

# INFORMS HEALTHCARE 2013

**June 23-26, 2013**

Chicago Marriott Downtown

Magnificent Mile

Chicago, Illinois

**TECHNICAL CO-SPONSORS**

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INFORMS Simulation Society

Canadian Operational Research Society

Health Systems Engineering Alliance

Northwestern Center for Engineering  
& Health

Northwestern Institute for Public Health  
& Medicine

POMS, College of Healthcare  
Operations Management



**informatics**®

Yes

No

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~~Copies of papers abstracted in this meeting program are available only from the authors. Requests for papers should be sent to the authors at the addresses shown in the program. Individual issues of the program are available for \$20US per copy. Orders must be prepaid and sent to INFORMS, 7240 Parkway Drive, Ste. 300, Hanover, MD.~~

No

## THANKS TO OUR SPONSORS!



Yes -  
TBD



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Institute for Public Health and Medicine  
[www.feinberg.northwestern.edu/ipham/centers/engineering-health.html](http://www.feinberg.northwestern.edu/ipham/centers/engineering-health.html)



NORTHWESTERN  
UNIVERSITY

Dear Friends and Colleagues,

Welcome to Chicago. It gives me great pleasure to see you here. The INFORMS Healthcare 2013 organizing committee and cluster chairs have worked hard to put together an excellent conference program, which I hope you will find valuable.

This conference is very timely as U.S. healthcare is going through a major change with pressure to reduce cost, and improve patient safety and healthcare delivery. The Affordable Care Act is transforming the dynamics with which future healthcare will be delivered in the U.S., and the ripple effects of this change will be felt worldwide. The operations research and management science community is ideally positioned to provide technical expertise to lead this change, and our value is being recognized by the medical community. The goal behind this conference is to bring researchers from different communities and stakeholders together to facilitate a dialogue and share knowledge and insights that can facilitate our leadership in this important area.

It is heartening to see that the INFORMS Healthcare 2013 Conference has grown in size from the previous event in 2011. We have 440 papers and invited cluster chairs covering the areas of healthcare operations management, health systems engineering, healthcare scheduling, hospital operations, medical decision and policy making, data analytics, rural health, and radiation therapy to name a few. This successful program was possible due to our technical co-sponsors: Canadian Operational Research Society; Production and Operations Management Society-College of Healthcare Operations Management; INFORMS' Health Applications Society, Data Mining Section, Simulation Society, MSOM, Optimization Society, Computing Society and the Public Programs, Service and Needs Section; Health Systems Engineering Alliance; Northwestern Institute for Public Health & Medicine; and Northwestern Center for Engineering & Health.

We are also pleased to have our plenary speaker, Dr. Basit Chaudhry, Medical Scientist and Lead Research Clinician for IBM's Watson division. Dr. Chaudhry, after completing his medical training in internal medicine, earned a PhD in biomedical informatics and health services research. He will highlight the role of Watson technology in providing cognitive and decision support in healthcare. The program also features a student paper competition, panels benefiting from contributions from care providers, a reception, networking lunch and a poster session.

I am grateful to the program chair, Hari Balasubramanian, and the members of the organizing committee, Cerry Klein, Steven Shechter, Vedat Verter, Dionne Aleman, Turgay Ayer, Mehmet Begen, Stephen Chick, Amy Cohn, Brian Denton, Diwakar Gupta, Eva Lee, Elisa Long, Omid Nohadani, Ronald Rardin, Burhaneddin Sandikci and Kai Yang for their efforts in helping organize this meeting. The professionalism of the INFORMS staff made the work of organizing this conference much easier. It was truly a pleasure to work closely with all of them in this endeavor.

Thank you all for coming to INFORMS Healthcare 2013 and presenting your work. While you are in Chicago do find the time to visit the many great attractions. I hope you will enjoy the conference and the windy city.

*Sanjay Mehrotra*

Sanjay Mehrotra  
General Chair

**NOTE:**

All technical sessions are held at Chicago Marriott Magnificent Mile, with meeting rooms located on levels 3, 5, 6 and 10. Check the Master Track Schedule on pages 12-13 for specific room locations.

**BADGES REQUIRED FOR TECHNICAL SESSIONS**

Healthcare 2013 badges must be worn to all sessions. Badges will be checked at the entrance to technical session areas. Attendees without badges will be directed to the registration desk to register and pick up their badges. *All attendees, including speakers and session chairs, must register and pay the registration fee.*

**TWEETS****Join the Twitter conversation!**

Add the hash tag #informshealthcare to your tweets to associate them with the conference. These tweets will be displayed in the Attendee Twitter Feed on the website home page, along with official conference tweets that will alert you to late-breaking information.

**SUNDAY, JUNE 23**

4:00pm-8:00pm Registration Chicago Foyer E, Level 5

**MONDAY, JUNE 24**

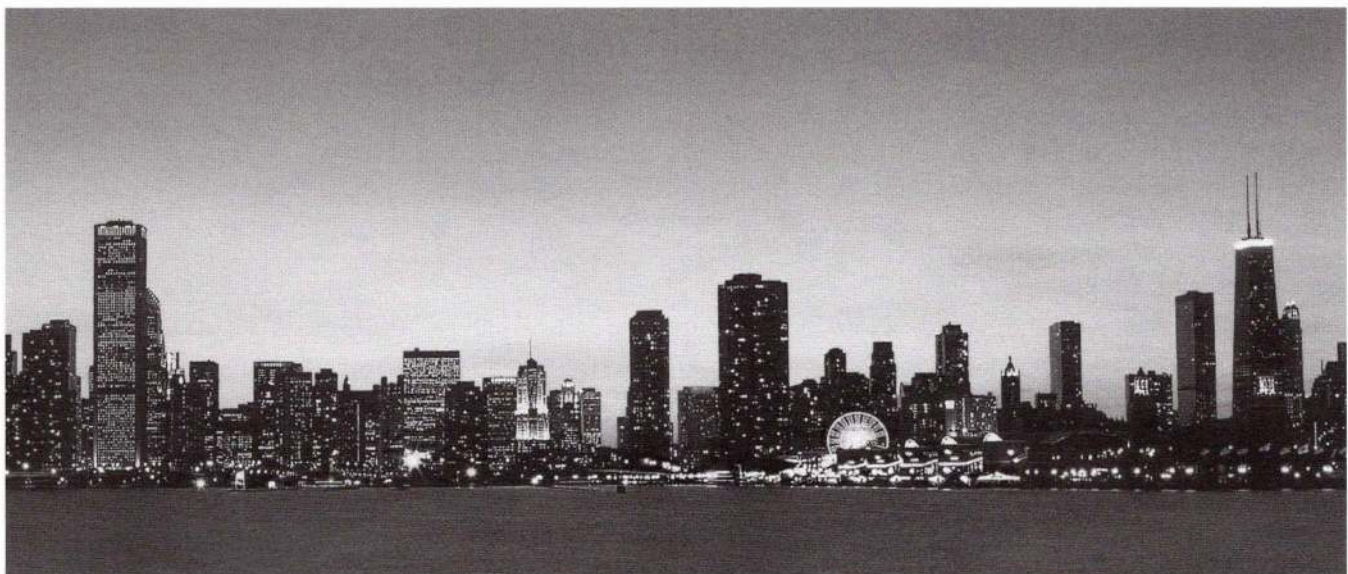
7:30am-5:00pm Registration Chicago Foyer E, Level 5  
 8:30am-10:00am Technical Sessions (MA)  
 10:00am-10:30am Coffee Break Chicago Foyer, Level 5  
 10:30am-11:45am Plenary: Basit Chaudhry Chicago DE, Level 5  
 11:45am-12:30pm Lunch Break (on your own)  
 12:30pm-2:00pm Technical Sessions (MB)  
 2:00pm-3:30pm Interactive/Poster Session with Refreshments Chicago DE, Level 5  
 3:30pm-5:00pm Technical Sessions (MC)  
 6:00pm-7:30pm Reception Chicago DE, Level 5

**TUESDAY, JUNE 25**

7:30am-5:00pm Registration Chicago Foyer E, Level 5  
 8:30am-10:00am Technical Sessions (TA) Chicago Foyer, Level 5  
 10:00am-10:30am Coffee Break Chicago Foyer, Level 5  
 10:30am-12:00pm Technical Sessions (TB) Chicago DE, Level 5  
 12:00pm-1:30pm Networking Lunch Chicago Foyer, Level 5  
 1:30pm-3:00pm Technical Sessions (TC)  
 3:00pm-3:30pm Refreshment Break Chicago Foyer, Level 5  
 3:30pm-5:00pm Technical Sessions (TD)  
 5:00pm-6:00pm HSEA Board Meeting Cook, Level 3  
 6:00pm-7:30pm HSEA Reception Chicago H, Level 5

**WEDNESDAY, JUNE 26**

8:00am-2:00pm Registration Chicago Foyer E, Level 5  
 8:30am-10:00am Technical Sessions (WA) Chicago Foyer, Level 5  
 10:00am-10:30am Coffee Break Chicago Foyer, Level 5  
 10:30am-12:00pm Technical Sessions (WB)  
 12:00pm-1:30pm Lunch Break (on your own)  
 1:30pm-3:00pm Technical Sessions (WC)



## SPEAKER GUIDELINES

### Audio-Visual Services

All session rooms will be equipped with a computer projector, but please note that you **must provide your own laptop** or pre-arrange to share with others in your session. Please follow these guidelines to ensure a successful presentation:

- Bring your laptop to your session. We strongly recommend that you pre-arrange with other speakers in your session to ensure that at least one of you brings a laptop from which you can project your talks.
- Bring your power supply cord with you. We recommend that you do not attempt to run your presentation off the laptop battery.
- If your laptop is not compatible with AC power, please bring an electrical adaptor so that you can connect to U.S. electricity.
- If you use an Apple product, you will need the appropriate adapter for the external video output.
- Arrive at your session at least 15 minutes before it begins. All presenters in a session should set up and test the connection to the projector before the session begins.
- We encourage speakers to put their presentations on a USB flash drive as a backup.

### Presentation Guidelines

The room and location of your session are listed in the Technical Sessions section and in the Master Track Schedule.

- Arrive at your session at least 15 minutes early for A/V set-up.
- Presentations are expected to be in English.
- Limit your presentation to key issues with a brief summary.
- Time your presentation to fit within your designated time span (determined by the number of presentations in the session), leaving time for audience questions.
- Bring copies of your paper or other handouts to distribute to the audience.
- No proceedings with complete papers are produced for this meeting. For any additional information, please contact the authors directly at the address supplied with each abstract.

### Assistance during Your Session, Questions, Program Changes or Cancellations

Come to the INFORMS Healthcare Registration Desk if you have general questions about the meeting or questions about your own presentation.

### Courtesy to Fellow Speakers

Attendees are asked to be respectful of their colleagues by turning off cell phones and mobile devices before presentations begin. In addition, please note that use of cameras and all recording devices is prohibited during sessions unless you have received prior permission from the speaker.

## SESSION CHAIR GUIDELINES

The role of the Session Chair is to coordinate the smooth running of the session. The chair:

- Begins and ends the session on time. Each session lasts 90 minutes, with the time per presentation determined by the number of papers in the session. Equal time should be given to each paper.
- Introduces each presentation (just the title of the paper and the name of the presenting author).
- Ensures that presentations are made **in the order shown in the program**. This allows for "session jumping." If a speaker cancels or does not attend, the original time schedule should be adhered to rather than sliding every talk forward.
- Completes the session attendance forms (forms will be in the room).
- Reminds the audience to (a) turn off all mobile devices and (b) that photography is not allowed without the prior permission of the speaker.
- We ask Session Chairs to notify us about any last-minute changes or cancellations; these changes will be posted outside the meeting rooms.

## REGISTRATION & GENERAL INFORMATION

### Badge Required for Technical Sessions

INFORMS Healthcare 2013 registration badges must be worn to all meeting sessions and events. Badges will be checked at the entrance to technical session areas and social events. Attendees without badges will be directed to the registration desk to pick up their badges and register. *All attendees, including cluster chairs, session chairs and speakers must register and pay the registration fee.*

Your registration fee includes admittance to the complete technical program. Also included are the Monday evening reception, networking lunch on Tuesday, and all morning and afternoon coffee breaks. No other meals are included.

### Internet

Wireless Internet (basic bandwidth for checking email and browsing the web) is available in the Exhibit area, Chicago Foyer, Level 5. Wireless is also available in the hotel lobby.

## WHERE TO GO FOR LUNCH

### Marriott Restaurants

Harvest (American)  
Rush Bar & Lounge

### Nearby Restaurants

- Bandera (American)  
535 N. Michigan
- Big Bowl (Chinese & Thai)  
60 E. Ohio
- Oysy (Sushi)  
50 E. Grand
- Pizzeria Uno  
29 E. Ohio
- Joe's Stone Crab (seafood, steaks)  
60 E. Grand
- Californina Pizza Kitchen  
52 E. Ohio

## MONDAY, JUNE 24

### Coffee Break & Exhibits

10:00am-10:30am  
Chicago Foyer E, Level 5

### Lunch Break

11:45am-12:30pm  
See list of restaurants within easy walking distance of the Marriott.

### Interactive/Poster Session & Refreshments

2:00pm-3:30am  
Chicago DE, Level 5

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### IBM Research

### Welcome Reception

6:00pm-7:30pm  
Chicago DE, Level 5  
A great opportunity to meet with colleagues and enjoy selections from our food displays. Cash bar; complimentary soft drinks and bottled water.

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## TUESDAY, JUNE 25

### Coffee Break & Exhibits

10:00am-10:30am  
Chicago Foyer E, Level 5

### Networking Lunch

*With roundtable discussion led by facilitators.*  
12:00pm-1:30pm  
Chicago DE, Level 5  
Each table will be hosted by a member of the conference committee or an INFORMS leader, who will facilitate discussion around the table. This is an opportunity to meet new people, so don't sit with folks you already know!

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### Refreshment Break & Exhibits

3:00pm-3:30pm  
Chicago Foyer E, Level 5

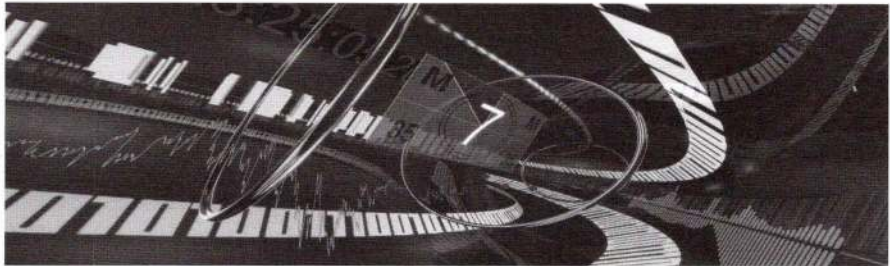
## WEDNESDAY, JUNE 26

### Coffee Break & Exhibits

10:00am-10:30am  
Chicago Foyer E, Level 5

### Lunch Break

12:00pm-1:30pm  
See list of restaurants within easy walking distance of the Marriott.



Announcing  
Third in a series of INFORMS topical conferences

# INFORMS CONFERENCE ON BIG DATA

June 22-24, 2014  
San Jose, California

Conference Co-Chairs:  
Margery H. Connor, Chevron Corporation  
Diego Klabjan, Northwestern University

Watch for information coming soon: [www.informs.org](http://www.informs.org)

Future mtg. Ad  
(Yes)

**MONDAY**

10:30am-11:45am  
Chicago DE, Level 5

**IBM Watson and the Application of Unstructured Data Analysis to Healthcare**

Basit Chaudhry, M.D., PhD  
Medical Scientist & Lead Research Clinician  
for Watson, IBM  
IBM Research

Healthcare is undergoing large-scale reorganizations in its structures, processes and business models. Insights derived from data will be fundamental to system transformation. At the same time, data, information and knowledge in healthcare are growing exponentially, creating new stressors on human cognition. Much of the data in healthcare is unstructured, e.g. narrative text in clinical notes. Currently, this data is largely unavailable for analysis through automated means.

IBM's Watson is a technology focused on analyzing unstructured data. Originally an outgrowth from the open domain question and answer branch of artificial intelligence, Watson enables users to pose questions in natural language and then returns sets of candidate answers scored by the probability of being correct. As a proof of concept, Watson challenged the two most successful champions in the history of the game show *Jeopardy!* in a contest and won. IBM is currently in the process of adapting Watson to the domains of healthcare and medicine. Current areas of research and development focus on improving the quality of cancer care, creating administrative efficiencies, and extracting patient histories from medical records. Through capabilities such as information extraction and knowledge representation, Watson offers a new potential model for how cognitive support can be provided in healthcare.



Basit Chaudhry is a medical scientist at IBM Research where his work focuses on using data analytics and information technology to modernize healthcare. His interests

include improving healthcare productivity, optimizing workforce utilization, and improving quality and efficiency of care. One of the initiatives he is involved with is the application of IBM's natural-language computing system, Watson—famous for its victories on the quiz show *Jeopardy!*—to clinical practice. After finishing his medical training in internal medicine, Chaudhry completed the Robert Wood Johnson Clinical Scholars program at UCLA, earning a PhD in biomedical informatics and health services research. He has worked in the Internal Medicine Department at UCLA and as a research scientist at the RAND Corporation. He has provided expertise to the U.S. Department of Health and Human Services and the Institute of Medicine, and recently served on a working group of the President's Council of Advisors on Science and Technology, coauthoring its 2010 policy report, "Realizing the Full Potential of Health Information Technology."



**MONDAY, JUNE 24**

2:00pm-3:30pm  
Chicago DE, Level 5

Be sure to attend this important and lively session. Interactive Session presentations allow authors to present projects that may be at early stages of development. This is an opportunity for colleagues working in similar areas to critique, make suggestions and provide encouragement. Light refreshments will be served.

Abstracts for these presentations are on pages 26-28.

**1 - Simulation Optimization of a Hospital Emergency Department**  
Richard Guerrero, University of Barcelona

**2 - A Markov Blanket Procedure for Determining Optimal Medication Mix for Poly-Pharmacy Patients**  
Abdolmanaf Zargoush, ESSEC Business School

**3 - Network-Based Methods to Identify Highly Discriminating Subsets of Biomarkers**  
Seyed Javad Sajjadi, University of South Florida

**4 - Evaluation of Degradation on Grasp Motion of Multiple Sclerosis Patients**  
Venkata Marella, University of Tennessee

**5 - Analysis of Attribute-Importance Measurement to Improve Healthcare Information System Usability**  
Pei-Fang Tsai, National Taipei University of Technology

**6 - Risk-Averse Healthcare Provider Selection in Lean and Agile Environment: A Goal Programming Approach**  
Mahbod Amouie, Northern Illinois University

**7 - Critical Success Measuring Criteria for BTB E-Commerce Usage in Chinese Medical Supply Chain Selling**  
Xiaomei Li, Tianjin University

**8 - Patient Centered or Physician Centered? What Do We Want from the Residents?**  
Yujiun Tsai, Texas A&M University

**9 - Capacity Planning for Publicly Funded Long-Term Care in the U.S.**  
Yan Li, Purdue University

**10 - Using Health IT Tools to Improve Immunization Management in Community Health Centers**  
Nathan Patrick Taylor, Alliance of Chicago Community Health Services

**11 - An Analysis of Sterile Injectable Oncology Drug Shortages in the California Medicaid Program**  
Eric C. Chen, Torrey Pines High School-San Diego

**12 - Analyzing the Impact of Government Expansion on U.S. Healthcare Financing: A Game-Theoretic Approach**  
Nan Kong, Purdue University

**13 - Developing a Mockup for a Tablet Computer to Improve Patient Safety by Reducing Diagnostic Errors**  
Kiumars Zolfaghari, Oregon State University

**14 - On Randomness of Initial Service Access Loads in u-Healthcare over LTE-Advanced Network**  
Ki-Dong Lee, LG Electronics

**15 - Human Risk Assessment for Simulated Central Venous Catheterization**  
David Johnson, Mayo Clinic

**16 - Integrated Medical Analytic Data Model for Evaluation of Unnecessary Laboratory Test Utilization**  
Bradley Brimhall, UMMC

**17 - New England Veterans Engineering Research Center's Postgraduate Health Systems Fellowship**  
Jordan Peck, New England VERC

**18 - Real-Time Decision Support System for Pandemic Influenza**  
Sunderesh Heragu, University of Louisville

**19 - Scheduling and Routing Physical Therapists Hospital-Wide**  
Daniel Gartner, Technische Universität München

**20 - Simulation Modeling of a Hospital Emergency Department**  
Shyam Prabhu, Mercy Health

**21 - Surgery Scheduling and the Impact of Post-Anesthesia Care Unit Flow**  
Maya Bam, University of Michigan

**22 - Validation Study on Potential Cervical Cancer Genes Identified by Microarray Data Analysis Study**  
Luis Irizarry, University of Puerto Rico at Mayaguez

**23 - Mining Electronic Health Records to Improve the Quality and Safety of Care**  
Juergen Klenk, Booz Allen Hamilton Inc.

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[TBO T

## INFORMS COMMUNITIES

**informs***Institute for Operations Research  
and the Management Sciences***INFORMS Health Applications Society**

The INFORMS Health Applications Society focuses on the topics of health applications, with the aim of identifying current and potential problems and contributions to their solutions; to lead in the development, dissemination, and implementation of knowledge and advancing the basic and applied research technologies on health applications.

**INFORMS Computing Society**

The INFORMS Computing Society (ICS) addresses the interface of OR and computing. Since their earliest days, OR and computing have been tightly linked. The practice of OR depends heavily on the availability of software and systems capable of solving industrial-scale problems: computing is the heart of OR in application. Major ICS interests are algorithms and software for modeling, optimization and simulation.

**INFORMS Data Mining Section**

The mission of the INFORMS Data Mining Section is to promote and disseminate research and applications among professionals interested in theory, methodologies and applications in data mining and knowledge discovery.

**INFORMS MSOM, Healthcare Operations Management SIG**

The Healthcare Operations Management SIG encourages interest in the field of healthcare operations management and facilitates domain-knowledge discussions of relevant high quality and high impact research and applications with physicians, hospital administrators and business executives in the general area of healthcare operations management.

**INFORMS Optimization Society**

The INFORMS Optimization Society has two goals: to promote the development and application of optimization methods and software tools for the solution of problems in ORMS, and to encourage the exchange of information among practitioners and scholars in the optimization area.

**INFORMS Section on Public Programs, Service and Needs**

The section is concerned with the application of operations research and management science to questions of public policy and the management of public resources. The systematic use of OR and MS techniques and tools aids decision making and the management of operations in the public sector.

**INFORMS Simulation Society**

The INFORMS Simulation Society is organized and operated exclusively for educational and scientific purposes: (a) to encourage the development and dissemination of knowledge in the area of simulation; and (b) to promote communication and interaction among individuals and organizations who share an interest in simulation.



Canadian Operational Research Society  
Société canadienne de recherche opérationnelle

**Canadian Operational Research Society**

The Canadian Operational Research Society (CORS), in existence since 1958, is a scientific and professional society that takes a leadership role in the advancement of both the theory and the practice of Operational Research (OR) in Canada and safeguards the existence of a vital Canadian OR community by promoting contact between people interested in the subject. CORS strives to meet its objectives with two publications—the journal *INFOR* and the *CORS-SCRO Bulletin*, a newsletter of society and related activities—the CORS web site, an annual conference, by providing funds for student travel to CORS/SCRO, and by supporting a diverse array of local section activities. CORS also represents the Canadian OR community in the International Federation of Operational Research Societies (IFORS).

**POMS****POMS, College of Healthcare Operations Management**

Production and Operations Management Society (POMS) is an international professional organization representing the interests of POM professionals from around the world. POMS consists of seven colleges, each college comprised around an operations management theme of interest to the society's members. One such college is the College of Healthcare Operations Management (CHOM). The mission of the CHOM is to improve the ability of healthcare systems around the globe to deliver high quality care efficiently and effectively by encouraging operations management research, training and dialog among key health care stakeholders, including researchers, health care providers, decision-makers, policy-makers and patients.



## Health Systems Engineering Alliance

Launched in 2012, the Health Systems Engineering Alliance (HSEA) is a collaboration of the growing number of health system engineering (HSE) academic programs engaged in research or teaching about engineered solutions to health promotion and care-delivery. In contrast to many other professional groups, HSEA membership is open to university-level academic programs active in HSE rather than individual researchers. A total of 41 have already joined, including two outside the U.S. To become a member, programs need only designate a faculty or staff coordinator as primary alliance contact and pay minimal annual dues (initially \$250). Coordinators, in turn, may enroll at no cost individual colleagues from their university who have educational or research experience in an engineering or allied healthcare field and seek access to the leaders and issues shaping health systems engineering. Contact [hsea@uark.edu](mailto:hsea@uark.edu) for further information.

Recognizing that many HSE programs are quite new, the goal of HSEA is to accelerate their development by providing a forum for sharing ideas, materials and lessons learned on both teaching and research about HSE. Specifically, an online Website/Hub is hosted at Purdue University's <http://catalyzecare.org/> (enter 'HSEA' in the 'Search' box). A listserv available to all members has been established to facilitate communication through Texas A&M University at [HSEA@listserv.tamu.edu](mailto:HSEA@listserv.tamu.edu).

Initially the HSEA focus is on education-sharing HSE course materials, student activities, degree/track designs, internship formats, employment opportunities and faculty/student exchanges. A Course Archive has been established within the website/hub where members can share their course plans, texts and references. A summer 2013 University of Toronto project will populate the archive with course information from numerous HSEA members. In addition, five related sessions at this INFORMS conference have been organized by HSEA Board members Cerry Klein (University of Missouri), Amy Cohn (University of Michigan), Mike Carter (University of Toronto),

and Sharon Johnson (Worcester Polytechnic Institute). Two sessions address undergraduate and graduate program goals and options (MA01 and TB01). Three more showcase student research projects in HSE at the Universities of Toronto and Michigan (MB01, MC01, TA01).

HSEA is also co-hosting with the University of Michigan's Center for Healthcare Engineering and Patient Safety and the University of Missouri a networking reception at 6:00pm, Tuesday, June 25, to bring together educators and especially students with interest in HSE.



**McCormick**

Northwestern Engineering

## Northwestern Center for Engineering & Health

The Center for Engineering and Health brings together investigators with cross disciplinary engineering expertise in engineering and information technologies, advanced analytics, mathematical modeling, and operations research who work in partnership with healthcare administrators, health services researchers, epidemiologists, and other clinical-investigators. The center researchers are engaged in knowledge and hypothesis generation, predictive modeling, decision sciences, robust device design, and optimization within healthcare while taking a systems approach to solving different aspects of health and healthcare operations and delivery problems.



## Northwestern Institute for Public Health & Medicine

The goal of Northwestern's Institute for Public Health and Medicine (IPHAM) is to accelerate innovation at the interface of medicine and public health and achieve measurable improvements in health for patients and populations. By developing and supporting research that combines the best ideas across disciplines, IPHAM aims to improve the health of our communities, our city and the world. Nine founding centers—Behavior and Health, Buehler Center on Aging, Health and Society, Community and Health, Engineering and Health, Global Health, Healthcare Studies, Patient-Centered Outcomes, and Population Health Sciences—support the vision and mission of the IPHAM through focused and collaborative research and education. IPHAM Centers are major organizational entities for activities pertaining to public health and the interface of medicine and public health. IPHAM also houses the cross-cutting Center for Education in Public Health, which provides a home for critical Masters and PhD programs relevant to the education and training of diverse public health and health services research professionals. Each of IPHAM's centers supports strong interdisciplinary research programs and provides a home for academic and community scholars conducting research that is linked to IPHAM's overall mission.

T30 - No but list in Thank you!

## EXHIBITORS

Visit the exhibitors in the Chicago Foyer.  
Coffee breaks will be held in the area.

**AnyLogic North America, LLC**

3333 Warrenville Rd., Ste. 200  
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AnyLogic is the only simulation tool that supports discrete event, agent based, and system dynamics modeling providing solutions to complex, business challenges. We are excited to announce the up-coming launch of AnyLogic 7! Stay tuned... Although very intuitive, our consultants are available, through every step of the modeling process.

**Evolent Health**

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www.evolenthealth.com

Evolent Health offers the leading provider-led, unified population health managed services solution. Through long-term operating partnerships with health systems, we integrate the technology, tools and on-the-ground resources to deliver population health capabilities locally and at scale.

**INFORMS**

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**Lehigh University**

Healthcare Systems Engineering  
200 West Packer Ave.  
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www.lehigh.edu/hse

Healthcare Systems Engineering is a new professional master's degree program designed to prepare graduate students for engineering and management careers in organizations engaged in delivering healthcare and health related products and services. The need for professionals in this area is strong and growing due to the aging of the population and a national crisis of rapidly increasing healthcare costs.

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Yes

## FUTURE MEETINGS

**2013**

July 1-4  
**EURO-INFORMS Joint International Meeting**  
Università di Roma - La Sapienza  
Rome, Italy  
<http://www.euro2013.org/>

October 6-9  
**INFORMS Annual Meeting 2013  
Minneapolis**  
Minneapolis Convention Center & Hilton  
Minneapolis  
Minneapolis, Minnesota  
<http://meetings2.informs.org/minneapolis2013/>

**2014**

March 30-April 1  
**INFORMS Conference on Business Analytics & Operations Research**  
Westin Boston Waterfront  
Boston, Massachusetts

June 22-24  
**INFORMS Conference on Big Data**  
San Jose, California  
Co-Chairs: Diego Klabjan, Northwestern University; Margery Conner, Chevron Corp.

