Midwest Healthcare Management Conference

2019

ILLINOIS
Gies College of Business

Thursday, August 15

Participants check-in
Dinner on your own

Friday, August 16

8–8:15 am · Meet in I Hotel Lobby
Shuttle to BIF leaves at 8:15 am

8:30–9:15 am · BIF 2057 · Registration & Breakfast

9:15–9:30 am · BIF 2043 · Inauguration
Sridhar Seshadri & Cele Otnes

9:30–9:45 am · BIF 2043 · Welcome
Jeff Brown, Dean, Gies College of Business

9:45–10:15 am · BIF 2043 · Keynote Speech
Stephen Boppart, Executive Associate Dean & Chief Diversity Officer of Carle
Illinois College of Medicine
*Addressing Healthcare Challenges through Innovations in Medicine and Medical
Education*

10:15–10:30 am · BIF 2057 · Break

10:30 am–12 pm · BIF 2043 · Session 1: Healthcare Supply Chains

Presentation 1: Diwakar Gupta
Operational Challenges faced by Global Health Organziations
Discussant: Jingwen Yang

Presentation 2: Diwas KC
The Effects of Multi-Siting on Productivity and Quality
Discussant: Diwakar Gupta

Presentation 3: Jingwen Yang
*Designing Safe and Scalable Precision Medicine Supply Chains: Evaluating
the Implementation of CPIC Guidelines for Psychiatric Care Delivery*
Discussant: Diwakar Gupta

12–1 pm · BIF 2057 · Lunch

1–1:45 pm · BIF 2043 · Keynote Speech
John Birge, Jerry W. & Carol Lee Levin Distinguished Service Professor of
Operations Management, Booth School of Management, U Chicago
Adaptive Methods for Clinical Trials and Optimal Treatment Protocols

1:45–3:15 pm · BIF 2043 · Session 2: Healthcare Analytics

Presentation 1: Han Ye
Predictive Encounter Decisions in Chronic Diabetes Care
Discussant: Yi Tang

Presentation 2: Eren Mehmet
Augmenting Radiologists, Decision Making Based on Mammography Using Deep Learning
Discussant: Han Ye

Presentation 3: Yi Tang
Advancing Equity in the Mental Helathcare Supply Chains: Empirical Evidence of a Mobile App
Discussant: Eren Mehmet

3:15–3:30 pm · BIF 2057 · Break

3:30–4:15 pm · BIF 2043 · Presentation

Ruby Mendenhall & Martin Burke, Carle Illinois College of Medicine
Strategies to Democratize Helathcare Delivery: The Role of Community Members and Citizen Scientists

4:15–5:45 pm · BIF 2043 · Session 3: Empirical Methods in Healthcare Delivery

Presentation 1: Vishal Ahuja
How Continuity in Service Impacts Process Control: An Empirical Examination of Primary Care Physicians
Discussant: Ujjal Kumar Mukherjee

Presentation 2: Paola Martin
Vaccine Procurement Contracts for Developing Countries
Discussant: Vishal Ahuja

Presentation 3: Ujjal Mukherjee
Enabling Healthcare Delivery with High Tech Innovation: A Longitudinal Field Study of Robot-Assisted Surgery
Discussant: Paola Martin

5:45–6:15 pm · Take Shuttle to I Hotel

7–9 pm · I Hotel · Dinner

Saturday, August 17

8–8:15 am · Meet in I Hotel lobby
Shuttle to BIF leaves at 8:15 am

8:30–9 am · BIF 2057 · Registration & Breakfast

9–9:45 am · BIF 2043 · OSF Presentation

9:45–11:15 am · BIF 2043 · Session 4: Healthcare Finance

Presentation 1: Mili Mehrotra
Gainsharing Contracts for CMS' Episode-Based Payment Models
Discussant: Julian Reif

Presentation 2: Julian Reif
What Do Workplace Wellness Programs Do? Evidence from the Illinois Workplace Wellness Study
Discussant: Mili Mehrotra

