorge A. Acuna, University of South Florida, Tampa, FL, United States, Jose L. Zayas-Castro, Felipe A. Feijoo

In 2019, 66.5% of all bankruptcies in the US were tied to medical issues, and 26.1 million people did not have health insurance at any point. In this talk, we investigate the effects of hospital mergers in healthcare markets with cooperative and competitive schemes through a bi-level problem with strategic interactions between hospitals, insurers, and patients. We analyze the market equilibrium, premiums prices, and quality for different scenarios (including SARS-CoV-2). At the same time, we propose possible governmental interventions to increase competition and reduce health prices.

■ FA09

Virtual Room 09

Smart and Connected Health

Contributed Session

Chair: Caroline Marra, Harvard Business School, Boston, MA, 02472, United States

1 - Promoting Physical Activity Through Prosocial Incentives on Mobile Platforms

Yuan Yuan, Massachusetts Institute of Technology, Cambridge, MA, United States, Christos Nicolaides, Dean Eckles, Alex Pentland

Designing incentives to encourage physical activity is challenging. Instead of conventional incentives, such as monetary and social incentives, our study aims at examining how prosocial incentives on mobile platforms promote fitness behavior. Deploying a 30-million field experiment on WeChat and following up with a large-scale matching design, we provide evidence of the impact of prosocial incentives on more outdoor physical activities. Our further analysis suggests that this prosocial incentive may be as effective as the social incentive. Our study offers insights into how to introduce and design effective prosocial incentives to promote health-benefiting behaviors.

2 - Implications of COVID-19 on Flexible Emergency Department Design Using Discrete Event Simulation

Jennifer HI. Lather, Assistant Professor, University of Nebraska-Lincoln, Omaha, NE, United States, Yasaman Ahmadi

The pandemic highlighted resourced strained healthcare systems and designs. In this paper, we discuss implications for changes of an ED which underwent a renovation and process flow changes to alleviate demand increases prior to the pandemic and present feedback from 30 ED doctors, nurses, and technicians on the recent ED redesign and workflow changes, pre-and-post- pandemic, to understand the impact of the design and process changes in the context of the changing processes associated with the pandemic. We present implementation of these process changes into ED's redesign simulations to evaluate performance.

3 - The Use of Connected Digital Products in Clinical Research Following the COVID-19 Pandemic: A Comprehensive Analysis of Clinical Trials

Caroline Marra, PhD Candidate, Harvard Business School, Boston, MA, United States, William J. Gordon, Ariel D. Stern

In an effort to mitigate COVID-19 related challenges for medical research, the FDA issued guidance encouraging virtual clinical trials in March 2020. We document trends in the use of connected digital products (CDPs), tools that enable remote patient monitoring and telehealth, by applying a comprehensive search algorithm to trial registry data. CDP usage increased by only 1.7 percentage points, from 14.1% (n=23,473) of trials started in the ten months before COVID-19 onset to 15.8% (n=26,009) of trials started post-onset ($p<0.01$). Trials for COVID-19 drove the increase, suggesting that new options to stimulate use of connected technology have yet to be widely incorporated into clinical research.

■ FA10

Virtual Room 10

Causal Inference and Causal Inference and Machine Learning

Contributed Session

Chair: TI Tongil Kim, University of Texas at Dallas, Richardson, TX, 30322-1059, United States

1 - Pricing the Cost of Algorithmic Risk for Medical Malpractice
Agni Orfanoudaki, Massachusetts Institute of Technology, Cambridge, MA, United States, Dimitris Bertsimas

As machine learning algorithms start to get integrated into the decision-making process of healthcare organizations, insurance products will be developed to protect their owners from risk. We introduce a quantitative framework for insurance companies, machine learning modelers, and healthcare practitioners in order to price the risk of these products. Using properties of the model, such as discrimination performance, interpretability, generalizability, and robustness, we provide mathematical formulations for its financial evaluation. We present a case study of medical malpractice in the context of breast cancer detection where we estimate the risk exposure of a binary classifier.

2 - Efficacy of Early Extubation of Mechanical Ventilation After Cardiac Surgery: Multi-institutional Study
Hyejin Cho, PhD Student, Purdue University, West Lafayette, IN, United States

The decision of when to remove mechanical ventilation from patients after cardiac surgery plays a critical role in the length of stay and mortality. A generalized regression model is developed to identify the risk factors related to mechanical ventilation. In addition, the efficacy of early extubation was investigated through the propensity score matching when we have unbalanced data. Data was synthesized from the original observations of 30,714 patients under 18 years old from 13 multi-institutions across the country who underwent cardiovascular surgery. This study might be used together to better evaluate the center performance.

3 - Can the U.S. Healthcare Physician Ownership Change Affect Pharmaceutical Prescriptions?
Taewook Lim, University of Texas, Dallas, Dallas, TX, United States, Tongil "Ti" Kim

The US healthcare physician market is experiencing a major transformation as hospitals have acquired individual physicians at an unprecedented rate. We examine Medicare prescription data in Minnesota and Wisconsin over 4 years to answer how hospital acquisition influences physician's prescription behavior. Using the differing Medicaid expansion as an instrumental variable, we find that acquired physicians increase the number of prescriptions per beneficiary post acquisition. We observe greater effects among female and physicians with higher average patient volumes. The effect diminishes if the acquiring hospital is teaching hospital or has a stronger drug monitoring policy.

■ FA11

Virtual Room 11

Health Analytics and Contemporary Issues in Health Care

General Session

Chair: Min Chen, Florida International University, Weston, FL, 33331, United States

Co-Chair: Xuan Tan, Florida International University, Weston, FL, 33331, United States

1 - Learning From Mistakes: (How) Did Nursing Homes Improve their Response across Different Waves of COVID-19 Infections
Niam Yaraghi, University of Miami, Miami, FL, United States, Ram Goapl, Xu Han

Nursing homes' residents and staff constitute the largest proportion of the fatalities associated with COVID-19 epidemic. In this research we examine how nursing homes in California changed their response to COVID-19 as the pandemic progressed through three different waves. We show that performance improvements happened and that such improvements were associated with organizational factors and managerial decisions.

2 - Deep Significance Clustering: A Novel Approach for Automated, Fair, and Predictive of Risk-stratified and Predictive Subphenotypes
Yiye Zhang, Weill Cornell Medicine, New York, NY, 10065, United States

Deep significance clustering (DICE) is a self-supervised learning framework to identify risk-stratified and predictive subphenotypes of patients using electronic health records (EHRs). Enabled by an optimization process which enforces statistical significance between the outcome and subphenotype membership, DICE jointly trains three components, representation learning, clustering, and outcome prediction while providing interpretability to the deep representations. DICE also allows unseen patients to be predicted into trained subphenotypes for population-level risk stratification. We evaluated DICE using EHR datasets derived from two urban hospitals. DICE demonstrated superior performance in the cluster purity and prediction metrics. Clinical evaluation of DICE-generated subphenotypes revealed meaningful distributions of member characteristics across subphenotypes, and higher risk ratios between subphenotypes. Furthermore, DICE-generated subphenotype membership alone was moderately predictive of outcomes.

3 - Repairing the Digital Divide Can Increase the Service Divide: The Effects of Patient Portals on Kidney Allocation
Srinivasan Raghunathan, University of Texas - Dallas, Information Systems, Richardson, TX, 75080-3021, United States, Yeongin Kim, Mehmet U.S. Ayvaci, Bekir Tanriover

An uneven diffusion of IT across individuals at different socioeconomic levels could lead to a disparity in the value that it offers, which is referred to as the digital divide. Recent policy efforts and wider adoption have decreased the digital divide in health IT, particularly around patient portals. However, whether the adoption of patient portals improved the allocation process and reduced the service divide in the kidney transplant context is not yet fully understood. Our study shows that a patient access to portals can reduce the time to receiving a kidney transplant, therefore positively contributing to the reduction of an important inefficiency. However, the impact varies on sub-populations based on the education level of patients, some clinical indicators, age, and geographical location. The finding suggests that the efforts to bridge the digital divide may benefit some patient groups at the expense of other groups, leading to further disparities in the care service.