November 9-12  
**INFORMS Annual Meeting 2014 San Francisco**  
Hilton San Francisco & Parc 55 Wyndham  
San Francisco, California

**2015**

April 12-14  
**INFORMS Conference on Business Analytics & Operations Research**  
Hyatt Huntington Beach  
Huntington Beach, California

June 14-17  
**CORS INFORMS International**  
Sheraton Montreal  
Montreal, Canada

November 1-4  
**INFORMS Annual Meetings 2015 Philadelphia**  
Pennsylvania Convention Center & Marriott  
Philadelphia Downtown  
Philadelphia, Pennsylvania

TBD

## SPONSORED

**Canadian Operational Research Society**

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**INFORMS Data Mining Section**

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**INFORMS Health Applications Society**

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**INFORMS Health Applications Society: Student Paper Competition**

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**INFORMS MSOM, Healthcare Operations Management**

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**INFORMS Optimization Society**

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**INFORMS Simulation Society**

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Associate Professor, Industrial  
& Systems Engineering  
Texas A&M University  
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Yes

## MONDAY

TrackRoom	MA 8:30-10:00	Plenary 10:30-11:45	MB 12:30-2:00	Interactive/ Poster Sessions & Refreshments 2:00-3:30	MC 3:30-5:00
1	Chicago F, Level 5 HSE: Undergraduate Program Options/Goals	<b>Basit Chaudhry: IBM Watson &amp; the Application of Unstructured Data Analysis to Healthcare</b>	Undergrad Projects from University of Toronto	<b>Chicago DE Level 5</b>	Student Research Projects in HC Eng. & Patient Safety II
2	Chicago G, Level 5 HC Costs, Analytics & Process Eng.		Topics in Healthcare Data Analytics		Data Driven Modeling & Analysis of HC Apps.
3	Chicago H, Level 5 Healthcare Finance		Opt. Models & Methods in HC		Cancer Treatment Planning & Ops.
4	Scottsdale, Level 5 Managing & Discharging Inpatients		Hospital Operations		Joint CORS/SPPSN: Queueing Models in EMS Systems
5	Miami, Level 5 Joint HAS/SPPSN: Preferences & Risk Mgt. in HC		Healthcare Policy & Planning		Supply Chains & Procurement
6	Los Angeles, Level 5 Population-Level Models of Interventions & Disease Outcomes		Optimal Screening & Treatment Decisions		Medical Decision Making I
7	Kansas City, Level 5 Scheduling Services in Healthcare		Inpatient Management		Impact of Patient Flow Mgt. on Patient Service
8	Kane, Level 3 Recent Advances-Proton Radiation Treatment Planning		Radiation Therapy under Uncertainties		Cancer Therapy Optimization
9	McHenry, Level 3 Opt. Models for Kidney Allocation & Transplantation		Managing Performance of Health Teams		Designing HC Change: From Frontline Process to National Policy
10	Cook, Level 3 HC Scheduling & Capacity Mgt.		Primary Care Panel Design		Nursing Homes/Home Health
11	Dupage, Level 3 Patient Centered Models of Care		Emergency Dept. Operations		Empirical Healthcare Operations
12	Water Tower, Level 10 Evidence Based Health Services O.R.		Prescriptive Healthcare Analytics		Data-Driven Modeling of Hospital Operations
13	Navy Pier, Level 10 Medical Decision Making		Agent-Based Modeling: Predicting Future HC Requirements		Simulation in Emergency Care
14	Huron, Level 10 ORAHS 1: What Makes a Model Useful?		Improving HC Delivery in Sub-Saharan Africa		Healthcare in Other Countries
16	Houston, Level 5 No Session		Chemotherapy Patient & Resources Mgt. in Oncology Clinics		Advances in Modeling & Analyzing Spread of Infectious Diseases
17	Denver, Level 5 No Session		Topics in Medical Scheduling		Operating Room Planning and Scheduling

## TUESDAY

*Yes*

Track Room	TA 8:30-10:00	TB 10:30-12:00	TC 1:30-3:00	TD 3:30-5:00
1 Chicago F, Level 5	Student Research Projects in HC Eng. & Patient Safety I	Panel: Current Trends/Needs for Graduate Education for HCSE	Panel: Affordable Care Act- The Change of HC Landscape	Healthcare Scheduling
2 Chicago G, Level 5	Data Driven Approaches to Identify & Treat Critical Illness	Healthcare Analytics on Big Data	Patient-Centered Data Analytics	Evidence-Based Approaches to Resource Mgt. in HC
3 Chicago H, Level 5	Radiation Therapy Optimization	Optimization in Radiation Therapy	Opt. in Radiation Therapy Treatment Planning	Optimization & Analytics
4 Scottsdale, Level 5	Healthcare Operations	System Modelling	Quantitative Models for Outpatient Care	Mathematical Models in Cancer Therapy
5 Miami, Level 5	Math Modeling & Analysis of Infectious Disease Dynamics	Epidemics & Pandemics Models	Healthcare Operations	Joint HAS/ISIM: HC Applications at Mayo Clinic
6 Los Angeles, Level 5	Inpatient Medical Decision Making	Joint MDM/SPPSN: Health Policy Analysis	Medical Decision Making II	Stochastic Models in Medical Policy Making
7 Kansas City, Level 5	Outpatient Appointment Scheduling	Improving Service in Healthcare Networks	Outpatient Operations	Modeling Surgical & Operating Room Costs
8 Kane, Level 3	Advances in Rural Health	Rural Health in the Hospital Setting	Community Health	EMR, EHR, HIT: Implementation Barriers & Strategies
9 McHenry, Level 3	Models of Access Involving Geography I	Models of Access Involving Geography II	Patient Flow Models	CHOIR (Ctr. for HC Operations Improvement & Research)
10 Cook, Level 3	Improving Patient Flow in Outpatient Systems	Scheduling Strategies in Hospitals & Academic Medical Centers	Organ Transplant Waitlist Models	Capacity Management
11 Dupage, Level 3	Electronic Health Records/ Health IT	HAS Student Paper Competition Finalists	Modeling Methods & Apps. in Hospital Performance Improvement	Empirical Research in Hospital Operations
12 Water Tower, Level 10	Generating Care Coord. Insights Using Qualitative Methods	Healthcare Policy and Finance I	Topics in Patient Flow	Hospital Readmission Modeling & Analysis
13 Navy Pier, Level 10	Joint SPPSN/Health Operations: OR Apps. in the Vaccine World	Large-Scale Simulation for HC Decision & Operations Advances	Issues in Public Health	Modeling Infectious Diseases
15 O'Hare, Level 10	Economics & Policy Modeling at U.S. CDC	OR Modeling in Medical Decision Making	Surveillance at Patient & Population Level	Empirical Operations in Healthcare

## WEDNESDAY

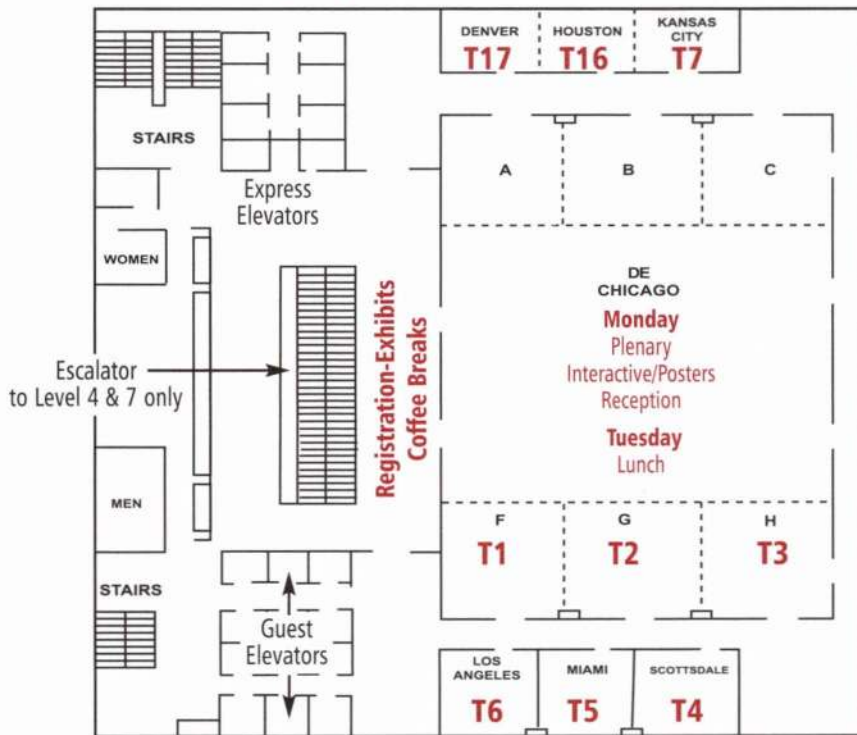
Track Room	WA 8:30-10:00	WB 10:30-12:00	WC 1:30-3:00
1 Chicago F, Level 5	Joint HAS/ISIM: HIV & Networks	Healthcare Services	HC Analytics in CMS Systems Engineering Innovation Ctr
2 Chicago G, Level 5	Data Driven Approaches to Identify & Treat Critical Illness	Hospital Operations	Patient Flow Models for Resource Allocation
3 Chicago H, Level 5	Dynamic Opt. of Clinical Treatments	Big Data in Healthcare	No Session
4 Scottsdale, Level 5	Joint HAS/MDPM: Policy & Decision Making in Disasters & Public Health Emergencies	Modeling for Opt. of Healthcare Delivery	Industry-Academic Research Partnership: Advances & Challenges
7 Kansas City, Level 5	Surgical Operations	Healthcare Operations	No Session
8 Kane, Level 3	Chronic Diseases: Screening & Treatment	Modeling Cancer Behavior, Screening, Treatment	No Session
9 McHenry, Level 3	Application of OR in Healthcare	Challenging Decisions in Pharmaceutical Supply Chains	Persepectives on Integrated Analytics in Healthcare
10 Cook, Level 3	ORAHS 2- Modeling for Planning Decisions	Healthcare Policy & Finance II	Healthcare Policy & Finance III
11 Dupage, Level 3	No Session	Empirical Studies on Hospital Operations	Advances in Healthcare Delivery
18 Northwestern, Level 6	Scheduling & Patient Flow for Healthcare O.R.	Challenges in Sudden Cardiac Arrest	No Session

yes

Track numbers shown for Technical Session Rooms

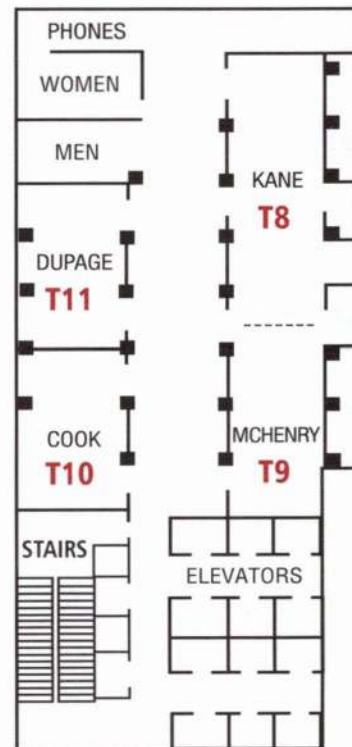
## 5TH FLOOR

### TRACKS 1-7, 16, 17



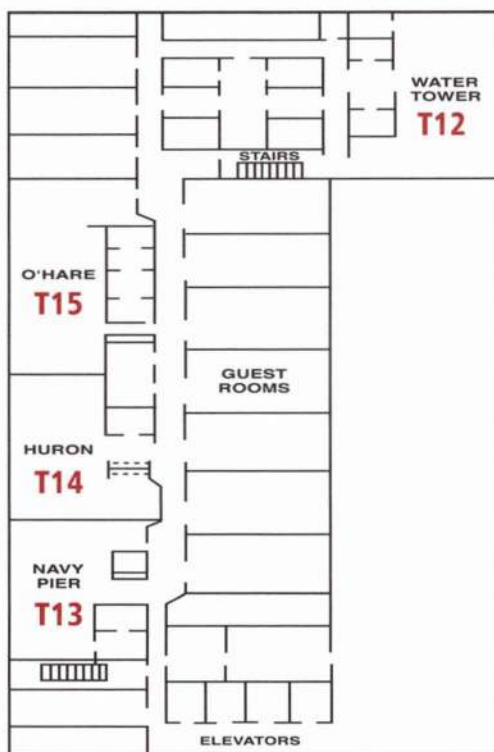
## 3RD FLOOR

### TRACKS 8-11



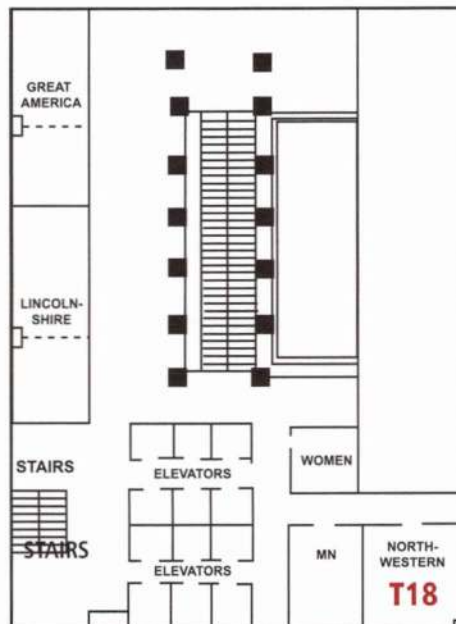
## 10TH FLOOR

### TRACKS 12-15



## 6TH FLOOR

### TRACKS 18



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**Stairs**  
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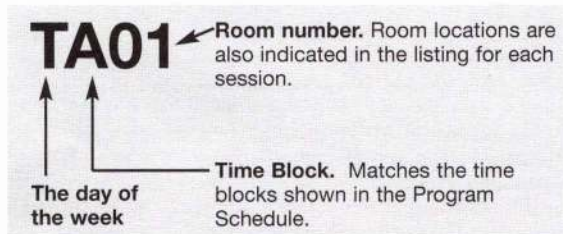
## How to Navigate the Technical Sessions

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

- This Technical 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 (pages 66-72).
- The floor plan on page 14 shows you where technical session tracks are located).
- The Master Track Schedule is on pages 12-13

## Quickest Way to Find Your Own Session

Use the Author Index (page 66) — the session code for your presentation will be shown along with the room location. You can also refer to the full session listing for the room location of your session.



## Time Blocks

### Monday

- A — 8:30am - 10:00am
- Plenary - 10:30am - 11:45am
- B — 12:30pm - 2:00pm
- Poster Session - 2:00pm - 3:30pm
- C — 3:30pm - 5:00pm

### Tuesday

- A — 8:30am - 10:00am
- B — 10:30am - 12:00pm
- C — 1:30pm - 3:00pm
- D — 3:30pm - 5:00pm

### Wednesday

- A — 8:30am - 10:00am
- B — 10:30am - 12:00pm
- C — 1:30pm - 3:00pm

## Monday, 8:30am - 10:00am

### ■ MA01

01- Chicago F

#### Health Systems Engineering: What are Undergraduate Program Options and Goals?

Cluster: Health Systems Engineering Alliance (HSEA)

Invited Session

Chair: Sharon Johnson, Worcester Polytechnic Institute, 100 Institute Road, Worcester, MA, 01609-2280, United States of America, sharon@wpi.edu

#### 1 - Panel Discussion: Health Systems Engineering Undergraduate Program Options and Goals

Moderator: Sharon Johnson, Worcester Polytechnic Institute, 100 Institute Road, Worcester, MA, 01609-2280, United States of America, sharon@wpi.edu. Panelists: Amarnath Banerjee, Shi-Jie (Gary) Chen

In this session, panelists from Northern Illinois University, Worcester Polytechnic Institute and Texas A&M University will present their approach to health systems engineering at the undergraduate level, focusing on goals and program options. A moderated discussion will follow the short presentations by panelists, focused on the needs, goals, and challenges of such programs.

### ■ MA02

02- Chicago G

#### Health Care Costs, Analytics and Process Engineering

Contributed Session

Chair: Keunho Choi, Research Associate, Wayne State University, 4815 4th Street, Detroit, MI, 48202, United States of America, kchoi@wayne.edu

#### 1 - Quantifying the Cost of Unnecessary Medical Laboratory Testing using Integrated Medical Analytics

Bradley Brimhall, Medical Director, UMMC, 812 Norwich Drive, Madison, MS, 39110, United States of America, brimhall6@stanfordalumni.org

Overutilization of diagnostic testing represents a source of unnecessary costs to the health care system. We analyzed data from an academic hospital system, a reference laboratory serving two hospital systems, as well as a national payer and large regional payer to evaluate the costs of unnecessary testing. Looking at just a few testing scenarios, we identified potential annual cost savings of >\$60,000 and >\$500,000 for a hospital system and reference laboratory, respectively. Annual payments for these unnecessary tests was >\$3 million and >\$7 million for a national and regional payer.

#### 2 - Development of Hidden Cost Factor Extraction System (HiCoFES) for Reusable Medical Equipment

Jihoon Kim, Wayne State University, 4815 Fourth St., #2037, Detroit, MI, 48202, United States of America, jhkim4hg@wayne.edu, Junheung Park, Kyoung-Yun Kim, Will Jordan, Michael Lederle

To calculate total cost of ownership of reusable medical equipment (RME) such as endoscopes, hidden costs (e.g. reprocessing and repair costs) should be included. An artificial intelligence based system has been developed to extract hidden cost factors from the distributed data repositories for calculating the current total cost and predicting expected costs of RME. Extracted cost factors were applied to estimate the future costs of RME to support the decision making of equipment acquisition.

#### 3 - To Develop the Supporting Technologies for an Artificial Pancreas

Ahmed Gomaa, Assistant Professor, Marywood University, 2300 Adams Ave., Scranton, PA, 18509, United States of America, agomaa@marywood.edu

At this stage, we are developing a generic wireless platform that is connected physically to a smart phone. A mobile application remotely sends insulin dose release commands to an insulin pump that is attached to a diabetic patient. Using analytics and data mining, the application coordinates the food intake as recorded by the smart phone camera, and activity level of the patient as recorded by the smart phone sensor to estimate the required amount of insulin to be delivered.

#### 4 - Usability Measure Selection for an Automated Usability Analytics Platform in Healthcare

Keunho Choi, Research Associate, Wayne State University, 4815 4th Street, Detroit, MI, 48202, United States of America, kchoi@wayne.edu, Scott Russell, Carolyn Psenka, Richard Ellis, Kyoung-Yun Kim, Valerie Curtis, Jason Saleem, Zia Agha, Alan Calvitti

Current usability practices in human-computer interaction (HCI) require tremendous human effort and time to analyze and resolve usability challenges. In multiple site healthcare systems, like VA Medical Centers, it is critical to provide timely system improvements. Our aim is to create an automated usability analytics platform for the EHR to further timely system improvements through automated measures of usability and to present the issues and challenges of developing such automated measures.

### ■ MA03

03- Chicago H

#### Healthcare Finance

Sponsor: INFORMS Optimization Society

Sponsored Session

Chair: Aurelie Thiele, Associate Professor, Lehigh University, 200 W. Packer Ave., Rm. 329, Bethlehem, PA, 18015, United States of America, aurelie.thiele@lehigh.edu

##### 1 - Robust Partial Capitation

Aurelie Thiele, Associate Professor, Lehigh University, 200 W. Packer Ave., Rm. 329, Bethlehem, PA, 18015, United States of America, aurelie.thiele@lehigh.edu

We investigate the optimal trade-off between fee-for-service and flat-fee payment (capitation) systems, the combination of which has been touted by health policy experts as having strong potential to slow the rise in healthcare costs. We incorporate high cost uncertainty through the multi-range robust optimization model of Duzgun and Thiele and analyze several capitation models both from a theoretical perspective and in numerical experiments.

##### 2 - Robust Risk Adjustment in Health Insurance

Tengjiao Xiao, Lehigh University, 200 W. Packer Ave., Bethlehem, PA, 18015, United States of America, tex209@lehigh.edu, Aurelie Thiele

This paper introduces robust optimization models to address ambiguity and uncertainty in risk adjustment which is used to quantify payment transfers across health plans. In particular, this paper develops robust scoring mechanisms, investigates the usefulness of having multiple risk scores instead of a single number, and tests the impact of the time horizons involved.

##### 3 - Robust Value-Based Insurance Design

Shuyi Wang, Lehigh University, 445 Webster St., Bethlehem, PA, 18015, United States of America, shw210@lehigh.edu, Aurelie Thiele

Value-based insurance design (VBID) encourages positive behavior from the insured by, for instance, providing preventive care for free or with lower coinsurance. We describe quantitative models to set cost-sharing levels for an Essential Benefit Package's tiered benefits. We tie the probability of a patient undergoing a procedure to the financial burden the coinsurance would represent, given income. We use robust optimization to capture uncertainty on customer behavior and procedure benefit.

### ■ MA04

04- Scottsdale

#### Managing and Discharging Inpatients

Sponsor: CORS, Canadian Operational Research Society

Sponsored Session

Chair: Peter Vanberkel, Professor, Dalhousie University, Dept. of Industrial Engineering, 5269 Morris Street, Room 201, Box 15000, Halifax, NS, B3H 4R2, Canada, pvanberk@dal.ca

##### 1 - Inpatient Discharge Scheduling

Tammy Sieminowski, Attending Physician, Bridgepoint Hospital, 14 St Matthews Rd., Toronto, ON, Canada, tsiemin@rogers.com, Sean Sit, Laith Azer, Dionne Aleman

Discharging inpatients is a complex, multistep process. Research suggests that reducing day to day variability in the number of patients discharged can positively affect patient flow. Discharges from our neurorehabilitation unit are scheduled manually using heuristics generated by healthcare teams with no analytic background. We have analyzed current discharge patterns, and generated solutions to reduce variability using DES. It is anticipated this work

will allow healthcare providers to improve discharge scheduling and decrease fluctuations in health system capacity.

##### 2 - Understanding Medium Term In-Patient Occupancy in Acute Hospitals: A Methodology and a Case Study

Derek Atkins, University of British Columbia, Sauder School of Business, 2053 Main Mall, Vancouver, BC, V6T 1Z2, Canada, derek.atkins@sauder.ubc.ca, Zoha Zargham, Lu Zhao

Several mitigating actions are available in a 2-6 week horizon to ease in-patient occupancy congestion in acute hospitals if we could better understand and predict their consequences. To facilitate such understanding and prediction we developed, on behalf of Vancouver Coastal Health, a simple, maintainable and portable tool. Unlike most previous methods involving simulation or optimization, our method simply calculates the risk of congestion, or over occupancy. We describe this tool in terms of a pilot study undertaken at Vancouver General Hospital, a 780 bed tertiary facility.

##### 3 - Queuing Models of Case Managers

Fernanda Campello, University of Alberta, 2-24 Business Building, Edmonton, AB, T6G 2R6, Canada, campello@ualberta.ca, Robert Shumsky, Armann Ingolfsson

Many service systems use case managers who have repeated interactions with each customer until service is completed (e.g., emergency department doctors, social workers). We propose a stochastic model of a case manager system and formulate models that provide performance bounds for the system. We examine interactions among system parameters, including the impact on system performance of setting case-load limits. We also investigate heuristics for setting these limits.

### ■ MA05

05- Miami

#### Joint Session HAS/SPPSN: Preferences and Risk Management in Health Care

Sponsor: Healthcare Applications Society & Public Programs, Services and Needs

Sponsored Session

Chair: Mehmet Ayvaci, Assistant Professor, University of Texas-Dallas, Jindal School of Management, 800 W. Campbell Rd., SM33, Dallas, TX, 75080, United States of America, mehmet.ayvaci@utdallas.edu

##### 1 - Priority-Driven Resource Allocation in Response to Mass-Casualty Events

Alex Mills, Assistant Professor, Indiana University, Kelley School of Business, Bloomington, IN, United States of America, millsaf@indiana.edu, Nilay Argon, Serhan Ziya

A mass-casualty event (MCE) consists of one or more incidents, overwhelming the emergency response system. Recently, resource-based prioritization policies have been developed for use in MCE, but resource allocation models do not incorporate information about patients' triage classes or their probability of survival. We bridge this gap by showing that to maximize the number of survivors, resource allocation heuristics must take into account the prioritization policy being used by responders.

##### 2 - The Role of Patient Preferences in Managing Post-Mammography Diagnostic Decisions

Mehmet Ayvaci, Assistant Professor, University of Texas-Dallas, Jindal School of Management, 800 W. Campbell Rd. SM33, Dallas, TX, 75080, United States of America, mehmet.ayvaci@utdallas.edu, Elizabeth Burnside, Guuzhan Alagoz

We explore the role of risk preferences in the context of breast cancer diagnostic decisions following mammography. In particular, we develop a risk-sensitive finite-horizon MDP model to maximize the total expected utility of a patient where utility is defined over quality-adjusted survival duration. Our study provides a modeling framework and empirical analysis for tailoring sequential interventions towards preference-sensitive care.

##### 3 - Risk-Sensitive Treatment Decisions to Minimize Coronary Heart Disease Events

Greggory Schell, PhD Candidate, University of Michigan, Ann Arbor, MI, 48105, United States of America, schellg@umich.edu, Mariel Lavieri, Jeremy Sussman, Rodney Hayward, Wyndy Wiitala

Patients at risk of coronary heart disease (CHD) events, e.g. heart attacks, are treated with antihypertensive medications to manage their systolic blood pressure (SBP). We develop a Markov decision process formulation to determine the optimal allocation of scarce resources across the patient's lifetime which minimizes the total expected number of CHD events. Our model considers the patient's risk-sensitivity by modeling treatment effects on SBP through the conditional value at risk measure.

## ■ MA06

06- Los Angeles

### Population-level Models of Interventions and Disease Outcomes

Cluster: Medical Decision Making

Invited Session

Chair: Maria Mayorga, Assistant Professor, Clemson University, 110 Freeman Hall, Clemson, SC, United States of America, mayorga@clemson.edu

#### 1 - Predicting Liver Transplant Capacity using Simulation

Maria Mayorga, Assistant Professor, Clemson University, 110 Freeman Hall, Clemson, SC, United States of America, mayorga@clemson.edu, Stephanie Wheeler, Sid Barritt, Eric Orman, Hector Toro-Diaz

We predict future liver transplant (LT) trends using a discrete event simulation (DES) model informed by current demographic trends and estimate the number of future organ donors required to maintain current LT levels. We use the UNOS database to identify factors associated with donor liver discard using multivariable logistic regression which are input into the population level DES to estimate future LT utilization. Predictions show that the number of discarded organs is increasing and are more often from donors who are older, obese, diabetic, hypertensive, and donated after cardiac death.

#### 2 - Perspective Matters: Choosing a Simulation Study Design for Optimizing Colorectal Cancer Outcomes

Kristen Hassmiller Lich, Assistant Professor, University of North Carolina at Chapel Hill, 135 Dauer Drive, Chapel Hill, NC, 27599, United States of America, klich@unc.edu, Maria Mayorga, Stephanie Wheeler, Nadeepa Wickramage

We present the problem statement and motivation for developing a North Carolina-based agent-based model to support research and translation priority setting around colorectal cancer screening. After introducing the model, we will discuss the decision we faced about simulation study design and the advantages and disadvantages of alternate approaches including cohort based, multiple-cohort, or population based designs.

#### 3 - A Discrete Event Simulation Estimating Health and Economic Impacts of Smoking Cessation Approaches

Stephanie Wheeler, Assistant Professor, University of North Carolina at Chapel Hill, 135 Dauer Drive, CB #7411, Chapel Hill, NC, 27516, United States of America, Stephanie\_Wheeler@unc.edu, Maria Mayorga, Odette Reifsnider, Raquel Kelly Kohler

Considering the significant health and economic burden of smoking and the unavailability of a "magic bullet" for smoking cessation, comparative effectiveness studies are needed to evaluate different smoking cessation options and corresponding outcomes. We developed a discrete event simulation model to compare the effects of multiple smoking cessation interventions (nicotine replacement therapy, varenicline, bupropion, and non-pharmacologic-assisted quitting) on prevalence of smoking-related diseases, mortality, quality of life, and costs at the US population level.

#### 4 - Design and Implementation of Enhanced Disease Registry for Depression Tele-Screening and Monitoring

Shinyi Wu, Assistant Professor, University of Southern California, 3715 McClintock Ave., GER 240, Los Angeles, CA, United States of America, shinyiwu@usc.edu, Irene Vidyanti

Managing chronic conditions such as depression requires periodic screening and monitoring. Healthcare providers often are time pressured to communicate with patients via telephone. Automatic telephonic assessment (ATA) holds promise to improve productivity. However, successful implementation of the ATA requires integrating its results into existing provider workflow through an Enhanced Disease Registry (EDR). We described the design of an EDR used alongside an ATA system within a trial to assess depressive symptoms of 400 patients and presented preliminary results.

## ■ MA07

07- Kansas City

### Scheduling Services in Healthcare

Sponsor: POMS, College of Healthcare Operations Management

Sponsored Session

Chair: Nadia Lahrichi, Professor, Ecole Polytechnique de Montreal, CP6079 Succ Centre-ville, Montreal, QC, H3C3A7, Canada, nadia.lahrichi@polymtl.ca

#### 1 - Stochastic Online Appointment Scheduling of Multi-Step Sequential Procedures in Nuclear Medicine

Eduardo Perez, Assistant Professor, Texas State University, 601 University Drive, San Marcos, TX, 78666, United States of America, eduardopr@txstate.edu, Lewis Ntamo

Nuclear medicine uses advanced technology and radiopharmaceuticals for the diagnosis and treatment of patients. Procedures in nuclear medicine are multistep, and have to be performed under strict time windows constraints. In this work, we develop stochastic online scheduling algorithm to optimize patient and resource schedules. We report on computational results based on a real clinic, historical data, and both patient and management performance measures.

#### 2 - Navigating the Competitive Healthcare Market: Baptist Outpatient Services Case Study

Joyce Elam, Florida International University, Modesto Maidique Campus, MARC 340, Miami, FL, 33131, United States of America, elamj@fiu.edu, Aya Chacar, Nancy Borkowski

Baptist Outpatient Services (BOS) is a subsidiary within Baptist Health South Florida (BHSF) - the largest healthcare provider in South Florida. This case study examines the strategies employed by BOS to achieve tremendous growth since its inception in 1996 and to become the largest contributor to the net earnings of BHSF.

#### 3 - An Intelligent Approach for Appointment Scheduling In Healthcare Services

Arefeh Mohammadi, Southern Illinois University, 690 N. Main St., Apt. B, Edwardsville, IL, 62025, United States of America, armoham@siue.edu, Emmanuel Eneyo

This paper examines the application of sweep-coverage mechanism of multi-agent systems in a home healthcare setting. The therapists as agents travel to the patients' location and complete the treatment process collaboratively. The objectives are to provide the treatment schedule and to ensure all the patients are covered using minimum resources.

#### 4 - Increasing Capacity in the Operating Room for Thyroidectomy Patients

Nadia Lahrichi, Professor, Ecole Polytechnique de Montreal, CP6079 Succ. Centre-ville, Montreal, QC, H3C3A7, Canada, nadia.lahrichi@polymtl.ca, Phillip Troy, Lawrence Rosenberg

To decrease the backlog of patients needing thyroidectomies, we develop a mathematical model solved with CPLEX that aims to increase the rate at which these procedures will be performed in a large teaching hospital within a pre-defined block operating theatre schedule. Scenario analysis to determine the best strategy for scheduling patients is performed.

## ■ MA08

08- Kane

### Recent Advances in Proton Radiation Treatment Planning

Cluster: Radiation Therapy

Invited Session

Chair: Gino Lim, University of Houston, 4800 Calhoun Rd., Houston, TX, United States of America, ginolim@Central.uh.edu

#### 1 - Recent Developments in Intensity Modulated Proton Therapy Treatment Planning Optimization

Gino Lim, University of Houston, 4800 Calhoun Rd., Houston, TX, United States of America, ginolim@Central.uh.edu, Wenhua Cao

Intensity modulated proton therapy (IMPT) is one of the most advanced radiation therapy techniques for cancer patients. However, mathematical optimization for determining IMPT treatment variables has not been well addressed. Typical IMPT optimization problems are not only large-scale but also with uncertain parameters. In this talk, optimization methods for choosing IMPT treatment beam angles, selecting proton energy levels, and determining intensity profiles will be discussed.

## 2 - An Investigation of Effects of Intra-Fraction Motion on Intensity Modulated Proton Therapy Treatment

Xiaodong Zhang, University of Texas, MD Anderson Cancer Center, 1840 Old Spanish Trail, Houston, TX, 77054, United States of America, xizhang@mdanderson.org, Yupeng Li, Laleh Kardar, Wenhua Cao, Gino Lim

In this study, the dosimetric impact of interplay effect between pencil beam scanning and respiratory motion on IMPT treatment for the lung cancer was evaluated. A tool was developed to simulate the delivery of a scanning proton beam to a moving lung tumor. The dynamic dose distributions at different numbers of fractions with and without repainting were compared to the corresponding 4D composite doses. We show that IMPT is possible to treat lung cancer safely with regular fractionation.

## 3 - Optimizing Beamlet Weights in IMPT Treatment Planning using a Molecular Dynamics Method

Wenhua Cao, University of Houston, E206 Engineering Bldg. 2, Houston, TX, 77204, United States of America, wcao@central.uh.edu, Li Liao, Xiaodong Zhang

A molecular dynamics (MD) method was developed to optimize beamlet weights in intensity modulated proton therapy (IMPT) treatment planning. One clinical prostate patient case was used in this study. Based on testing with different initial solutions of beamlet weights, we demonstrated that the MD method was able to avoid local minima while the conventional gradient optimization method such as L-BFGS method failed to escape from local minima in certain starting conditions.

## MA09

09- McHenry

## Optimization Models for Kidney Allocation and Transplantation

Cluster: Healthcare Operations Management

Invited Session

Chair: Murat Kurt, Assistant Professor, University of Buffalo, 415 Bell Hall, North Campus, Buffalo, NY, 14260, United States of America, muratkur@buffalo.edu

### 1 - Predicting Long Run Geographic Disparities in Kidney Transplantation via Fluid Approximations

Ashley Davis, Northwestern University, 2145 Sheridan Road, Evanston, IL, 60208, United States of America, ashleydavis2012@u.northwestern.edu, Daniela Ladner, Sanjay Mehrotra, John J. Friedewald

Organ allocation cannot discriminate by geography, but geographic disparities continue to increase over time in kidney transplantation. Understanding of how geographic disparities will change in the future is limited. A queuing network of the kidney transplant system was developed to estimate long run queue behaviors. Long run transplant waiting times vary by over 12 years and waitlist mortality rates vary by over 36% across the country. Changes to kidney allocation policy are necessary.

### 2 - Optimal Screening Strategies of Patients on the Kidney Transplant Waiting List

Alireza Sabouri, University of British Columbia, Vancouver, BC, V6T 2C2, Canada, Alireza.Sabouri@sauder.ubc.ca, Steven Shechter, Tim Huh

The health condition of patients on the kidney transplant waiting list deteriorates while they are waiting for an organ arrival and hence they may no longer be suitable for transplant. Therefore, transplant centers screen waiting patients at various intervals to identify ineligible patients. We propose a model for finding screening strategies that minimizes the expected screening cost and the expected penalty cost associated with transplanting an organ to an ineligible patient.

### 3 - What Drives the Geographical Differences in Deceased Donor Organ Procurement in the United States?

Mazhar Arikan, University of Kansas, 1300 Sunnyside Ave., Room 315D, Lawrence, KS, 66045, United States of America, mazhar@ku.edu, Baris Ata, John J. Friedewald, Rodney Parker

The deceased-donor kidney allocation system suffers from severe shortages of available organs while there is significant variation in the procurement rates across different geographies in the US. The empirical analysis of the kidney procurement, donor and recipient data reveals that the intent of procurement increases significantly with organ quality, the median waiting time for a transplant, and the competition among transplant centers. A counterfactual study shows that broader sharing of lower quality organs leads to an increase in the procurement rates.