Presentation 3: Tianchen Zhao
Demand Estimation of Mass Gathering Healthcare in Developing Countries: The Case of Kumbh Mela at Ujjain
Discussant: Mili Mehrotra

11:15–11:30 am · BIF 2057 · Break

11:30 am–1 pm · BIF 2043 · Session 5: Scheduling in Healthcare

Presentation 1: Lavanya Marla
Ambulance Abandonement Study
Discussant: Yuqian Xu

Presentation 2: Pengyi Shi
Timing It Right: Balancing Inpatient Congestion versus Readmission Risk at Discharge
Discussant: Marla Lavanya

Presentation 3: Yuqian Xu
The Interplay between Online Reviews and Physician Demand: An Empirical Investigation
Discussant: Pengyi Shi

1–1:10 pm · BIF 2043 · Closing Remarks

1:10–1:30 pm · BIF 2057 · Lunch & Participants Depart

Keynote 1:

Addressing Healthcare Challenges through Innovations in Medicine and Medical Education

Healthcare expenditures in the US, as a percentage of GDP, far exceed other high-income countries and are on an unsustainable trajectory. Innovations in medical technologies, processes, and healthcare delivery systems offer promising solutions to address the challenges associated with improving care, making care more widely accessible, and making care more affordable. Equally important are innovations in medical education, such as in our new Carle Illinois College of Medicine, that will develop future physicians, innovators, and entrepreneurs to drive and implement these future changes in healthcare.

Stephen A. Boppart

Interim Executive Associate Dean and Chief Diversity Officer
Carle Illinois College of Medicine
Department of Electrical and Computer Engineering
Department of Bioengineering
University of Illinois

Stephen Boppart is an Abel Bliss Professor of Engineering and a strong advocate for engineering in medicine to advance human health and our healthcare systems. He has been involved in visioning, establishing, and developing the engineering-based Carle Illinois College of Medicine, and he is currently the interim executive associate dean and chief diversity officer. Boppart received his PhD in Medical and Electrical Engineering from MIT, his MD from Harvard Medical School, and his residency training at the University of Illinois in internal medicine. He is dedicated to integrating innovation, technology, and engineering into medical education for the next generation of physicians.

Keynote 2:

Adaptive Methods for Clinical Trials and Optimal Treatment Protocols

Many healthcare issues involve choices among actions where outcome distributions are not known. This talk will describe adaptive procedures to make such choices to achieve complete learning while also ensuring low regret.
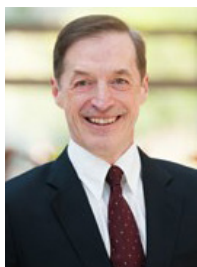
John R. Birge
Jerry W. and Carol Lee Levin Distinguished Service
Professor of Operations Management
Booth School of Business
University of Chicago

John R. Birge studies mathematical modeling of systems under uncertainty, especially for maximizing operational and financial goals using the methodologies of stochastic programming and large-scale optimization. His research has been supported by the National Science Foundation, the Ford Motor Company, General Motors Corporation, the National

Institute of Justice, the Office of Naval Research, the Electric Power Research Institute, and Volkswagen of America. He has published widely and is the recipient of the Best Paper Award from the Japan Society for Industrial and Applied Mathematics, the Institute for Operations Research and the Management Sciences Fellows Award, and the Institute of Industrial Engineers Medallion Award. He has been elected to the National Academy of Engineering.

Keynote 3:
Strategies to Democratize Healthcare Delivery: The Role of Community Members and Citizen Scientists

There are 7.7 billion people on our planet, and there is perhaps one thing we can all agree on: everyone wants to be healthy. The Health Maker Lab (HML) recognizes that there are countless community members and citizen scientists who care passionately about their own health and that of their families and communities. The HML further understands that their outside-the-specialist-box thinking informed by firsthand life experiences with unmet medical needs—such as attention deficit hyperactivity disorder, trauma from gun violence, diabetes, and limited access to medical information—is a powerful and largely untapped resource that stands ready and able to revolutionize thinking about healthcare.