4 - A Combined Clustering and Multilevel Modeling Approach to Explore the Association between Nutrition and Growth for Very Low Birth Weight Infants
Irem Sengul Orgut, University of Alabama, Tuscaloosa, AL, 35406-3105, United States, Karen Smilowitz, Gustave Falciglia

Understanding the relationship between nutrition and growth for very low birth weight (birth weight < 1500 g) infants is critical for optimizing nutrition delivery. Using clustering techniques, we identify population sub-groups based on infant characteristics and comorbidities and study the association between nutrition and growth for these sub-groups. We perform analysis of existing health records from 115 infants at Lurie's Children Hospital in Chicago, IL. We find that infants separated into two distinct clusters show different associations between calorie and protein intake and growth.

■ FA12

Virtual Room 12

Healthcare Logistics and Supply Chain

Contributed Session

Chair: Srinivasa Prasanna, IIIT-Bangalore, Opposite Infos, Bangalore, 560100, India

1 - A Data-driven Digital Application to Support the Capacity Planning of the COVID-19 Vaccination Process
Tara Zver, Vrije Universiteit Amsterdam, Amsterdam, Netherlands, Renze Dijkstra, Daan Otto, Berend Markhorst, Nina Malbasic

In this session, an advanced decision support system (DSS) is presented, which supports the decision-making of the capacity planning of the Dutch COVID-19 vaccination process. The DSS aims to minimize the per-class waiting-time for the locations of the medical hubs and the distribution of available vaccines and healthcare professionals over the medical hubs over time. As the user is given the freedom to experiment with different starting positions and strategies, the DSS is ideally suited to support the dynamic environment of the COVID-19 vaccination process. Based on the DSS, a practical approach is currently being developed that might be implemented nationally.

2 - Capacitated Facility Location-Allocation Model for COVID-19 Vaccine Distribution to Developing Countries
Bonn Kleiford Seranilla, University of Luxembourg, Luxembourg City, Luxembourg, Glenn Paclijan, Ingrid Yvonne Madrial, Lucky John Tutor, Marcjie Klimenc Templa

We present a specialised capacitated facility location-allocation model for the COVID-19 vaccine distribution. The model determines optimal facility locations where the COVID-19 vaccination rollout should take place from a roster of candidate locations. When a location is chosen, the model also provides the optimal number of vaccine administrators - doctors, nurses, etc - and the optimal allocation of the population to be vaccinated. The optimal solution may assist local government units (LGUs) for their decision-making strategies in order to minimise overall costs, especially for cities in rural areas. A numerical experiment is carried out using the data from a city in the Philippines.

3 - The Impact of Integrated Supply Chain Management on Patients Focus

Esam Mustafa, Athabasca University, Athabasca, AB, Canada

This study explores the impact of integrated supply chain management on patients-focus care in healthcare organizations. Data of a sample of 150 healthcare specialists from 15 different healthcare organizations were collected using questionnaires and analyzed using Structural Equation Modeling. The findings indicate that integrated supply chain management has strong impact on patients-focus care. These findings will help managers in healthcare organizations to enhance their supply chain management to improve their patients-focus service.

4 - High Speed Delivery of Vaccines and Other Medications in COVID-19 Pandemic in India

Srinivasa Prasanna, Professor, IIIT-Bangalore, Bangalore, India, Abhilasha Aswal, Anushka Babu, Sunil K. Vuppala

The COVID-19 Pandemic poses worldwide challenges. In developing economies like India, it is a great challenge to treat, socially distance, and vaccinate a significant section of the population. Many areas are hard to reach, and vaccines and other medications have a very short shelf life unless deeply refrigerated.In this talk we describe a drone based system, which conveys vaccines and other medications from a central hub, to remote locations, at high speed, cost effectively. We describe the system structure (hardware and software), the operations, and lessons learnt from an initial rollout.The lessons learnt would be useful in scaling such a service nationwide, serving 100's of millions of people.

■ FA13

Virtual Room 13

Analytical Approaches to Improve Mental Care Delivery

General Session

Chair: Martin Cousineau, HEC Montréal, Montréal, QC, Canada

1 - Unveiling Clinical Notes in an Outpatient Psychiatry Clinic Through Text Mining

Fan E, McGill University, Montréal, QC, H2W. 1L8, Canada, Angelos Georghiou, Vedat Verter, Daniel Frank

Psychiatric clinical notes are medical and eloquent, with both professional judgements and personal touches. To understand clinical notes involves parsing through meanings between words. Our research uncovers indicators, previously hidden in the abundance of words, correlated with hospitalization risks by text-mining tens of thousands of psychiatric notes. We will also demonstrate the benefit of our text analysis on the overall mental care cost through simulation.

2 - Heeding the Early Warnings: The Revolving Door Problem of Psychiatric Patients

Hossein Hejazian, McGill University, Montréal, QC, Canada, Beste Kucukyazici, Javad Nasiry, Vedat Verter, Daniel Frank

Readmitting recently-discharged psychiatric patients (the "revolving door problem") leads to adverse patient health outcomes and inefficient use of hospital resources. We study this phenomenon using a dataset from 28 hospitals in Quebec, Canada. We focus on inpatient length-of-stay (LOS) as a key factor and show that disaggregating the data at the diagnosis level yields more homogeneous samples and explains the mixed results in the literature on the effect of LOS on readmission risk.

3 - A Prototype for the Recommendation of Treatment-resistant Depression Treatments

Martin Cousineau, Assistant Professor, HEC Montréal, Montréal, QC, H3T. 2A7, Canada, Laurent Charlin, Vedat Verter

This work consists in a prototype for the personalized recommendations of treatment-resistant depression treatments using recommender systems. After characterizing the dataset, we explore in this work the performance of a factorization machine with two different treatment definitions as well as different variables describing the patients and treatments.

Friday, 12:40PM - 2:10PM

■ FB01

Virtual Room 01

Healthcare Informatics I

Contributed Session

Chair: Rakesh Ravi, North Carolina State University, Raleigh, NC

1 - Does Defining Medical Jargon in a Community Hospital Setting Improve Comprehension?

John Patrick Lalor, University of Notre Dame, Notre Dame, IN, United States, Wen Hu, Matthew Tran, Hao Wu, Kathleen Mazor, Hong Yu, Hong Yu

We assess an intervention for automatically defining medical jargon (NoteAid) on EHR note comprehension for participants in a hospital setting. Participants were recruited from a hospital in Massachusetts to take the ComprehENotes test of EHR note comprehension with or without NoteAid. For comparison, we recruited participants from AMT. Participants in both intervention groups (community hospital and AMT) scored significantly higher than participants in the control groups ($P < .001$). Average score for hospital participants was significantly lower than the average score for the AMT participants ($P < .001$). Education had a significant effect on scores for the hospital participants ($P < .001$).

2 - Green Vaccination Supply Chains: An Environment-protection Model and Application in Pharmaceutical Industry

Ilya Levner, PhD Student, Bar Ilan University, Ramat Gan, Israel, Avi Herbon

The objective is to minimize the total seasonal cost of all vaccine distribution in a centralized DC and its corresponding clinics using clean technologies under resource and environment protection constraints. We present an application of HMO Clalit which demonstrates the efficiency and applicability of the suggested model. Computerized runs have confirmed the essential positive effect of the environment protection activities.