## 4 - Integer Programming-Based Equilibrium Selection in the Timing of Prearranged Paired Kidney Exchanges

Amin Dehghanian, University of Pittsburgh, Dept. of Industrial Engineering, Pittsburgh, PA, United States of America, amd120@pitt.edu, Murat Kurt, Andrew Schaefer

Paired kidney exchange (PKE) is an emerging clinical strategy which overcomes blood type and/or tissue incompatibilities between ESRD patients and the donors. We consider a stochastic game formulation of the patients' transplant timing decisions in a prearranged PKE and develop a customized computationally efficient method to tackle the MILP representation of the resulting equilibrium conditions. We illustrate the efficiency of our approach on real clinical instances.

## MA10

10- Cook

## Healthcare Scheduling and Capacity Management

Cluster: Healthcare Scheduling

Invited Session

Chair: Nan Liu, Assistant Professor, Columbia University, 600 W. 168 St., New York, NY, 10032, United States of America, nl2320@columbia.edu

### 1 - Appointment System (AS) Design for Fairness-based Operational Performance Targets

William Millhiser, Assistant Professor, City University of New York, One Bernard Baruch Way, New York, NY, 10010, United States of America, william.milhiser@baruch.cuny.edu, Emre Veral

We define generalizable principles in AS template design to meet operational targets of (1) managed and fair waiting times and (2) dependable session end times to control providers' overtime. We use an iterative simulation methodology where each patient's finish time distribution determines the next patient's appointed arrival time. Our findings suggest that the resulting templates do follow generalizable patterns, moderated by allowances that account for service times, variability, show rates, and managerially established performance targets of patient delays and providers' overtime.

### 2 - Optimal Advanced Scheduling, with Expediting

Van-Anh Truong, Columbia University, 500 West 120th St., New York, NY, 10027, United States of America, vt2196@columbia.edu

We consider the advanced scheduling of a generic resource to satisfy demand from two separate demand classes, an urgent demand class, which must be satisfied on the day of arrival, and a regular demand class, which can be satisfied on a future date. The problem is motivated by the scheduling of MRI exams in a pediatric hospital. We propose the first strategic use of expediting in advanced scheduling as a tool to increase operational flexibility and improve system efficiency. We provide the first theoretical analysis within the domain of advanced scheduling. We show that under a simple transformation of the state space, the dynamic advanced scheduling problem with expediting is well-structured. In particular, the value function is convex and submodular in the states, and the optimal schedule is monotone in the states. We prove a number of other theoretical properties of an optimal schedule. We develop a simple threshold algorithm that obeys these theoretical properties. We analyze data from an actual hospital to show the potential benefits of our algorithm. Compared to a myopic policy, which minimizes current costs without accounting for the effects of current decisions on the future, we show that our algorithm is highly robust, dominates the myopic policy and routinely costs 20% or lower than the myopic policy in computational experiments with a wide range of control parameters.

### 3 - Capacity Management of Online Appointment Scheduling

Bo Zhang, IBM T.J. Watson Research Center, 1101 Kitchawan Road, Yorktown Heights, NY, 10598, United States of America, bozhang@gatech.edu, Peter van de Ven, Nan Liu

Consider an electronic patient appointment booking system for making online reservations. The system displays a set of available time slots and the patient selects an acceptable slot or leaves if none are acceptable. We propose blocking popular slots during initial stages, 'forcing' early patients to select less popular ones and increasing long-term utilization. We study the tradeoff between losing early patients (blocking too long) and having little flexibility later on (blocking too little).

## ■ MA11

11- Dupage

### Patient Centered Models of Care

Cluster: Improving Hospital Operations

Invited Session

Chair: Hari Balasubramanian, Assistant Professor, University of Massachusetts-Amherst, 160 Governors Drive, Amherst, MA, 01003, United States of America, hbalasubraman@ecs.umass.edu

#### 1 - Designing Patient Centered Health Care: A Comparative Systems Approach

Paul Fishman, Group Health Research Institute, Seattle, WA, United States of America, fishman.p@ghc.org, Zeld Zabinsky, Joseph Heim

Patient-centered health care organizes services so that the right care is provided at the right time to maximize individual and population health outcomes. U.S. health care and the dominant fee for service model, is focused on reimbursable events with little incentive to organize production to achieve the best patient outcomes. We describe a systems approach to organizing health services that can support the patient centered transformation of U.S. health care.

#### 2 - Implementing a Patient-Centered Surgical Home to Improve Out-Patient Surgical Processes of Care and Outcomes

Douglas Morrice, Professor, University of Texas, Austin, 2110 Speedway Stop B6500, Austin, TX, 78712, United States of America, douglas.morrice@mcombs.utexas.edu, Ester Wang, Jonathan F. Bard, Luci Leykum, Susan Noorily, Poornachand Veerapaneni

As the healthcare system becomes outcome-based, it's critical to improve the safety and efficiency of the episodes of care. In an out-patient surgery process, different types of physicians are involved at different stages of the surgical care and information items regarding patients' health condition are generated at each institution. However, due to the fragmented surgical episodes of care, healthcare providers often find themselves spending a considerable amount of time collecting information items that are missing from their patients' medical records. The issue of information deficiency [1] in the surgical episodes, to the best of our knowledge, has not been properly addressed but deserves great attention because it not only reduces clinic capacity and operation efficiencies, but also lowers the overall quality of care in the out-patient surgery process. We are working with the UT Health Science Center (UTHSC) at San Antonio to develop a Patient-Centered Surgical Home model, which is a recent concept proposed by the Anesthesiology Society of America. Under this model, we envision the Anesthesiologist Preoperative Clinic (APC) as a coordinator and integrator and we use computer simulation, process mapping and statistical analysis to address research problems: 1. How can we improve the information flow among providers at different stages of the surgical episode of care to ensure an efficient and complete exchange of the patients' medical records? 2. What are acceptable levels of performance vis-a-vis resource utilization, patient waiting times, and overtime? 3. How to assess the improvement of the quality of care? The concept of PCSH has not yet been widely implemented or studied, which motivates this research.

#### 3 - using Empirical Data to Classify Patients for Improved Appointment Scheduling

Hyun Jung Oh, PhD student, University of Massachusetts, Amherst, 160 Governors Drive, Amherst, MA, 01003, United States of America, hjoh0814@gmail.com, Hari Balasubramanian, Ana Muriel

Based on empirical data from a family medicine practice, we propose a new patient classification to improve patient sequencing and scheduling. We formulate appointment scheduling problem under the classification and two service stages (nurse and provider) as a stochastic program. Our analysis of optimal schedules and a variety of sequences provide broader guidelines for the adequate coordination of nurse and provider, and strategies for introducing slack to counter the effect of variability.

## ■ MA12

12- Water Tower

### Evidence Based Health Services Operations Research

Cluster: Patient Flow and Care Coordination

Invited Session

Chair: Joris van de Klundert, Professor, Erasmus University Rotterdam, P.O. Box 1738, Rotterdam, Netherlands, vandeklundert@bmg.eur.nl

#### 1 - Iterative Branch-and-Price for Hierarchical Multi-Criteria Kidney Exchange

Kristiaan Glorie, Erasmus University Rotterdam, P.O. Box 1738, Rotterdam, 3000 DR, Netherlands, glorie@ese.eur.nl, Joris van de Klundert, Albert Wagelmans

Kidney exchange is an increasing modality that allows the exchange of kidneys between two or more incompatible patient-donor pairs. Typically, the aim is to find an allocation of donors to patients that is optimal with respect to multiple hierarchical criteria. We present an iterative branch-and-price algorithm for clearing such multi-criteria kidney exchanges with large patient-donor pools. We propose how the pricing problem can be solved in polynomial time for a general class of criteria.

#### 2 - Creating Evidence in Operating Room Management with Eight University Medical Centers in the Netherlands

Sylvia Elkhuizen, Erasmus University Rotterdam, P.O. Box 1738, Rotterdam, 3000 DR, Netherlands, elkhuizen@bmg.eur.nl, Geert Kazemier, Elizabeth van Veen-Berkx

In 2004, eight University Medical Centers in the Netherlands started a collaboration with the aim to create learning opportunities concerning planning and control of Operating Room departments. First, a structure for time registrations was agreed upon. Each hospital daily registers data considering the use of their OR's, like surgical time, first-case tardiness and turn-over time. In two-monthly meetings, learning is facilitated, based on quantitative analyses and exchange of management practices.

#### 3 - Evidence Based Health Service Operations in Networks for Diabetes Care

Joris van de Klundert, Professor, Erasmus University Rotterdam, P.O. Box 1738, Rotterdam, Netherlands, vandeklundert@bmg.eur.nl

Increasingly, health care demand arises from age related, chronic, and/or multimorbid conditions. Meeting these demands requires prolonged health servicing by a network of health service providers. Hence the operations of regional health service networks are of increasing importance. We present a model for regional health service networks and an evaluation framework which aims to advance the evidence base. We apply it to benchmark diabetes care in Europe and in The Netherlands.

## ■ MA13

13- Navy Pier

### Medical Decision Making

Sponsor: Simulation Society

Sponsored Session

Chair: Peter Frazier, Assistant Professor, Cornell University, 232 Rhodes Hall, Ithaca, NY, 14853, United States of America, pf98@cornell.edu

#### 1 - Evaluation of Surveillance Strategies for Secondary Renal Cell Carcinoma

Jennifer Mason, Assistant Professor, University of Virginia, P.O. Box 800717, Charlottesville, VA, 22908, United States of America, jem4yb@virginia.edu, Tracey Krupski

Renal cell carcinoma (RCC) is a surgical disease for which radiation and chemotherapy provide little chance of cure. When detected early, patients may be treated with partial nephrectomy to remove the cancer and retain renal function; however, these patients are at risk for recurrence. We present a Monte Carlo simulation model to compare published surveillance strategies to identify RCC recurrence. We present numerical results to illustrate differences in cost and time to recurrence diagnosis.

## 2 - Dynamic Programming for Individualized, Response-Guided Therapy

Archis Ghate, University of Washington, Seattle, WA,  
United States of America, archis@u.washington.edu, Minsun Kim

We propose a stochastic dynamic programming framework for making dosing decisions in response-guided therapy. The state equals a numerical score of disease condition and the decisions correspond to dose levels. We prove the existence of a monotone optimal policy in which dose levels increase with worsening disease conditions. We present numerical results on a cancer radiotherapy example.

## 3 - Design and Evaluation of an In-Patient Flow Modeling Framework for Hospital Bed Capacity Decisions

Louis Luangkesorn, Research Assistant Professor, University of Pittsburgh, 1048 Benedum Hall, 3700 O'Hara St., Pittsburgh, PA, 15261, United States of America, lol11@pitt.edu,  
Theologos Bountourelis, Andrew Schaefer, Spencer Nabors, Gilles Clermont

While most hospital patient flow models have been focused on individual units and based on recorded length of stay data, these are flawed as they treat congestion as exogenous to the system. We develop a framework that treats a hospital as a whole and takes the medically indicated length of stay as input. We demonstrate the framework with data from a local hospital and that using this model is a more accurate reflection of conditions in the hospital and can result in better capacity decisions.

## MA14

14- Huron

### ORAHs 1- What Makes a Model Useful?

Cluster: International Health OR

Invited Session

Chair: Sally Brailsford, Professor, University of Southampton, Southampton Management School, Southampton, SO17 1BJ, United Kingdom, S.C.Brailsford@soton.ac.uk

#### 1 - Short-Term Forecasting of Demand for a Pediatric Cardiac Intensive Care Unit

Martin Utley, University College London, London, United Kingdom, m.utley@ucl.ac.uk

As part of a "modellers in residence" programme at a paediatric hospital, we adapted, calibrated and implemented an analytical stochastic model of short-term bed demand for a cardiac intensive care unit. The tool is currently being used on a daily basis within the unit to assist management and planning. I will outline the model and then discuss the technical and non-technical issues concerning the evaluation of the work, including client and user perspectives on what would make a "useful" model.

#### 2 - Modelling Supply and Demand for Dental Care in Sri Lanka

Sally Brailsford, Professor, University of Southampton, Southampton Management School, Southampton, SO17 1BJ, United Kingdom, S.C.Brailsford@soton.ac.uk, Dileep De Silva

We present a system dynamics model of the supply and demand for dental healthcare in Sri Lanka, which represents the complex career progression of dentists and captures the behavioral effects of employment prospects and government policy. This is augmented by a demand prediction model based on empirical data collected for the study. The model enabled the Sri Lankan Ministry of Health to test different training and staffing policies. The optimal policy has been implemented in practice.

#### 3 - A Practical Implementation of Integrated Duty and Workstation Rostering for Physicians at Hospitals

Jens Brunner, University of Augsburg, Universitätsstr. 2, Augsburg, 86159, Germany, jens.brunner@wiwi.uni-augsburg.de

This research addresses a personnel scheduling problem at hospitals. We present two new mixed integer linear programming models - a duty-roster and a workstation-roster model. Both are applied in practice. The objective function of both models considers fairness aspects. Furthermore, the models are integrated in a new software tool that has an intuitive user-interface. Computational results indicate that high quality schedules can be obtained. We compare the schedules with common practice at our cooperation hospital.

## 4 - Modelling Long Term Outcomes in Stroke Thrombolysis: Save a Minute – Save a Day

Leonid Churilov, Florey Institute of Neuroscience and Mental Health, Melbourne Brain Centre, Heidelberg, Australia, leonid.churilov@gmail.com, Mahsa Keshtkaran, Atte Meretoja

Although intravenous thrombolytic therapy for ischaemic stroke is more effective when delivered early after symptom onset, in-hospital delays of >60 mins are common. We quantified the disability adjusted life years patients gain from faster treatment. Reducing the average delay by 20 mins resulted in one month of extra disability-free life. The effect of being faster varied with the patients' life-expectancy. Stroke teams should start pushing their patients to the CT with a hasty step.

## Plenary

### Monday, 10:30am - 11:45am

Chicago DE

#### IBM Watson and the Application of Unstructured Data Analysis to Healthcare

Cluster: Plenary

Invited Session

Basit Chaudry, IBM Research, Washington, DC, United States of America, bichaudh@us.ibm.com

Healthcare is undergoing large-scale reorganizations in its structures, processes and business models. Insights derived from data will be fundamental to system transformation. At the same time, data, information and knowledge in healthcare are growing exponentially creating new stressors on human cognition. Much of the data in healthcare is unstructured e.g. narrative text in clinical notes. Currently, this data is largely unavailable for analysis through automated means. IBM's Watson is a technology focused on analyzing unstructured data. Originally an outgrowth from the open domain question and answer branch of artificial intelligence, Watson enables users to pose questions in natural language and then returns sets of candidate answer scored by the probability of being correct. As a proof of concept, Watson challenged the two most successful champions in the history of the game show Jeopardy! in a contest and won. IBM is currently in the process of adapting Watson to the domains of healthcare and medicine. Current areas of research and development focus on improving the quality of cancer care, creating administrative efficiencies, and extracting patient histories from medical records. Through capabilities such as information extraction and knowledge representation, Watson offers a new potential model for how cognitive support can be provided in healthcare.

### Monday, 12:30pm - 2:00pm

## MB01

01- Chicago F

#### Undergraduate Projects from University of Toronto

Cluster: Health Systems Engineering Alliance (HSEA)

Invited Session

Chair: Michael Carter, University of Toronto, 5 King's College Road, Mechanical and Industrial Engineering, Toronto, ON, M5S 3G8, Canada, mike.carter@utoronto.ca

#### 1 - Optimizing the Operational Impact of a Neurovascular Unit using Discrete Event Simulation

Franklin Ko, University of Toronto, 27 King's College Circle, Toronto, ON, Canada, frnklnk@gmail.com, Bernadette Gavin, Terry Ng, Peter Tan

This project uses direct data analysis and discrete event simulation modeling to study the impact of introducing a neurovascular unit into an acute care hospital. Analysis of data generates insights into the effects of certain factors on operational outcomes. Simulation experiments integrating patient flow and hospital operations allow us to predict the best use of available resources under different patient volume and bed availability conditions.

**2 - North York General Hospital: Reducing AMHOP Patient Wait Time to See a Psychiatrist**

Susie Yin, University of Toronto, 21 Alessia Court, Richmond Hill, ON, Canada, susie.yin@mail.utoronto.ca

One prevailing issue within the Adult Mental Health Outpatient Program (AMHOP) department at the North York General Hospital is the increasing wait times experienced by first-time patients from when they initially book the appointment to when they actually meet with the psychiatrist. Therefore, the main purpose of the thesis project at the North York General Hospital AMHOP department is to provide insight into the potential causes of the increasing queue and wait time, as well as possible solutions to improve the situation.

**3 - Improving Process Flow of Ultrasound Examinations at North York General Hospital**

Wen Di Guo, University of Toronto, 3 Win Timbers Cres., Stouffville, ON, L4A0Y8, Canada, andy.guo@mail.utoronto.ca, Greg Dungca

The Ultrasound process flow at North York General Hospital was interested in optimizing its process flow. It was analyzed using BPMN diagrams, lean and simulation. Problems to the flow were attributed to use of radiologists. A number of recommendations were given: assigning designated scan rooms to technologists, enabling staff from outside of the Medical Imaging Department to schedule ultrasound examinations, more stringent assignment and effective use of priority levels.

**■ MB02**

02- Chicago G

**Topics in Healthcare Data Analytics**

Cluster: Healthcare Data Analytics

Invited Session

Chair: Adel Alaeddini, Assistant Professor, University of Texas at San Antonio, Department of Mechanical Engineering, One UTSA Circle Drive, San Antonio, TX, 78249, United States of America, adel.alaeddini@utsa.edu

**1 - Graph Estimation with Joint Additive Models**

Ali Shojaie, Assistant Professor, University of Washington, Department of Biostatistics, F-650 Health Sciences Bldg., Seattle, WA, United States of America, ashojaie@uw.edu

In recent years, there has been considerable interest in estimating conditional independence graphs, especially in the high-dimensional setting. Most prior work in this area has assumed that the observations are drawn from a multivariate Gaussian distribution, or that conditional dependence relationships among variables are linear. In fact, these two sets of assumptions are roughly equivalent. Unfortunately, if the assumption of Gaussianity is violated, then the resulting conditional independence estimates can be inaccurate. To address this limitation, we present a semi-parametric method, Sparse Conditional Estimation with Joint Additive Models (SpaCE JAM), which allows for arbitrary additive conditional relationships among the features. We present an efficient algorithm for its computation, and prove that our estimator is consistent. We also extend our method to estimation of directed graphs with known causal ordering. Using simulated data, we show that SpaCE JAM enjoys superior performance to existing methods when there are non-linear relationships among the features, and is comparable to methods that assume multivariate normality when there are linear conditional dependence relationships among the features. We also illustrate our method on a cell-signaling data set.

**2 - A Framework for Healthcare Utilization Analyses**

Ping Huang, Research Scientist, Regenstrief Center for Healthcare Engineering, Purdue University, 203 Martin Jischke Drive, West Lafayette, IN, 47907, United States of America, huang74@purdue.edu, Steve Witz, Wei Liu

With risk shifting from payers to providers in health care, medical management of population quality and cost is crucial to the effective implementation of accountable-care delivery models. We develop a framework for analyses of healthcare utilization data to assist providers' understanding of cost, resource utilization and health risks of their patient population. We further identify strategies addressing these issues and model their effect on improving population health outcomes and cost.

**3 - A Comprehensive Probabilistic Framework for Prediction of Patients' Readmission to Medical Centers**

Adel Alaeddini, Assistant Professor, University of Texas at San Antonio, Department of Mechanical Engineering, One UTSA Circle Drive, San Antonio, TX, 78249, United States of America, adel.alaeddini@utsa.edu, Jonathan Helm

A comprehensive probabilistic framework based on integration of Survival Models, Bayesian Inference, and Local Regression Analysis is developed to provide accurate real-time estimate of readmission to hospitals. The framework connects information from different patients and personalizes the estimate for each single. It also effectively addresses the problem of few readmission records. Finally, it efficiently considers the effect of patients' related factors changes over time.

**■ MB03**

03- Chicago H

**Optimization Models and Methods in Healthcare**

Sponsor: INFORMS Optimization Society

Sponsored Session

Chair: Marina Epelman, Associate Professor, University of Michigan, 1205 Beal Avenue, Ann Arbor, MI, United States of America, mepelman@umich.edu

**1 - Monitoring Quality and Fairness of Service in Stochastic Operating Room Allocation and Scheduling**

Siqian Shen, Assistant Professor, University of Michigan, Ann Arbor, MI, 48109, United States of America, siqian@umich.edu, Yan Deng, Brian Denton

This paper optimizes OR usage subject to probabilistic guarantees on on-time surgery completion. We first consider opening ORs and assigning surgery blocks with a joint probability for completing surgeries in all ORs on time. We then formulate multiple chance constraints with different risk levels to reflect tradeoffs in operating heterogeneous OR resources. We also consider surgery scheduling, and use chance constraints to study the fairness issue associated with individual surgeries. The paper reformulates all models as mixed-integer programs, and develops various cutting-plane algorithms.

**2 - Optimal Physician Traveling Assignment for Improving Care Access in an Outpatient Care Network**

Yan Li, Research Assistant, Purdue University, 206 S. Martin Jischke Drive, West Lafayette, IN, 47906, United States of America, li528@purdue.edu, Qipeng Zheng, Nan Kong

We study the problem of scheduling mental health consultation sessions at satellite clinics within an outpatient specialty care network to improve patients' access to care. We formulate the problem as a three-dimensional assignment problem, and impose physicians' travel preferences. We develop a branch-and-price based algorithm. Our experiments demonstrate conditions under which the idea of scheduling sessions at satellite clinics is appealing and show the efficiency of our algorithm.

**3 - Optimal Decision Making in Disease Prevention and Epidemic Control**

Yan Deng, University of Michigan, Ann Arbor, MI, United States of America, yandeng@umich.edu, Yevgeniy Vorobeychik, Siqian Shen

We study the problems of disease prevention and epidemic control. The paper formulates various static models involving budgeted binary decisions of vaccination and facility closure. The goal is to minimize the expected infected population given heterogeneous infection rates and visiting preferences. We use exact dynamic programming and approximation algorithms, and test the approaches on a simulated instance. It shows that solutions obtained from static models perform well in dynamic settings.

## ■ MB04

04- Scottsdale

### Hospital Operations

Contributed Session

Chair: Sanchoy Das, Professor, New Jersey Institute of Technology, University Heights, Newark, NJ, 07102, United States of America, das@njit.edu

#### 1 - Case Mix and Capacity Planning in the Healthcare Sector: A Case Study at Jessa Hospital

Guoxuan Ma, KU Leuven, Naamsestraat 69, Leuven, Belgium, guoxuan.ma@econ.kuleuven.be

Jessa Hospital is a hospital merger with three different campuses, each of which may receive patients with a same pathology. Also, most wards were mixed with patients from two different departments in the past. In order to ensure patients with a certain pathology can be admitted to a same ward in one campus, the hospital need move beds from one campus to the other, so that all beds of one specialty are assigned in one campus as much as possible. This paper studies this capacity planning problem.

#### 2 - Development of a Highly Detailed, Highly Resolved In-Silico Hospital Population to Simulate Outbreak

Jose Jimenez, Graduate Student, Virginia Tech, Virginia Bioinformatics Institute, 2404 Culpeper Road, Alexandria, VA, 22308, United States of America, jjimenez@vbi.vt.edu

Objective: To develop a highly detailed, highly resolved synthetic or in-silico hospital population that will help predict, control and determine adequate policies regarding outbreaks of healthcare-acquired infections. Background: In the United States, 1 in 20 hospitalized patients becomes infected every year with a healthcare-associated infection (HAI), and 20% of HAI patients become infected in intensive care units (ICUs). Some of the complications of HAIs include increased morbidity, increase of drug-resistant infections, and a strain in the resources of healthcare systems. Methodology: De-identified patient information in the form of electronic medical records was collected from two regional hospitals in Southwest Virginia for the period of one year. Direct observations of healthcare professionals were conducted at both hospitals. Using patient and healthcare worker data we created an in-silico population for each one of the two hospitals following the first principles of development of agent-based proto-populations [3-4]. Multiple infection scenarios were used to simulate outbreaks within the hospitals and test interventions such as vaccinations, use of antibiotics, and hand washing. A bacterium called *Clostridium Difficile* was chosen as the main infectious agent due to its prevalence and importance among HAIs. The scenarios were simulated using a simulation algorithm called EpiSimdemics created by the Network Dynamics and Simulation Laboratory at Virginia Tech. The scenarios were iterated 100 times each. Results: two in-silico populations were developed utilizing medical records and direct observations of healthcare professionals. Infection of the in-silico population varied drastically by scenario and simulation of treatment helped to slow the outbreaks. The use of high performance simulation of HAIs will assist in improving HAI prevention and control plans, and planning for optimal allocation of limited healthcare resources to reduce morbidity and mortality of patients with HAIs.

#### 3 - Fast Algorithms for ICU Models with Speed-Up: Avoiding Stochastic Simulation

Jamol Pender, Graduate Student, Princeton University, 13 Lawrence Drive Apt 104, Princeton, NJ, 08540, United States of America, jamol.pender@gmail.com

We develop new Gaussian approximations for computing the mean and variance of healthcare models with time varying rates that incorporate speed-up, a phenomenon seen in hospital dynamics. Typically these models have discontinuous rate functions, which make the dynamics more complicated. Currently, in order to observe the effects of changing parameters, one must perform a simulation for the queuing process and observe the changes in the mean and variance behavior as a function of the parameters. However, simulation is computationally expensive and takes even longer for large scale systems. Thus, by using the functional Kolmogorov forward equations approach developed by Massey and Pender [MP], we show that it is beneficial to use a Gaussian closure approximation to obtain a more accurate estimate of the true dynamics for queuing models with speed-up. This method avoids the use of simulation and simply requires the solution of five differential equations, which are extremely fast to solve. Using a more accurate estimate for the mean and variance dynamics, gives us a more accurate estimate of the probability of speed-up, which is a useful measure of quality in healthcare.

#### 4 - Hospital Unit of Care: A Standardized Equivalency Measure for Hospital Output

Sanchoy Das, Professor, New Jersey Institute of Technology, University Heights, Newark, NJ, 07102, United States of America, das@njit.edu, Shivon Boodhoo

A standardized productivity output measure for a hospital unit of care (HUC) is presented. A HUC is defined as the resources required to provide one general inpatient day. We derive a roll-up equivalency parameter for all services the hospital provides. There are six HUC components: (i) case-mix adjusted inpatient

days (ii) discharge disposition (iii) intensive care (iv) nursery (v) outpatient care and (vi) ancillary services. Model application is demonstrated on a set of 17 honor roll hospitals. An application on 203 hospitals shows the HUC is better correlated than Adjusted Patient Days (APD) to hospital operating costs.

## ■ MB05

05- Miami

### Healthcare Policy and Planning

Sponsor: Healthcare Applications Society

Sponsored Session

Chair: Anahita Khojandi, University of Pittsburgh, 1048 Benedum Hall, Pittsburgh, PA, United States of America, ank83@pitt.edu

#### 1 - Growth Model for a Large Academic Medical Center

Dustin Kuchera, Senior Health Systems Engineering Analyst, Mayo Clinic, 200 First Street SW, Rochester, MN, 55902, United States of America, kuchera.dustin@mayo.edu, Steven Crowley, Franz Hebl

In 2011, Mayo Clinic sought information on how focused growth impacted the larger Mayo Clinic system. A system dynamics model was built to model growth scenarios. The model depicted the complex Mayo Clinic system as many small components, including outpatient appointments, surgeries, and inpatient stays. A decision-maker could adjust these components and estimate the impact on resources in the system. This exercise confirmed Mayo Clinic needed to change its approach to growth.

#### 2 - Strategic Health Care Workforce Planning

Weihong Hu, University of Southern California, 3715 McClintock Avenue, GER 240, Los Angeles, CA, 90089-0193, United States of America, weihongh@usc.edu, Xiang Liu, Mariel Lavieri, Alejandro Toriello

We propose a long-term workforce management model for a large health care system with arbitrary deterministic non-decreasing demand, using infinite linear programming. The model monitors hiring, training and promotion of a type of health care worker across the entire system. We provide a series of conditions the system can satisfy to ensure that one-period lookahead policies are optimal. We also give a sensitivity analysis of the cost impact of various system parameters, such as demand.

#### 3 - Optimal Implantable Cardioverter Defibrillator (ICD) Generator Replacement

Anahita Khojandi, University of Pittsburgh, 1048 Benedum Hall, Pittsburgh, PA, United States of America, ank83@pitt.edu, Timothy Brown, William Barrington, Lisa Maillart, Mark Roberts, Oleg Prokopyev

ICD generator replacement involves a trade-off between prematurely exposing the patient to the risk of replacement surgery and allowing for the possibility that the device is unable to deliver therapy when needed. Currently, replacements are performed using a one-size-fits-all approach. We develop a Markov decision process model to determine patient-specific optimal replacement policies to extend the patient lifetime. Under these policies, patients on average undergo 8-19% fewer surgeries.

## ■ MB06

06- Los Angeles

### Optimal Screening and Treatment Decisions

Cluster: Medical Decision Making

Invited Session

Chair: Douglas Bish, Virginia Tech, 250 Durham Hall, Blacksburg, VA, 24060, United States of America, drb1@vt.edu

#### 1 - Going Beyond Same-for-All Testing of Infectious Agents in Donated Blood

Ebru Bish, Associate Professor, Virginia Tech, Blacksburg, VA, 24061, United States of America, ebru@vt.edu

Blood products are essential for many medical treatments, and their safety, in terms of being free of infectious agents that can be spread through their use, is crucial. However, blood screening tests are not perfectly reliable, and may produce false negative or false positive results. We characterize important structural properties of a new testing scheme and show that it may lead to a significant improvement in the safety of blood products over current policies in use by Blood Centers.

## 2 - Optimal Simultaneous Dynamic Monitoring and Treatment Control for Chronic Diseases

Pooyan Kazemian, PhD Candidate, University of Michigan, 1205 Beal Ave., Ann Arbor, MI, 48105, United States of America, pooyan@umich.edu, Mark Van Oyen, Jonathan Helm, Mariel Lavieri, Joshua Stein

Leveraging stochastic control theory, we address the problem of dynamic monitoring and control of chronic diseases. We present how, without loss of optimality in the joint control problem, one can find the optimal control of disease risk factors separately from the optimal timing of tests and the optimal set of tests. The patient-centered model optimizes disease monitoring and controls risk factors to limit disease progression. Glaucoma is discussed as a case study.

## 3 - A Bi-criteria Optimization Approach for Robust Glycemic Control for Patients with Type 2 Diabetes

Yuanhui Zhang, North Carolina State University, 111 Lampe Dr., Raleigh, NC, 27695, United States of America, yzhang29@ncsu.edu, Jennifer Mason, Nilay Shah, Steven Smith, Brian Denton, James Wilson

We present a bi-criteria robust MDP (BRMDP) framework to model the treatment decisions for glycemic control for patients with type 2 diabetes. We discuss the special structure of the model including properties that can exploit to achieve computational advantages. We present results for the set of Pareto-optimal solutions obtained by solving the BRMDP model. Computational results based on a large clinical data set are presented to illustrate the structure and performance of the optimal policy.

## ■ MB07

07- Kansas City

### Inpatient Management

Sponsor: Manufacturing and Service Operations Management  
Sponsored Session

Chair: Carri Chan, Columbia University, Columbia Business School, 3022 Broadway, Room 410, New York, NY, 10027, United States of America, cwchan@columbia.edu

## 1 - Determining the Optimal Configuration of Hospital Inpatient Rooms

Tolga Tezcan, University of Rochester, Simon Graduate School of Business, Cs-3-110r Carol Simon Hall, Rochester, NY, 14627, United States of America, tolga.tezcan@simon.rochester.edu, Edial Pinker

We study the optimal configuration of hospital in-patient rooms with private and semi-private rooms. We assume that the demand is random and seasonal. We propose a computationally efficient solution procedure. Using our model we study the appropriateness of the recent trends in hospital design calling for 100% private rooms. We show that even with isolation patients such an extreme approach could result in a significant degradation in the access of patients to hospital beds.

## 2 - From Process Changes to Reduced Re-Admissions: A Financial ROIC Calculator for Project BOOST

Itai Gurvich, Northwestern University, Kellogg School of Management, 2100 Sheridan Road, Evanston, IL, 60208, United States of America, i-gurvich@kellogg.northwestern.edu, Eric Park, Jan Van Mieghem, Jiajun Zhang

Project BOOST (Better Outcomes by Optimizing Safe Transitions), led by Northwestern Memorial Hospital, promotes a toolkit of process changes to reduce patient re-admissions. Our collaboration with the hospital studies how BOOST tools impact patient outcomes and financial results. A product of this collaboration is a return on investment calculator (ROIC). The ROIC assists hospital administrators in making informed decisions regarding the adoption of specific elements of the BOOST toolkit.