Martin Burke
Assistant Professor
Department of Chemistry
University of Illinois

Martin Burke completed his undergraduate studies at Johns Hopkins University in 1998 and his PhD at Harvard University in 2003. After completing an MD at Harvard Medical School, he joined the faculty in the Department of Chemistry at the University of Illinois in June of 2005. His research interests are in the area of organic chemistry with a specific focus on the synthesis and study of small molecules with protein-like functions.

Ruby Mendenhall
Associate Professor
Department of African American Studies
Department of Sociology
Assistant Dean for Diversity and Democratization of Health Innovation
Carle Illinois College of Medicine
University of Illinois

Ruby Mendenhall is an affiliate at the Woese Institute for Genomic Biology and an assistant dean at the Carle Illinois College of Medicine. Using surveys, interviews, crime statistics, police records, data from 911 calls, wearable sensors, and genomic analysis, Mendenhall examines how living in racially segregated neighborhoods with high levels of violence affects Black mothers' mental and physical health. She examines the role of the Earned Income Tax Credits in decreasing financial stress and improving health outcomes. She studies the medicalization of poverty and the need to prevent social conditions that create disease (e.g., poor quality housing, economic insecurity, etc.).

Session 1: Healthcare Supply Chains

Presentation 1: Operational Challenges Faced by Global Health Organizations

Diwakar Gupta, Professor, Information Risk and Operations Management, McCombs School of Business, University of Texas at Austin

Global health organizations such as the global alliance for vaccines and immunization (Gavi), are actively engaged in helping bring life-saving pharmaceutical products (in particular vaccines) to the developing world. These organizations rely on funds donated by federal, state, and local governments, foundations, businesses, and philanthropists. Donated funds are used to create incentives for pharmaceutical companies to bring vaccines to developing country markets. A whole host of operational challenges arise in this setting. This talk will address three challenges. (1) How much budget should GHOs make available in a particular procurement cycle? This decision is affected by demand uncertainty, the potential that more effective vaccines may be available in the future, and future prices. (2) What procurement contract design should the GHO use? What should be the terms of the chosen contract? (3) How should GHOs manage competition? Should they engage with a single supplier or multiple suppliers of vaccines? The talk will use the example of the Advanced Market Commitment contract, which has been implemented by Gavi, to explain the institutional background and opportunities for future contribution by OM scholars.

Presentation 2: The Effects of Multi-Siting on Productivity and Quality

Diwas KC, Associate Professor, Information Systems & Operations Management, Caldwell Research Fellow, Goizueta Business School, Emory University

In the modern workplace, it is increasingly common for workers to concurrently attend to tasks across multiple physical locations. However, frequent site switching can lead to increased setup and overhead costs. Specifically, workers expend significant time and cognitive effort getting reoriented with personnel, operating processes, tools, and resources whenever they switch sites. In this paper, we look at the productivity and quality implications of multi-site work. To estimate the effect of multi-site operations on performance, we turn to a setting where multi-site worker assignment is common: that of physicians who have admitting privileges at multiple hospitals. We collected detailed data on individual physicians practicing in 83 hospitals between 1999 and 2010. Our extensive data set includes detailed operational and clinical factors associated with over 940,000 patient encounters. Our empirical analysis takes the form of a panel, where we follow a given physician over time, and link short-term multi-siting to patient level outcomes. We find that multi-siting negatively impacts productivity. Specifically, for each additional site at which a physician works, we observe a 2.1% increase in patient length of stay. For each site served, the likelihood of a patient developing a complication increases by 3%. Greater travel distance between sites, lack of focus at a given site, and congestion-related negative spillovers between sites explain the performance declines due to multi-siting. In addition, we find that the performance declines due to multi-site operation are reduced among low-complexity patients, and among highly experienced physicians.