3 - Big Data System to Identify Emerging Trends on COVID-19 from Multiple Data Sources

Rakesh Ravi, Research Assistant Professor, North Carolina State University, Raleigh, NC, United States

New data on COVID-19 is becoming available at an unprecedented rate and from multiple channels. Public health stakeholders rely on these diverse sources of information, e.g., medical journals and the news, to make decisions that affect people's lives. Our parallel processing full stack system consists of Natural Language Processing and topic modeling modules that parse the data streams from diverse sources, including PubMed, LexisNexis, and Twitter, every two weeks to identify emerging topics and trends. The resulting structured data powers an interactive web application that contains dashboards and customizable views allowing stakeholders to make informed decisions.

■ FB02

Virtual Room 02

Deep Learning, Epidemic Intelligence and COVID-19

General Session

Chair: Eman Leung, The Chinese University of Hong Kong, Hong Kong

1 - A Protocol for Building Epidemic Intelligence: An AI-driven Simulation Model on Acute and Postacute Service Utilizations in Response to COVID-19 Outbreaks in HK

Yuchen Wei, City University of Hong Kong, Hong Kong, China, Eman Leung, Marc Cheong, C. T. Hung, E. K. Yeoh

Syndromic surveillance has been the essential tool for managing epidemics with the detection of outbreaks in their early stages, the monitoring of the size, spread, tempo and trend of outbreaks, and the provision of reassurance that an outbreak has not occurred. WHO (2014) has set the benchmark modes of epidemic surveillance and the corresponding response as informed by different modes of surveillance. In the past decade, surveillance has expanded beyond tracking diseases and has started tapping into publicly available data on the internet in the form of infoveillance or infodemiology (Johnson et al. 2004; Eysenbach, 2006; Spruit & Lytras, 2018; Samaras, Garcıa-Barriocanal and Sicilia, 2020). However, little has been done to align WHO's benchmark of an epidemic response system

with the recently expanded data source for epidemiology. Nor any attention was paid to how different sources of information that exist in silos due to technical, legal or bureaucratic reasons be integrated and/or triangulated to inform epidemic response. The objective of the current study is to demonstrate with actual data from electronic health records and data available in the public domain that transfer learning algorithm can be used to triangulate different data sources that exist in silo to inform the response of systemwide capacity planning and resource allocation with a machine-learning driven simulation model. The results of the current study can inform the development of an epidemic intelligence system whose objective is to response to any potential demand surge associated with the pandemic by adjusting the capacity, resource allocation and buffering of the healthcare system.

2 - Risk-scoring Residential Buildings for Poor General Health and COVID-19 Susceptibility

Jingjing Guan, City University of Hong Kong, Tat Chee Avenue, Kowloon Tong, Hong Kong, Eman Leung, Albert Lee, Hendrik Tieben

The current study applies deep learning algorithms to identify risk factors that contribute to poor general health, and the order of their contributions, using health needs assessment data collected from residents of the public housing estate in one HK district before the SARS pandemic and the concurrent data on the built environment of their residence. The analysis revealed that different elements of ones' built environment, as well as their configurations, were not only associated with the residents' general health before SARS, but is also predictive of the number of confirmed COVID cases in the buildings. The finding of the current study can inform: compulsory testing and quarantine decisions, location of HK community-oriented primary care and urban planning and development policies.

3 - Effects of Ambulatory Sensitive and Chronic Conditions, Mental Health, Social Determinants of Health, and the Built Environment on Individual Susceptibility to COVID-19

Eman Leung, City University of Hong Kong, Hong Kong, China, JingJing Guan, Sam Ching, Olivia Lam, Shirley Tong

Much attention has been paid to the transmission rate of COVID-19 and how different public settings affected the social transmission. Research has also examined how individuals' pre-existing condition such as ambulatory sensitive or chronic conditions affect one susceptibility to COVID-19. However, the contextual factors and the individual factors do not exit in vacuum. Nor do they exit independently from the one's built environments or the social determinants of health that exist in one social ecology. The current study applied deep learning algorithms to examine the interactions among factors from different levels of one's social ecology (for example between one's chronic disease status and his/her built environment) selected in accordance with their contribution to COVID outcome. Findings from the current study may inform the design of multi-component primary care interventions.

4 - How COVID-19 Affects Social Service Provision, Service Demand and Client Outcome in HK: Data-driven Optimization and Machine Learning-driven Simulation

Penny Siu, City University of Hong Kong, Hong Kong, China, Sammy Ngai, Dennis Lee, Eman Leung, Angel Chan

While HK's medical and social services are bureaucratically and informationally siloed, the frequent hospitalizations that are expected of the vulnerable population are mitigated by social services that meet its hygienic, instrumental and restorative needs. However, COVID-19 disrupted the service provision of the social service sector, even though the needs for hygienic, instrumental and restorative services continues to grow as a function of population aging. The current study applies deep learning algorithms to identify factors responsible for the growing demands of different types of social services and the effect of COVID-induced service disruption on patients' demands of service and their outcome, and constructs a machine learning-driven simulation model for understanding the underlying dynamic among the capacity, supply, demands and outcomes of the social service system studied. Results of the current study can inform the capacity planning of social services and policy development of the social service sector.

5 - A Protocol for Mitigating the Impact of COVID-19 and Other Communicable Diseases in Educational Setting to Enable a Safe Learning Environment for Students with AI

Albert Lee, City University of Hong Kong, Hong Kong, China, Eman Leung, Lancelot W. Mui

Evidence has shown reduced transmission potential both from and to individuals under age 20 in the household context but very limited data exploring transmission patterns in schools. Health promotion can make a difference to school health practice and student behaviours There is a strong need to conduct further research to enable schools going back to normal. Here we propose to apply deep learning algorithm to develop a school framework for precautionary measures on COVID-19 and tools assessing risk perceptions, health literacy on infection control and precautionary behaviours, and analysis of their correlations as school-based quality improvement cycle for infection control.

■ FB03

Virtual Room 03

Data Mining Applications

General Session

Chair: Michael W Carter, University of Toronto, Toronto, ON, M5S 3G8, Canada

1 - Creating a Generic Emergency Department Discrete Event Simulation Model

Evgueniia (Jenya) Doudareva, PhD Student, University of Toronto, Toronto, ON, M5S. 3G8, Canada, Michael Carter

Problems in the Emergency Department (ED), such as prolonged length of stay (LOS) and resource allocation, are associated with increased patient morbidity and mortality. Our research focused on creating a novel generic discrete event simulation (DES) model for EDs that is flexible enough to be applied globally through inputs. While DES is an established approach for modeling ED settings, the literature on the development and use of generic ED DES models is limited. We developed a model that represents the flow of patients from the point of entry, through the ED's key actions, such as triage, physician assessment, ordering of tests, and consult, until the patient is either discharged or admitted. The model was tested and validated on seven Ontario sites, one Alberta site, two UK sites, and one US site. The validation results showcase that a flexible generic approach to ED DES modeling is possible, can be deployed rapidly, is customizable, and can produce meaningful insights into specific ED bottlenecks with accuracy comparable to single-site models.

2 - Applying Stochastic Programming for Nurse Workforce Planning at Inpatient Units and the Nurse Resource Team

Xiarui Xie, M.A. Sc., University of Toronto, Toronto, ON, M5S. 3G8, Canada, Michael W. Carter

Nurse workforce planning is complex due to varying patient census and unknown nurse availabilities. We propose an analytical tool to assist hospitals to maintain an adequate nurse workforce while effectively utilize nursing budgets for a medium-term planning horizon. We apply time series models to predict nurse turnover and retirement, then develop a two-stage stochastic programming model to minimize total expected labor cost. Optimal hiring decisions are generated with uncertain patient census and nurse absenteeism. We compare the results of the model with heuristic nurse staffing methods, and showcase the potential saving. Sensitivity tests are conducted to generate managerial insights.