## 3 - Nurse Allocation: Step-Down Units Versus Intensive-Care Units

Carri Chan, Columbia University, Columbia Business School, 3022 Broadway, Room 410, New York, NY, 10027, United States of America, cwchan@columbia.edu, Mor Armony, Bo Zhu

The use of step-down units (SDUs) in hospitals has been a matter of controversy in the medical community. On one hand, an SDU alleviates ICU congestion by providing a safe care environment for post-ICU patients before they can be transferred to the general wards. On the other hand, SDUs can take capacity away from the already over-congested ICU. We propose a queueing model that provides SDU sizing guidelines, noting that under some circumstances this optimal size is zero.

## ■ MB08

08- Kane

### Radiation Therapy under Uncertainties

Cluster: Radiation Therapy  
Invited Session

Chair: Omid Nohadani, Assistant Professor, Purdue University, 315 N. Grant Street, Grissom Hall, West Lafayette, IN, 47907, United States of America, nohadani@purdue.edu

## 1 - Time-Resolved Stochastic IMRT Planning

Arkajyoti Roy, Purdue University, School of Industrial Engineering, West Lafayette, IN, 47907, United States of America, roya@purdue.edu, Omid Nohadani

Conventional radiation therapy plans are repeatedly delivered over the extent of several weeks. However spatiotemporal changes can degrade the outcome of the treatment. A stochastic time-resolved model allows redistribution of dose per fraction based on such changes, and mitigates the effect of uncertainties in such changes. It improves not only tumor control, but more importantly spares critical organs, particularly in the worst-case. The performance is demonstrated based on clinical cases.

## 2 - A Robust Semi-Infinite Linear Programming Approach for Radiotherapy Planning

Hao Zhang, University of Maryland School of Medicine, 22 S. Greene St., Baltimore, MD, 21201, United States of America, hzhan001@umaryland.edu, Hamid Ghaffari, Warren D. D'Souza

Conventional radiotherapy planning approach incorporates organ motion using internal target volume (ITV) plus margin, which could lead to overdosing the healthy tissues. And the organ function distribution is assumed to be uniformly distributed. In this research we propose a semi-infinite model which incorporates organ function distribution and motion probability mass functions. Compared to the ITV approach, our approach resulted in 35% less dose to healthy tissue while significantly spared the high functioning area.

## 3 - Robust Multi-Modality Treatment Planning

Omid Nohadani, Assistant Professor, Purdue University, 315 N. Grant Street, Grissom Hall, West Lafayette, IN, 47907, United States of America, nohadani@purdue.edu

The treatment of cancerous tumors with external radiation is planned based on initial data and independent of other modalities. The resulting plans do not vary over the course of the treatment. When Chemotherapy is combined, the sensitivity of the tissue to radiation changes over time. Based on clinical cases, we demonstrate that proposed robust method can harness this evolution and provides strategies that are intrinsically insensitive to deviations from the assumed temporal path.

## ■ MB09

09- McHenry

### Managing the Performance of Health Teams

Cluster: Healthcare Operations Management  
Invited Session

Chair: Jonathan Patrick, Assistant Professor, University of Ottawa, Telfer School of Management, Ottawa, ON, K1N 6N5, Canada, Patrick@telfer.uottawa.ca

## 1 - Designing an Agent-Based System to Support Workflow Execution by an Interdisciplinary Healthcare Team

Davoud Astaraky, University of Ottawa, MET Research Group, 55 Laurier Avenue East, Ottawa, ON, K1N 6N5, Canada, davoud.ataraky@gmail.com, Szymon Wilk, Craig Kuziemy, Wojtek Michalowski, Pavel Andreev

The purpose of this study is to show creation of MET4 decision support system to facilitate collaboration among the members of an interdisciplinary healthcare team (IHT). Having such support will allow a team to manage more effectively complex chronic conditions where IHT members must collaborate by performing in a coordinated manner a set of tasks defined by a workflow and associated with disease-specific clinical practice guidelines. The architecture of the MET4 system is designed according to an agent-oriented paradigm. Specifically, we use the O-MaSE (Organization-based Multi-agent System Engineering) method that allows for iterative translation of functional requirements into architectural components (e.g., agents). The agent-oriented paradigm is extended with ontology-driven design to implement ontological models representing knowledge required by specific agents to operate. The architecture allows for the creation of a CDSS that integrates support for all tasks from the workflow model, and interacts with hospital information systems.

## 2 - Managing a Clinical Practice with Turnover and Follow-ups: Panel Sizing in Oncology

Peter Vanberkel, Professor, Dalhousie University, Dept. of Industrial Engineering, 5269 Morris Street, Room 201, Box 15000, Halifax, NS, B3H 4R2, Canada, pvanberk@dal.ca, Scott Tyldesley, Martin Puterman, Nelly Litvak

This paper develops queuing models to determine the appropriate number of patients under physician care, for an oncology practice. The key features that distinguish this from other panel size models are high patient turnover rates, multiple patient and appointment types and planned follow-up care. The paper develops queuing network models for mature and developing practices to determine new patient acceptance rates which ensure practices operate within certain performance thresholds.

## 3 - Assessing Performance of Physicians using DEA with Penalization of Asymmetric Weight Selection

Javier Fiallos, Msc Student, University of Ottawa, 55 Laurier Avenue East, Ottawa, ON, K1N 6N5, Canada, jfiallos@uottawa.ca, Wojtek Michalowski, Jonathan Patrick, Ken Farion

This research presents a tool to assess the performance of Emergency Department physicians. The evaluation considers criteria such as efficiency of resource utilization, patient throughput and quality of health outcomes. We propose the use of DEA (Data Envelopment Analysis) which facilitates multi-criteria evaluations by reducing the subjectivity involved in the assignment of weights to performance components. Preliminary results show this approach may provide a sound evaluation model.

## ■ MB10

10- Cook

### Primary Care Panel Design

Cluster: Healthcare Scheduling

Invited Session

Chair: Wen-Ya Wang, Department of Marketing and Decision Sciences, San Jose State University, One Washington Square, San Jose, CA, 95192-0069, United States of America, wenya.wang@sjsu.edu

#### 1 - Primary Care Practice Design under Case-Mix

Hari Balasubramanian, Assistant Professor, University of Massachusetts-Amherst, 160 Governors Drive, Amherst, MA, 01003, United States of America, hbalasubraman@ecs.umass.edu, Asli Ozen, Nan Liu

Our objective is to develop methods for evaluating access to care and continuity of care in commonly-used primary care delivery models adjusted for patient case-mixes; and to study how these two system performance measures change under panel (re)design and provider capacity pooling (i.e., patient sharing).

#### 2 - Patient Scheduling in a Mobile Health Care Setting with Patient No-Shows

Karen Smilowitz, Associate Professor, Northwestern University, Evanston, IL, 60208, United States of America, ksmilowitz@northwestern.edu, Samuel Ellis, Martin Savelsbergh

We present work motivated by an ongoing collaboration with a mobile asthma care provider. Our study focuses on the scheduling challenges caused by patient no-shows. We address this issue through an improved scheduling model that incorporates incentives. We present a comparison with alternate scheduling policies.

#### 3 - Physician Panel Design

Wen-Ya Wang, Department of Marketing and Decision Sciences, San Jose State University, One Washington Square, San Jose, CA, 95192-0069, United States of America, wenya.wang@sjsu.edu, Diwakar Gupta

This paper focuses on the physician panel design problem of determining the patient composition (i.e. panel size and types of patient) for physician panels. In particular, we investigate how clinics would allocate a given pool of two types of patients who have different propensity for requesting urgent appointments (i.e. non-urgent/advance-book/non-acute vs. urgent/same-day/acute) to two identical physicians. We identify the optimal patient and capacity allocation strategies that maximize the clinic's overall expected reward under different capacity-demand scenarios.

## 4 - Panel Size and Overbooking Decisions for Appointment-Based Services under Patient No-Shows

Nan Liu, Assistant Professor, Columbia University, 600 W. 168 St., New York, NY, 10032, United States of America, nl2320@columbia.edu, Serhan Ziya

To capture delay-dependent patient no-shows, we use stylized queuing models to model the appointments scheduled for a clinic. We consider two different problems. In the first one, the service capacity is fixed and the decision variable is the panel size. In the second one, both the panel size and service capacity (i.e., overbooking level) are decision variables. The objective in both problems is to maximize some net reward function, which reduces to system throughput for the first problem. We characterize the optimal decisions and investigate how they change with other model parameters.

## ■ MB11

11- Dupage

### Emergency Department Operations

Contributed Session

Chair: Jerome Niyirora, Binghamton University, 4400 Vestal Parkway East, Binghamton, NY, 13850, United States of America, jndayis1@binghamton.edu

#### 1 - On Minor Emergency Visits - a Case Study

Lourdes Zubietta, Professor, Bishop's University, 2600 College St., Sherbrooke, QC, J1M 1Z7, Canada, lzubietta@ubishops.ca, Suzan McNider Taylor, José Ramón Fernández-Peña

Demand at emergency departments (ED) continues to increase at many hospitals, mainly for less urgent cases (CTAS IV and V). There is debate about the causes for such higher demand but agreement on its multidimensional structure. The objective of this research is to better understand the use of hospital emergency rooms for minor problems by probing relations between diagnostic codes and demographic variables like area of residence, age, gender, and socioeconomic variables aggregated in levels of material and social deprivation by communities [1]. The first part of this study assessed the role that age, gender, and place of residence play in choosing the ED to visit [2, 3]. It also revealed some differences in the prevalence of groups of diagnostic codes at the neighbourhood level. This study shows areas of residence with high incidence of respiratory and mental health problems and expands the analysis to specific diagnostic codes. We reviewed 42 months of administrative data (2006-2009) of minor emergency visits from two hospitals in Sherbrooke, Quebec. Data mining algorithms [4] were applied to classify the visits and unveil main associations between diagnostic codes, geographic areas [5] and socioeconomic and patient characteristics. These research findings lead to improved measurement of health status at the neighbourhood level. It also shows prevalence of health conditions that affect ED and clinic workloads, important in the planning of primary care demand at emergency rooms, local clinics and other health care services.

#### 2 - Case Study: Exploratory Data Analysis on Length of Stay in an Emergency Department

Biao Wang, University of Waterloo, 200 University Ave., West Waterloo, ON, N2L 3G1, Canada, b67wang@uwaterloo.ca, Jennifer Jewer, Kenneth McKay, Ashok Sharma

An extensive exploratory data analysis was conducted on length of stay (LOS) in a specific emergency department (ED) at a medium sized community hospital in Canada to identify the contributions of both patient and system factors. Several regression frameworks were used to fit the data. The results suggest that the LOS in the ED for the majority of patients might be accurately explained by the ED's basic queuing behavior when combined with the crowded factor.

#### 3 - A Kinetic Model of Emergency Room: In Search of Optimal Staffing by a Physicians' Group Manager

Jerome Niyirora, Binghamton University, 4400 Vestal Parkway East, Binghamton, NY, 13850, United States of America, jndayis1@binghamton.edu

Congestion is a serious problem in many emergency rooms as the number of non-urgent visits is on the rise while the clinical resources are increasingly scarce. Potential consequences include patients leaving without receiving care, delayed care, and possible poor quality of care. We address this problem, from the perspective of the manager of a Physicians Group. Using kinetic equations, we try to capture the relations between the number of patients waiting for care and the dynamics of pooled physicians' resources. Our stationary model show important equilibrium solutions of the at-risk number of patients in the queue and the absolute utilization of physicians' resources. Using time-varying patient arrival rate, we establish approximations of the physician resource demand, with and without patient abandonment. Optimal staffing levels are determined using Optimal Control Theory, in light of quality of services and bounded control. We analyze the case where staffing costs are linear and where they are convex and increasing. In both cases we establish necessary and sufficient conditions of optimality. Our results indicate that the physicians' opportunity costs play a particularly important role when determining on the optimal staffing policy.

## ■ MB12

12- Water Tower

### Prescriptive Healthcare Analytics

Sponsor: Healthcare Applications Society

Sponsored Session

Chair: Bruce Golden, Professor, University of Maryland, College Park, MD, United States of America, bgolden@rhsmith.umd.edu

#### 1 - Prostate Cancer Detection using MRI Data

David Anderson, University of Maryland, Robert H. Smith School of Business, College Park, MD, 20742, United States of America, danderson@rhsmith.umd.edu, Bruce Golden, Hao Zhang

Prostate cancer, while relatively prevalent, is a hard disease to diagnose. Current methods are either invasive, painful, and expensive, or lack sufficient accuracy. We demonstrate a method of classifying patient risk of prostate cancer using features generated from MRI images. This method is minimally invasive and has 70% predictive accuracy, comparable to other prediction methods currently in use.

#### 2 - Simulating Potential Facility Layouts for Proton Therapy Treatment Centers

Stuart Price, PhD student, University of Maryland, 8201 16th St., Silver Spring, MD, 20910, United States of America, sprice@rhsmith.umd.edu, Bruce Golden, Hao Zhang, Edward Wasil

Proton therapy is a form of external beam radiation therapy that has proven equally effective with fewer side effects than x-ray intensity radiation therapy for the treatment of some types of cancer. Despite its promise, adoption is limited by the high cost of the required facilities. New facilities are being built with layouts designed to treat more patients. We simulate multiple facility layouts to compare patient throughput, wait-time, equipment utilization and employee overtime.

#### 3 - Optimal Intervention Programs in Health Care Systems

Margrét Bjarnadóttir, University of Maryland, 4324 Van Munching Hall, College Park, MD, United States of America, margret@rhsmith.umd.edu, Leila Zia

This research examines the problem of finding optimal intervention policies under outcome uncertainty. In particular the study blends predictive modeling with a nonlinear cost/benefit optimization model to maximize the overall benefit, through selecting the optimal scale of the intervention program(s). Single and multi-level interventions as well as blended policies are considered. A case study of patients' no-shows from a cancer outpatient clinic is presented.

## ■ MB13

13- Navy Pier

### Agent-based Modeling for Predicting Future Healthcare Requirements

Sponsor: Simulation Society

Sponsored Session

Chair: Charles Macal, Director, Argonne National Laboratory, Decision & Information Sciences Division, 9700 S. Cass Avenue, Argonne, IL, 60439, United States of America, macal@anl.gov

#### 1 - Agent-Based Cardiovascular Disease (CVD) Model for India

Ruslan Horblyuk, Director, Health Economics, GE Healthcare, 9900 W Innovation Dr., Wauwatosa, WI, 53226, United States of America, Ruslan.Horblyuk@ge.com, Diane Graziano, Charles Macal, Chaitanya Sarawate, Sumit Sharan, Mitchell Higashi, Michael North, Denise Kruzikas, Nicholson Collier

Using India as an example of a rapidly growing emerging market with substantial private healthcare, we have applied agent-based modeling to simulate healthcare infrastructure expansion, initially limited to CVD diagnosis and treatment, and inform complex policy and investment decisions by affording cost-effectiveness and profitability analyses. Extending this model's simulations to other disease states and inclusion of additional health and economic metrics are under investigation.

#### 2 - An Agent-Based Model of Vascular Disease Remodeling in Pulmonary Arterial Hypertension

Eric Tataru, Argonne National Laboratory, Decision & Information Sciences Division, 9700 S. Cass Ave., Argonne, IL, 60439, United States of America, tataru@anl.gov, Roger Edwards, Jonathan Ozik, Nicholson Collier, Joe Alexander, Michael North

We have developed a multi-scale, 3D agent-based model (ABM) of mammalian arterial blood vessels specifically focusing on the pathobiology of pulmonary arterial hypertension (PAH), a disease that may involve pathologies in any of the various signaling pathways, cell types, layers, or connective structures in blood vessel walls.

#### 3 - A New Methodology for Analysis of Dispersion in Pulmonary Vascular Branching

Michael North, Deputy Director, Argonne National Laboratory, Decision & Information Sciences Division, 9700 S. Cass Ave., Argonne, IL, 60439, United States of America, north@anl.gov

Vascular branching is a promising indicator of pulmonary hypertensive disease progression. Quantification of branching complexity offers an endpoint that can be used to assess response to therapy as well as identify patient subtypes. The purpose of this study was to investigate whether a novel approach to the analysis of dispersion in pulmonary vascular branching could differentiate healthy vs. diseased branching patterns. We developed a density analysis approach for quantifying pulmonary vascular structure based on a two-step process: 1) extraction of vascular branching patterns from imaging data, and 2) calculation of dispersion as a repeatable measure of branching complexity. The results set the stage for agent-based modeling.

#### 4 - Agent-Based Modeling of the Spread of Community-Associated MRSA

Charles Macal, Director, Argonne National Laboratory, Decision & Information Sciences Division, 9700 S. Cass Avenue, Argonne, IL, 60439, United States of America, macal@anl.gov

Community-associated methicillin-resistant *Staphylococcus aureus* (CA-MRSA) are strains of the bacterium *S. aureus* that are responsible for skin and soft tissue, blood, bone, and other infections that can be life threatening. CA-MRSA strains are resistant to standard antibiotics related to penicillins and have a high prevalence in the general community, as well as in healthcare facilities. We are developing a fine-grained agent-based model of CA-MRSA for the Chicago metropolitan area.

## ■ MB14

14- Huron

### Improving Healthcare Delivery in Sub-Saharan Africa

Cluster: Healthcare in Developing Countries

Invited Session

Chair: Gemma Berenguer, Purdue University, West Lafayette, IN, United States of America, gemmabf@purdue.edu

#### 1 - Benchmarking for Improving the Efficiency of In-Country Organizations in Global Health Supply Chains

Gemma Berenguer, Purdue University, West Lafayette, IN, United States of America, gemmabf@purdue.edu, Ananth Iyer, Prashant Yadav

This work studies supply chain organizations in sub-Saharan Africa that are involved in the delivery of healthcare products financed by USG or the Global Fund. Our goal is to encourage the culture of continuous improvement among these organizations. In this direction, we aim to provide organizations with better evaluation and operational tools to achieve higher efficiency rates. To empirically measure productive efficiency we employ operations research tools such as data envelope analysis.

#### 2 - Improving HIV Early Infant Diagnosis (EID) Supply Chains in Sub-Saharan Africa

Jonas Oddur Jonasson, PhD Student, London Business School, Regent's Park, London, NW1 4SA, United Kingdom, jjonasson.phd2010@london.edu, Sarang Deo, Jeremie Gallien

Early infant diagnosis (EID) of HIV is vital in resource limited settings. An EID system is a network of clinics and labs. Each lab is a batch arrival, batch service queue. We derive an approximation of waiting time in such queues as a univariate function of utilization. This approximation is incorporated in optimization formulations to maximize system participation. Results are validated using a general simulation model, based on data provided by the operators of the Mozambique EID network.

## ■ MB16

16- Houston

### Chemotherapy Patient and Resources Management in Oncology Clinics

Sponsor: INFORMS Optimization Society

Sponsored Session

Chair: Lewis Ntaimo, Associate Professor, Texas A&M University, 3131 TAMU, College Station, TX, United States of America, [ntaimo@tamu.edu](mailto:ntaimo@tamu.edu)

#### 1 - DEVS-CHEMO: A Discrete Event Simulation for Oncology Clinic Operations

Lewis Ntaimo, Associate Professor, Texas A&M University, 3131 TAMU, College Station, TX, United States of America, [ntaimo@tamu.edu](mailto:ntaimo@tamu.edu), Michelle Alvarado, Tanisha Cotton, Eduardo Perez

We present a discrete event system specification (DEVS) simulation model for outpatient oncology clinic operations called DEVS-CHEMO. DEVS-CHEMO models the behavior of clinic resources (nurses, chemotherapy chairs, pharmacy, waiting room, etc.) and cancer patients as they arrive for their chemotherapy appointments. DEVS-CHEMO allows for evaluating patient scheduling algorithms and clinic operational policies. We test and validate DEVS-CHEMO using real data from an oncology clinic.

#### 2 - Mean-Risk Stochastic Programming for Scheduling Chemotherapy Patients

Tanisha Cotton, PhD Candidate, Texas A&M University, 3131 TAMU, College Station, TX, 77095, United States of America, [Tanisha.G.Cotton@gmail.com](mailto:Tanisha.G.Cotton@gmail.com), Michelle Alvarado, Lewis Ntaimo

Oncology clinics face tight resource and scheduling constraints due to increased demand, cyclic chemotherapy treatment plans, and complex and uncertain treatment durations. This talk presents the model and results of using a risk averse two-stage stochastic programming approach to efficiently schedule chemotherapy nurses, patients, and chairs based on a real oncology clinic.

#### 3 - A Simulation-Optimization Approach for Managing Chemotherapy Appointments under Uncertainty

Michelle Alvarado, PhD Student, Texas A&M University, 3131 TAMU, College Station, TX, 77843, United States of America, [michelle.mcgaha@gmail.com](mailto:michelle.mcgaha@gmail.com), Tanisha Cotton, Lewis Ntaimo

Scheduling chemotherapy treatments is a difficult task due to the cyclic nature of the treatment regimens, variability of treatment lengths, and patient acuity levels. We present an integrated simulation-optimization methodology for scheduling and managing chemotherapy patients. We use a discrete event simulation to model clinic operations and a stochastic programming model to schedule patients and resources. Results based on real patient data from a Texas oncology clinic will be reported.

## ■ MB17

17- Denver

### Topics in Medical Scheduling

Sponsor: INFORMS Optimization Society

Sponsored Session

Chair: Amy Cohn, University of Michigan, 1205 Beal Ave., Ann Arbor, MI, United States of America, [amycohn@umich.edu](mailto:amycohn@umich.edu)

#### 1 - using Mathematical Programming to Improve Scheduling for Medical Residents

Young-Chae Hong, University of Michigan, Department of Industrial and Operations, 1205 Beal Ave., Ann Arbor, MI, 48109, United States of America, [hongyc@umich.edu](mailto:hongyc@umich.edu), Amy Cohn, Micah Long, Elizabeth Perelstein, Ariella Rose

Scheduling medical residents is a complex task, with many rules and requirements to enforce. Despite the challenges of this large-scale combinatorial problem, it is typically solved manually by the chief resident. The result is not only an enormous effort on behalf of the chief, but also a schedule that frequently violates requirements. In contrast, optimization-based techniques can not only quickly identify feasible schedules but also address desirable metrics such as equity across residents, the opportunity to attend continuity clinics, and reduced impact of night shifts on sleep deprivation. This can lead to better short-term patient care and also better long-term care, as residents are better able to have adequate training opportunities and thus the quality of their training is improved. We present our optimization-based tool and discuss the challenges of a multi-criteria objective function. In particular, we focus on sleep issues and present real-world results from the University of Michigan Medical School, where this tool is used in practice in the pediatric emergency department.

#### 2 - Resource Allocation and Risk Analysis of Renal Dialysis Centers in Ontario

Mahsa Shateri, University of Toronto, Toronto, ON, Canada, [mahsa.shateri@utoronto.ca](mailto:mahsa.shateri@utoronto.ca), Michael Carter

A tool is created by integrating the results of a mixed integer programming model, a heuristic algorithm, and an M/M/s queuing model to determine the appropriate ratios for nurses and possible combinations of patients for dialysis centers in Ontario while ensuring a high quality of care for patients.

#### 3 - Scheduling Residents to Achieve Adequate Training on Procedures with Random Occurrences

Ryan Chen, University of Michigan, Ann Arbor, MI, United States of America, [ryanchen@umich.edu](mailto:ryanchen@umich.edu), Amy Cohn, Rishindra Reddy, Mark Daskin, Jacob Seagull, Andrea Obi, Jennifer Chung

Residents have certification case requirements for a variety of procedures (e.g., heart transplants). Call schedules rotate on a regular basis. Procedure occurrences are random. Thus, all residents will not necessarily accrue enough cases even if the total number of cases exceeds the number of residents times the requirements per resident. We develop a simulation model of this problem and outline alternative scheduling rules that increase the number of residents who can be certified.

## Monday, 2:00pm - 3:30pm

### Poster Session

Chicago DE

Chair: Sanjay Mehrotra, Professor, Industrial Engineering & Management Sciences, McCormick School of Engineering Professor, Institute for Health Studies, Feinberg School of Medicine

#### 1 - Simulation Optimization of an Hospital Emergency Department

Richard Guerrero, University of Barcelona, Av. Diagonal, 645, Barcelona, 08038, Spain, [rguerreroici@gmail.com](mailto:rguerreroici@gmail.com)

Healthcare costs have dramatically increased and healthcare organizations have been under pressure to provide increased quality of care for their patients. This research deals with increasing patient satisfaction and keeping cost in the ED to a minimum, integrating simulation with optimization in a decision support tool of the Rfo Hortega University Hospital Emergency Department in Spain. Four scenarios of demand of patients were modeled, and we predicted a three months simulated period.

#### 2 - A Markov Blanket Procedure for Determining Optimal Medication Mix for Poly-pharmacy Patients

Abdolmanaf Zargoush, PhD Candidate, ESSEC Business School, Avenue Bernard Hirsch, Cergy-Pontoise, France, [b00114510@essec.edu](mailto:b00114510@essec.edu)

We demonstrate how medications of poly-pharmacy patients could be optimized by examining comparative effectiveness of the medications in extant data warehouses. For each patient, similar individuals are found in the data and the experience of these cases is used to guide the patient. We use 5 years of data for 19,223 diabetic patients to learn a causal network of interactions among diabetes medications, demographic variables, comorbidities, severity measures and survival. On the basis of a heuristic method, then, we show how a statistically derived Bayesian network can be used to optimally recommend the combination of medications.

#### 3 - Network-Based Methods to Identify Highly Discriminating Subsets of Biomarkers

Seyed Javad Sajjadi, University of South Florida, ENB 118, 4202 E. Fowler Ave., Tampa, FL, 33620, United States of America, [ssajjadi@mail.usf.edu](mailto:ssajjadi@mail.usf.edu), Xiaoning Qian, Bo Zeng, Amin Ahmadi Adl

We formulate a new network-based framework to identify effective biomarkers by searching for groups of synergistic risk factors with high predictive power. To integrate interactions with individual predictive power of risk factors, we formulate a network optimization model to derive a collection of cliques with maximum total weight. An analytical algorithm based on column generation method is developed to achieve optimal or near optimal solution. Experiments with real and synthetic datasets show that our methods can identify important biomarkers with better prediction accuracy.

#### 4 - Evaluation of Degradation on Grasp Motion of Multiple Sclerosis Patients

Venkata Marella, Phd Candidate, The University of Tennessee, 307 East Stadium Hall, Knoxville, TN, 37919, United States of America, [lmarella@utk.edu](mailto:lmarella@utk.edu), Rupinder Sawhney, Rogério Peruchi

Multiple sclerosis is a degenerative neurological disease with no definite causes and no cure, with a progression into physical and cognitive disability and causing difficulties in activities for daily living. The most common symptom in MS patient is impairment of hand function that can be assessed by wide variety of hand assessment tests. The methodology presented is based on work measurement and design of experiment on grasp motion applied to hand assessment, in order to obtain degradation rate of individuals affected by multiple sclerosis. The evaluated degradation can help in predicting the future needs of the patient.

#### 5 - Analysis of Attribute-Importance Measurement to Improve Healthcare Information System Usability

Pei-Fang Tsai, Assistant Professor, National Taipei University of Technology, 1, Sec. 3, Zhongxiao E. Rd., Taipei, 10608, Taiwan - [ROC\\_p.jennifer.tsai@gmail.com](mailto:ROC_p.jennifer.tsai@gmail.com)

Healthcare information system (HIS) contributes to a high-quality, efficient patient care by providing good supports to the administrative and medical tasks required. This study is to develop a methodology to evaluate HIS usability in the healthcare delivery. While investigating the usefulness of the existing HIS as the usability performance, this method includes users' expectation for the ideal HIS in the survey. Based on the survey data, the relative levels of "high importance/performance" and "low importance/performance" are dynamically distinguished by the 75th percentiles and 25th percentiles, respectively. The analytical results in the case study provide insights in system design to further improve the usability of HIS under specific clinical environment.

#### 6- Risk-Averse Healthcare Provider Selection in Lean and Agile Environment: A Goal Programming Approach

Mahbod Amouie, Northern Illinois University, 1307 W. Lincoln Hwy., Apt. 8120, DeKalb, IL, United States of America, [mamouie1@niu.edu](mailto:mamouie1@niu.edu), Amirhossein Meisami

An essential reconsideration of the United States healthcare system has never been as noticed as today. The poster attempts to deal with the process of providing efficient quality healthcare from the perspective of healthcare insurers and individuals. Applying an integrated fuzzy analytic hierarchy process and multi-objective goal programming, the study focuses on both lean and agile criteria as well as risk-averse capabilities of care providers in selection process and patient flow management.

#### 7- Critical Success Measuring Criteria for BTB E-Commerce Usage in Chinese Medical Supply Chain Selling

Xiaomei Li, Tianjin University, College of Management and Economics, Tianjin, China, [li996@purdue.edu](mailto:li996@purdue.edu), Zhaofang Mao, Chengbo Wang, Tong Yang, Ligu Wang, Jun Wang, Xuezhong Chen

This paper focuses on the determination and prioritisation of the critical success measuring criteria of e-commerce application and ongoing usage in selling functions of medical supply chain member organizations; these criteria guide and measure the successful usage of business to business e-commerce system in their daily business conduction/transactions.

#### 8- Patient Centered? or Physician Centered? What Do We Want from the Residents?

Yujiun Tsai, Texas A&M University, Dept. Industrial & Systems Eng., 3131 TAMU, College Station, TX, 77843, United States of America, [yj2009@neo.tamu.edu](mailto:yj2009@neo.tamu.edu)

The effectiveness of medical education practice has long been discussed. Duty-hour are ruled by law to improve patient safety. Preference of spending most of the day in the operating room over the clinic are cast by supervising physicians as well as residency review committee. Educational intensity through rotations is highly expected by the faculty. Moreover, the continuity of care is also brought into more and more attention in regard to learning goals. The purpose of this presentation is to examine the current knowledge domain and offer insight into residency training.

#### 9- Capacity Planning for Publicly Funded Long-Term Care in the U.S.

Yan Li, Research Assistant, Purdue University, 206 S. Martin Jischke Drive, West Lafayette, IN, 47906, United States of America, [li528@purdue.edu](mailto:li528@purdue.edu), Nan Kong, Laura Sands, Mark Lawley

Long-term care provides services to people with chronic disease or disability, many of whom are older adults eligible for public funding. Little is known on what capacity is needed for providing community-based care to a continuously aging population. In this work, we formulate an optimal control problem with the objective of minimizing social spending. We apply several discretization methods and reformulate the problem as nonlinear programs. We conduct case studies on dementia patients.

#### 10- using Health IT Tools to Improve Immunization Management in Community Health Centers

Nathan Patrick Taylor, Quality Informatics Manager, Alliance of Chicago Community Health Services, 215 W. Ohio St., Chicago, IL, 60654, United States of America, [ntaylor@alliancechicago.org](mailto:ntaylor@alliancechicago.org), Shannon Pohl

Managing immunization care is an ongoing challenge for community health centers (CHCs). For CHCs, their patient population consists primarily of low-income, underinsured, uninsured, and other marginalized communities, where their access to health care is limited and their knowledge and compliance to obtaining immunizations is at increased risk. Maintaining up-to-date immunizations amongst this patient population, according to CDC recommendations [1], can directly help to improve public health and decrease the potential for infectious disease spreading across the community. The Alliance of Chicago Community Health Services (the Alliance), a health center-controlled network of 32 CHCs across 11 states, has focused on this challenge, with overarching goals of increasing the quality of immunization care provided and improving immunization rates. They have utilized health information technology (IT) tools for documentation, reporting and monitoring, using the electronic health record (EHR) as its primary database for immunization data. The Alliance will outline the key clinical and community health issues that CHCs have identified in immunization care, data strategies implemented to support clinical workflows, and reporting approaches to proactively target patients at risk.

#### 11 - An Analysis of Sterile Injectable Oncology Drug Shortages in the California Medicaid Program

Eric C. Chen, 10th Grade student, Torrey Pines High School, San Diego, CA, 92130, United States of America, [eric.chen.2015@gmail.com](mailto:eric.chen.2015@gmail.com)

This study investigated how the national drug shortage crisis affected the California Medicaid program in the sterile injectable oncology (SIO) drug group. The contributions are three fold: (1) it integrated multiple sources to create a unique dataset, (2) it quantified the SIO drug shortage impact on patients, and (3) it examined reasons for the crisis proposed by other researchers using scientific methods. This study furthers the pursuit of solutions to the complex drug shortage problem.

#### 12 - Analyzing the Impact of Government Expansion on U.S. Healthcare Financing: A Game-Theoretic Approach

Nan Kong, Assistant Professor, Purdue University, 206 S. Martin Jischke Dr., West Lafayette, IN, United States of America, [nkong@purdue.edu](mailto:nkong@purdue.edu), Murat Kurt, Zhen Zhu, Andrew L. Liu

In healthcare financing, service overutilization and private insurance surcharge are two major sources that do not contribute to the well-being improvement of the care recipients. We analyze the impact of including government as a payer in the financing system for employment-based health insurance. We formulate a leader-follower game to capture the interaction between the government and private insurers. Three government expansion mechanisms are studied analytically and numerically.