Presentation 3: Designing Safe and Scalable Precision Medicine Supply Chains: Evaluating the Implementation of CPIC Guidelines for Psychiatric Care Delivery

Jingwen Yang, PhD Candidate, Supply Chain and Operations Management, Carlson School of Management, University of Minnesota at Minneapolis.

This study reports the findings of an empirical study on the effect of implementing Clinical Pharmacogenetics Implementation Consortium (CPIC) guidelines on the safety and scalability of precision medicine supply chains. The therapeutic context of this study is psychiatric care. The empirical analysis is based on a 10-year drug panel data on serious adverse drug events, total prescription counts, CPIC guidelines and other relevant variables collected and assembled from multiple reliable sources: FDA, Bloomberg, and CPIC. Empirical analysis in this study involves the estimation of difference-in-differences (DID) negative binomial fixed effect regression models. The results indicate that CPIC guidelines are associated with increased safety of precision medicine supply chain, evidenced by reduction in serious adverse events. The results also indicate that CPIC guidelines are associated with an improvement in the scalability of precision medicine supply chain, evidenced by an increase in total prescription counts when the CPIC guidelines have a high level of evidence. The overall reduction of serious adverse drug events is estimated to be 62.8% after the implementation of CPIC guidelines which is about 56 serious adverse drug event cases on average per-drug, per-quarter. The overall increase in total prescription counts is estimated to be 20.9% after the implementation of CPIC guidelines with a high level of evidence which is approximately 353,042 total prescription counts on average per-drug, per-quarter. The key contribution of this study is in demonstrating, empirically, how the implementation of CPIC guidelines is improving the safety and scalability of precision medicine supply chain for psychiatric care delivery.

Session 2: Healthcare Analytics

Presentation 1: Predictive Encounter Decisions in Chronic Diabetes Care

Han Ye, Assistant Professor, Business Administration, Gies College of Business, University of Illinois

In this paper, we develop a two-stage decision framework that considers predicted diabetes risks of individual patients as inputs, which healthcare organizations can implement for optimally customizing patient encounters for management of diabetes care. In the first stage of our two-stage framework, we use machine-learning-based predictive analytic models on past clinical measures, demographic information, and socioeconomic status of patients to predict future diabetes risk for individual patients. In the second stage, we use the predicted diabetes risks as inputs to build a decision analytic model to optimally allocate healthcare resources to individual patients. Furthermore, we propose a heuristic solution to the optimal resource allocation model for implementation purposes. For the purpose of the study, we partnered with a large clinic in the United States for collection of data at an individual patient level. We combine the patient-level information with patients' information on patients' immediate social and economic environments to build the predictive analytic models. The primary contribution of the study is the integrative decision framework for personalizing patient encounters for diabetes care. We also contribute by providing an implementable machine-learning-based predictive analytic model on real and large data set. Specifically,

we show that combining patient-level clinical and demographic information with patient population-level socioeconomic information can significantly improve accuracy of diabetes risk prediction. Methodologically, we contribute by considering an innovative solution to endogeneity concerns in prediction problems, and by proposing a regularization-based variable selection in a hierarchical random effect modeling setup. Theoretically, we contribute to the growing stream of literature on optimally managing appointment scheduling of patients by providing a practically implementable predictive-analytics- and decision-analytics-based framework for effective management of repeated appointment schedules for delivery of chronic care.

Presentation 2: Augmenting Radiologists' Decision Making Based on Mammography Using Deep Learning

Mehmet Eren Ahsen, Assistant Professor, Business Administration, Gies College of Business, University of Illinois

Despite their increasing ubiquity, we do not yet understand when and how machine learning algorithms best augment human intelligence. Here, we present results from a unique crowdsourcing challenge, the Digital Mammography DREAM Challenge, in breast cancer diagnosis based on mammograms. The DM Challenge is an international effort with over 1,100 individuals participating, comprising 126 teams from 44 countries. Motivated by the difference between cognitive powers of machine learning methods and human beings in solving prediction problems of heterogeneous difficulty, we developed an ensemble algorithm that optimally combines algorithmic predictions with expert judgments. Our results demonstrate that, while no single algorithm outperformed the human expert, an ensemble of AI algorithms developed during the challenge combined with a radiologist assessment could improve overall performance.