3 - A Data Driven Inpatient Bed Demand Forecasting Model for Exploring Surge Mitigation Strategies

Ji Min Kim, University of Toronto, Toronto, ON, Canada, Michael W. Carter, Tammi Hawa, Michael Caesar, Andre D'Penha, Brenda Kenefick, Fayez Quereshy

Healthcare expenditure has increased over the past few years due to aging populations, increased ambulatory costs, and most recently the global pandemic induced by the COVID-19 disease. While resources are bound by physical and budgetary constraints, hospitals have frequently experienced medical surges, where their programs are near or at full capacity. Hospitals have adopted strategies to mitigate such a surge, however, the optimality of these decisions is currently unknown. This study proposes a data-driven inpatient bed demand simulation model that enables the exploration of surge mitigation strategies based on the forecasted bed demand in the upcoming week at each program level.

4 - A Data-driven Optimized Patient Appointments Scheduling Model for CT Simulation and Radiation Treatment

Fan Jia, M.A.Sc., University of Toronto, Toronto, ON, Canada, Michael W. Carter

Timely radiation treatment is important for cancer patients' oncological results. A data-driven approach is used to optimize the patient scheduling process. Using data from 2010 to 2020 of a large Canadian cancer center, patient arrival patterns are predicted using time series analysis to optimally allocate patients to different machines and reserve slots for urgent patients. Pre-treatment durations are estimated using machine learning algorithms. A Mixed Integer Programming model is developed to minimize the number of patients exceeding the target treatment wait time of 14 days. The output appointment schedule is evaluated with patient wait time statistics and machine utilization rate.

5 - Modeling Supply of General Internists in Ontario

Pooja Bhalerao, University of Toronto, Toronto, ON, Canada, Michael W. Carter

With increasing population and fast-growing senior age group, need for internists is increasing in Ontario. Predicting future talents is an essential part of planning for the workforce. We have developed a system dynamics model to predict the supply of internists. The objective is to enable simulation of various 'what-if' scenarios. The model could be a powerful tool in supply-demand planning.
Keywords: planning for workforce, internists, system dynamics, supply-demand planning

■ FB04

Virtual Room 04

Genetics, Personalization and Data-driven Decision-making in Healthcare Operations

General Session

Chair: Kuang Xu, Stanford Graduate School of Business, Stanford, CA, 94305-7216, United States

Co-Chair: Mine Su Erturk, Stanford University, Stanford, CA, 94305-7181, United States

1 - Nursing Home Staff Networks and COVID-19

Elisa F Long, Associate Professor, UCLA, Los Angeles, CA, United States, Keith Chen, Judith Chevalier

Skilled nursing homes (SNFs) accounted for a disproportionate share of COVID-19 fatalities worldwide, with outbreaks persisting despite the March 2020 nationwide ban on visitors. Using device-level geolocation data for 50 million smartphones, we analyze SNF connections via shared staff and observe 500,000 individuals entering at least one SNF, with 5.1% entering two or more facilities. Nursing homes share connections with 7.1 other facilities, on average. Network measures of connectivity, including node degree, strength and Eigenvector centrality, are highly predictive of COVID-19 cases, whereas traditional regulatory quality metrics are unimportant in predicting outbreak size.

2 - Estimating Heterogeneous Treatment Effects with Modern Mixed Integer Programming Methods

Zilong Wang, Georgia Institute of Technology, Atlanta, GA, United States, Zhaowei She, Turgay Ayer, Shihao Yang

Classifications based on treatment effect heterogeneity has always been of great import in many fields such as personalized medicine, business intelligence, and policy making. State of the art techniques, such as causal trees or random forests, are either based on highly restrictive classifiers, e.g. axis-aligned cuts in tree based method, or too complex to interpret, e.g. soft classification in forest based method. In this work, we explore this problem through the lens of modern Mixed Integer Programming as a unifying framework and present our findings.

3 - An Inverse Optimization Approach to Measuring Clinical Pathway Concordance

Nasrin Yousefi, PhD Candidate, University of Toronto, Toronto, ON, Canada, Timothy Chan, Yusuf Shalaby, Maria Eberg, Katharina Forster, Claire Holloway, Luciano Ieraci

We quantify the concordance of patient-traversed pathways to the clinical pathways using a data-driven inverse optimization method. Our methodological approach considers a patient's journey as a walk in a directed graph, where the costs on the arcs are derived by solving a two-stage inverse shortest path problem. We apply our methodology to a real dataset of colon cancer patients and show that it has a statistically significant association with survival. Finally, we develop a rigorous framework to illustrate how our concordance measurement can be used to detect variations in health system performance or bottlenecks in the delivery of care.

4 - Sequential Genealogy Search for Genetic Privacy

Mine Su Erturk, Stanford University Graduate School of Business, Stanford, CA, 94305-7181, United States

Investigative genetic genealogy has emerged as a powerful technique to identify individuals by leveraging genetic information and genealogical networks. The current practice relies on a static data collection paradigm which has raised concerns regarding privacy. Inspired by these discussions, we introduce a framework to study privacy exposure in a graph search problem and study a trade-off between privacy and search costs. Our results show that a carefully designed sequential search procedure outperforms static data collection approaches in terms of the privacy vs. search cost trade-off. Moreover, we provide a characterization of the optimal trade-off and propose a family of policies that achieve this optimal trade-off. Finally, we validate our theoretical results via numerical experiments on both real genealogical networks and synthetic networks and discuss the policy implications of our results.

■ FB05

Virtual Room 05

Applications of Analytics for Army Medical Response and Delivery

General Session

Chair: Michael McShea, Health System Innovation Lead, Johns Hopkins Applied Physics Laboratory, Laurel, MD, United States

1 - The Future Combat Operating Environment and How Technology Can Assist in Maximizing Mission Success

Matthew Quinn, Telemedicine and Advanced Technology Research Center, Fort Detrick, MD, United States, Jeremy C. Pamplin

Peer competition on a future battlefield in a multi-domain operating environment will be different that wars previously fought. Computers and machines will change the nature of war making it faster and more lethal. Imagining how technology can support both medical care and warfighter optimization is necessary to successfully execute the military mission and manage both massive casualty numbers but also casualties in remote, resources limited environments from which evacuation is impossible or delayed. Winter is here and the arctic environment poses new challenges to overcome. This presentation will provide an overview of how to imagine this future operating environment and pose challenges for the research community to solve.

2 - Interoperability and Medical Automation for Future Military Operations

Jose Salinas, PhD, U.S. Army Institute of Surgical Research

Future military medical care will use state of the art technologies in clinical decision support, artificial intelligence, and automation to provide clinical personnel with the additional tools needed to optimize the care of combat casualties. These technologies will need to support many different battlefield environments from prehospital and austere environments to mass casualty situations requiring large amounts of resources. In order to develop these capabilities, the need for medical device interoperability standards and data commons will be key. This presentation will discuss various aspects of AI, automation, and medical standards to support future military medical capabilities.

3 - Assisting the Combat Medic – From Remotely Managed Therapeutics to Automated Medical Systems

Nathan Fisher, US. Army Futures Command, Medical Research and Development Command, Telemedicine and Advanced Technology Research Center, Fort Detrick, MD, United States

Future Army operating concepts imply challenges to the current model of casualty evacuation and field care, and thus new capabilities may be required. Current research efforts focus on systems designed to augment medical care capability and capacity by providing remote monitoring of patient vitals, remote control of life-supporting therapies, and telemedicine support and guidance to the local care providers. These next-gen systems will rely on remote human experts and will pave the way for fully automated systems by providing the necessary data for furthering development.

4 - Enabling Technologies for Autonomous Medical Systems

Michael McShea, Health System Innovation Lead, Johns Hopkins Applied Physics Laboratory, Laurel, MD, United States

Autonomous medical systems have a unique context in the growing field of autonomous systems. New concepts of assurance and trustworthiness are needed that take into account the complexity of patient conditions, the clinical process, and the demanding environments that the technology will be used, such as on the battlefield and in mass casualty situations. This talk will highlight emerging concepts in trustworthy AI, and advancements needed in system design and human machine teaming and integration to enable autonomous medical systems.