#### 13 - Developing a Mockup for a Tablet Computer to Improve Patient Satisfaction and Reducing Diagnostic Errors

Kumars Zolfaghari, Graduate Student, Oregon State University, 155 NW Kings Blvd, Corvallis, OR, 97330, United States of America, [zolfaghk@onid.orst.edu](mailto:zolfaghk@onid.orst.edu), Kenneth Funk

A great deal of mortality in the health care system is the result of medical error and diagnostic error is a significant contributing factor. Diagnostic error has been relatively absent from medical literatures for the past decades. The objective of this research is to develop a mockup for a tablet computer that visualizes important patient information and facilitates the process of differential diagnosis.

#### 14 - On Randomness of Initial Service Access Loads in u-Healthcare over LTE-Advanced Network

Ki-Dong Lee, LG Electronics, 10225 Willow Creek Road, San Diego, CA, 92131, United States of America, [ilovelte@gmail.com](mailto:ilovelte@gmail.com), Sang Kim

The evolution of the mobile service market has profound implications onto the "lifestyle" of today's people living in the era of "networking" - how they read newspapers, buy and sell goods, involve themselves in social networking and even more. It is even more valuable for new business and research opportunity as the current generation foresees some of key impacts to come, such as climate change and world population aging. The aging population, reported by The United Nations, will have substantial impact on changes in economy, such as job market, due to the imbalance between the increasing elderly population and the decreasing young population. Disaster, natural or not, will be one of the priority issues to study in the domain of mobile service. Having these huge potential opportunities in mind, this paper will attempt to draw attention to the application of the evolving networking technology to ubiquitous healthcare service, specifically to the need of efficient handling of randomness inherently resulting from the use of so-called Long Term Evolution-Advanced (LTE-Advanced) systems. Depending on the type of use in u-healthcare, the size of u-healthcare data per instance can be quite small but the arrival rates of u-healthcare data are expected to be substantially high. We formulated the probabilistic behavior of the Initial Service Access attempts and proposed an efficient method to improve the congestion situation typically caused when the patient population is large.

**15 - Human Risk Assessment for Simulated Central Venous Catheterization**

David Johnson, Principal Engineer, Mayo Clinic, 200 1st Street SW, Rochester, MN, 55905, United States of America, dmjohnson@mayo.edu

Central venous catheterization (CVC) is one of most common practiced procedures in the ICU. CVC is associated with complications and potential life-threatening outcomes. The analysis of the CVC procedure from a perspective of Human Risk Assessment (HRA) will provide more insights into the contribution of human error to the system engineering problem of the CVC procedure. This research performs an HRA methodology as a novel approach to quantifying the human error risk component associated with a CVC.

**16- Integrated Medical Analytic Data Model for Evaluation of Unnecessary Laboratory Test Utilization**

Bradley Brimhall, Medical Director, UMMC, 812 Norwich Drive, Madison, MS, 39110, United States of America, brimhall6@stanfordalumni.org, Bryan Clements

Conservatively 19% of clinical laboratory testing is unnecessary and is a large source of waste within the healthcare system. An integrated data model including not only laboratory data, but also other clinical data, more detailed financial data, and operational data would greatly facilitate identification of clinical resource utilization patterns and costs, thereby permitting healthcare systems to prioritize and focus efforts to reduce unnecessary testing. Integration of diagnostic and laboratory coding (LOINC) would facilitate comparisons between hospitals/clinics.

**17- New England Veterans Engineering Research Center's Postgraduate Health Systems Fellowship**

Jordan Peck, Industrial Engineer, New England VERC, 11 Overlook Ridge Drive, Revere, MA, 02151, United States of America, Jordan.peck@va.gov, Ashley Benedict, Bradley Watts, Brian Shiner, Tom Rust

New England VERC has recruited fellows with specific engineering training and interest in healthcare. Focusing on fellows who arrive with a common set of skills has allowed us develop a more advanced curriculum in health systems engineering. Over the first three years 11 fellows have gained valuable work experiences and have had broad exposure to real-life health systems engineering.

**18- Real-Time Decision Support System for Pandemic Influenza**

Sunderesh Heragu, University of Louisville, 132 Eastern Parkway Room 209A, Louisville, KY, 40059, United States of America, S.heragu@louisville.edu, Farshad Majzoubi, Lihui Bai, Mehdi Zakerifar, Kari Kelton, Jose Bejarano, Gerald Evans, Gail DePuy, Ruth Carrico

The events of recent years have shown that preparation and informed decision-making are key factors in efficiently mitigating the effects of disaster situations, regardless of their nature. An effective decision making process for these situations requires tools that render precise information in a timely fashion such that operational capabilities can be assessed and action plans implemented or revised as necessary. The PanFlu Real-Time Decision Support System (RTDSS) supports logistics and planning by Commonwealth of Kentucky public health and emergency response personnel in the event of an influenza epidemic. The PanFlu RTDSS is composed of a suite of models that support state and local personnel in managing multiple aspects of pandemic response, including: —Distribution of the Strategic National Stockpile of antivirals throughout the state; —Management of a statewide network of mental health professionals to support emergency response personnel; —Dispatching Emergency medical services (EMS) vehicles throughout a local jurisdiction; —Designing and simulating a mass vaccination clinic serving a local jurisdiction; —Optimizing the workflow of the emergency department of a hospital; and —Simulating the spread of the epidemic and the impact of control measures. This interactive poster presentation will focus on the EMS dispatch, mass vaccination clinic, and epidemic simulation models of the PanFlu RTDSS.

**19- Scheduling and Routing Physical Therapists Hospital-Wide**

Daniel Gartner, Technische Universität München, TUM School of Management, Arcisstr. 21, München, 80333, Germany, Daniel.Gartner@wi.tum.de, Markus M. Frey, Rainer Kolisch

Next to surgeries, physical therapies represent a substantial part of hospital treatments. In our study, we focus on scheduling physical therapists with the objective to balance workload that consists of the time to perform therapy jobs plus the travel time to move between job locations. To solve the problem, we present two mixed-integer programming models, a decomposition and a heuristic approach currently in use. Real world problem instances are employed to evaluate our methods.

**20- Simulation Modeling of a Hospital Emergency Department**

Shyam Prabhu, Healthcare Process Engineer, Mercy Health, 14528 S. Outer Forty St., 100, Chesterfield, MO, 63017, United States of America, shyam.prabhu@mercy.net, Mark Dowell, Qingbiao Ni

The emergency department or an ED operation within a hospital is a challenging area for healthcare professionals due to its complexity, demand variability and high level of service required. Lean - Six Sigma methodologies have been applied to an ED environment to improve operations; however, the dynamic modeling of an ED from end-to-end has not been an emphasis. This exercise presents a simulation methodology for modeling an ED operation with 2D and 3D animation in the context of a case study.

**21 - Surgery Scheduling and the Impact of Post-Anesthesia Care Unit Flow**

Maya Bam, University of Michigan, Industrial and Operations Engineering, 1205 Beal Ave., Ann Arbor, MI, 48109, United States of America, mbam@umich.edu, Brian Denton, Mark Van Oyen

Efficient surgery scheduling is vital for hospitals due to the high cost associated with surgeries, as well as for patients since adverse events can occur because of long wait times or operating room (OR) boarding. Surgery scheduling in multiple ORs considering downstream resources like the post-anesthesia care unit (PACU) has not been well studied. We present an optimization model that minimizes cost for the hospital while preventing blocking of the ORs due to overutilization of the PACU.

**22 - Validation Study on Potential Cervical Cancer Genes Identified by Microarray Data Analysis Study**

Luis Irizarry, University of Puerto Rico at Mayaguez, P.O. Box 250842, Aguadilla, PR, 00604, United States of America, luis.irizarry7@upr.edu

The Applied Optimization Group at UPRM has been analyzing publicly available microarray data as multiple criteria optimization (MCO) problem. One of the methods that can be used to solve an MCO problem is data envelopment analysis (DEA). By using DEA, it is possible to find which genes change the most their expression between the conditions being compared in a microarray experiment. This work started with a set of genes selected through DEA applied to cervical cancer microarray data. A comprehensive literature search was undertaken to investigate the role of these genes, aiming to bridge data- and mathematically-driven results with biological meaning. DEA was applied to two cervical cancer microarray databases and 53 genes were selected as changing significantly their expression between normal and cancer tissues. Literature searches were performed for each one of the genes to find out if they and/or their products had been reported previously as playing roles in cervical cancer, or in other types of cancer. The information for the selected genes was obtained using Pubmed and Genecards. This work concentrated on the following information: alternate names, brief description of function, cancers related to the gene, previous uses as a therapeutic marker, and indirect relations to cancer. The results showed that 8 of the 53 genes identified have not been associated with a cancer before; thus, making them interesting leads to follow. There were 23 instances of a gene being directly related to a cancer, 55 instances where a gene had been used as a therapeutic or prognostic marker and 54 instances where the genes had an indirect relation to cancer. This study supports the analysis of microarray data as an MCO problem. It shows that there is still useful information that can be obtained from the available data, and presents 8 genes not associated with cancer before that are worth of further investigation.

**23 - Mining Electronic Health Records to Improve the Quality and Safety of Care**

Juergen Klenk, Booz Allen Hamilton Inc., McLean, VA, United States of America, klenk\_juergen@bah.com, Kathryn Schulke

Improving quality of care is a central theme of healthcare reform. Clinical information systems, such as electronic health record (EHR) management systems, contain data that have the potential to offer significant insights in how to improve quality of care. Booz Allen collaborated with a large hospital system to apply our Quality Improvement Lifecycle to demonstrate how EHR data can be leveraged into actionable information that can drive improved outcomes for hospital acquired infections (HAIs) such as sepsis. The poster explains the data-driven Quality Improvement Lifecycle, how it was applied step-by-step to the problem, analytic techniques employed, and results obtained.

**Monday, 3:30pm - 5:00pm****MC01**

01- Chicago F

**Student Research Projects in Healthcare Engineering and Patient Safety II**

Cluster: Health Systems Engineering Alliance (HSEA)

Invited Session

Chair: Amy Cohn, University of Michigan, 1205 Beal Ave., Ann Arbor, MI, United States of America, amycohn@umich.edu

**1 - using Discrete Event Simulation to Improve Service Quality in an Ambulatory Oncology Infusion Center**

Spyros Potiris, Graduate Student, University of Michigan, 1205 Beal Avenue, Ann Arbor, MI, 48109, United States of America, spotiris@umich.edu, Brian Denton, Christopher Friese, Autumn Heiney, Amy Cohn

In this study we use discrete event simulation to identify major bottlenecks in the operation of an ambulatory infusion center, in order to increase satisfaction and safety of both patients and nurses. Important issues we investigate using our simulation model include the impact of scheduling and sequencing patient appointments throughout the day on performance measures, such as patient waiting times, nurse utilization, and infusion chair utilization. In addition, we examine how different types of regimens affect patient infusion times, and the subsequent implications for patient scheduling.

**2 - Assessing and Maintaining Quality of Care for Veterans with Mental Health Disorders**

Sett Oo, Worcester Polytechnic Institute, WPI - Box#2507, 100 Institute Road, Worcester, MA, 01609, United States of America, sett\_paing\_oo@wpi.edu, Lazaro Rodriguez, Evren Simsek, Christine Tang, Renata Konrad, Andrew Trapp, Isa Bar-On, Bradley Watts, Brian Shiner

Veterans at the White River Junction VA Medical Center are screened annually for mental health disorders. Patients who screen positive may be treated in Primary Care, Primary Mental Health Care (PMHC) and/or Specialized Mental Health Care. We assign quality ratings to patients depending on the type and duration of treatments received. We also use a simulation model for the PMHC clinic to determine additional workforce required to accommodate all patients in need of mental health treatment.

**3 - Increasing Granularity in an Agent-Based Pandemic Simulation Model**

Alexandra Szatan, University of Toronto, Toronto, ON, Canada, alexandra.szatan@mail.utoronto.ca, Buser Say, Mario Ventresca, Dionne Aleman

In modeling the spread of pandemic disease, accuracy in population representation is important in order to reflect the real world. Through the addition of school, workplace, and transportation environments to an agent-based simulation model of the greater Toronto area, Ontario, Canada, the effects of the inclusion of these environments on disease spread in a largely urban setting are explored.

**MC02**

02- Chicago G

**Data Driven Modeling and Analysis of Healthcare Applications**

Cluster: Healthcare Data Analytics

Invited Session

Chair: Saeede Ajorlou, Wayne State University, 4815 4th St., Detroit, MI, United States of America, er7212@wayne.edu

**1 - Microbiome Data and Women's Health**

Paul Brooks, Associate Professor, Virginia Commonwealth University, P.O. Box 843083, Richmond, VA, United States of America, jpbrooks@vcu.edu, VCU Microbiome Consortium

The human microbiome is the community of bacteria that occupy various body habitats. The Vaginal Microbiome Consortium at VCU has been investigating the relationship between the vaginal microbiome and disease/physiology. This talk presents methods for visualizing human microbiome data using a new method for PCA, describes an experimental protocol for countering bias in metagenomic experiments, and presents clinically-relevant relationships between the microbiome and women's health.

**2 - Analytics of Obesity Increase in US Children from 1963 to 2012**

K.P. Unnikrishnan, Director, NorthShore University HealthSystem, Ctr. for Clinical &amp; Research Informatics, Research Institute, Evanston, IL, United States of America, kunnikrishnan@northshore.org, Xiang Zhong, Jingshan Li

Anthropometric measurements such as weight, stature (height), and body mass index (BMI) provide reliable indicators of children's growth. The 2000 CDC growth charts are the national standards in the United States for these important measures. But these growth charts were generated using data from 1963-1994. To understand the growth patterns of US children since 1994, we generate weight-for-age, stature-for-age and BMI-for-age percentile curves for both boys and girls aged 2-20 through the methods used to generate the 2000 CDC growth charts. Our datasets are from the National Health and Nutrition Examination Survey (NHANES) for years 1999-2010 and from NorthShore University HealthSystem's Enterprise Data Warehouse (NS-EDW) for years 2006-2012. The weight and BMI percentile curves generated from NS-EDW and NHANES data differ substantially from the CDC percentile curves, while those for stature do not differ substantially. We conclude that the population weight and BMI values of US children in recent years have increased significantly since 2000 and the 2000 CDC growth charts may no longer be applicable to the current population of US children. Our charts poignantly reveal the increasing obesity of American children.

**3 - Workload Estimation Model for Patient Centered Medical Homes (PCMH)**

Saeede Ajorlou, PhD Student, Wayne State University, 4815 4th Street, Detroit, MI, 48203, United States of America, er7212@wayne.edu, Issac Shams, Kai Yang

PCMH becomes a popular team-based approach which use different healthcare professionals to provide comprehensive care. However, clinical workload estimation model is needed to match the capacity portfolio of PCMH team with the actual clinical workload. In this talk, using healthcare demand and supply portfolio data from VHA, we develop a balanced workload estimation model based on generalized linear mixed model that can predict workload demands for a relevant set of PCMH professionals.

**MC03**

03- Chicago H

**Cancer Treatment Planning and Operations**

Contributed Session

Chair: Daliborka Stanojevic, University of Maryland School of Medicine, Department of Radiation Oncology, 22 South Greene Street, Baltimore, MD, 21201, United States of America, dstanojevic@umm.edu

**1 - Resource Planning for Colorectal Cancer Treatment**

Onur Arslan, Northeastern University, 360 Huntington Avenue, Boston, MA, 02115, United States of America, arslan.o@husky.neu.edu, Ayten Turkcan

We developed an analytical method to estimate the demand for colorectal cancer treatment and allocate resources to provide timely care. We proposed an agent-based model that incorporates several factors such as population characteristics, patient health status, treatment guidelines, and detailed resource requirements for each treatment type. The proposed model is simulated to show that it gives realistic estimates of the health services utilization for given capacity allocations.

**2 - Determining Chemotherapy Nurse Panel Size in Infusion Clinics**

Bohui Liang, Northeastern University, 360 Huntington Avenue, Boston, MA, 02115, United States of America, liang.boh@husky.neu.edu, Ayten Turkcan

In this study, our aim is to determine the panel size of chemotherapy nurses in oncology clinics where primary nursing model is used. We propose an integer programming model to allocate new chemotherapy patients to nurses based on nurses' current panel and new patients' treatment plans such that each patient can see the same nurse throughout the treatment. The proposed model can improve patient and staff satisfaction by providing a balanced workload and enhancing the continuity of care.

### 3 - Optimizing Strategic Growth in a Cancer Hospital using Linear Programming

Isaac Wagner, Memorial Sloan-Kettering Cancer Center, 405 Lexington Avenue, 3rd Floor, New York, NY, 10174, United States of America, wagneri@mskcc.org, Sasha Bartashnik, Tian Shen, Ari Caroline

Memorial Sloan-Kettering Cancer Center seeks to balance cancer care quality with tightening resources. Linear programming is applied to optimize financial contribution from patient activity within resource constraints based on current and expected patterns of care. Areas for selective program growth for the treatment of patients of different diseases are identified in context of outcomes, research opportunity, and market share analytics. We outline challenges of using OR modeling for strategic growth decision making in a hospital setting and walk through methodology, results and implementation.

### 4 - A Patient Population Based Approach for Disease Site Specific IMRT Treatment Planning

Daliborka Stanojevic, University of Maryland School of Medicine, Department of Radiation Oncology, 22 South Greene Street, Baltimore, MD, 21201, United States of America, dstanojevic@umm.edu, Warren D. D'Souza, Hao Zhang, Robert R. Meyer

Existing Intensity-Modulated Radiation Therapy (IMRT) treatment planning requires highly computationally expensive procedures both for aperture selection and radiation dose optimization. We present a population-based methodology that can alleviate both issues by employing advanced machine-learning algorithms and progressive dose optimization. Our case study indicates that our methods provide high-quality treatment plans that are superior to the conventional IMRT treatment planning.

## MC04

04- Scottsdale

### Joint Session CORS/SPPSN: Queuing Models in Emergency Medical Services (EMS) Systems

Sponsor: CORS, Canadian Operational Research Society & Public Programs, Services and Needs

Sponsored Session

Chair: Armann Ingolfsson, University of Alberta, School of Business, Edmonton, AB, T6G 2R6, Canada, aingolfs@ualberta.ca

Co-Chair: Bora Kolfal, University of Alberta, School of Business, Edmonton, AB, Canada, bkolfal@ualberta.ca

#### 1 - Modeling Red and Yellow Alert Durations for Ambulance Systems as Partial Busy Periods

Amir Rastpour, PhD Candidate, University of Alberta, School of Business, Edmonton, AB, Canada, rastpour@ualberta.ca, Bora Kolfal, Armann Ingolfsson

Ambulance system red and yellow alerts are time periods during which all or most ambulances are busy, respectively. Modeling such systems as Erlang loss systems, we obtain the first moment of alert period duration, showing them to be independent of the shape of the service time distribution. We study the impact on alert duration of increasing the number or service speed of ambulances. We show that our results are consistent with empirical data from Calgary. We also obtain alert duration Laplace Transform and higher moments when the service time distribution is Generalized Hyperexponential.

#### 2 - Service Systems with Adaptive Servers

Mohammad Delasay, PhD Candidate, University of Alberta, School of Business, Edmonton, AB, Canada, delasays@ualberta.ca, Armann Ingolfsson, Bora Kolfal

Healthcare servers do not work at a constant speed - they may speed up to clear a queue and slow down when fatigued. We develop a queuing model in which service rates change with the system load\* (number of busy servers) and overwork\* (number of users served in the current busy period). Our model is a quasi-birth-and-death process with special structure that simplifies calculation of performance measures. We demonstrate how using models that ignore adaptive server behavior can result in inconsistencies between planned and realized performance and can lead to oscillations in staffing.

#### 3 - Optimizing Compliance Tables for Ambulance Repositioning

Ramon Alanis, Sr. Health Operations Researcher, Alberta Health Services, 10700 - 104 Avenue, Edmonton, AB, T5J 4S2, Canada, Ramon.Alanis@albertahealthservices.ca, Armann Ingolfsson, Bora Kolfal, Fernanda Campello

We investigate a collection of performance evaluation models and optimization methods to obtain compliance tables, ranging from a greedy heuristic combined with a realistic Markov chain performance evaluation model to an integer program that incorporates much simpler performance evaluation. Using

stochastic ordering, we show how to use the integer program to obtain bounds on realistic performance measures and we study how nesting and "doubling up" impacts compliance table performance.

## MC05

05- Miami

### Supply Chains and Procurement

Contributed Session

Chair: Dharmaraj Veeramani, Robert A. Ratner Chair Professor, University of Wisconsin-Madison, 4101 Mechanical Engineering Building, 1513 University Ave., Madison, WI, 53706, United States of America, raj@ie.engr.wisc.edu

#### 1 - Transshipment and Substitution Policies for Vendor Managed Inventory in Blood Products Supply Chain

Amonsiri Vilasdaechanont, University of Wisconsin-Madison, 4158 Mechanical Engineering Building, 1513 University Ave., Madison, WI, 53706, United States of America, vilasdaechan@wisc.edu, Dharmaraj Veeramani

We study transshipment and blood group substitution in demand fulfillment process under the Vendor Managed Inventory (VMI) approach to maximize utilization of blood products inventory, and to minimize cost and shortage. Our mixed integer programming models consider both demand fulfillment and delivery routing decisions in a single period setting. Our computational studies shed insight into the performance of the VMI approach under different policies and model parameter settings.

#### 2 - Health Care Product Procurement in Dual Supplied Systems

Cigdem Gurgur, Associate Professor, Purdue University, Doermer School of Business, 2101 East Coliseum Blvd., Fort Wayne, IN, 46825, United States of America, gurgur@ipfw.edu

In this study we consider supplier selection and quantity allocation decisions for a health care organization that may purchase a number of unbundled products and refurbished products under stochastic demand. We use data from a large healthcare provider in Indiana to test the implications of our study.

#### 3 - Transforming Supply Chain Management of Blood using Radio Frequency Identification (RFID)

Dharmaraj Veeramani, Robert A. Ratner Chair Professor, University of Wisconsin-Madison, 4101 Mechanical Engineering Building, 1513 University Ave., Madison, WI, 53706, United States of America, raj@ie.engr.wisc.edu

This NIH-funded project is the first-ever comprehensive research effort on applying RFID technology for automatic identification and management of blood across the entire transfusion medicine supply chain, from blood collection at a donor site to transfusion to a patient in a hospital. The goal is to create a fail-safe system for automatic identification and data capture to reduce medical errors and enhance safety, quality, and cost-effectiveness of patient-centered transfusion care.

## MC06

06- Los Angeles

### Medical Decision Making I

Contributed Session

Chair: Tal Ben-Zvi, Stevens Institute of Technology, Castle Point on Hudson, Hoboken, NJ, 07030, United States of America, tbenzvi@stevens.edu

#### 1 - Modelling Long Term Outcomes in Stroke Thrombolysis: Save a Minute – Save a Day

Leonid Churilov, Florey Institute of Neuroscience and Mental Health, Melbourne Brain Centre, Heidelberg, Australia, leonid.churilov@gmail.com, Mahsa Keshtkaran, Atte Meretoja

Although intravenous thrombolytic therapy for ischaemic stroke is more effective when delivered early after symptom onset, in-hospital delays of >60 mins are common. We quantified the disability adjusted life years patients gain from faster treatment. Reducing the average delay by 20 mins resulted in one month of extra disability-free life. The effect of being faster varied with the patients' life-expectancy. Stroke teams should start pushing their patients to the CT with a hasty step.

## 2 - Optimal Control for Predicting Drug Dosage in Superovulation Stage of In-Vitro Fertilization

Kirti Yenkie, PhD Student/Research Assistant, University of Illinois, Chicago, 1033 South Oakley Blvd., Chicago, IL, 60612, United States of America, kirtiyenkie@gmail.com, Urmila Diwekar

In vitro fertilization (IVF) is one of the most highly pursued assisted reproductive technology worldwide. The IVF procedure is divided into four stages: superovulation, egg-retrieval, insemination/fertilization and embryo transfer. Superovulation is the most crucial stage in IVF, since it involves external injection of hormones to stimulate development and maturation of multiple oocytes. The maximum amount of effort and money for IVF procedure goes into superovulation. Although numerous advancements have been made in IVF procedures, little attention has been given to modifying the protocols based on a predictive model. A model for the follicle growth dynamics and number as a function of the injected hormones and patient characteristics has been developed and validated. The modeling basics were adapted from batch crystallization moment model, since moments are representatives of specific properties like number, shape and size of the particles under consideration. Based on this model, the dosage of the hormones to stimulate multiple ovulation or follicle growth is predicted by using the theory of optimal control. The objective of successful superovulation is to obtain maximum number of mature oocytes/follicles within a particular size range. Using the mathematical model involving follicle growth dynamics and the optimal control theory, optimal dose and frequency of medication customized for each patient is predicted for obtaining the desired result.

## 3 - Breast Cancer Detection: Making Predictions using Partially Observable Markov Decision Processes

Tal Ben-Zvi, Stevens Institute of Technology, Castle Point on Hudson, Hoboken, NJ, 07030, United States of America, tbenzvi@stevens.edu, Donald Lombardi, Jingyi Chen

This study considers a situation where a patient is monitored for cancer. Once enough indications are given for the existence of cancer cells (for example, through screening), the patient is considered a cancer patient and treatment is suggested. The objective is to design an optimal strategy that guarantees accurate and timely cancer detection. We show that the optimal policy is of a Control Limit Threshold (CLT).

## MC07

07- Kansas City

## Impact of Patient Flow Management on Patient Service

Sponsor: POMS, College of Healthcare Operations Management  
Sponsored Session

Chair: Jonathan Helm, Assistant Professor, Indiana University, 1275 East Tenth Street, Business School, Room 680, Bloomington, IN, 47405, United States of America, helmj@indiana.edu

## 1 - Fluctuating Demand in a Hospital: How Quick-response Decisions Impact Staffing Levels and Cost

Jan Schoenfelder, Indiana University, Kelley School of Business, 1309 E. Tenth Street, Room 752-49, Bloomington, IN, 47401, United States of America, janschoe@indiana.edu, Daniel Wright, Edwin Coe, Kurt Brethauer

In this paper, we present a multi-stage stochastic programming model that incorporates quick-response decisions into the nurse staffing process. Focusing on a partially multi-skilled workforce and patient reallocation, we evaluate the cost saving potential of these quick-response actions and identify relationships between capacity utilization and potential cost benefits.

## 2 - Modeling Hospital-Wide Patient Flows using Simulation

Asli Ozen, University of Massachusetts-Amherst, Amherst, MA, 01003, United States of America, aslozen@gmail.com, Hari Balasubramanian

In hospitals nationwide, misaligned bed capacity results in ED crowding and PACU holds. We used patient admission rates, surgery schedules, bed placement rules, length of stays and capacity information from Baystate Medical Center (Springfield, MA) to develop computer based optimization and simulation model to improve capacity allocation of inpatient beds. Our goal is to provide guidelines on how hospitals should manage their inpatient bed capacity in the presence of demand and LOS variability.

## 3 - Prioritizing Wait-Sensitive Patients in an Overloaded Health Care System

Yu Wang, Indiana University, Business School, 1309 E. 10th Street, Room 736-7, Bloomington, IN, 47405, United States of America, yw39@indiana.edu, Alex Mills

In a mass-casualty incident (MCI), even some critically injured patients have to wait for treatment. Because their condition will deteriorate while waiting, the time needed to treat them will increase; thus, it may be inappropriate to model service times as wait-independent. We model a multiclass clearing system where service time is sensitive to waiting time. By analyzing this system, we gain insights on how wait-time sensitivity should be incorporated when prioritizing patients in a MCI.

## MC08

08- Kane

## Cancer Therapy Optimization

Cluster: Healthcare Operations Management  
Invited Session

Chair: Timothy Chan, University of Toronto, 5 King's College Rd., Toronto, ON, M5S 3G8, Canada, tcychan@mie.utoronto.ca

## 1 - Beam Orientation Optimization for Radiation Therapy Treatment Planning

Troy Long, PhD Candidate, University of Michigan, Ann Arbor, MI, United States of America, troylong@umich.edu, Edwin Romeijn

Beam orientation optimization selects stationary beam positions to produce a both high quality and efficiently deliverable treatment plan, resulting in a large-scale combinatorial optimization problem. We study an efficient method for selecting beam orientations for IMRT treatments that explicitly incorporates the quality of the resulting optimal dose distribution and compare our method to other techniques.

## 2 - Simultaneous Optimization of Dose Distributions and Fractionation Schemes Based on the BED Model

Jan Unkelbach, Massachusetts General Hospital, 30 Fruit Street, Boston, MA, United States of America, junkelbach@partners.org, Chuan Zeng, Martijn Engelsman

The biologically equivalent dose (BED) concept is used to determine optimal fractionation schemes for radiotherapy. Optimal fractionation has been investigated independently of IMRT planning, which optimizes the spatial dose distribution. In this work, we discuss the interdependence of the two problems. It is shown that the standard BED model gives rise to non-uniform spatio-temporal fractionation schemes in which it is optimal to deliverer distinct dose distributions in different fractions.

## 3 - Deliverable Multi-Criteria Navigation for Intensity-modulated Radiation Therapy by Sharing Segments

Albin Fredriksson, KTH Royal Institute of Technology & RaySearch Laboratories, Department of Mathematics, Stockholm, SE-100 44, Sweden, albfre@kth.se, Rasmus Bokrantz

Directly deliverable navigation for multicriteria step-and-shoot radiation therapy treatment planning is considered. We introduce simultaneous direct step-and-shoot optimization of multiple plans subject to constraints that some aperture shapes are shared across plans. This method can be used to improve upon the plans generated by previous methods for deliverable navigation. We also discuss how the proposed method may enable convergence towards the exact Pareto surface.

## ■ MC09

09- McHenry

### Designing Healthcare Change: From Frontline Process to National Policy

Cluster: Healthcare Operations Management

Invited Session

Chair: Neil McEvoy, Director, University of Toronto, Department of Mechanical Engineering, 5 King's College Road, Toronto, ON, M5S 3G8, Canada, neil.mcevoy@utoronto.ca

#### 1 - Improving Prediction of Surgery Duration using Operational and Temporal Factors

Enis Kayis, Assistant Professor, Ozyegin University, Nisantepi District, Orman Street, Cekmekoy, Istanbul, 34794, Turkey, enis.kayis@ozyegin.edu.tr, Shelen Jain, Haiyan Wang, Meghna Patel, Tere Gonzalez, R.J. Ramamurthi, Cipriano Santos, Sharad Singhal, Jaap Suermondt, Karl Sylvester

Inherent uncertainties in surgery durations impact critical metrics about the performance of an operating room (OR). In this paper we study whether operational and temporal factors can be used to improve naive surgery estimates. We validate our method with two years of detailed operational data. We conclude that while improving estimates of surgery durations is possible, the inherent variability in such estimates remains high, necessitating caution in their use when optimizing OR schedules.

#### 2 - A Simulation Model for Reconfiguring Specialist Outpatient Phlebotomy Service in Queen Mary Hospital

Kenneth Yip, Operations Research Manager, Hong Kong West Cluster, Hospital Authority, 102 Pok Fu Lam Road, Hong Kong, Hong Kong - PRC, ycm021@ha.org.hk, S.K. Pang, K.T. Chan, C.K. Chan, T.L. Lee

The Specialist Outpatient Department of Queen Mary Hospital in Hong Kong served about 400,000 attendances per year. Its phlebotomy service was decentralized, where each of the clinics ran its own independently. A discrete-event simulation model was developed to evaluate how centralization would enhance efficiency and performance. Several variations were made to the model to test different staffing strategies, which enabled hospital management to arrive at the service's ideal configuration.

#### 3 - Evidence-Based Health Reform - in Search of What Works

Neil McEvoy, Director, University of Toronto, Department of Mechanical Engineering, 5 King's College Road, Toronto, ON, M5S 3G8, Canada, neil.mcevoy@utoronto.ca

Evidence-based health reform has not been used frequently in selecting strategies at a national level. Institutional theory suggests that outcomes are path dependent and possibly unique to local conditions. This research combines frontier and time series analysis to establish causal and contextual relationships between factors over four decades among 21 OECD countries. The pilot study shows evidence of recognizable dynamic behaviour in response to one national reform initiative.

## ■ MC10

10- Cook

### Nursing Homes/Home Health

Contributed Session

Chair: William Massey, Professor, Princeton University, ORFE Department, Sherrerd Hall, Princeton, NJ, 08544, United States of America, wmassey@princeton.edu

#### 1 - Staffing, Operational Flexibility and Labor Laws: Evidence from Nursing Home Chains

Lauren Xiaoyuan Lu, Assistant Professor of Operations, University of North Carolina at Chapel Hill, Kenan-Flagler Business School, Chapel Hill, NC, 27599, United States of America, lauren\_lu@unc.edu, Susan Lu

It is well established in the operations management (OM) literature that pooling resources across different facilities allows firms to reduce resource investment under demand uncertainty. Despite the importance of resource pooling in OM theory, related empirical evidence is rare due to lack of detailed operational data. In this paper, we use staffing data from the nursing home industry to study the effect of resource pooling on staffing decisions and operational flexibility.