Presentation 3: Advancing Equity in the Mental Healthcare Supply Chain: Empirical Evaluation of a Mobile App

Yi Tang, PhD Candidate, Supply Chain and Operations Management, Carlson School of Business, University of Minnesota, Minneapolis

The gap between the supply and demand for mental healthcare is raising alarms in the US and around the world. Over the years, the gap has continued to grow with dysfunctional and debilitating consequences for individuals and populations. Certain populations are suffering more by having significantly less-than-average treatment rates and treatment efficacy. Mobile health technologies are believed to have the potential to reduce the disparities in mental healthcare delivery by breaking the geographical and temporal barriers and by providing a psychologically safe environment for people in need. This study seeks to evaluate this disparity-reducing effect by empirically analyzing the data collected from Marbles, a mobile mental health app that provides users with a Mood Reflection Score that is statistically significant and negatively associated with the well-known and widely used PHQ-9 (Patient Health Questionnaire with 9 items) and the GAD-7 (Generalized Anxiety Disorder scale with 7 items) scores. The study results suggest that underserved populations in terms of gender, sexual orientation, and race ethnicity did not have significantly less help-seeking behavior in the mobile app setting compared to their traditionally better-served

counterparts. These results indicates that mobile apps provide equal opportunities to people from underserved population to seek mental health help. We then tested whether underserved populations benefit from using the apps the same way that their counterparts do. The results demonstrated that certain traditionally underserved populations (in terms of sexual orientation and race/ethnicity) benefit more from using the self-monitoring function compared to their better-served counterparts. However, post hoc analysis of two subgroups of mobile app users – Low Mood Reflection subgroup and High Mood Reflection subgroup – indicated that this disparity-reducing effect was significant only for the mobile app users in the High Mood Reflection subgroup. Furthermore, the pattern of disparities was still observed in the anonymous community function: certain subpopulations in terms of gender and race/ethnicity benefit less from exchanging social support compared to their traditionally better-served counterparts. Thus, additional online community features need to be introduced in mobile mental health apps with equity advancement in mind.

Session 3: Empirical Methods in Healthcare Research

Presentation 1: How Continuity in Service Impacts Process Control: An Empirical Examination of Primary Care Physicians.

Vishal Ahuja, Assistant Professor, Information Technology and Operations Management, Cox School of Management, Southern Methodist University

In many service operation settings, customers repeatedly interact with service providers. An important question from a service design perspective is how valuable it is to maintain continuity of service for individuals in achieving process control, as experienced by the customer. This is particularly important in settings where variability can have disastrous consequences, as in the case of healthcare services where patients with chronic conditions visit primary care offices repeatedly. Therefore, we explore these questions in the context of diabetes, a chronic disease. We use a detailed and comprehensive data set from the Veterans Health Administration, the largest integrated healthcare delivery system in the United States, which permits us to control for potential sources of heterogeneity. We analyze over 300,000 patients over an 11-year period who suffer from both diabetes (whose successful management requires continuity of care) and kidney disease (a major complication of diabetes). We use an empirical approach to quantify the relationship between continuity of care and one important clinically important short-term (intermediate) outcome: variability in hemoglobin A1c, a reliable measure of patient's short-term glucose levels that is used to monitor diabetes. We calculate two measures of variability – coefficient of variation (CV) and root mean squared error (RMSE) – to quantify A1c variability and find that they are linked to substantial increase in three important health outcomes: inpatient visits, length of stay, and readmission rate. We find that continuity of care is related to improvements in A1c variability. Moreover, we find that the improvements are not linearly improving in continuity, but rather, the relationship is curvilinear, whereby outcomes improve and then decline in increasing continuity of care, suggesting that there may be value in having multiple providers. Finally, we find that continuity of care leads to improvement in clinician decision-making through a more effective use of prescription drugs to control diabetes. We conduct extensive robustness checks and sensitivity analyses to validate our findings. Identifying the amount of continuity of care to provide is of interest both to practitioners and to policymakers as that can help in designing appropriate policies for staffing and work allocation.