■ FB06

Virtual Room 06

Medical Decision Making 2

Contributed Session

Chair: Kellas Cameron, University of South Florida, Tampa, FL, 33602, United States

1 - Did England's Policies on Sepsis and Antibiotic Resistance Have Their Intended Effects?

Christos Oikonomou, INSEAD, Fontainebleau, France, Stephen E. Chick, Steve Harris, Edward Palmer, Mervyn Singer, Spyros Zoumpoulis

Sepsis is a life-threatening condition. The treatment guidelines of sepsis mandate immediate usage of antibiotics in suspected cases. However, the increase of antibiotic resistance has raised concerns regarding the appropriate usage of antibiotics. These concerns led to the design of policies in 2016 in England that target the potential excess usage of antibiotics in all levels of care. Using patient level data from intensive care units of several hospitals in England, we study the impact of such policies on the medical decisions on antibiotic treatment, health outcomes and hospital operations.

2 - Developing Personalized Diabetic Retinopathy Screening Recommendations

Poria Dorali, University of Houston - Cullen College of Engineering, Houston, TX, United States, Zahed Shahmoradi, Christina Weng, Taewoo Lee

Diabetic retinopathy (DR) is the leading cause of blindness among working-age Americans. While timely screenings can help prevent up to 98% of DR-related vision loss, currently only 30-60% of the patients are screened on a yearly basis due to high cost and inconvenience. Teleretinal imaging (TRI) is emerging as an affordable screening tool that has the potential to increase screening rate, yet there are questions as to how it can be implemented to maximize clinical benefit and patient adherence. We develop a POMDP model that determines patient-specific optimal screening policies that takes into account health and cost savings preferences as well as compliance behavior.

3 - Partially Observable Markov Decision Process for Diabetes Management with Blood Glucose Missing Data

Jiao Xiang, Chongqing University of Posts and Telecommunications, Chongqing, China, Haiyan Yu

The incompleteness of blood glucose data in patients with diabetes seriously affects the accuracy of decision-making on injecting insulin. This paper proposes a model of partially observable Markov decision process (POMDP) with missing data, which aids patients with diabetes for blood glucose management. For the missing at random data, the Metropolis-Hastings algorithm is adapted to impute the incompatibleness. Then the `complete' data is substituted into the POMDP model to obtain the optimal solution (action). The efficacy of this method is verified through simulation and real-world case studies.

4 - Reducing Unexpected Readmission: Utilizing Data-driven Decision Support Systems to Identify Patient-specific Readmission Prevention Strategies

Kellas Cameron, Assistant Professor, University of South Florida, Tampa, FL, United States

Physicians have difficulty accurately identifying which patients are most likely to be readmitted within 30 days, and thus, in the United States, the readmission rate for chronic disease patients remains over 20%. Data-driven decision support systems can provide physicians an additional tool to identify high-risk patient types. This work develops a statistical model to utilize patient-specific information to not only more accurately identify the patients most likely to be readmitted, but also the reasons for this increased risk - whether for condition-related or socio-economic reasons. This allows physicians to suggest patient-specific readmission prevention strategies.

■ FB07

Virtual Room 07

Healthcare Quality and Safety 1

Contributed Session

Chair: Veda Sripada, Stony Brook University, New York, United States

1 - Building in Sustainability to an "Opt-out" Tobacco Treatment Referral Workflow at Mayo Clinic Cancer Center

Dawn Beighley, Principal Health Systems Engineer, Mayo Clinic - Rochester, Rochester, MN, United States

Cessation among cancer patients who smoke improves treatment outcomes, yet few patients are referred to and even fewer complete tobacco treatment. As part of the NCI Cancer Moonshot program, we designed an "opt-out" referral system that automatically refers patients who smoke to a tobacco treatment specialist. However, we found that most of these patients did not schedule or complete their appointment. Our objective was to learn why these automatically referred patients did not schedule nor complete a consultative visit with the Tobacco Treatment Specialist (TTS) and improve our referral process with targeted interventions.

2 - Using DEA to Reduce Hospital-acquired Infections

Veda Sripada, Student, Stony Brook University, Stony Brook, NY, United States, Herbert F. Lewis, Christine Pitocco

We propose a novel implementation of DEA to measure hospital efficiency in terms of HAIs. Our study focuses on four major categories of HAIs in New York State, which are major financial and patient safety threats to the hospital industry. Using DEA allows for efficiency measurement simultaneously across all infection categories as well as observation of individual infections.

3 - Does Health Information Exchange Improve Long-term Care Service Quality? Evidence from the Panel Data Analysis of the U.S. Long-term Care Facilities

Fang Wan, University of Rochester, Rochester, NY, United States Huiwen Xu, Avi Seidmann

We study the impact of HIE on the service quality of long-term care (LTC) facilities based on a five-year period (2013-2017) panel data of the U.S. LTC facilities. Our results show a reverse impact of the HIE adoption on the readmission rate of LTC facilities. The readmission rate of a LTC facility with an operational HIE is reduced by 6% on average as compared to the rate of a facility without operational HIE. We also find that the integration of HIE and Telemedicine further lowers the readmission rate. Our findings empirically demonstrate the importance of promoting effective data exchange in LTC facilities and identify the conditions of using IT integration to modify the value that HIE creates.

■ FB08

Virtual Room 08

Health Care Operations 3

Contributed Session

Chair: Jennifer L. Mendoza-Alonzo, University of South Florida, Tampa, FL, 33617-2112, United States

1 - A Bi-linear Knapsack Model for Optimal Resource Allocation in the Deployment of Mobile Health Clinics

Ang Li, University of Houston, Houston, TX, United States, Jiming Peng

Resource allocation plays an important role in the operational management for healthcare service providers under limited resource. We consider the issue of maximizing the coverage of the immunization in vulnerable communities by delivering vaccines via mobile health clinics. In order to address the challenge of overlapped demand coverage, we introduce a novel bi-linear knapsack problem (BLKP). BLKP is a special case of the quadratic knapsack problem (QKP) which is known to be NP-hard. We propose an alternative update scheme (AUS) and show that the new AUS runs in polynomial time and provides a constant approximation to the original BLKP. Incorporated local search heuristics improves the solution.

2 - Analysis of Multi-registry Kidney Exchange Programs with Individual Rationality Constraints

Utkarsh Verma, Indian Institute of Technology, Bombay, Mumbai, India, Narayan Rangaraj

Kidney exchange programs have been developed to overcome the compatibility challenges for the patient with incompatible donors in kidney transplantation. A registry of such incompatible donor-recipient pairs is created, and compatibility is achieved through the exchange of donors. Single-center kidney exchange registries may not have a significant pool size for achieving the full benefits of the kidney exchange program. Thus multi-registry exchange transplants seem to be a natural way forward. In this paper, an Integer Programming model for a multi-registry exchange program has been proposed with individual rationality constraints for each registry.

3 - Optimization in Assistive Technology Programs: Case Study Banc De Moviments in Barcelona

Helena Ramalhinho Lourenco, Full Professor, Universitat Pompeu Fabra, Barcelona, Spain, Jesica de Armas, Jessica Rodriguez-Pereira, Bruno Vieira

The ageing population worldwide is rising and, as their autonomy tends to decrease, they will need support to perform their daily activities in a joyful and independent way. Assistive Technology (AT) programs aim to collect donated products, store them, and make them accessible to this population. In this work, we analyze the AT operations, based on Circular Economy perspective, and develop mathematical based tools to help managers to make better decisions. These tools support decisions on location, inventory, and routing problems and are used by a social program in Barcelona, Spain.