#### 2 - Optimization of Medium-Term Home Health Care Planning

Andrea Trautsamwieser, University of Natural Resources and Life Sciences, Vienna, Feistmantelstraße 4, Vienna, 1180, Austria, andrea.trautsamwieser@boku.ac.at, Patrick Hirsch

In home health care planning a work schedule has to be found such that each client is visited by appropriate nurses in a given time window on specific days while respecting working time requirements. We propose a branch-and-price-and-cut approach to optimize the planning. A variable neighborhood search approach is used to generate a good initial solution, while 2path cuts are added to strengthen the LP formulation. Medium sized instances can be solved to optimality within reasonable computing time.

#### 3 - Integrated Approach to Support Logistics Decisions with Hierarchical Dependencies in Home Healthcare

E. Valentina Gutiérrez, PhD, Universidad del Valle, Ciudad Universitaria Meléndez, Calle 13 No.100-00, Cali, 76000, Colombia, valentina.gutierrez@correounivalle.edu.co, Carlos Julio Vidal

We study the hierarchical interdependencies among strategic and tactical decisions in the context of Home Health Care (HHC) logistics management. The objective is to develop an integrated approach to support districting and staff management decisions in a hierarchical framework. The approach is based on a decomposition-aggregation structure of HHC services, in which each planning level has an associated model. A case study of an intermediate city in Colombia, South America is presented.

#### 4 - Nursing Home Bed Planning Based on Medicaid Bed-Hold Payment Policies

William Massey, Professor, Princeton University, ORFE Department, Sherrerd Hall, Princeton, NJ, 08544, United States of America, wmassey@princeton.edu

Certificate of need (CoN) regulations control the number of nursing home beds through Medicaid reimbursement incentives. We develop new algorithms to estimate the nursing home bed demand and find the profit-optimal staffing number. We analyze a multi-server queueing model. Our model uses non-homogeneous Poisson arrivals but the service times need not be exponentially distributed. We give explicit formulas for the transient mean number of beds and the CoN profit function.

## ■ MC11

11- Dupage

### Empirical Healthcare Operations

Cluster: Improving Hospital Operations

Invited Session

Chair: Stefan Scholtes, Professor, University of Cambridge, Judge Business School, Cambridge, CB2 1AG, United Kingdom, s.scholtes@jbs.cam.ac.uk

#### 1 - Cohort Turnover and Productivity: The July Phenomenon in Teaching Hospitals

Robert Huckman, Professor, Harvard Business School, 435 Morgan Hall, Boston, MA, United States of America, rhuckman@hbs.edu, Hummy Song, Jason Barro

We consider the impact of cohort turnover on productivity in the context of teaching hospitals. Specifically, we examine the impact of the annual July turnover of residents in American teaching hospitals on levels of resource utilization and quality. We find that this annual cohort turnover results in increased resource utilization (i.e., higher length of hospital stay) but find evidence that is less conclusive regarding the impact on quality (i.e., mortality rates).

#### 2 - Measuring the Level-of-Care in the Intensive Care Unit: The Nurse-to-Severity Ratio

Song-Hee Kim, Columbia University, New York, NY, 10027, United States of America, sk3116@columbia.edu, Carri Chan, Gabriel Escobar

The most widely used indicator for level-of-care in the medical community is the nurse-to-patient ratio. We suggest the nurse-to-severity ratio as an alternative for measuring the level-of-care in ICUs, where the term severity refers to severity of illness. Using two econometric frameworks, we find that the severity-adjusted ICU congestion level has significant effects on not only the number of future ICU admissions and discharges, but also on patient care paths and outcomes.

**3 - The Effect of Focus on the Service Portfolio of Acute Hospitals**

Stefan Scholtes, Professor, University of Cambridge,  
Judge Business School, Cambridge, CB2 1AG, United Kingdom,  
s.scholtes@jbs.cam.ac.uk

We examine the effect of focus on some services on mortality and length of stay across the portfolio of hospital services. Using discharge records of 1,142,633 inpatient admissions in 569 departments of 97 German hospitals, we find that a patient has a lower mortality risk but also a longer length of stay when her primary condition falls within a focus service of her hospital. We also consider the effect on non-focus patients and find that non-focus patients of a hospital have shorter length of stay when the hospital's service portfolio is highly concentrated. There is no evidence in our data that this efficiency gain is associated with an increased mortality risk for the non-focus patients. Finally, we consider the effect of misalignment of hospital and departmental focus and find that the beneficial effect of focus at the hospital level is largely eroded when focus patients at the hospital level are treated in departments where they are not a focus group. We discuss implications of our findings for strategic hospital management.

**4 - An Empirical Study of Ambulance Diversion**

Eric Park, Northwestern University, Kellogg School of  
Management, Evanston, IL, United States of America,  
eric-park@kellogg.northwestern.edu, Sarang Deo, Itai Gurvich

We study the effect of a policy change that was intended to reduce ambulance diversions in LA County, CA. We find that the new policy succeeded in its purpose of reducing the time spent on diversion but did not reduce the fraction of ambulances being diverted. A possible explanation for this outcome, identified by our empirical analysis, is a misuse of diversion before the policy change coupled with moderate operational improvements after the change.

**MC12**

12- Water Tower

**Data-driven Modeling of Hospital Operations**

Cluster: Patient Flow and Care Coordination

Invited Session

Chair: Nan Liu, Assistant Professor, Columbia University,  
600 W. 168 St., New York, NY, 10032, United States of America,  
nl2320@columbia.edu

**1 - Assessing Dynamic Discharge Policies at Acute Care Hospitals via Discrete-Event Simulation**

Nan Kong, Assistant Professor, Purdue University, 206 S. Martin  
Jischke Dr., West Lafayette, IN, United States of America,  
nkong@purdue.edu, Pratik Parikh, Charuhas Thakar,  
Elizabeth Crawford

Hospitals are under pressure to avoid unnecessary post-discharge readmission, which may encourage them to delay patient discharges. In contrast, the effect of ED crowding on resource utilization and ambulance diversion may encourage hospitals to discharge patients earlier. In this work, we develop a discrete-event simulation model to analyze the effect of acute patient discharge timing on a variety of performance measures such as ED waiting/boarding, ambulance diversion, and readmission rates.

**2 - Improving Medical Laboratory Operations via Discrete-Event Simulation**

Lesley Meng, Research Associate, Massachusetts General Hospital  
ITA, 101 Merrimac St., 10th Floor, Boston, MA, 02114, United  
States of America, lesley@mgh-ita.org, Richard Liu, Connor  
Essick, Mark Gendron, Nan Liu, Ellinor Peerschke, Melissa Pessin

We have developed a discrete event simulation model for the central medical laboratory of the Memorial Sloan-Kettering Cancer Center in New York City. Our simulation model captures the process flow of patient specimens undergoing chemical tests, and is validated against true laboratory throughput times. Balancing both complex demand trends with internal operations, our model seeks to fulfill the overall purpose of optimizing laboratory operational effectiveness and efficiency at the hospital.

**3 - Modeling the Use of Prediction to Improve Patient Flow in a Hospital**

Jordan Peck, Industrial Engineer, New England VERC,  
11 Overlook Ridge Drive, Revere, MA, 02151,  
United States of America, Jordan.peck@va.gov, James Benneyan,  
Deborah Nightingale, Stephan Gaehe

Studies have suggested that prediction can be used to improve flow between an Emergency Department and Hospital. A discrete event simulation of the system is developed to study the potential value of collecting and sharing such predictions. It is found that sharing ED prediction information leads to best patient flow performance when using specific schedules dictating IU response to the information.

**MC13**

13- Navy Pier

**Simulation in Emergency Care**

Sponsor: Simulation Society

Sponsored Session

Chair: Sean Barnes, University of Maryland, R.H. Smith School of  
Business, College Park, MD, United States of America,  
sbarnes@rhsmith.umd.edu

**1 - Analysis and System Development of Disease Propagation and Mitigation for Effective Mass Dispensing**

Chien-Hung Chen, Georgia Institute of Technology,  
755 Ferst Drive, NW, Atlanta, GA, 30332,  
United States of America, cchen@isye.gatech.edu, Eva Lee

This work is joint with CDC. On top of a large-scale simulation/optimization decision support system, RealOpt, we propose and implement disease propagation model to both numerically and simulation-wise analyze the propagation of highly infectious disease within dispensing sites. This study helps to identify effective mitigation strategies such triage accuracy, process batch size, and required throughput, and further examine the trade-off between operational efficiencies and intra-POD infections.

**2 - Relieving Crowding: How Improving Emergency Department Flow Evolves over 24 Hours**

Eric Hamrock, Sr. Project Administrator, Johns Hopkins Medical  
Institute, 600 N. Wolfe St., Admin 421D, Baltimore, MD, 21287,  
United States of America, ehamrocl@jhmi.edu

Problem: The study sought to determine the effects of reducing length of stay (LOS) on temporal patterns of patient flow and demand for emergency department (ED) resources. Methods: Separate discrete event simulation (DES) models were developed to characterize the effects of reducing patient LOS on waiting time, waiting room census, and ED care area census (i.e., staffing needs). Contributions: Delays experienced by evening arrivals were most significantly reduced providing the opportunities for cost savings by reducing staff overnight.

**3 - Modeling the Impact of Environmental Cleaning on the Transmission of Hospital-Acquired Infections**

Sean Barnes, University of Maryland, R.H. Smith School of  
Business, College Park, MD, United States of America,  
sbarnes@rhsmith.umd.edu

The potential acquisition of antibiotic-resistant pathogens continues to threaten the safety of patients in many healthcare settings. Environmental contamination can play a significant role in causing these unintended outcomes, but modeling efforts to this point have minimized or neglected its contribution to overall prevalence levels. We develop an agent-based model of the transmission of antibiotic-resistant pathogens in an intensive care unit to compare the impact of environmental cleaning relative to the hand washing practices of health care workers.

**MC14**

14- Huron

**Health Care in Other Countries**

Contributed Session

Chair: James Belohlav, Professor, DePaul University, Department of  
Management, 1 East Jackson Blvd., Chicago, IL, 60604,  
United States of America, jbelohla@depaul.edu

**1 - Efficiency Scores for Primary Care in Brazilian Municipalities: A Two Stage Approach**

Maria C. Sampaio de Sousa, Professor, Universidade Federal da  
Paraíba, Rua Silvino Lopes 710/901, Ed. Portland, Tambu,  
Joao Pessoa, 58039-190, Brazil, csampaiodesousa@gmail.com,  
Tarciana Liberal, Borko D. Stosic

We computed DEA efficiency scores for Primary Health care in Brazilian municipalities by means of a two stage approach. The first stage detects influential municipalities and selects them with a lower probability by using an extended jackstrap approach. The second stage shows that location, demographic structure and input composition affect efficiency and explain part of the differential performance among municipalities. Moreover, municipalities with higher income, education and health indicators tend to be more efficient. Lastly, the analysis of residual efficiency scores, besides contributing to reduce performance differences across municipality sizes, indicates that gross efficiency scores overestimate the managerial performance of the primary care system.

## 2 - Medical Quality Assessment using the Evidential Reasoning Approach

Guilan Kong, Peking University, Medical Informatics Center,  
No. 38 Xueyuan Road, Haidian District, Beijing, China,  
guilan.kong@hsc.pku.edu.cn, Xiemin Ma, Lue-Ping Zhao,  
Jun Zhang

We employed a novel evidential reasoning (ER) approach to assess medical quality in this study. The ER approach can help to aggregate both objective indicators and subjective expert judgments in medical quality assessment. The distributed assessment results generated via ER can help to provide a holistic medical quality view of a hospital. Furthermore, medical quality ranking produced by the ER approach can help to provide a criterion for medical resources allocation.

## 3 - The Moderated Mediation Effects between Leadership Effectiveness and Burnout in Healthcare Context

Ya-Ling Kao, National Cheng Kung University, Transportation & Communication Management, 1 University Road, Tainan, 701, Taiwan - ROC, ylkao1211@gmail.com, Ching-Fu Chen, Li-Fang Chen

A moderated mediation model of leadership effectiveness, supervisor support, coworker support, and burnout was tested using a sample of 608 registered nurses from 36 nursing departments of a Taiwanese hospital. The results indicated that supervisor support mediated the leadership effectiveness-burnout relationship. Moreover, leadership effectiveness negatively moderated the supervisor support-burnout relationship.

## 4 - Technology, Improvement Programs and Organizational Culture in Saudi Arabia and Canadian Hospitals

James Belohlav, Professor, DePaul University, Department of Management, 1 East Jackson Blvd., Chicago, IL, 60604, United States of America, jbelohla@depaul.edu, John Olson, Rajesh Tyagi

The current study examines the relationship among implementation of healthcare technology, adoption of quality improvement programs and organizational culture. A national survey of hospitals was undertaken for public hospitals in Saudi Arabia (n=111) and not-for-profit hospitals in Canada (n=111). It was found that culture mediated the relationship of healthcare technology implementation and quality improvement programs adoption.

## MC16

16- Houston

### Advances in Modeling and Analyzing Spread of Infectious Diseases

Cluster: Medical Decision Making

Invited Session

Chair: Reza Yaesoubi, Post-Doctoral Research Fellow, Harvard School of Public Health, 641 Huntington Ave., Boston, MA, 02115, United States of America, reza.yaesoubi@gmail.com

#### 1 - A Simulation Optimization Approach to Epidemic Forecasting

Elaine Nsoesie, Virginia Tech, Virginia Bioinformatics Institute, Blacksburg, VA, 24061, United States of America, onelaine@vbi.vt.edu, Kalyani Nagaraj, Sara Shashaani, Madhav Marathe, Richard Beckman

We introduce a simulation optimization (SIMOP) approach for real-time forecasting of influenza epidemics. This study is part of a project aimed at using simulation, classification, statistical and optimization techniques to forecast epidemic curves and infer underlying model parameters. We forecast epidemics based on influenza-like-illness data and scenarios simulated over synthetic social networks. In some cases, peak time can be predicted as early as seven weeks before the actual peak.

## 2 - Operational Modeling and Urgent Computing of Emerging Infectious Viruses

Diana Prieto, Assistant Professor, Western Michigan University, 4601 Campus Dr., Kalamazoo, MI, 49008, United States of America, diana.prieto@wmich.edu, Peter Holvenstot

In this presentation, we describe recent contributions to enable operational modeling of emerging infectious viruses. In particular, we describe the conditions under which an agent based model can automatically obtain epidemiological information from a real outbreak, and translate the information into model parameters without the need of model calibration. In addition, we present our recent results in urgent computation of model outputs during an outbreak.

## 3 - Observation-Based Case Finding Policies for Controlling Tuberculosis Epidemics

Reza Yaesoubi, Post-Doctoral Research Fellow, Harvard School of Public Health, 641 Huntington Ave., Boston, MA, 02115, United States of America, reza.yaesoubi@gmail.com

Current tuberculosis (TB) control strategies depend on passive case detection (i.e. self-presentation), but slow progress against TB has led to new interest in active approaches for early detection of TB cases. Here, we characterize case finding policies that use TB notifications and the annual budget to determine when to switch between passive and active case finding. We show that observation-based policies strictly dominate static policies that pre-specify the frequency of active case finding.

## MC17

17- Denver

### Operating Room Planning and Scheduling

Cluster: Healthcare Scheduling

Invited Session

Chair: Bjorn Berg, Assistant Professor, George Mason University, 4400 University Drive, MS 4A6, Fairfax, VA, 22030, United States of America, bberg2@gmu.edu

#### 1 - Optimal Allocation of Operating Room Time between Surgical Specialties

Steph Carew, University of British Columbia, 2053 Main Mall, Vancouver, BC, V6T 1Z2, Canada, steph.carew@mba.sauder.ubc.ca, Mahesh Nagarajan, Steven Shechter

We examine how to allocate operating room hours to different surgical specialties at the British Columbia Children's Hospital. This is a longer-run planning decision which has major effects on the wait time experience of the patient population. To evaluate policies, we construct and validate a simulation model of patient arrival and appointment processes. We then apply optimization and dynamic programming techniques to recommend improved allocation policies.

#### 2 - Surgical Block-Scheduling: A Systematic Approach for Surgical Bed Management

Mohammad Mehdi Ghotboddini, McGill University, 1001 Sherbrooke West, Montreal, QC, H3A 1G5, Canada, Mohammad.ghotboddini@mail.mcgill.ca, Valerie Vandal, Vedat Verter, Lawrence Rosenberg

In the absence of a systematic approach for utilizing the bed resources of a surgical unit, the cancellation and rescheduling of elective surgeries remains a formidable challenge. Although resource allocation problems have been studied, the incorporation of expected bed availability in the planning process is yet to be fully explored. This approach could potentially align the best interests of hospital administrators, surgeons, and patients, and hence there provides an opportunity for stakeholder buy-in to the developed solutions.

#### 3 - On Improving Operating Room Schedules

Diwakar Gupta, Professor, University of Minneapolis, 111 Church St. SE, Minneapolis, MN, 55455, United States of America, guptad@me.umn.edu, Sandra Potthoff, Fei Li

This talk will focus on improving operating rooms' efficiency by rescheduling advance-booked surgeries. We formulate the rescheduling problem as a variant of the bin-packing problem with constraints that prevent same-doctor-surgeries' overlap. We then identify certain features of doctors who perform multiple procedures to obtain bounds on the number of ORs needed. This leads to a branch and bound algorithm, which when tested on multiple hospitals' data shows potential for significant savings.

**Tuesday, 8:30am - 10:00am**

■ **TA01**

01- Chicago F

**Student Research Projects in Healthcare Engineering and Patient Safety I**

Cluster: Health Systems Engineering Alliance (HSEA)

Invited Session

Chair: Amy Cohn, University of Michigan, 1205 Beal Ave., Ann Arbor, MI, United States of America, amycohn@umich.edu

**1 - VA Linen Distribution Optimization**

Joaquin Serrano, Worcester Polytechnic Institute, 100 Institute Road, Worcester, MA, 01609, United States of America, joaquin.serrano@wpi.edu, Xuanya Zhang, Silvia Zamora, Gary McCarthy, Sharon Johnson, Ashley Benedict

Linen is a backstage service that is critical for a hospital's functioning. Our team created a refill and distribution system that optimizes the use of linen at the VA's West Roxbury Campus by applying lean concepts to improve the efficiency of the process with the goal of providing the best patient care.

**2 - Delay in Home Respiratory Therapy: A System Analysis of Delay in Out-Patient Equipment Delivery**

Katherine Breiding, University of Southern California, 1105 Seal Way, Seal Beach, CA, 90740, United States of America, breiding@usc.edu, Sheila Kun, Greg Placencia, Sally Ward, Thomas Keens

Delay in the durable medical equipment (DME) delivery process for out-patients postpones initiation of home therapy and sometimes causes adverse clinical consequences. There is currently no standard for how long the DME delivery process should take. This study investigates possible reasons for delay in this process. It draws on DME delivery records from the Pediatric Pulmonology Department of Children's Hospital Los Angeles for patients between April 2011 and March 2012.

**3 - Centralizing Patient Transport at Tampa General Hospital**

Vanessa Morales, University of South Florida, 8809 Cameron Crest Dr., Tampa, FL, 33620, United States of America, vanessam@mail.usf.edu, Alan Guagliardo, Alvaro Mario Vargas

Tampa General Hospital is working with process engineering to develop a workload model for transport and non-transport tasks in areas that have their own transporters. The goal is to determine whether to centralize transport services based on service level expectations and find process improvement opportunities. The team conducting the observations performed time studies on the transporters to find the distribution of tasks and times within the Cardiovascular Center department.

■ **TA02**

02- Chicago G

**Data Driven Approaches to Identify and Treat Critical Illness: Methodology**

Sponsor: Data Mining

Sponsored Session

Chair: Michael Pinsky, University of Pittsburgh, 3550 Terrace Street, Department of Critical Care Medicine, Pittsburgh, PA, 15261, United States of America, pinskymr@ccm.upmc.edu

Co-Chair: Artur Dubrawski, Senior Systems Scientist, Carnegie Mellon University, The Robotics Institute, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States of America, awd@cs.cmu.edu

**1 - Learning Temporal Rules to Forecast Instability in Intensive Care Patients**

Mathieu Guillaume-Bert, Postdoctoral Scholar, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States of America, mathieug@andrew.cmu.edu

We look at vital signs as time series which can potentially indicate periods of patient instability. Typically, such data are interpreted as dynamical systems smoothly transition between states. We instead focus on detecting discontinuities in vitals as indications of imminent instability. We use these change points to learn temporal rules that predict instability. We evaluate alternative change point detection strategies and effectiveness of the approach at forecasting patient health status.

**2 - Prediction of Cardiorespiratory Instability in Stepdown Units**

Gilles Clermont, Critical Care Physician, University of Pittsburgh Medical Center, University Drive C, Pittsburgh, PA, 15240, United States of America, cler@pitt.edu, Michael Pinsky, Marilyn Hravnak, Olufunmilayo Ogunde

Cardiorespiratory instability is associated with worse outcome and preventing such events would be useful. We collected high-frequency vital signs in 311 patients for >29,000 patient-hours. 105 patients experienced instability. A large set of derived features enriched patient state description. We developed models to predict instability over a 4 hour horizon. Models achieved good discrimination of patients developing instability, but not of when instability would become clinically overt.

**3 - Multi-Parameter Patient Monitoring using Data Fusion Techniques**

Iain Strachan, OBS Medical, Brooke House, 174 Milton Park, Abingdon, OX144SE, United Kingdom, iain.strachan@obsmedical.com

The Visensia(TM) multi-parameter patient monitoring system will be described, illustrating how it can provide early warning of patient deterioration by detecting unusual combinations of parameters probabilistically. We also demonstrate how three of the five vital signs used in Visensia can be derived from a Pulse Oximeter PPG signal. A novel algorithm for deriving respiration rate from the PPG by fusion of Heart Rate Variability and PPG amplitude will be shown, with preliminary results.

■ **TA03**

03- Chicago H

**Radiation Therapy Optimization**

Sponsor: INFORMS Optimization Society

Sponsored Session

Chair: Timothy Chan, University of Toronto, 5 King's College Rd., Toronto, ON, M5S 3G8, Canada, tychan@mie.utoronto.ca

**1 - Robust Optimization for Biologically-Guided Intensity-Modulated Radiation Therapy**

Heyse Li, University of Toronto, 5 King's College Road, Toronto, ON, Canada, heyse.li@mail.utoronto.ca, Timothy Chan, Jean-Pierre Bissonnette, Thomas Purdie

Biologically guided intensity modulated radiation therapy (BG-IMRT) has the opportunity to improve cancer treatment quality. However, images are noisy and dose prescriptions derived from them are subject to uncertainty. We develop a robust optimization model to design BG-IMRT plans that are de-sensitized to this uncertainty. Computational results show improvements in TCP and deviation from prescription dose compared to a non-robust model, while maintaining healthy tissue dose levels.

**2 - The Effect of Tumor Repopulation on Optimal Fractionation Schedules in Radiation Therapy**

Jagdish Ramakrishnan, Massachusetts Institute of Technology, 70 Pacific St., Cambridge, MA, 02139, United States of America, jagdish@MIT.EDU, Thomas Bortfeld, John Tsitsiklis, Jan Unkelbach

In radiation therapy, the fractionation schedule, i.e. the total number of treatment days and the dose delivered per day, plays an important role in treatment outcome. In this work, we analyze the effect of repopulation on the optimal fractionation scheme by using popular tumor growth models. Our main conclusion is that due to accelerated repopulation, larger dose fractions are suggested later in the treatment to compensate for the increased tumor proliferation.

**3 - Selecting Beam Angles in Intensity Modulated Proton Therapy Treatment Planning**

Gino Lim, Associate Professor, University of Houston, Houston, TX, United States of America, ginolim@uh.edu, Wenhua Cao

We present a new approach for selecting optimal beam angles for intensity modulated proton therapy (IMPT). This work focuses on potential benefits of BAO on intensity modulated proton therapy (IMPT). A robust BAO algorithm is proposed to find beam angles while considering IMPT delivery uncertainties. We show clinical benefits of our approach using actual prostate and skull base cancer cases. We discuss the potential of the proposed method for improving IMPT plan quality: dosimetric benefits and robustness under uncertainties.

## ■ TA04

04- Scottsdale

### Healthcare Operations

Contributed Session

Chair: Diane Bischak, Associate Professor, University of Calgary, Haskayne School of Business, 2500 University Drive NW, Calgary, AB, T2N 1N4, Canada, [diane.bischak@haskayne.ucalgary.ca](mailto:diane.bischak@haskayne.ucalgary.ca)

#### 1 - using SFA to Measure the Efficiency of Primary Healthcare Centers

Martha Ramirez-Valdivia, Assistant Professor, Universidad de La Frontera, Avenida Francisco Salazar 01145, Casilla 54 D, Temuco, 4811230, Chile, [martha.ramirez@ufrontera.cl](mailto:martha.ramirez@ufrontera.cl)

Primary healthcare plays a significant role in the welfare of a society where evaluating its management's performance is a necessity. Effective regulation demands the development of measures of comparative performance in order to establish a good level of operation. This article applies SFA techniques to the same data set of 259 municipalities who administer PHC centers in Chile in order to estimate their efficiency scores and ranking. We include five variables, two outputs and three inputs. For urban municipalities, the efficiency average value reaches 70.89% and for rural ones 65.83%.

#### 2 - Planning for Patient Testing at a Pulmonary Function Laboratory

Diane Bischak, Associate Professor, University of Calgary, Haskayne School of Business, 2500 University Drive NW, Calgary, AB, T2N 1N4, Canada, [diane.bischak@haskayne.ucalgary.ca](mailto:diane.bischak@haskayne.ucalgary.ca), Warren Davidson, Charlene Fell, Sachin Pendharkar

For some outpatient clinic healthcare appointments, it is desirable for patient testing to be scheduled immediately prior to the appointment with the physician. To assure that testing is completed in time despite the variation in testing requirements across patients and clinics with different characteristics, we develop an assignment model for scheduling physician clinics and a simulation model to determine whether service level requirements are met by a particular arrangement of clinics.

#### 3 - Production Processes Redesign in Orthopedic Clinic for Better Physicians' Utilization

Yusta Simwita, PhD Student, Molde University College, 2110.6402, Molde, Norway, [Yusta.W.Simwita@himolde.no](mailto:Yusta.W.Simwita@himolde.no), Berit Helgheim

We report the use of simulation and queuing theory in redesigning production processes for better utilization of physicians at orthopedic clinic in Tanzania. Standardizing and transferring some activities from specialized surgeons with high workloads to other workstation, lead to efficient physicians utilization, increased throughput and quality of care.

## ■ TA05

05- Miami

### Mathematical Modeling and Analysis of Infectious Disease Dynamics, Prevention, and Control

Sponsor: Healthcare Applications Society

Sponsored Session

Chair: Eva Enns, Assistant Professor, University of Minnesota School of Public Health, Division of Health Policy and Management, 420 Delaware Street SE, Minneapolis, MN, 55455, United States of America, [eenns@umn.edu](mailto:eenns@umn.edu)

#### 1 - Link Removal for Stochastic Epidemic Control over Networks

Eva Enns, Assistant Professor, University of Minnesota School of Public Health, Division of Health Policy and Management, 420 Delaware Street SE, Minneapolis, MN, 55455, United States of America, [eenns@umn.edu](mailto:eenns@umn.edu), Margaret Brandeau

The control of infectious diseases that spread through close contact often focuses on interrupting the network of contacts. We previously developed an optimal quarantining algorithm that identified which links should be removed in order to disconnect the maximum number of susceptible nodes from infected ones, given a budget constraint on the number of links that can be removed. In this presentation, we compare the performance of this and other link removal schemes in reducing the likelihood of an epidemic in a stochastic model of disease transmission through a fixed contact network.

#### 2 - Information Acquisition in Dynamic Health Policy

Lauren Cipriano, PhD Candidate, Stanford University, Huang Engineering Center, Stanford, CA, United States of America, [cipriano@stanford.edu](mailto:cipriano@stanford.edu), Thomas Weber

We previously developed a model for a cohort-specific health-intervention decision as an optimal stopping problem where a given age cohort's imperfectly observable disease prevalence evolves randomly across successive periods. Based on this model, we determine an optimal information acquisition policy in terms of population screening experiments for online model identification. We apply this extended model to develop an optimal testing program for Hepatitis C at routine medical visits.

#### 3 - Calibration Methods of an Agent-Based Model for Clostridium Difficile Control

James Codella, Graduate Student, University of Wisconsin-Madison, 1115. E. Wilson St., Madison, WI, 53703, United States of America, [codella@wisc.edu](mailto:codella@wisc.edu), Oguzhan Alagoz, Nasia Safdar

Clostridium difficile infection (CDI) affects 500,000 Americans every year, and causes nearly 20,000 deaths annually. We develop an agent-based simulation to model the transmission dynamics and strategies to control CDI. Furthermore, we describe methods to calibrate a natural history Markov model for CDI and techniques to validate the simulation.

## ■ TA06

06- Los Angeles

### Inpatient Medical Decision Making

Cluster: Medical Decision Making

Invited Session

Chair: Jennifer Mason, Assistant Professor, University of Virginia, P.O. Box 800717, Charlottesville, VA, 22908, United States of America, [jem4yb@virginia.edu](mailto:jem4yb@virginia.edu)

#### 1 - Simulation of Human Error in Implementation of an Insulin Infusion Protocol for Stress Hyperglycemia

Edward Ortiz, University of Virginia, Charlottesville, VA, United States of America, [eao7r@virginia.edu](mailto:eao7r@virginia.edu), Stephen Patek

Using a computerized model of stress hyperglycemia, combined with an in silico population of 100 critically ill patients, a current insulin therapy protocol was simulated. Different timing errors of blood glucose (BG) sampling were simulated, each using the identical set of 100 in silico patients. The impact of seemingly minor human errors in timing of BG sampling was found to be significant. These should be controlled when studying the treatment of stress hyperglycemia.

#### 2 - Evaluating Automated Rules for Augmented Monitoring in Inpatient Settings

Bruce Morlan, MS Statistician, Mayo Clinic, Health Care Policy and Research, 200 First Street Sw, Rochester, MN, 55905, United States of America, [morlan.bruce@mayo.edu](mailto:morlan.bruce@mayo.edu), James Naessens, Jeanne Huddleston, Matthew Johnson, Joel Hickman

Medical settings provide an overwhelming array of real-time data. The literature provides equally overwhelming numbers of possible automated rules for filtering this data. Using physiological monitoring data for a one-year longitudinal cohort of general care inpatients, we developed and test methodologies based on F-scores, decision analysis and survival models to predict need for escalating care. The methods are demonstrated using five published rules and one internally developed rule.

#### 3 - Predicting Hospital-Acquired Sepsis in an Acute Care Setting using a Dynamic Bayesian Network

Eun Gyoung Han, University of Utah, 1125 Medical Plaza, Salt Lake City, UT, 84112, United States of America, [ehan@cs.utah.edu](mailto:ehan@cs.utah.edu), Peter Haug, Kathryn Kuttler, John Holmen

Annual incidence of sepsis, a systemic inflammatory response, is 0.3% with 30% mortality in diagnosed cases across the US. Direct cost estimates for sepsis in ICUs across the US surpass \$40,000 per patient. One in every 20 hospital patients has a hospital-acquired infection (HAI), many of them sepsis. We introduce a temporal model capable of predicting the HAI form of sepsis before onset and discuss temporal data processing. Our goal is sizeable reductions in morbidity, mortality, and costs.

## ■ TA07

07- Kansas City

**Outpatient Appointment Scheduling**Sponsor: Manufacturing and Service Operations Management  
Sponsored Session

Chair: Michele Samorani, Assistant Professor, University of Alberta, 3-20B Business Building, Edmonton, AB, T6G 2R6, Canada, samorani@ualberta.ca

**1 - No-Show Behavior and its Influence on Appointment Scheduling**  
Shannon Harris, University of Pittsburgh, Katz Graduate School of Business, Pittsburgh, PA, 15260, United States of America, sharris@katz.pitt.edu, Jerrold May

Patient no-shows complicate appointment scheduling systems. No-show behavior appears to be a function of appointment traits, patient demographics, and prior patient no-show behavior. In our VA predictive analytics model, prior patient behavior is the most significant factor and is currently modeled using a tenth-order Markov model. We discuss an alternative way of representing prior patient behavior using an optimization model and its impact on the VA predictive analytics model.