Presentation 2: Vaccine Procurement Contracts for Developing Countries

Paola Martin, PhD Candidate, Information Risk and Operations Management, McCombs School of Business, University of Texas at Austin

In recent years, several global health organizations (GHOs) have experimented with market-based procurement contracts to encourage pharmaceutical companies to bring late-stage vaccines to developing-country markets. Pharmaceutical companies often find such markets financially unattractive because developing countries have limited ability to pay and the demand is highly uncertain. The current practice of some GHOs is tantamount to offering a per-dose sales subsidy to the manufacturer, which is paid by the GHO on top of the base price paid by developing countries. The subsidy is required because the base price is not enough, by itself, to induce the manufacturer to commit capacity for developing-country markets. A natural question that arises in this context is whether alternate contract designs may lead to higher capacity commitment while keeping the GHO's budget fixed. In this talk, we propose and analyze three contract designs that include the current practice and two alternatives inspired by the contracts studied in the operations management literature. We show that the best contract design depends on the size of the budget, and that GHOs can increase capacity commitment (over the contract design used in practice) by choosing the budget-appropriate contract design and optimal parameters for the chosen design. We also perform a calibrated numerical study to show the benefit of switching from the current contract to an optimal one.

Presentation 3: Enabling Healthcare Delivery with High-Tech Innovation: A Longitudinal Field Study of Robot-Assisted Surgery

Ujjal Kumar Mukherjee, Assistant Professor, Business Administration, Gies College of Business, University of Illinois

Increasingly, the conduct of many critical and complex healthcare delivery procedures are being enabled by high-tech innovations. Robotic surgical technology is a high-tech innovation that is specifically aimed at reducing variation of surgical outcomes. Robotic surgical technology has features and functionalities to reduce surgical outcome variations due to skill heterogeneity of surgeons and surgical team members. In this paper, we report the findings of a longitudinal field study aimed at investigating the operations of a surgical robot (da Vinci robot) throughout its life cycle at a large multi-specialty hospital. Specifically, the study objectives are to (i) understand the impact of surgical robot on the variation in the outcomes of surgical procedures, given input heterogeneity, e.g., heterogeneity in the skills and experience of surgeons and surgical team members, and (ii) analyze the nuanced mechanisms of surgeon and surgical team learning that lead to effective usage of robots in performing surgeries. The major findings of the study are the following. First, we find that the robotic surgical interface does indeed mitigate outcome variations that are otherwise expected across surgical procedures. Second, we find that the learning mechanism in the context of a robot-assisted surgery is more nuanced than cumulative volume-based learning. Third, we find that given specific levels of surgical volume, individual learning of a surgeon is significantly dependent on the regularity with which the surgeon performs robot-assisted surgeries. Finally, this study sheds light on the interdependency of duration and quality outcome measures of robot-assisted surgical procedures, thereby providing new insights into the speed versus quality debate in managing healthcare operations.

Session 4: Healthcare Finance

Presentation 1: Gainsharing Contracts for CMS' Episode-Based Payment Models

Mili Mehrotra, Associate Professor of Business Administration, Gies College of Business, University of Illinois

The Centers for Medicare and Medicaid Services (CMS) has introduced several Episode-based Payment Models (EPMs). CMS pays the hospital and physicians participating in that EPM on a fee-for-service basis. These payments are reconciled against a target price, resulting in either a gain or loss to the hospital. The hospital may also have gains or losses from its internal operations. It may incentivize physicians to select a treatment option that will improve quality and reduce costs by offering to share gains and losses. CMS has placed restrictions on what gains or losses may be shared and implemented stop loss and gain provisions (SLSG) for the hospital and the physicians, which affect the physicians' choice of treatment options. In this paper, we consider a class of linear gainsharing functions and study the impact of the SLSG provisions, the maximum savings potential, and the risk preferences of the hospital and physicians on gainsharing and the choice of treatment options.