4 - Controllable and Non-controllable Factors to Measure Performance in Primary Care Practices Under Medicare Alternative Payment Models

Jennifer L. Mendoza-Alonzo, University of South Florida, Tampa, FL, United States, José Zayas-Castro, Armin Lüer-Villagra

We analyze the comprehensive primary care plus (CPC+) and primary care first (PCF) that comprise fee-for-service, traditional capitation, and pay-for-performance (P4P) components. The issue is that the P4P considers factors not controlled by the practice. We modify the P4P to include controllable and non-controllable variables using a probabilistic classification model. We develop mixed-integer programming and a 2k factorial design to conclude. As a result, the regression coefficients and the hospital admission threshold have a significant effect on the profit and revenue. They are more notable in the PCF. The PCF's downside is that it displays high variability in the output variables.

■ FB10

Virtual Room 10

eHealth and Telemedicine I

Contributed Session

Chair: Grace Trinidad, University of Michigan Medical School, Ann Arbor, MI, United States

1 - Consumption Variety in Food Recommendation

Nathan Yang, Assistant Professor in Marketing, Cornell University, Ithaca, NY, United States

Our study makes use of data from a popular mobile fitness app, with large volumes of daily food logs of thousands of users. We first confirm that consumption variety is associated with potential health benefits, such as lower overall calories consumed, higher vegetable consumption, and lower snack consumption. In light of these suggestive health benefits from consumption variety, we seek out to design a novel multi-criteria food recommendation system (FOODVAR) that can accommodate for variety in recommended foods, which we show can improve the algorithm's evaluation metrics.

2 - The More Complex the More Inefficient: Evidence from Online Health Knowledge Sharing Platform Incentive Mechanism

Yuanyuan Dang, South China University of Technology, Guangzhou, China

How to incentive a physician to contribute online is quite an important issue for the platform. We conduct a natural experiment and find that(1) material incentives can positively promote doctors' knowledge contribution behavior; (2) the role of single task incentives in the field of online health science popularization platform to promote doctors' knowledge contribution behavior routine (3)) Material incentives with different levels of complexity have different degrees of promoting the knowledge contribution behavior of doctors with different professional titles, and their promotion effect on doctors with middle and low professional titles is more significant.

3 - Desire for Control Over Data and the Public's Comfort with Sharing Health Data with Third-party Commercial Companies

M. Grace Trinidad, University of Michigan Medical School, Ann Arbor, MI, United States, Jodyn Platt, Sharon Kardia

Healthcare partnerships with third-party commercial companies have been met with reservations from the public about how the data is used. We surveyed the US public (n = 1841) to learn more about comfort with sharing health data with third-party commercial companies and desire for control over data use. Weighted OLS and stepwise regression modeling were used to estimate contributing factors to the public's comfort. Most strongly associated are: trust in the health system, confidence in existing laws, and desire for notification. These results suggest that increasing trust in the health system may have a greater impact on the public's comfort than efforts to address privacy concerns alone.

■ FB11

Virtual Room 11

Public Health Operations Research

Contributed Session

Chair: J. J. Van De Klundert, United States

1 - Strategic Location of Citizen Responder System Defibrillators

Robin Buter, University of Twente, Enschede, Netherlands, Derya Demirtas, Erwin Hans, Hendrik Koffijberg, Johann Hurink, Arthur Nazarian

Automated external defibrillators (AEDs) are placed in public to decrease response time and increase survival rate from out of hospital cardiac arrest (OHCA). Volunteers are alerted by a citizen responder system and are asked to retrieve a nearby AED. However, many AEDs are barely used due to poor location choices. We develop an algorithm that creates candidate AED locations and chooses near-optimal locations for new AEDs. Large instances can be solved since locations are created dynamically, keeping the problem size manageable while being able to evaluate a very granular set of locations. We apply this methodology to a case study from the Netherlands and show that coverage of OHCAs can improve by 25%.

2 - Developing a Hybrid Simulation for Public Health in Brazil: Modelling the Impact of Telehealth in Primary Care

Vivianne Horsti dos Santos, PhD Student, University of Kent, Canterbury, United Kingdom, Kathy Kotiadis, Maria Paola Scaparra

Ageing population increases the demand for primary care and long-term care and requires adequacies on social systems, such as healthcare systems. One possible solution to tackle the increase in demand for primary care is the implementation of telehealth. In this sense, this research aims to use hybrid simulation to evaluate the impacts of teleconsultation on delivering of primary care service offered by public health in a southern region of Sao Paulo city, Brazil. The model supports decision-making around implementing telehealth in public health in Brazil and evaluating a new healthcare delivery impact on patient access to care.

3 - Eliminating Racial Waiting Time Disparity for Deceased Kidney Donation in the USA

J. J. Van de Klundert, Professor, Prince Mohammad bin Salman School of Business & Entrepreneurship, KAEC, Saudi Arabia

Inequities in deceased donor organ transplantation waiting times have received considerable attention and motivated allocation policy reforms in many countries. There are 90.000 patients on the wait list for kidney transplantation in the United States, with waiting times varying considerably among patients from different blood types and ethnicities. We present new models to analyze and maximize equity of transplant waiting times and probabilities using queuing theory, network flow models, and Rawls' theory of justice. We formally establish how policies as currently practiced, which use blood type incompatible donation can resolve the otherwise persistent inequalities and inequities.

Friday, 2:20PM - 3:50PM

■ FC01

Virtual Room 01

Healthcare Informatics II

Contributed Session

Chair: Haiyan Yu, Chongqing University of Posts and Telecommunications, School of Economics and Management, Chong qing Uni, Chongqing, 40065, China

1 - A New Algorithm for Convex Biclustering and its Extension to the Compositional Data

Binhuan Wang, Assistant Professor, NYU. School of Medicine, New York, NY, United States, Lanqiu Yao, Jiyuan Hu, Huilin Li

Biclustering allows simultaneously clustering rows and columns in a matrix-format data set, providing results in a checkerboard-like pattern for visualization and exploratory analysis. Multiple biclustering algorithms have been developed in the past two decades, while the application of biclustering has not progressed in parallel with the algorithm techniques, e.g., biclustering for increasingly popular microbiome research data is under-applied due to compositional constraints. We propose a new convex biclustering algorithm based on the ADMM algorithm, and we tailor it to the algorithm specifically to tackle compositional constraints confronted in microbiome data.

2 - The Role of Patient Travel Tolerance in Defining a Urology Practice's Medicare Market in Alabama for the Surgical Treatment of Prostate Cancer

Bunyamin Ozaydin, Assistant Professor, University of Alabama Birmingham, Birmingham, AL, United States, Peyton Hulgan, Curtis Spraitzar

This study defined the Urology Centers of Alabama (UCA) market with respect to Medicare beneficiaries in Alabama who have been diagnosed with prostate cancer and received a radical prostatectomy to meet the urological needs of this rapidly growing patient population. A market analysis was conducted using CMS-1500 to determine how UCA is operating within its defined market. The data set included 342 Medicare beneficiaries from Alabama and received a radical prostatectomy between January 1, 2019 to July 31, 2019. The study revealed UCA holds a large percentage of market share in Alabama, and Medicare beneficiaries residing in Alabama are willing to travel longer distances for a radical prostatectomy.

3 - Evidence Based Practice
Coleen R. Wilder, Associate Professor, Valparaiso University, Valparaiso, IN, United States, Cristina Ritzema, Gail Dunleavy

It is important to understand how evidence-based practice (EVP) is understood and adopted by the nursing community. This study will assess nurses' beliefs and confidence in implementing EVP, their level of use, and identify cultural factors that may impact implementation. The study concerns a Magnet-recognized hospital. The findings will be used to identify strengths and opportunities to best support EBP.