**2 - A Two-Phase Approach for Multi-Category Appointment Scheduling in Outpatient Clinics**

Yidong Peng, North Dakota State University, Dept. Industrial and Manufacturing Eng., 202M Civil and Industrial Eng. Building, Fargo, ND, 58102, United States of America, yidong.peng@ndsu.edu, Jing Shi, Xiuli Qu, Nan Kong

Our study is motivated by the existing problems of a women's clinic: prolonged patient waiting and provider idle time. A two-phase approach is proposed for designing a weekly scheduling template for outpatient clinics providing multiple types of services. Our approach is intended to not only address the common issues on outpatient appointment scheduling, but also consider extra restrictions due to substantial changeover time between certain pairs of services in the studied clinic.

**3 - The Provider's Wait-Preempt Dilemma**

Michele Samorani, Assistant Professor, University of Alberta, 3-20B Business Building, Edmonton, AB, T6G 2R6, Canada, samorani@ualberta.ca, Subhamoy Ganguly

When a patient with a later appointment shows up early and the provider is idle, the provider faces a dilemma: whether to wait for the patient scheduled next, or to preempt. Using an analytic approach that considers clinic-overtime and patient wait-times, we suggest guidelines for resolving the dilemma.

## ■ TA08

08- Kane

**Advances in Rural Health**

Cluster: Rural Health

Invited Session

Chair: Ashlea Bennett Milburn, University of Arkansas, 4207 Bell Engineering Center, Fayetteville, AR, 72701, United States of America, ashlea@uark.edu

**1 - Global Health: Optimizing the Use of Scarce Resources**

Eva Lee, Professor and Director, Georgia Institute of Technology, Atlanta, GA, United States of America, evakylee@isye.gatech.edu

This work is joint with CDC. We describe resource allocation of healthcare personnel in Tanzania. A simulation-optimization framework is designed to capture the entire hospital workflow and patient demands. Services and personnel are optimized within the simulation environment to achieve the best throughput while minimizing the wait-time and queue length. This work has been successfully implemented and resulted in 2-fold increase of throughput while reducing 93% of the wait-time.

**2 - Home Telehealth Technology Adoption for Rural Health**

Nebil Buyurgan, University of Arkansas, 4207 Bell Engineering Center, Fayetteville, AR, 72701, United States of America, nebilb@uark.edu, Serdar Kilinc

The purpose of this study is to understand and evaluate the nation-wide quantitative impacts of home telehealth adoption among home health agencies. We address two types of home telehealth; telemonitoring (remote patient monitoring) and interactive home telehealth. A system dynamics model that simulates the diffusion of home telehealth technologies over time is developed to investigate the impact of the adoption in rural healthcare.

**3 - Bilingual Diabetes Education Computer Kiosks Support Rural Health Providers**

Jane Bolin, Professor, Texas A&amp;M Health Science Center, Southwest Rural Health Research Center, Health Policy &amp; Management, 1266 TAMU, College Station, TX, 77840, United States of America, JBolin@srph.tamhsc.edu, Marcia Ory

A Diabetes Education Kiosk was developed in English and Spanish to test the feasibility of providing diabetes education in rural and underserved populations with high rates of diabetes. The kiosk was tested over 11 months in clinics, pharmacies and community center. Over 5,000 users of the kiosk were documented. Computerized technology offers support for rural providers seeking to provide diabetes education through easily accessible and cost-effective diabetes education kiosks.

**4 - Uncovering Hidden Costs in Home Health Supply Chains**

Ashlea Bennett Milburn, University of Arkansas, 4207 Bell Engineering Center, Fayetteville, AR, 72701, United States of America, ashlea@uark.edu, Scott Mason

Critical time is diverted from patient care when home health nurses engage in supply chain duties such as ordering, retrieving and delivering patient supplies. A model to assess the level of nursing resources required by a set of home health supply chain practices is developed. The model is used to determine the distribution of home health nurse supply chain involvement in the United States. Results estimate that on average, home health nurses spend 170 hours on supply chain duties annually.

## ■ TA09

09- McHenry

**Models of Access Involving Geography I**

Contributed Session

Chair: Laura McLay, Associate Professor, University of Wisconsin-Madison, 1513 University Avenue, Madison, WI, 53706, United States of America, lmclay@wisc.edu

**1 - The Impact of Spatial Accessibility on Pediatric Asthma Health Outcomes**

Nicoleta Serban, Associate Professor, Georgia Institute of Technology, 765 Ferst Dr., Atlanta, GA, 30331, United States of America, nserban@isye.gatech.edu, Erin Garcia, Julie Swann

We study the association between severe outcomes in pediatric asthma and spatial accessibility, a measure of geographic access. We develop optimization models to match patients to physician offices, mimicking the process through which people choose care providers. We use the optimization model's output to estimate the spatial accessibility of children with asthma, which is then linked to severe outcomes (emergency room visits and hospitalizations) using generalized regression models controlling for confounding factors such as demographics, socio-economic status and living conditions.

**2 - using Optimization to Create Hospital Networks for Mass Casualty Disasters**

Maria Bull, Professor, Universidad Catolica de la Santisima Concepcion, Alonso de Ribera 2850, Concepcion, Chile, mbull@ucsc.cl, Jose Sepulveda

The hospital coordination is guided by the National Response Framework and the Joint Commission on Accreditation of Healthcare Organizations. Although these guidelines suggest collaborative planning among hospitals that provide services to a contiguous geographic area, there is not specific guideline to define the hospitals that have to shape the network to respond to a disaster management. This research combines optimization and frontier analysis to determine beforehand, efficient cooperative-hospital networks to conduct the response to mass casualty disasters.

**3 - Integrated Models for Locating and Dispatching Ambulances**

Laura McLay, Associate Professor, University of Wisconsin-Madison, 1513 University Avenue, Madison, WI, 53706, United States of America, lmclay@wisc.edu, Sardar Ansari, Maria Mayorga

We propose mixed integer programming (MIP) models for identifying how to locate and dispatch ambulances to patients via district design. The model maximizes the coverage level, i.e., the fraction of high-priority patients that can be responded to within nine minutes by pre-locating ambulances at stations, assigning each call location to open stations according to a priority list, and balancing the workload across the ambulances.

## ■ TA10

10- Cook

**Improving Patient Flow in Outpatient Systems**

Cluster: Healthcare Scheduling

Invited Session

Chair: Chester Chambers, Assistant Professor, John Hopkins University, 100 International Drive, Baltimore, MD, 21202, United States of America, cchamber@jhu.edu

**1 - Process Analysis for Spinal Cord Stimulation Modality**

Giles Reinhardt, Associate Professor, DePaul University, 1 E. Jackson Blvd., DePaul Center 7000, Chicago, 60604, United States of America, greinhar@depaul.edu, Kayode Williams

Spinal cord stimulation has been in clinical use for chronic pain for four decades and is still one of the most expensive treatment modalities available. We propose a process analysis approach to model, measure and improve its delivery while maintaining its effectiveness.

**2 - Assessing Appointment Systems' Operational Performance with Policy Targets**

William Millhiser, Assistant Professor, City University of New York, One Bernard Baruch Way, New York, NY, 10010, United States of America, william.millhiser@baruch.cuny.edu, Emre Veral, Benedetto Valenti

We propose a paradigm shift in how outpatient appointment system (AS) performance is evaluated. We address the dilemma between the wait time of heterogeneous patients and provider idle and overtime by using a stochastic model to assess their respective probabilities of exceeding established time thresholds (not by optimizing a cost function). Analysis shows that traditional AS have serious shortcomings (i.e., inconsistent service levels) and we conclude that the managerial decision space so far investigated in the literature is inadequate for exercising operational control over AS performance.

**3 - using Pre-Processing to Improve Resident Medical Education and Service Delivery in AMC Pain Center**

Kayode Williams, Assistant Professor, Johns Hopkins School of Medicine, 600 N Wolfe St., Osler 292, Baltimore, MD, 21287, United States of America, kwilli64@jhmi.edu

The Affordable Care Act continues to drive the transformation of healthcare delivery in academic medical centers (AMC). This study provides a possible solution to the key limitation in AMC, the efficiency of patient throughput and resident education. Our results demonstrate that by moving some of the educational activities ahead of clinic time by preprocessing, this led to reduced variability, wait time, and increased capacity without reducing the patient face time with the physician.

**4 - Cyclic Scheduling in Ambulatory Clinics in Academic Medical Centers**

Chester Chambers, Assistant Professor, John Hopkins University, 100 International Drive, Baltimore, MD, 21202, United States of America, cchamber@jhu.edu

Outpatient clinics in Academic Medical Centers (AMC) have more complex process flows due to the teaching mission of the institution. The resulting systems are neither single - nor multi-server queues because attending physicians make decisions in real time regarding resident involvement based on system load. This work develops a model of an appointment system based on data collected at several clinics. It defines an optimal patient schedule by analyzing cycles that can be repeated to fill the schedule. The resulting schedule has been implemented in the JHU Outpatient Center and results may be reported.

## ■ TA11

11- Dupage

**Electronic Health Records/ Health IT**

Contributed Session

Chair: Sasha Romanosky, New York University, 40 Washington Square W., New York, NY, 10012, United States of America, sasha.romanosky@nyu.edu

**1 - Information Technology Assimilation in Health Care: Impacts on Patient Satisfaction and Mortality**

Haizhen Lin, Assistant Professor, Indiana University, 1309 E. 10th St., Bloomington, IN, 47405, United States of America, hzlin@indiana.edu, Hillol Balal

Implementation of information technologies (ITs) has been suggested as a major driver for improving the quality of health care in the United States. However, prior research on the impacts of ITs has been inconclusive. We examine the impact of ITs on patient satisfaction and outcomes using hospital-level longitudinal data from 2005 to 2011. Drawing on the resource-based view of

firm theory and prior research on IT assimilation, we hypothesize that a high degree of IT assimilation will lead to favorable health outcomes. We find supportive evidence using fixed effect model analysis.

**2 - Analysis of Electronic Health Records Meaningful Use Gap Assessment Data**

Wenbo Cai, Assistant Professor, New Jersey Institute of Technology, 323 Martin Luther King Jr. Blvd., Newark, NJ, 07103, United States of America, cai@njit.edu, Sanchoy Das

In an effort of assisting New Jersey physicians to achieve the meaningful use of Electronic Health Record (EHR), NJ-HITEC has created a database of over 2000 physician assessments. Our research analyzes this database to understand factors that contribute to higher adoption and use levels. We characterize physicians' score behavior on the meaningful-use criteria, identify the strong and weak meaningful-use measures, and examine the score variance between profiled practice groups and EHR systems.

**3 - The Potential Impact of Electronic Health Records on Patient Centered Care in Primary Care Encounter**

Onur Asan, University of Wisconsin-Madison, 3017 University Avenue, Madison, WI, 53711, United States of America, asan@wisc.edu, Enid Montague

This study explores how electronic health records (EHRs) can be used to improve patient centered care in primary care encounters. To achieve this goal, lag sequential analysis have been used to assess information flow between physician, patient and EHRs in primary care encounters.

**4 - The Dr. Jekyll and Dr. Hyde of Health IT: Does Health IT Increase Medical Billing Fraud?**

Sasha Romanosky, New York University, 40 Washington Sq. W., New York, NY, 10012, United States of America, sasha.romanosky@nyu.edu, Idris Adjerid

Over the past 10 years, there has been a significant push to adopt electronic measures to help collect, record, and manage personal health information. The benefits of Health IT (HIT) are compelling: reduced costs, and improved patient outcomes. However, widespread adoption of health information systems may also have perverse effects such as medical billing fraud facilitated by cloning and upcoding of electronic health records. Using data collected from the HIMSS dataset, the FTC, we estimate the effect of HIT adoption on medical billing fraud. Preliminary results show that hospital adoption of HIT is associated with an increase in medical billing fraud.

## ■ TA12

12- Water Tower

**Generating Care Coordination Insights Using Qualitative Methods**

Cluster: Patient Flow and Care Coordination

Invited Session

Chair: Sharon Johnson, Worcester Polytechnic Institute, 100 Institute Road, Worcester, MA, 01609-2280, United States of America, sharon@wpipi.edu

**1 - Identifying Complex Patients and Care Coordination Needs**

Mustafa Ozkaynak, Postdoctoral Fellow, Worcester Polytechnic Institute, 100 Institute Road, Worcester, MA, 01609, United States of America, mozkaynak@wpipi.edu, Abir Kanaan, Jennifer Donovan, Bengisu Tulu, Sharon Johnson, Adam Rose

We explored the care of complex patients who receive anticoagulation therapy, identifying patient complexity factors (comorbidities, alcohol addiction and lack of daily living resources) as well as care coordination challenges. Identified challenges were grouped as organizational, interdisciplinary and lack of community resources. We then qualitatively examined the relationships between complexity factors and challenge categories, to inform the design of processes and other structural elements of care.

**2 - using Qualitative Methods to Understand Electronic Health Record use in Primary Care Encounters**

Enid Montague, Northwestern University, Feinberg School of Medicine, Chicago, IL, United States of America, enid.montague@northwestern.edu, Onur Asan

The aim of this study was to identify and describe how patients and providers interact with electronic health records during primary care encounters. A video based ethnographic approach was used to classify the encounters into distinct patterns based on clinicians' interactions with the technology and patients. Ethnographic methods are useful for understanding complex interactions in health care systems and can inform subsequent quantitative analyses and design solutions.

**3 - Care Coordination Between and among Patients and Providers**

Rupa Valdez, Assistant Professor, University of Virginia, P.O. Box 800717, Charlottesville, VA, 22908, United States of America, rupa.valdez@virginia.edu

Two qualitative studies were conducted to understand care management for patients with chronic conditions in home/community settings. The studies examined (1) homecare nursing services following IT implementation and (2) patients' health information communication practices with social network members. These studies highlight the complexity of care coordination, make it tractable by explicating elements of the work system, and demonstrate the integration of qualitative and quantitative methods.

**TA13**

13- Navy Pier

**Joint Session SPPSN/Health Operations: OR Applications in the Vaccine World**

Sponsor: Public Programs, Services and Needs & Healthcare Operations Management

Sponsored Session

Chair: Rubén Proaño, Assistant Professor, Rochester Institute of Technology, Gleason College of Engineering, Rochester, NY, 14623, United States of America, rpmeie@rit.edu

Co-Chair: Osman Ozaltin, University of Waterloo, 200 University Avenue, Waterloo, ON, N2L 3G1, Canada, oozaltin@uwaterloo.ca

**1 - Optimal Design of the Annual Influenza Vaccine with Manufacturing Autonomy**

Osman Ozaltin, University of Waterloo, 200 University Avenue, Waterloo, ON, N2L 3G1, Canada, oozaltin@uwaterloo.ca, Oleg Prokopyev, Andrew Schaefer

Seasonal influenza is a major public health concern, and the first line of defense is the flu shot. We propose a bilevel multi-stage stochastic mixed-integer program that maximizes societal benefit of the flu shot under autonomous profit maximizing manufacturers. Calibrated over publicly available data, our model returns the optimal flu shot composition and timing in a stochastic and dynamic environment. We derive analytical results, and perform extensive numerical experiments.

**2 - Infectious Disease Mitigation: From Contact Networks to Public Policies**

Mario Ventresca, Postdoctoral Fellow, University of Toronto, Toronto, ON, Canada, mario.ventresca@utoronto.ca, Dionne Aleman

Graph theoretic measures of node importance are used to identify candidate individuals for vaccination in a contact network representation of the greater Toronto area. Combined with census information, data mining tools are then employed to derive public policies that aim to limit infectious disease spread over the network. We examine the quality and usefulness of these hypothetical public policies with respect to limiting the basic reproductive number.

**3 - Vaccine Prioritization: A Multi-Attribute Group Decision Making Problem with Heterogenous Information**

Rubén Proaño, Assistant Professor, Rochester Institute of Technology, Gleason College of Engineering, Rochester, NY, 14623, United States of America, rpmeie@rit.edu, Timothy Schmoke

Vaccine stakeholders need to prioritize vaccine initiatives under development to ensure that most promising projects are pursued. However, this prioritization is complex because vaccine initiatives are at different developmental stages, target different diseases, and provide different value to the stakeholders, who have different and often conflicting interests. We presents a heuristic integrating AHP and DEA to automate the vaccine prioritization process when input information is heterogeneous.

**4 - HERMES: Simulation Modeling of Country Vaccine Supply Chains Throughout the World**

Bruce Lee, Associate Professor, University of Pittsburgh, 200 Meyran Avenue., Suite 200, Pittsburgh, PA, 15213, United States of America, BYL1@pitt.edu, Diana Connor, Angela Wateska, Bryan Norman, Jayant Rajgopal, Joel Welling, Leila Haidari, Leslie Mueller, Michelle Schmitz, Jim Leonard, Brigid Cakouros, Proma Paul, Shawn Brown, YuTing Weng

This session will cover our HERMES (Highly Extensible Resource for Modeling Supply Chains) software platform and its applications in different countries in Asia and Africa to address a wide variety of questions such as the impact of new vaccine introduction, changes in doses per vaccine vial, making vaccines thermostable, and adding influenza vaccine to the routine immunization supply chain.

**TA15**

15- O'Hare

**Economics and Policy Modeling at the US Centers for Disease Control and Prevention**

Sponsor: Healthcare Applications Society

Sponsored Session

Chair: Adam Skelton, Chief, Prevention Effectiveness Branch, U. S. Centers for Disease Control and Prevention, 3804 Ledan Rd., Gainesville, GA, 30506, United States of America, afz6@cdc.gov

**1 - A Resource Allocation Model for CDC's HIV Prevention Budget**

Emine Yaylali, Steven M. Teutsch Prevention Effectiveness Fellow, US Centers for Disease Control and Prevention, Atlanta, GA, 30333, United States of America, wqj3@cdc.gov, Stephanie Sansom, Feng Lin

We use a linear programming model to optimize the allocation of the Centers for Disease Control and Prevention's HIV prevention budget for the United States. The model distributes a given budget among prevention interventions and populations so that the number of new HIV cases averted is maximized. The model uses epidemic data and data on the costs and efficacy of prevention programs. Results include number of new cases prevented and the average cost per case prevented under different allocations.

**2 - Costs of Informal Care for Elderly Stroke Survivors**

Heesoo Joo, Steven M. Teutsch Prevention Effectiveness Fellow, US Centers for Disease Control and Prevention, 4770 Buford Hwy., NE, Atlanta, GA, 30341, United States of America, wqm5@cdc.gov, Guijing Wang, Jing Fang, Diane Dunet

We estimated informal care hours for elderly stroke survivors using difference-in-difference methods and costs using a replacement approach. An elderly stroke survivor uses 37.4 additional informal care hours per month. For the US population, the cost of additional informal caregiving hours was estimated to be \$15.5 billion annually. The study will be helpful to decision-makers in understanding the cost of stroke and in allocating resources for prevention of stroke and stroke-related disability.

**3 - Cost-Effectiveness of Testing for HBeAg or Hepatitis B Viral Load to Reduce Perinatal Hepatitis B Transmission from HBsAg-positive Pregnant Women**

Lin Fan, Steven M. Teutsch Prevention Effectiveness Fellow, US Centers for Disease Control and Prevention, Atlanta, GA, 30333, United States of America, wqm3@cdc.gov

A Markov decision model was constructed to estimate the cost-effectiveness of 2 alternative strategies compared to the current recommended strategy of routine screening of pregnant women for HBsAg, and active-passive immunoprophylaxis for the infants born to HBsAg positive women. The two alternative strategies are: (1) testing for maternal HBeAg among HBsAg positive pregnant women; (2) measuring HBV DNA load among HBsAg positive pregnant women. We assume maternal treatment with lamivudine occurs from 28 weeks of gestation through 4 weeks post-delivery when HBeAg is positive or when the HBV DNA is high ( $=108$  copies/ml) before active-passive immunoprophylaxis for all infants. We conducted the analysis for the U.S. 2010 birth cohort (about 4 million pregnant women) from the healthcare system perspective. We used a life expectancy of 80 years.

**4 - Modeling the Impact of Water, Sanitation, Hygiene and Oral Cholera Vaccine Implementation in Haiti**

Isaac Chun-Hai Fung, Steven M. Teutsch Prevention Effectiveness Fellow, US Centers for Disease Control and Prevention, 1600 Clifton Road NE, Atlanta, GA, 30333, United States of America, CFung@cdc.gov, Jordan W. Tappero, David L. Fitter, Rebekah H. Borse, Martin I. Meltzer

A static model taking into account the indirect effect of oral cholera vaccine and water, sanitation and hygiene interventions was used to estimate the potential number of cholera cases averted by these interventions. The rate of expanding intervention coverage is found to be an important factor that drives the results (cumulative cases of cholera averted). Water, sanitation and hygiene interventions are complementary to oral cholera vaccine.

**Tuesday, 10:30am - 12:00pm**

## ■ TB01

01- Chicago F

### **Panel Discussion - Current Trends and Needs for Graduate Education for Health Care Systems Engineering**

Cluster: Health Systems Engineering Alliance (HSEA)

Invited Session

Chair: Otto Salguero, University of Pittsburgh, Pittsburgh, PA, United States of America, ots1@pitt.edu

#### **1 - Panel Discussion - Current Trends and Needs for Graduate Education for Health Care Systems Engineering**

Moderator: Otto Salguero, University of Pittsburgh, Pittsburgh, PA, United States of America, ots1@pitt.edu. Panelists:

Hari Balasubramanian, Kalyan Pasupathy, John Fontanesi

Where is the potential and the value of operations research in healthcare?

—Users in industry perspectives —Academic perspectives Where are the academic programs focusing efforts on? Where are the research efforts leading the profession? Are there any gaps that deserve to be addressed? How can operations research be made more relevant to healthcare practice?

## ■ TB02

02- Chicago G

### **Healthcare Analytics on Big Data**

Cluster: Healthcare Data Analytics

Invited Session

Chair: Jimeng Sun, IBM TJ Watson Research Center, Yorktown Heights, NY, United States of America, jimengsun@gmail.com

#### **1 - Tools for Creating a Learning Health System: Experiences in the Intensive Care Unit**

Suchi Saria, Assistant Professor, Johns Hopkins, Baltimore, MD, United States of America, suchi.saria@gmail.com

ICU is a complex and chaotic environment. Information on an individual's health state is buried in numerous measurements. Timely, coordinated and accurate care is necessary in managing these acutely ill patients. This talk discusses new opportunities and data-driven approaches for informing the delivery of care in ICU. We introduce tools for measuring care processes, integrating data for risk assessment and discuss how a human-machine collaborative system could help continually improve outcomes.

#### **2 - Data-Driven Patient-Centered Healthcare**

Nitesh Chawla, Associate Professor, Notre Dame, Notre Dame, IN, United States of America, nchawla@nd.edu

Proactive personalized medicine is expected to bring fundamental changes in healthcare. Can we then take a data-driven approach to discover nuggets of knowledge and insight from the big data in healthcare for patient-centered outcomes and personalized healthcare? Can we answer the question: What are my disease risks? This talk will focus on our work that takes the data and networks driven thinking to personalized healthcare and patient-centered outcomes.

#### **3 - Six Research Challenges for the Security and Privacy of Health Information Technology**

Carl Gunter, University of Illinois at Urbana-Champaign, Champaign, IL, United States of America, cgunter@illinois.edu

The effective use and acceptance of health information technology (HIT) by the public depend on employing proper protections for the security and privacy of health information. This talk will discuss six key areas need to be addressed by big data technologies in this area: (1) access controls and audit, (2) encryption and trusted base, (3) automated policy, (4) mobile health (mHealth), (5) identification and authentication, and (6) data segmentation and de-identification.

#### **4 - Scalable Predictive Modeling Platforms for Healthcare Analytics**

Jimeng Sun, IBM TJ Watson Research Center, Yorktown Heights, NY, United States of America, jimengsun@gmail.com

The rapid growth in adoption of electronic health records (EHRs), especially by large medical group practices affords, poses a unique opportunity to develop novel, cost-effective predictive models to detect diseases in their earliest stage, as a means to monitor patient status, motivate engagement, initiate proven disease-modifying interventions, and to slow or prevent progression. Building a successful predictive model is a major undertaking that involves multi-disciplinary teams (e.g., clinicians, computational linguists, data miners and software engineers). The complexity of the data, modeling, and evaluation of models among team members requires highly effective means of communication and scalable execution engine. The final panel presentation discusses the development a predictive modeling pipeline that enables a common understanding of the data, and the models and validation. The predictive model pipeline encapsulates the work from different types of users from the multi-disciplinary teams in order to facilitate communication and the pace of model development and validation. A scalable model building engine to train and validate a large number of predictive models in parallel is built using Hadoop.

## ■ TB03

03- Chicago H

### **Optimization in Radiation Therapy**

Sponsor: INFORMS Optimization Society

Sponsored Session

Chair: Hamed Yarmand, Postdoctoral Research Fellow, Massachusetts General Hospital and Harvard Medical School, Proton Therapy Center, MGH, 30 Fruit Street, Boston, MA, 02114, United States of America, yarmand.hamed@mgh.harvard.edu

#### **1 - Direct Leaf Trajectory Optimization for Volumetric Modulated Arc Therapy Planning**

David Papp, Postdoctoral Fellow, Massachusetts General Hospital/Harvard, 30 Fruit Street, Boston, MA, 02114, United States of America, dpapp@partners.org, Jan Unkelbach

We present a new method for the optimization of VMAT plans. Inspired by the fact that IMRT plans with about  $N=20$  beams yield near-optimal treatment plans, we divide the arc into  $N$  arc segments in which the leaves move unidirectionally, delivering a single intensity-modulated field per segment. The piecewise linear leaf trajectories are then directly optimized. Machine constraints and interdigitation are included. The model provides conformal plans for a variety of cases with short delivery time.

#### **2 - A Robust-CVaR Model and Constraint Generation Solution Method for Breast Cancer IMRT**

Houra Mahmoudzadeh, University of Toronto, 5 King's College Rd., Toronto, ON, M5S 3G8, Canada, hora@mie.utoronto.ca, Timothy Chan, Thomas Purdie

We present a new optimization framework for radiation therapy treatment planning of left-sided breast cancer patients. Our model combines robust optimization, to account for patient breathing patterns, with a conditional value-at risk (CVaR) representation of dose-volume criteria. We propose a constraint generation solution method to efficiently solve large-scale problems of this type, and compare its computational complexity with that of solving the robust counterpart. Clinical data is used to test our model, which is compared with conventional treatment planning methods.

#### **3 - Effective Heuristic Cuts for Beam Angle Optimization in Radiation Therapy**

Hamed Yarmand, Postdoctoral Research Fellow, Massachusetts General Hospital and Harvard Medical School, Proton Therapy Center, MGH, 30 Fruit Street, Boston, MA, 02114, United States of America, yarmand.hamed@mgh.harvard.edu, David Craft

We propose and investigate a novel heuristic approach to considerably reduce the computation time for the mixed integer programming (MIP) formulation of beam angle optimization problem in radiation therapy. We introduce a family of heuristic cuts based on the concept of "adjacent beams." The methodology can be applied to intensity modulated radiation therapy (IMRT) and stereotactic body radiation therapy (SBRT). We show the effectiveness of the proposed heuristic cuts on two clinical cases, a liver and a head and neck case.

## ■ TB04

04- Scottsdale

### System Modelling

Sponsor: CORS, Canadian Operational Research Society

Sponsored Session

Chair: Michael Carter, Professor, University of Toronto, 5 King's College Road, Toronto, ON, M5S 3G8, Canada, carter@mie.utoronto.ca

#### 1 - Location-Allocation Modeling for the Primary Care System Network in Ontario

Anna Graber-Naidich, Toronto University, Toronto, ON, Canada, annagr26@gmail.com, Vedat Verter, Michael Carter

Currently, there are five main primary care models operating in Ontario. Researchers agree that it is extremely challenging to understand what mix of models is best in order to meet population and health system needs. Our research is motivated by the need for a tool that will test the outcomes of different policies on such important measures as travel distance, operative cost and quality of service. The proposed mixed integer model receives as an input the primary care needs of the population in an area and provides the optimal locations of facilities and their types.

#### 2 - Whole-System Patient Flow Simulation Model

Ali Vahit Esensoy, University of Toronto, 5 King's College Road, Toronto, ON, Canada, ali.esensoy@utoronto.ca, Michael Carter

Cross-sector patient flow model is a system dynamics simulation focused on the flow rates of patients between health system sectors, the related feedback structures. It takes a whole-system, strategic perspective, and is designed to produce output that captures the direction and magnitude resulting from policy changes around patient pathways and service levels. We discuss our development process, the model components and examples of policy analyses conducted using the final simulation.

#### 3 - New Methods for Early Identification of ESRD Patients with High Intensity Acute Hospital Use

Somayeh Sadat, Senior Methodologist, Cancer Care Ontario, 505 University Avenue, Toronto, ON, M5V 3V2, Canada, Somayeh.Sadat@cancercare.on.ca, Ali Vahit Esensoy, Kiren Handa

A small percentage of end stage renal disease (ESRD) patients require a disproportionately large degree of high-intensity acute care during the first year of dialysis. Geospatial analysis revealed varying rates of high intensity use among different regions. To identify underlying risk factors, we used readily available information from pre-dialysis year to build a Bayesian Network predictive model that enables proactive identification of high intensity acute care use upon the start of dialysis.

## ■ TB05

05- Miami

### Epidemics and Pandemics Models

Contributed Session

Chair: Kari Kelton, University of Louisville, 132 Eastern Parkway Room 211, Louisville, KY, 40292, United States of America, kari.kelton@louisville.edu

#### 1 - Simulation Optimization for Allocation of Epidemic-Control Resources

Parastu Kasaie, PhD Candidate, University of Cincinnati, 3231 Bishop Street, Cincinnati, OH, 45520, United States of America, kasaiept@mail.uc.edu, David Kelton

We consider the problem of resource allocation (RA) in the control of epidemics where a fixed budget is allocated among competing healthcare interventions to achieve the best health benefits and propose a simulation-optimization framework, using agent-based simulation and response surface methodology, to address a general form of the problem.

#### 2 - Comparison Study of Simulation Optimization for Epidemic Forecasting

Sara Shashaani, Virginia Tech, Virginia Bioinformatics Institute, Blacksburg, VA, United States of America, sshashaa@vbi.vt.edu, Jiangzhuo Chen, Madhav Marathe, Elaine Nsoesie

In this study we compare different optimization methods in combination with individual-based model simulations to forecast dynamics of an infectious disease. The methods compared are Nelder-Mead Simplex, NOMAD and HOPSPACK. Constraints such as non-negativity, upper bound, and summation of probability decision variables are required for efficient search. We observe that the different optimization methods have different convergence rates and perform better under different settings.

#### 3 - Simulation of Mass Vaccination Clinics as Points of Dispensing for Pandemic Outbreaks

Jose Bejarano, University of Louisville, 788 Raymond Kent Ct., Apt. 3, Louisville, KY, 40217, United States of America, jdbjea01@louisville.edu, Ruth Carrico, Sunderesh Heragu, Gail DePuy, Gerald Evans

During the 2009 H1N1 influenza outbreak, the city of Louisville, Kentucky used a drive-thru mass vaccination clinic that resulted in the vaccination of more than 19,000 people in two days. Based on this experience, a computer simulation model including both drive-thru and conventional walk-up vaccination areas was developed to assist communities of various sizes design a mass vaccination clinic that meets their emergency management planner's desired performance measures of patient time in system, number of cars waiting, and worker utilization.

#### 4 - EpiCast: Real-time Simulation of Pandemic Influenza

Kari Kelton, University of Louisville, 132 Eastern Parkway, Room 211, Louisville, KY, 40292, United States of America, kari.kelton@louisville.edu, Sunderesh Heragu

The EpiCast model of pandemic influenza supports real-time tracking and decision making by state and local public health and emergency response personnel. It contains three sub-models based on the classic SIR compartment model: a NowCast model to estimate the actual number of cases based on reporting delays; a FutureCast meta-population model to simulate the geographic spread of the epidemic; and a DecisionCast model to evaluate the impact of control measures.

## ■ TB06

06- Los Angeles

### Joint Session MDM/SPPSN: Health Policy Analysis

Cluster: Medical Decision Making & Public Programs, Services and Needs

Invited Session

Chair: David Hutton, Assistant Professor, University of Michigan, 1415 Washington Heights, Ann Arbor, MI, 48109, United States of America, dwhutton@umich.edu

#### 1 - Impact of Disease Surveillance Systems in the Epidemiologic Characterization of Pandemic Outbreaks

Eric Meisheri, Research Assistant, Western Michigan University, Dept. of Industrial Engineering, 4601 Campus Dr. (Office E-229), Kalamazoo, MI, 49008, United States of America, eric.r.meisheri@wmich.edu, Richard Van Enk, Peter Holvenstot, Diana Prieto

In the U.S., most of the information about a developing pandemic influenza outbreak comes from data collected by State viral surveillance labs (VSL). This study will examine and evaluate their sampling methods using a simulation developed over an existing disease spread model. We expect to find significant differences between the underlying pandemic trend and what is reported via the current sampling methods and to offer suggestions for improvement.