Presentation 2: What Do Workplace Wellness Programs Do? Evidence from the Illinois Workplace Wellness Study

Julian Reif, Assistant Professor of Finance, Gies College of Business, University of Illinois

Workplace wellness programs cover over 50 million US workers and are intended to reduce medical spending, increase productivity, and improve well-being. Yet, limited evidence exists to support these claims. We designed and implemented a comprehensive workplace wellness program for a large employer and randomly assigned program eligibility and financial incentives at the individual level for nearly 5,000 employees. Over 56 percent of eligible (treatment group) employees participated in the program. We find strong patterns of selection: during the year prior to the intervention, program participants had lower medical expenditures and healthier behaviors than nonparticipants. The program persistently increased health screening rates, but we do not find significant causal effects of treatment on total medical expenditures, other health behaviors, employee productivity, or self-reported health status after more than two years. Our 95 percent confidence intervals rule out 84 percent of previous estimates on medical spending and absenteeism. Note: this paper has been "conditionally accepted" by a journal, but is still undergoing nontrivial revisions and has not been resubmitted yet to the journal. In addition, it is part of a larger, ongoing research project that will yield more papers. I am happy to present some of that ongoing analysis alongside the results of this paper.

Presentation 3: Demand Estimation of Mass Gathering Healthcare in Developing Countries: The Case of Kumbh Mela in India

Tiancheng Zhao, PhD Candidate, Business Administration, University of Illinois

Managing healthcare during mass gatherings, defined as a congregation of a relatively large number of people in a specific location for a specific purpose over a relatively short

duration of time ranging from a few days to a few months, especially in underdeveloped and developing communities that are characterized by severe resource constraints and population pressures, is a critical policy issue for governmental and nongovernmental organizations. Managing healthcare during mass gatherings requires careful planning, which requires estimation of potential healthcare demand based on factors that affect such demand. Often, managing healthcare during mass gatherings requires dynamic forecasting of healthcare demand depending on trends of infections, if any, and mobilizing and reorganizing resources accordingly. However, literature in healthcare demand estimation during mass gatherings for policy making, as well as operations planning purposes, is scarce and nascent. Therefore, the primary objective of this paper is to understand factors associated with healthcare demand during mass gatherings, and to use those factors to propose a methodology for dynamically predicting healthcare demand during mass gatherings in developing nations. We use admission data for a period of several years spanning a period before, during, and after Kumbh Mela, a massive religious gathering, from a large multispecialty hospital located in Ujjain, India, to study the effect of mass gatherings on hospital admissions. We propose a spatial-Poisson arrival model to predict the effect of mass gatherings during Kumbh Mela on different disease groups. The results show that the effect of mass gatherings on hospital admissions is heterogeneous on different disease groups and regions with different geographic and demographic parameters. We use the results of our study to provide insights that can be useful for future events.

Session 5: Scheduling in Healthcare

Presentation 1: Ambulance Abandonment Study

Lavanya Marla, Assistant Professor, Industrial and Enterprise Systems Engineering, University of Illinois