4 - Constrained Optimization for Stratified Treatment Rules
Haiyan Yu, Chongqing University of Posts and Telecommunications, Chongqing, China, Ping Yu

The constrained optimization model of the proposed method is formulated by maximizing the treatment response while minimizing the sample weight divergence because the weight divergence influences the robustness of the treatment regimen with covariate balance constraints. The method obtains the optimal solution of sample weights that take account of both covariate and the adaptive feature. Thus, the solution guarantees the consistency of the estimation of treatment response. To configure the parameters, we implement the nested uniform designs to reduce the number of trials for searching the intermediate variables on weight regularization and the trade-off between optimality and robustness.

■ FC04

Virtual Room 04

Empirical Studies of Worker Discretion

General Session

Chair: Maria R. Ibanez, Kellogg School of Management at Northwestern University, Evanston, IL, 60208-0898, United States

1 - Effects of Medical Cannabis Legalization on Emergency Department Operations: Evidence from New Jersey
Maksim Yakovlev, PhD Student, Northwestern Kellogg, Evanston, IL, United States, Maria Ibanez

Since 2012, when Colorado and Washington emerged as the first US states to legalize recreational cannabis sales to the public, MCL and RCL laws have recently been passed in many more states. In our work, we investigate the effect of MCL (medical cannabis legalization) on ED operations. We primarily focus on examining unit/physician learning of treatment methods for cannabis-related cases and shifts in racial disparity in the quality of medical care. We use a comprehensive dataset from the Healthcare Cost and Utilization Project (HCUP) spanning from 2008 to 2014. For our analysis, we rely on the passage of MCL in New Jersey as an experimental setup and apply IV and difference-in-differences approaches.

2 - Telemedicine Follow-up and Hospital Operations
Shujing Sun, University of Texas at Dallas, Rochester, NY, 14623-1226, United States, Wei Gu, Meng Li

Telemedicine has started to revolutionize the healthcare service. In this paper, we study the impact of telemedicine on healthcare operations by collaborating with a large hospital that adopted telemedicine for follow-up visits. Besides its direct effect on improving patients' access to virtual follow-up care, we find that telemedicine generates significant cross-channel (i.e., from online to onsite) and cross-service (i.e., from follow-up to other visits) spillover effects.

3 - Do Management System Standards Indicate Superior Performance? Evidence from the OHSAS 18001 Occupational Health and Safety Management System Standard
Kala Viswanathan, United States

We study whether companies that adopt the OHSAS 18001 Occupational Health and Safety Management system standard actually exhibit superior safety performance. Analyzing proprietary certification data from some of the world's largest certification companies and injury microdata from the U.S. Bureau of Labor Statistics, we find that U.S. establishments certified to the OHSAS 18001 standard indeed tend to be safer workplaces. The OHSAS 18001 standard attracts establishments with fewer injury and illness cases than comparable non-adopters (a selection effect), and certification leads to subsequent declines in such cases (a treatment effect). We also find evidence that more intensive regulator inspector scrutiny promotes OHSAS 18001 adoption, and no evidence that regulators reduce their scrutiny of adopters. These results provide rare evidence the adoption of a management system standard serves as a credible indicator of superior operational performance.

4 - The Effects of Discretion on Worker Attraction
Maria R. Ibanez, Kellogg School of Management at Northwestern University, Evanston, IL, 60208-0898, United States

Workers often have discretion over how to organize their work. Using data from job postings, we investigate how indicators of different types of discretion over operational factors (or of lack of discretion) affect job applications. By doing so, we show how operations management decisions can affect human resources. Our findings contribute to the debate about advantages and disadvantages of worker discretion, and have implications for managers deciding when to offer discretion.

■ FC05

Virtual Room 05

Artificial Intelligence Applications for Military Medicine

General Session

Chair: Peter Walker, PhD, Cognitive Science, United States Navy, Arlington, VA, 22217, United States

1 - High Quality Classification of Task-based Functional MRI with Graph Neural Networks is Feasible Even with Coarse Data Parcellation
Krzysztof Fiok, University of Central Florida, Orlando, FL, United States, Waldemar Karwowski, Farzad Vasheghani

Automatic assessment and classification of brain images for medical diagnosis and treatment based on functional MRI (fMRI) is a challenging task that can be addressed using graph neural networks (GNNs). Our study demonstrates that fMRI recordings obtained during experimental sessions where different tasks were conducted can be correctly classified even when coarse data parcellation is utilized. Our experiments indicate that mixing recently proposed methods for creating representations of neural graphs allows obtaining high-quality results.

2 - Interpretability of Medical Machine Learning Models
Fei Wang, PhD, Computer Science, Weill Cornell Medical College, New York, NY, United States

In recent years more and more machine learning models have been developed and applied in medicine. Many of these models are complex and black-box in nature. Because of the importance of transparency of medical machine learning models, their interpretability becomes critical. In this talk I will summarize the existing approaches for interpreting black-box machine learnings, point out their potential pitfalls and solutions. I will also discuss the different need for different levels of model interpretation in clinical decision support.

■ FC07

Virtual Room 07

Healthcare Quality and Safety II

Contributed Session

Chair: Sohyun Park, University of Minnesota Carlson School of Management, Storrs, United States

1 - How Does Internal Hiring of Attending Physicians Affect Hospital Quality Management?
Kellas R. Cameron, Assistant Professor, University of South Florida, Tampa, FL, United States, Gleb Zavadskiy, Holly Waters

Physicians play an important role in hospital quality management. Therefore, it is a critical decision for the hospitals on whom to hire. In teaching hospitals, there is the choice of whether to hire internally from their own residents, or externally from other programs. In this work, we determine the advantages from hiring internally on hospital conformance quality, patient experiential quality, and research innovation. We then create a decision support system to help hospitals decide their optimal internal hiring level and program size in order to maximize the cost reductions associated with the quality improvements derived from internal hiring.

2 - Association of Health Insurance Coverage and Probability of Dying in an Emergency Department or Hospital from a Motor Vehicle Traffic Injury
Jim P. Stimpson, Professor, Drexel University, Philadelphia, PA, United States

The objective was to describe the association of health insurance coverage with the odds of mortality in an ED or hospital for adult victims of a motor vehicle crash. We pooled and averaged six years of annual hospital discharges from the Nationwide Emergency Department Sample (N = 2,526,063). Compared to the uninsured, the multivariate adjusted odds ratios for death were significantly ($p<0.001$) lower for Medicare (OR = 0.79), Medicaid (OR = 0.67), Private insurance (OR = 0.57), and other insurance (OR = O.57). Therefore, lack of health insurance was associated with a higher likelihood of death for patients admitted to an ED or hospital for injuries sustained from a motor vehicle crash.

3 - Competitive Dynamics of Physician Referrals in the Era of Accountable Care Organizations

Sohyun Park, University of Minnesota, Minneapolis, MN, United States, Russell Funk, Pinar Karaca-Mandic, Aks Zaheer

While advocates of healthcare reform are hopeful that accountable care organizations (ACOs) will bend the healthcare spending curve through enhanced care coordination, we consider a different view, exploring how ACOs may affect care cost and quality through changes in market structure and competition.For 3,436 regions from 2009 to 2014, we observe substantial variation in a regional referral-based market competition index, based on referral patterns from primary care physicians to surgeons. In addition, we find that regions with 15% or higher proportion of physicians in ACOs are 2.7% more concentrated in their referral patterns among physicians, compared to regions with no physicians in ACOs.

■ FC08

Virtual Room 08

Health Care Operations 4

Contributed Session

Chair: E. David Zepeda, Boston University School of Public Health, Health Law, Policy & Management, Boston University, Boston, MA, 02118, United States

1 - An Integrated Model for Platelets Logistics in Relief Operations: A Robust Optimization Approach

Afshin Kamyabniya, PhD Candidate in Management, University of Ottawa, Ottawa, ON, Canada, Antoine Sauré, Jonathan Patrick, Zohreh Noormohammadzadeh

We propose a logistics network model that allows regional blood units, hospitals, and shelters to share multi-type platelets using multiple integration mechanisms. The model allocates multi-type platelets to patients according to ABO/Rh(d)-compatible blood substitutions and accounts for the impact of the age of the platelets on the suitability for different types of injuries. To efficiently solve the model, we employ Lagrangian relaxation and the augmented epsilon-constraint method. Finally, to evaluate the performance of the proposed solution approach, we apply it to a possible earthquake in Tehran, Iran.

2 - Stochastic Outpatient Chemotherapy Scheduling Approach Considering the Workloads of Nurses

Sırma Karakaya, TED University, Ankara, Turkey, Serhat Gul, Melih Celik

Chemotherapy scheduling is a challenging problem due to uncertainty in infusion durations and non-homogeneous care level needs of patients. We study the problem of scheduling patient appointments and assigning patients to nurses under uncertainty in infusion durations. We consider instantaneous nurse workload, represented in terms of acuity levels, and chair availability while scheduling patients. We formulate a two-stage stochastic mixed-integer programming model for the problem. We propose a scenario-bundling based decomposition algorithm to find near optimal schedules. We use data of a major university hospital to generate managerial insights related to chemotherapy scheduling.

3 - Equitable Phlebotomy Dispatching and Scheduling Using a Ward Assignment Mixed Integer Program

Malfrine Das, Providence Health Care, Vancouver, BC, Canada, Mohammad Mehdi Ghotboddini, Sneha Mikkilineni Durga, Daniel Holmes

In collaboration with the Department of Pathology and Laboratory at St Paul's Hospital, we approach the problem of phlebotomy dispatching and scheduling. Difficulties and inefficiencies in how this service is delivered remain a concern due to delays in collection, reporting, and clinical intervention. A demand forecast model and mixed integer program were developed to inform decision-makers on how to best assign phlebotomists to different wards. Our solution reduces workload disparities and improves the turnaround time to improve patient care.

4 - Local Physician Practice Migration and Changes in Practice Style

E. David Zepeda, Boston University School of Public Health, Boston, MA, United States

Much interest exists in identifying strategies for changing physician practice style as research demonstrates that many physicians practice in a way that is not aligned with the best available scientific evidence. We investigated the extent to which a physician's work environment influences practice style at two levels of a work environment, the practice organization comprised of peers who shared administrative arrangements, and practice site comprised of peers who shared actual physical working space. We tracked physician migrations to new practice settings over a span of eight years to assess changes in practice style. For practice style, we focused on inappropriate use of diagnostic imaging.

■ FC11

Virtual Room 11

Public Sector OR and Health Care

Contributed Session

Chair: Sogand Sabahfar, Kansas State University, Manhattan, KS, United States

1 - Microecology of PrEP Usage in Mecklenburg County, NC, 2013-2019

Sagar Satyanarayana, UNC Charlotte, Charlotte, NC, United States, Gabriel Lopez Zenarosa, Brian Witt, Deepa Kumar, Patrick A. Robinson

PrEP is effective for HIV prevention but underused in Southern US, including Mecklenburg County, NC (MeckCo). Assessing PrEP use is critical for further PrEP implementation. We used pharmacy claims to find FTC+TDF and FTC+TAF used as PrEP and HIV-incidence data in MeckCo in 2013-2019. We computed PrEP-to-Need ratio (PnR) as number of patients with ≥21 doses divided by HIV incidences. We defined dose-adjusted PnR (daPnR) as doses/days in year divided by HIV incidences. MeckCo had 3,365 patients and 466,525 doses in 2013-2019. PnR and daPnR increased yearly, but patients of female sex, aged ≤24 years, or from certain areas are underserved. Demographic-targeted efforts to increase PrEP use are needed.

2 - Specimen Pickup and Delivery in UK's National Health Service: A Multi-tour Multi-vehicle Routing Problem with Time Windows, Maximum Tour Length and Synchronisations

Daniel Gartner, Cardiff University, Cardiff, United Kingdom

Transportation services in healthcare are under pressure to meet targets, especially when considering specimen transportation from primary and secondary health care locations. This paper explores the use of mathematical modelling and metaheuristic optimization for specimen transportation in a multi-hospital, multi-clinic and multi-pathology laboratory setting in the U.K. Our results that are currently implemented in practice reveal a substantial reduction of vans by meeting specimen transit time targets.

3 - Coalition Formation and Cost Allocation in Humanitarian Supply Chain

Sogand Sabahfar, Kansas State University, Manhattan, KS, United States, Jessica Heier Stamm

Collaboration in humanitarian supply chains may lead to higher quality services and significant cost savings. To achieve these benefits, two main questions must be answered: who should cooperate with whom and how should the savings be allocated among cooperative partners to ensure stability? We address these questions by (1) proposing and testing heuristics to identify coalition structures that minimize total social cost, and (2) identifying allocation mechanisms that belong to the coalition structure core. The results provide insights for managing humanitarian operations.

■ FC13

Virtual Room 13

Care Organization and Continuum

Contributed Session

Chair: Hemant K Bhargava, University of California, Davis, CA, 95616-5270, United States

1 - Simulating the Impact of Including Predictive Modeling in Appointment Decision-making for Chronic Liver Disease

Emily Lindblad, University of Michigan, Ann Arbor, MI, United States, Adam VanDeusen, Amy Cohn, Grace Su, Sameer Saini

Chronic liver disease (CLD) is a potentially fatal disease, and it is difficult to detect because of its long asymptomatic phase. New predictive models may help diagnose CLD earlier. We use discrete-event simulation to model how patients referred for CLD could be assigned to appointments based on the severity of patients' disease under various diagnostic models. We consider each model's predictive power and policies about collecting patient data used for model inputs. This work can help clinics assign CLD patients more accurately to an appointment type to align with patient needs.

2 - Hype or Hope? Selection and Performance of Value-based Health Care Organizations

Muktak Tripathi, Temple University, Philadelphia, PA, United States, Sezgin Ayabakan, Indranil R. Bardhan, Rajiv Banker

We study the rollout of Accountable Care Organizations (ACO) under the Medicare Shared Savings Program (MSSP) and examine the antecedents and consequences of ACOs self-selection into two-sided risk models. Our analysis based on MSSP ACO data finds that ACOs that exhibit greater resource complexity or serve specific sub-groups, such as non-acute care settings, are more likely to switch to a two-sided risk model and realize greater shared and generated savings, and marginally higher quality, compared to ACOs that remained in a one-sided risk model. However, these initial gains are not sustained over time, as two-sided ACOs exhibit a significant annual drop in their shared savings and quality.

3 - Using Innovative Technology to Improve ED Throughput and Communication Among Care Teams to Facilitate Timely Patient Admissions

Kiley Elizabeth Black, Director - Clinical Innovation, Spok, Eden Prairie, MN, United States, Christopher Snyder

TidalHealth is an IDN located in Maryland. Its flagship hospital is Peninsula Regional, a level 2 trauma 300-bed facility. Communication between the ED providers, case managers, and the hospitalist team traditionally has been through pagers and phone calls. Spok Go is a cloud-native platform designed to facilitate clinical communication. In February 2021, the ED started using Spok Go as the primary communication tool for the care team to coordinate patient admissions. Data was collected pre- and post-implementation. A reduction of 38 minutes was observed in Disposition to Admit time (“boarding time” in the ED), along with a 27 minute reduction in overall LOS. Other results are pending.

4 - Price Transparency in Healthcare: Design, Policy, and Likely Impact

Hemant K. Bhargava, University of California, Davis, CA, United States

Health care spending in the US. occurs under a veil of opacity regarding costs of prescribed care. New tools for price transparency are being promoted by Federal regulation and technology entrepreneurship.Our research aims to develop new knowledge and theory regarding the design, deployment, and use of price transparency tools, in the specific context of prescription drug products. This research is enabled through a unique collaboration and data-sharing with firms that are leading in the production and deployment of price transparency tools (e.g., Gemini Health, Blue Shield of California, and participating providers).”

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