In many emerging economies, callers may abandon ambulance requests due to a combination of operational (small fleet size), infrastructural (long travel times), and behavioral factors (low trust in the ambulance system). As a result, ambulance capacity, which is already scarce, is wasted in serving calls that are likely to be abandoned later. In this paper, we investigate the design of an ambulance system in the presence of abandonment behavior, using a two-step approach. First, because the callers' actual willingness to wait for ambulances is censored, we adopt a maximum likelihood estimator estimation approach suitable for interval-censored data. Second, we employ a simulation-based optimization approach to explicitly incorporate customers' willingness to wait in (a) tactical short-term decisions such as modification of dispatch policies and ambulance allocations at existing base locations, and (b) strategic long-term network design decisions of increasing fleet size and redesigning base locations. We calibrate our models using data from a major metropolitan city in India where historically 81.3% of calls were successfully served without being abandoned. We find that modifying dispatch policies or reallocating ambulances provide relatively small gains in successfully served calls (around 1%). By contrast, increasing fleet size and network redesign can more significantly increase the fraction of successfully served calls, with the latter being particularly more effective. Redesigning bases with the current fleet size is equivalent to increasing the fleet size by 8.6% at current base locations. Similarly, adding 29% more ambulances and

redesigning the base locations is equivalent to doubling the fleet size at the current base locations and adding 34% more ambulances and redesigning base locations is equivalent to a three-fold increase. Our results indicate that in the absence of changes in behavioral factors, significant investment is required to modify operational factors by increasing fleet size, and to modify infrastructural factors by redesigning base locations.

Presentation 2: Timing it Right: Balancing Inpatient Congestion versus Readmission Risk at Discharge

Pengyi Shi, Assistant Professor, Operations Management, Krannert School of Management, Purdue University

When to discharge a patient plays an important role in hospital patient flow management and patient outcomes. In this work, we develop and implement a practical decision support tool to aid hospitals in managing the delicate balance between readmission risk at discharge and ward congestion. We formulate the discharge decision framework as a large-scale Markov decision process (MDP) that integrates a personalized readmission prediction model to dynamically prescribe both how many and which patients to discharge each day. We overcome challenges from both the analytical and prediction sides. Due to patient heterogeneity and the fact that length-of-stay is not memoryless, the MDP suffers the curse of dimensionality. We derive useful structural properties and leverage an analytical solution for a special cost setting to transform the MDP into a univariate optimization; this leads to an efficient dynamic heuristic. Meanwhile, off-the-shelf prediction models alone could not provide adequate input for our decision support framework. To bridge this gap, we integrate several statistical methods to build a new readmission prediction model that allows us to implement our decision framework with existing hospital data systems. Through extensive counterfactual analyses, we demonstrate the value of our recommended discharge policy over our partner hospital's historical discharge behavior. We also discuss the implementation efforts of this discharge optimization tool at our partner hospital.

Presentation 3: The Interplay between Online Reviews and Physician Demand: An Empirical Investigation

Yuqian Xu, Assistant Professor, Business Administration, Gies College of Business, University of Illinois

In this paper, we derive various service-quality proxies from online reviews and study the relationship between these quality proxies and physician demand. To do so, we study a unique data set from one of the leading appointment booking websites in the United States that contains online physicians' appointments made over a five-month period, along with other online information. We propose a random coefficient choice model to characterize patient heterogeneity in physician choices, taking into account both numeric and textual user-generated content with text mining techniques. We derive from the text reviews the seven most frequently mentioned topics among patients: bedside manner, diagnosis, waiting time, service time, insurance process, physician knowledge, and office environment. We incorporate these service features into our choice model, and find a statistically significant relationship

between demand and four service features: bedside manner, diagnosis, waiting time, and service time. We proceed with counterfactual experiments, and simulate the impact of proposed policy changes. We find that rating improvement is indeed important in increasing physician demand and patient utility. The maximum possible demand improvement by increasing ratings is 7.24%, and patient utility improvement is 5.01%. Moreover, we find policies with specific improvement of an operational process or platform design can increase demand and utility even further. Broadly speaking, this paper shows how to incorporate quality proxies derived from social media information into a choice model to derive relationships between operational factors in healthcare delivery and patient choices. Our interdisciplinary approach provides a framework that combines machine learning and structural modeling techniques with empirical operations management.

Notes