#### 2 - Modelling the Influence of Human Behaviour on the Spread of Influenza

Elnaz Karimi, Concordia University, 1201 Hope Street, Montreal, QC, H3H 2A3, Canada, karimi.lnz@gmail.com, Ketra Schmitt, Ali Akgunduz

We introduce an agent-based model to incorporate the influence of individual behavioral decision making on the spread of influenza during a university semester. We consider vaccination, self-isolation and physical distancing as protective health behaviors. We apply the health belief model to evaluate behavior patterns and model them in the simulation.

## ■ TB07

07- Kansas City

### Improving Service in Healthcare Networks

Sponsor: POMS, College of Healthcare Operations Management

Sponsored Session

Chair: Masha Shunko, Purdue University, 403 W. State Street, West Lafayette, IN, 47906, United States of America, mshunko@purdue.edu

#### 1 - Waiting Patiently: An Empirical Study of Queue Abandonment in an Emergency Department

Robert Batt, University of Pennsylvania, 3730 Walnut Street, Suite 500, Philadelphia, PA, 19083, United States of America, batt@wharton.upenn.edu, Christian Terwiesch

We study patient abandonment from a hospital emergency department queue. We find that patients are influenced by what they observe in the waiting room: census, arrivals, and departures. Patients are also sensitive to being overtaken in the line. Patients also make inferences about the severity of the patients around them and respond differently to people more sick and less sick moving through the system. The fact that patients respond to visual stimulus suggests that in order to reduce patient abandonment hospitals should carefully manage what information patients have regarding their wait.

#### 2 - using Strategic Idleness to Improve Customer Service Experience in Service Networks

Jianfu Wang, PhD Candidate, University of Toronto, Rotman School of Management, 105 St. George Street, Toronto, ON, M5S 3E6, Canada, Jianfu.Wang08@Rotman.Utoronto.Ca, Opher Baron, Oded Berman, Dmitry Krass

In service networks the perception of waiting depends on how it is distributed among different stations. To better capture customers' perception of service quality managers should consider the probability of long waits in each station. In a queueing network with several stations, a policy that allows idling may reduce the probability of long waits. We demonstrate the advantage of strategic idleness by applying threshold based policies in a network with two single-server queues in tandem.

#### 3 - Bed-Block Management in Emergency Departments: The Role of Flexible Beds

Ohad Perry, Northwestern University, Industrial Engineering and Management, Evanston, IL, 60208, United States of America, ohad.perry@northwestern.edu, Soroush Saghafian

The bed-block phenomenon refers to situations in which emergency department (ED) patients who need to be hospitalized cannot be transferred to inpatient wards (IW) due to lack of available beds. In some instances, if patients block beds for a long time, they are transferred to so-called flexible beds, i.e., beds that are not in their designated IW. We emphasize the role of flexible beds, and find effective patient transfer and discharge policies that can alleviate the bed-block.

#### 4 - Value of Centralized Patient Routing to Emergency Departments under Optimal Surge Capacity Policy

Masha Shunko, Purdue University, 403 W. State Street, West Lafayette, IN, 47906, United States of America, mshunko@purdue.edu, Varun Gupta, Alan Scheller-Wolf

While many emergency departments (ED) in the US experience crowding, ambulances make decisions for patients' routing without information from the EDs, which worsens crowding. EDs try to overcome crowding using surge capacity. We find the optimal surge use policy and compare ED profit and patient wait time in two cases: 1) EDs share information, the central controller makes routing decision, and 2) ambulances make decision independently. We show when the information sharing has the highest value.

## ■ TB08

08- Kane

### Rural Health in the Hospital Setting

Cluster: Rural Health

Invited Session

Chair: Molly Jones, President, Inspire Medical, Inc., 2323 Lime Kiln Lane, Louisville, KY, 40222, United States of America, mjones@inspiremedical.com

#### 1 - Rural Physician Peer Review Process Improvement

Amarnath Banerjee, Texas A & M University, College Station, TX, United States of America, banerjee@tamu.edu, YeongIn Kim

Performing an objective peer review of physicians in a rural setting is often a challenge due to several constraints. A simulation based approach is used to model, analyze and improve an innovative peer review process designed and developed at the Texas A&M Health Science Center for inpatient and ambulatory setup.

#### 2 - The Role of Preventative Care for Congestive Heart Failure Patients in a Rural Health System

Renata Konrad, Worcester Polytechnic Institute, 100 Institute Rd., Worcester, MA, United States of America, rkonrad@wpi.edu, Christine Tang, Brent Faber, Andrew Trapp

Few benchmarks exist addressing the timing of preventative-care interventions for chronic care. Our goal is to develop a personalized preventative-care protocol accounting for demographics and disease severity. This talk presents results from the first study phase. Statistical analysis of comprehensive clinical, financial, and operations data illustrate the cost and quality impact of the lack of preventative-care for congestive heart failure patients in an isolated rural community-health system.

#### 3 - using Simulation to Improve the Quality and Efficiency of Patient Care in a Rural Hospital Emergency

Molly Jones, President, Inspire Medical, Inc., 2323 Lime Kiln Lane, Louisville, KY, 40222, United States of America, mjones@inspiremedical.com, Gerald Evans

A simulation model representing a rural hospital emergency department was constructed to assist in identifying improvements in the efficiency and quality of patient care. The emergency department studied has experienced in excess of a 150% increase in patient visits over a ten year period. Quality measures imposed by the Affordable Care Act were considered in identifying improvements.

#### 4 - Joint Location and Dispatching Decisions for Emergency Medical Service Systems

Hector Toro-Diaz, Clemson University, 204B Freeman Hall, Clemson, SC, United States of America, htoro@g.clemson.edu, Maria Mayorga, Laura McLay

Adequate use of ambulances saves lives. We propose a joint location and dispatching model for ambulances and a solution procedure based on genetic algorithms (GA). Minimizing the mean response time (MRT) is the initial objective, but expected coverage as well as fairness criteria (equalizing individual's response times and server's workloads) are also used and the trade-offs are quantified.

## ■ TB09

09- McHenry

### Models of Access Involving Geography II

Contributed Session

Chair: Farshad Majzoubi, University of Louisville, 132 Eastern Parkway RTDSS Lab, Louisville, KY, 40217, United States of America, f0majz01@louisville.edu

#### 1 - Minimizing the Spatial Mismatch of Ambulance Services in Tokyo

Takehiro Furuta, Nara University of Education, Takabatake-cho, Nara, Japan, takef@fw.ipsj.or.jp, Hozumi Morohosi

We focus on the spatial mismatch of ambulance services between supply and demand: the supply is the number of calls that can be responded to by a station and the demand is the number of calls. We develop a model that seeks to re-deployment of ambulances to minimize the sum of demand-weighted mismatches. We analyze how the re-deployment of ambulances affects where the spatial mismatch is reduced in Tokyo using the model.

#### 2 - Transportation Optimization: Solutions for Last-Mile Delivery of Essential Medical Products

Neelima Ramaraju, Director of Public Health Applications, LLamasoft, 201 S Main St., Ann Arbor, MI, 48103, United States of America, neelima@llamasoft.com

This paper documents the use of Transportation Guru<sup>®</sup>, a user-friendly vehicle routing and network optimization program, in planning last-mile delivery networks (routing, fleet-sizing, costing, etc.) for essential medical products in Sub-Saharan Africa. Methods to address unique challenges related to fleet types, capacities, road conditions, product characteristics, and seasonal constraints are discussed. Feedback from field studies performed in East and West Africa are also discussed.

#### 3 - Redesigning Organ Allocation Boundaries for Liver Transplantation in the United States

Naoru Koizumi, Associate Professor, George Mason University, 3351 N. Fairfax Dr., Arlington, VA, 22203, United States of America, nkoizumi@gmu.edu, Chun-Hung Chen, Nigel Waters, Monica Gentili, Rajesh Ganesan, Keith Melancon

Geographic disparities in access to and outcomes in transplants is a persistent problem widely discussed among transplant researchers. One of the alleged causes of disparities in the United States is administratively determined organ allocation boundaries that limit organ sharing across regions. This paper applies mathematical programming and simulation to construct and evaluate alternative liver allocation boundaries that achieve more geographic equity in transplants than the current system.

**4 - An Exact Method for Transporting Patients to Hospitals**

Farshad Majzoubi, University of Louisville, 132 Eastern Parkway  
RTDSS Lab, Louisville, KY, 40217, United States of America,  
f0majz01@louisville.edu, Mehdi Zakerifar, Sunderesh Heragu,  
Lihui Bai

Our problem considers transportation of patients to hospitals in real time. In order to better utilize the capacity of ambulances, each ambulance can serve a maximum of two patients. Hospitals are preselected for each patient and are treated as the input of the model. The objective is to minimize the overall travel distance of the EMS vehicles. Also, two types of time window constraints are imposed: time window for serving a patient at the scene and time window for transporting a patient to his or her hospital. We first model the problem in a way similar to the Vehicle Routing Problem with pick-up and delivery. We, then, propose an exact method using branch and price approach. Our experimental results show that the proposed method can obtain favorable results in a reasonable time, thus, this method can be implemented in a practical situation.

**■ TB10**

10- Cook

**Scheduling Strategies in Hospitals and Academic Medical Centers**

Cluster: Healthcare Scheduling

Invited Session

Chair: Retsef Levi, Professor, Massachusetts Institute of Technology, Sloan School of Management, 30 Wadsworth Street-Building E62-562, Cambridge, MA, 02142, United States of America, retsef@mit.edu

**1 - Who Should Emergency Physicians See Next?**

Yann Ferrand, Assistant Professor, Clemson University, College of Business and Behavioral Science, 123 Sistine Hall, Clemson, SC, 29634, United States of America, yferran@clemson.edu,  
Michael Magazine, Uday Rao, Todd Glass

To improve patient flow in an emergency department, we investigate a novel way to prioritize patients, by augmenting current prioritization practices with a consideration of actual time spent in the system. We use discrete event simulation to measure the performance of this approach in terms of patient wait time and length of stay, and compare it to the current practice at a specific emergency department.

**2 - Prediction and Optimization Techniques to Streamline Surgical Case Scheduling**

Ryan Graue, Massachusetts Institute of Technology,  
100 Main St., Cambridge, MA, 02140, United States of America,  
ryan.graue@sloan.mit.edu, Brett Simon, Elena Canacari,  
Vivek Farias, Retsef Levi

We have developed a demand prediction tool and a schedule optimization tool that work together to improve operating room resource utilization. The prediction tool is based on a multivariable linear regression model that generates elective surgical demand forecasts for each day between one and three weeks in advance, and the optimization tool is an integer linear program that allocates cases to rooms as efficiently as possible after block release while satisfying operational constraints.

**3 - Systematic Block Allocation in Large Academic Medical Centers**

Cecilia Zenteno, Post Doctoral Fellow, Massachusetts Institute of Technology, 100 Main St., E62-385, Cambridge, MA, 02138,  
United States of America, ceciliaz@mit.edu, Tim Carnes,  
Peter Dunn, Retsef Levi, Bethany Daily, Devon Price

We describe the large-scale implementation of data-driven surgical scheduling strategies at Massachusetts General Hospital (MGH). The strategies are based on a range of simulation and integer optimization techniques. The goals were to smooth the surgical census on the surgical floors and to increase timely access to non-elective patients. The models and analyses provided accurate predictions, supported the changes in the scheduling practices, and delivered rigorous methodologies to monitor and study the changes in the respective performance metrics.

**■ TB11**

11- Dupage

**HAS Student Paper Competition Finalists**

Sponsor: HAS Student Paper Competition

Sponsored Session

Chair: Burhaneddin Sandikci, Assistant Professor of Operations Management, University of Chicago, Booth School of Business, 5807 S. Woodlawn Ave., Chicago, IL, 60637, United States of America, burhan@chicagobooth.edu

Co-Chair: Steven Shechter, Assistant Professor, University of British Columbia, Sauder School of Business, 2053 Main Mall, Vancouver, BC, V6T 1Z2, Canada, steven.shechter@sauder.ubc.ca

**1 - ICU Admission Control: An Empirical Study of Capacity Allocation and its Implication on Patient Outcomes**

Song-Hee Kim, Columbia University, New York, NY, 10027,  
United States of America, sk3116@columbia.edu, Carri Chan,  
Gabriel Escobar, Marcelo Olivares

We examine how operational factors can impact ICU admission decisions and ultimately patient outcomes and hospital costs. We develop an econometric framework and use the instrumental variable approach to identify the effect of the endogenous admission decision on patient outcomes, where the endogeneity is caused by unobserved factors affecting both the admission decision and patient outcomes. We estimate the effects using a detailed patient-level dataset from an integrated healthcare delivery system with over 200,000 hospitalizations. We show that busy ICUs are associated with lower chance of admission (56% decrease on average), which further leads to substantial health and financial implications (roughly \$2.8 million per year for this hospital network). Furthermore, by factoring in the estimated benefit of ICU care determined by our econometric model into a stylized model for ICU admission control, we show that relatively simple admission policies that account for ICU congestion can have nearly optimal performance.

**2 - Generalized Inverse Multi-Objective Optimization with Application to Cancer Therapy**

Taewoo Lee, University of Toronto, 5 King's College Rd., Toronto,  
ON, M5Y3G8, Canada, taewoo.lee@utoronto.ca, Michael Sharpe,  
Tim Craig, Timothy Chan

We generalize the standard method of solving inverse optimization problems to allow for the solution of inverse problems that would otherwise be ill-posed or infeasible. In multi-objective linear optimization, given a solution that is not a weakly efficient solution to the forward problem, our method generates objective function weights that make the given solution a near-weakly efficient solution. Our generalized inverse optimization model specializes to the standard model when the given solution is weakly efficient and retains the complexity of the underlying forward problem. We apply our method to prostate cancer data obtained from Princess Margaret Cancer Centre. We demonstrate that clinically acceptable treatments can be generated using a small number of objective functions and inversely optimized weights - current treatments are designed using a complex formulation with a large parameter space in a trial-and-error re-optimization process. We also demonstrate how to identify objective functions that are most influential in treatment plan optimization.

**3 - Managing Hospital Inpatient Bed Capacity Through Partitioning Care into Focused Wings**

Thomas Best, University of Chicago, Chicago, IL, 60610,  
United States of America, tbest@chicagobooth.edu,  
Don Eisenstein, David Meltzer, Burhaneddin Sandikci

We consider the perspective of a hospital administrator, who decides whether to partition care into focused wings. The administrator faces a trade-off between forming large wings to pool demand and capacity, and forming specialized wings to focus on a narrow range of care types. To inform this decision, we provide an optimization framework utilizing sophisticated queueing models. Using data from an urban teaching hospital and a national database, we report analytical and numerical insights.

**4 - Iterative Branch-and-Price for Hierarchical Multi-Criteria Kidney Exchange**

Kristiaan Glorie, Erasmus University Rotterdam, P.O. Box 1738,  
Rotterdam, 3000 DR, Netherlands, glorie@ese.eur.nl,  
Joris van de Klundert, Albert Wagelmans

Kidney exchange is an increasing modality that allows the exchange of kidneys between two or more incompatible patient-donor pairs. Typically, the aim is to find an allocation of donors to patients that is optimal with respect to multiple hierarchical criteria. We present an iterative branch-and-price algorithm for clearing such multi-criteria kidney exchanges with large patient-donor pools. We propose how the pricing problem can be solved in polynomial time for a general class of criteria.

## ■ TB12

12- Water Tower

### Healthcare Policy and Finance - I

Contributed Session

Chair: Steven Cohen, Director, Center for Financing, Access and Cost Trends, Agency for Healthcare Research and Quality, 540 Gaither Road, Rockville, MD, 20850, United States of America, scohen@ahrq.gov

#### 1 - Hospital Sick Fund Contracting and Quality of Care: A Game Theoretical Approach

Dana Sherill-Rofe, Bar Ilan University, Shalom Yehuda 3, Jerusalem, Israel, sherild@biu.ac.il, Tatyana Chernomon

We focus on relationships between SFs and hospitals, both attempting to offer high quality treatment but hindered by austerity. We use double moral hazard in a game approach to learn about the effect of cooperation vs. non-cooperation on the efforts the players put in offering higher quality of care to increase internal demand. We focus on medical situations where patients can choose whether to use SF facilities or go to the hospital. We ask what motivates the players to invest, and whether it is lucrative to them and to social welfare.

#### 2 - Subsidized Vaccines a Policy Trap?

Ming Yi, Virginia Tech, Virginia Bioinformatics Institute, 1880 Pratt Drive, Blacksburg, VA, 24061, United States of America, yiming@vbi.vt.edu, Achla Marathe

We adopt an SIS model on scale-free networks to investigate the effect of different vaccine subsidization policies. The goal is to control the prevalence of the disease given a limited supply and voluntary uptake of vaccines. Results find that a uniform subsidization policy is always harmful and increases the prevalence of the disease, because the lower degree individuals' demand for vaccine crowds out the higher degree individuals' demand. Even a targeted program becomes a policy trap under certain conditions.

#### 3 - Trends in the Concentration and Persistence of Health Care Expenditures

Steven Cohen, Director, Center for Financing, Access and Cost Trends, Agency for Healthcare Research and Quality, 540 Gaither Road, Rockville, MD, 20850, United States of America, scohen@ahrq.gov

Estimates of health care expenses for the U.S. civilian non-institutionalized population are critical to policymakers and others concerned with access to medical care and the cost and sources of payment for that care. Medical care expenses are highly concentrated among a relatively small proportion of individuals in the community population. This presentation analyzes national trends in the concentration and persistence of health care expenditures to discern the factors most likely to drive health care spending and the characteristics of the individuals who incur them.

## ■ TB13

13- Navy Pier

### Large-scale Simulation for Healthcare Decision and Operations Advances

Sponsor: Simulation Society

Sponsored Session

Chair: Eva Lee, Professor and Director, Georgia Institute of Technology, Atlanta, GA, United States of America, evakylee@isye.gatech.edu

#### 1 - Modeling HIV Prevention, Detection and Treatment Strategies for High-Risk Population

Ruilin Zhou, Georgia Institute of Technology, Industrial & Systems Engineering, Atlanta, GA, United States of America, zhouri@gatech.edu, Eva Lee

This work is joint with CDC. We present large-scale decision models that capture entire population with defined risk groups. The models include estimates of infection per risk group over a long period of horizon with incorporation of the secondary transmission. Strategies to minimize overall infectivity and mortality through proper investment will be discussed.

#### 2 - using the PRISM Model to Compare Intervention Strategies for Reducing Cardiovascular Risk in the U.S.

Lawton Cooper, National Heart, Lung and Blood Institute, Bethesda, MD, United States of America, cooperls@nhlbi.nih.gov, Jack Homer, Kristina Wile, Diane Orenstein, Justin Trogon

PRISM is a highly detailed compartmental system dynamics model, under development since 2006 in conjunction with federal health agencies, for estimating the multiyear health and cost impacts of a wide variety of interventions addressing risks for cardiovascular disease. The model is used to test 50 different intervention individually and in combination, and to identify the most effective interventions in terms of several important health and medical cost metrics simulated out to 2040.

## ■ TB15

15- O'Hare

### OR Modeling in Medical Decision Making

Sponsor: Healthcare Applications Society

Sponsored Session

Chair: Shengfan Zhang, Assistant Professor, University of Arkansas, Fayetteville, AR, 72701, United States of America, shengfan@uark.edu

Co-Chair: Mahboubeh Madadi, University of Arkansas, Bell Engineering Building, Fayetteville, AR, 72701, United States of America, mmadadi@email.uark.edu

#### 1 - Understanding Factors That Influence Treatment Disparities in Breast Cancer Patients

Milton Soto, Research Assistant, Western Michigan University, 4601 Campus Dr., Kalamazoo, MI, 49008, United States of America, miltonrene.sotoferrari@wmich.edu, R. Rindy, Diana Prieto

The causes of cancer disparities in breast cancer treatment are complex, and include interrelated social, economic, and health system factors. We are currently conducting a systematic review and developing statistical models to analyze these complexities. The objective is to provide a comprehensive view of the relationships between factors and endpoints with respect to the different treatment and post-treatment options for breast cancer. Results from the implementation will be presented.

#### 2 - Non-Linear, Multi-Objective, Auto-Optimization Modeling for Health System Resource Decision Analysis

Lawrence V. Fulton, Assistant Professor, Texas State University, 611 University Drive, San Marcos, TX, 78666, United States of America, lf25@txstate.edu, Vivek Shah, Nathaniel D. Bastian

Healthcare decision-makers may want to investigate how centrally-controlled health system inputs and outputs might be adjusted to improve resource allocation decisions while balancing costs, quality and access. Hence, a model that adjusts resources automatically across all facilities to achieve maximum system efficiency would provide decision-support and insight for leaders interested in evaluating multiple objectives simultaneously. This work proffers a non-linear, multi-objective auto-optimization model that allows for the automatic adjustment of resources.

#### 3 - Patient-Centered Response to Acute Physiological Deterioration of Hospitalized Patients

Julie Ivy, Associate Professor, North Carolina State University, 111 Lampe Drive, Raleigh, NC, 27695-7906, United States of America, jsivy@ncsu.edu, Muge Capan, Jeanne Huddleston, Thomas R. Rohleder

Hospitalized patients are at risk of unexpected physiological deterioration characterized by acute and persistent abnormality in physiological measures. Failure of care providers to recognize this deterioration can lead to adverse events such as unplanned transfers to the ICU and death. We conduct statistical analyses using medical records and warning scores, and develop a Semi-Markov Decision Model to capture the dynamics of acute physiological deterioration and patient-centered rapid response.

#### 4 - A Nonlinear Programming Model to Optimize Mammography Screening Policies

Mahboubeh Madadi, University of Arkansas, Bell Engineering Building, Fayetteville, AR, 72701, United States of America, mmadadi@email.uark.edu, Shengfan Zhang, Edward Pohl

Mammography screening recommendations have been the subject of significant debate in recent years. In this study, a nonlinear programming model is developed to find the optimal mammography screening policy in terms of women's quality adjusted life years (QALYs), while taking benefits and risks of mammography into consideration. Two methods of breast cancer detection, mammography and self-detection, are considered in the model. We also consider the possibility of interval cancer in our model.

Tuesday, 1:30pm - 3:00pm

## ■ TC01

01- Chicago F

### Panel: Affordable Care Act: The Change of Healthcare Landscape

This panel includes healthcare experts from public and private sectors.

Cluster: Medical Decision and Policy Making  
Invited Session

Chair: Eva Lee, Professor and Director, Georgia Institute of Technology, Atlanta, GA, United States of America, evakylee@isye.gatech.edu

#### 1 - Panel: Affordable Care Act - the Change of Healthcare Landscape

Eva Lee, Professor and Director, Georgia Institute of Technology, Atlanta, GA, United States of America, evakylee@isye.gatech.edu, Stephen Chick, Michael Wright, Michael Schrage

In this panel, private and public leaders in healthcare will debate the impact of the Affordable Care Act on healthcare delivery, both in terms of quality of care and efficiency of care. Research and development challenges and opportunities will be highlighted.

## ■ TC02

02- Chicago G

### Patient-Centered Data Analytics

Sponsor: Data Mining  
Sponsored Session

Chair: Rema Padman, The H. John Heinz III College, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States of America, rpadman@andrew.cmu.edu

Co-Chair: Changmi Jung, Carnegie Mellon University, 4800 Forbes Ave., Room 3009, Pittsburgh, PA, 15213, United States of America, changmi@cmu.edu

#### 1 - Predicting Interest in Adopting Mobile and Social Media for Personal Health and Wellness Management

Sinjini Mitra, Assistant Professor, California State University, ISDS Department, SGMH-4113, Fullerton, CA, 92831, United States of America, smitra@fullerton.edu, Rema Padman

Health plans are exploring new and creative methods to reach out to members to offer health information, provide support, encourage healthy behaviors, and leverage the emerging trend among consumers to play a more active and engaged role in self health management. We analyze survey data from health plan members to understand their propensity for social and mobile media usage, the potential to connect technology with members' health and wellness needs and whether privacy and security concerns drive consumers' willingness to adopt such solutions.

#### 2 - Digital Innovation in Primary Care Delivery: A Study of eVisit Adoption

Changmi Jung, Carnegie Mellon University, 4800 Forbes Ave., Room 3009, Pittsburgh, PA, 15213, United States of America, changmi@cmu.edu, Rema Padman

In this study, we analyze the key features that distinguish early adopters of the online medical consultation service from patient portal consumers using data from a major healthcare provider in western Pennsylvania. In particular, we test the impact of attributes of innovation diffusion theory on eVisit adoption employing actual usage data. We analyze the effect of trialability on the real usage after the eVisit service is deployed as the attribute can be more clearly defined with the retrospective data.

#### 3 - Patient Migration and Duplicate Procedures: A Longitudinal Study of CHF Patients

Indranil Bardhan, Professor, The University of Texas at Dallas, Jindal School of Management, 800 West Campbell Road, Richardson, TX, 75080, United States of America, bardhan@utdallas.edu, Sezgin Ayabakan, Kirk Kirksey, Zhiqiang Zheng

This study investigates the impact of patient migration on duplicate tests for congestive heart failure patients. We hypothesize that migration across health systems will result in increased duplicate procedures, due to lack of visibility into patient medical history. We use a large dataset of outpatient and inpatient visits in North Texas from 2005 to 2012. Our econometric models shows that the duplication rate is higher when patients migrate across disparate hospitals.

## ■ TC03

03- Chicago H

### Optimization in Radiation Therapy Treatment Planning

Sponsor: INFORMS Optimization Society  
Sponsored Session

Chair: Troy Long, PhD Candidate, University of Michigan, Ann Arbor, MI, United States of America, troylong@umich.edu

#### 1 - Controlling the Degree of Robustness in Treatment Planning for Intensity-Modulated Proton Therapy

Rasmus Bokrantz, KTH Royal Institute of Technology & RaySearch Laboratories, Department of Mathematics, Stockholm, Sweden, bokrantz@kth.se, Albin Fredriksson

A mathematical framework for multicriteria optimization of intensity-modulated proton therapy IMPT is introduced, and its applicability to Pareto surface-based planning by interpolation between precomputed treatment plans evaluated. Linear interpolation between plans of variable degree of robustness is found unwarranted with respect to tumor control, while toggling between solutions in a discrete manner permits the tradeoff between robustness and plan quality to be examined interactively.

#### 2 - A Novel IMRT Plan Optimization Algorithm for Physician-Driven Plan Tuning

Masoud Zarepisheh, University of California - San Diego, Moores Cancer Center, San Diego, Ca, 92122, United States of America, mzarepisheh@ucsd.edu, Nan Li, Xun Jia, Steve Jiang

The conventional treatment planning procedure is a time-consuming and resource-demanding task that may need multiple iterations between the dosimetrists and clinicians after an initial plan is developed. We develop a new optimization algorithm to speed up this procedure by allowing the physician to interactively fine-tune the plan's DVH and iso-dose lines on top of the initially optimized plan. After the physician modifies the current plan, the algorithm will adjust the voxel-dependent optimization parameters to guide the plan towards the desired one.

#### 3 - Predicting Objective Function Weights for Multi-Criteria IMRT Planning using Patient Anatomy

Taewoo Lee, University of Toronto, 5 King's College Rd., Toronto, ON, M5Y3G8, Canada, taewoo.lee@utoronto.ca, Tim Craig, Michael Sharpe, Timothy Chan, Muhannad Hammad

Objective function weights for multi-criteria optimization for IMRT treatment planning are typically determined by a trial-and-error manner, which is time-consuming. We develop a regression model to predict the weights for IMRT prostate treatment planning using a previously developed inverse optimization problem (IOP) and patient anatomy. Treatment plans generated by the predicted weights from the regression model were very similar to clinical treatment plans. This approach may support the genesis of personalized weights in IMRT treatment planning.

## ■ TC04

04- Scottsdale

### Quantitative Models for Outpatient Care

Sponsor: CORS, Canadian Operational Research Society  
Sponsored Session

Chair: Beste Kucukyazici, Assistant Professor, McGill University, 1001 Sherbrooke West, Montreal, QC, H3A 1G5, Canada, beste.kucukyazici@mcgill.ca

#### 1 - Designing Individualized Treatment: An Application to Anticoagulation Therapy

Vedat Verter, Professor, McGill University, 1001 Sherbrooke West, Montreal, QC, H3A 1G5, Canada, vedat.verter@mcgill.ca, Beste Kucukyazici, Rouba Ibrahim, Michel Gendreau, Mark Blostein

The popular blood-thinning drug Warfarin is characterized by the complexity of the patient response. Its effective use requires taking an individualized treatment approach, tailored to each patient's specific condition. In practice, doctors rely mostly on intuition to decide which warfarin dose to prescribe initially, and how to make subsequent dose adjustments until a desired patient response is observed. Motivated by this lack of clarity in clinical guidelines, we propose a systematic, individualized, warfarin dose adjustment algorithm.

## 2 - Creating an Ambulatory Clinic Schedule for a New Hospital using Integer Programming

Brendan Eagen, University of Toronto, 5 King's College Road, Toronto, ON, Canada, brendan.eagen@mail.utoronto.ca, Timothy Chan, Michael Carter

The ambulatory clinic schedule plays a major role in the operations of a healthcare facility and can have a major impact on the efficiency of the care provided to patients. We present a real world ambulatory clinic scheduling problem faced by a growing hospital. We show the challenging nature of the problem, develop an integer programming model to solve the problem, and demonstrate the importance of the problem through its far reaching impact on hospital operations.

## 3 - Understanding Client Preferences for Preventive Care

Beste Kucukyazici, Assistant Professor, McGill University, 1001 Sherbrooke West, Montreal, QC, H3A 1G5, Canada, beste.kucukyazici@mcgill.ca, Lijie Song, Vedat Verter

In the context of preventive care, patient preferences are not well studied. In this study, we present a methodology based on empirical study to explore (1) factors that affect eligible population's decision to participate to preventive care programs, (2) service attributes that affect patients' choice of preventive care facilities, and (3) the impact of facility network design as well as service configuration on the efficiency of the overall system.

## TC05

05- Miami

### Healthcare Operations

Sponsor: Healthcare Applications Society

Sponsored Session

Chair: Sakine Batun, Assistant Professor, Middle East Technical University, Department of Industrial Engineering, Ankara, 06800, Turkey, sakine@metu.edu.tr

#### 1 - Dynamic Scheduling of Outpatient Procedure Centers

Bjorn Berg, Assistant Professor, George Mason University, 4400 University Drive, MS 4A6, Fairfax, VA, 22030, United States of America, bberg2@gmu.edu, Brian Denton

We present a new model for online decision making for problems motivated by outpatient procedure centers. The dynamic extensible bin packing problem is formulated as a multi-stage stochastic integer program. We present insights into the optimal solutions as well as provide bounds for the problem. Results, including the evaluation of a heuristic that is commonly implemented in practice, are presented as part of a case study based on a real outpatient procedure center.

#### 2 - Sequential Clinical Scheduling with Patient Reentrant: The Case of Mohs Micro-Surgery

Mark Alan Lawley, Purdue University, West Lafayette, IN, United States of America, malawley@purdue.edu, Stephen Steidle, Seokcheon Lee

Mohs Micrographic Surgery is used to excise skin cancers from areas of cosmetic importance. Thin layers are sequentially removed and tested for cancer cells. The stochastic number of removals complicates scheduling, with long wait times, overtime, and under-utilization being common. We develop scheduling methods that balance waiting, overtime, and revenue.

#### 3 - Optimal Management of Resource Capacity during Mass Casualties

Mohana Rajagopal, Singapore MIT Alliance, N3.2-01-36, 65 Nanyang Drive, Singapore, 637460, Singapore, S090054@e.ntu.edu.sg, Appa Iyer Sivakumar, Stephen C. Graves

Limited availability of beds in intensive care and regular wards in hospitals following mass casualty incidents requires planning policies to minimize both the number of waiting patients for treatment and resources used given the random patient arrival rate. A mixed integer programming model is formulated for determining resource allocation policies following mass casualty incidents.

## TC06

06- Los Angeles

### Medical Decision Making II

Contributed Session

Chair: Hsing Luh, Professor, National Chengchi University, Department of Mathematical Sciences, No. 64, Sec. 2, Zhi Nan Rd., Wenshan District, Taipei, Taiwan - ROC, sl@nccu.edu.tw

#### 1 - Enhanced Optimization Tools for Kidney Exchange Programs

Ana Viana, INESC TEC/ISEP.IPP, Campus da FEUP, Rua Dr Roberto Frias, Porto, Portugal, aviana@inescporto.pt, Filipe Alvelos, Xenia Klimentova, Miguel Constantino, Abdur Rais, João Pedro Pedrosa, Nicolau Santos, Paolo Tubertini

This presentation updates current work and optimization tools being developed under a project funded by the Portuguese Foundation for Science and Technology. The project aims at tackling certain optimization problems that typically arise in kidney exchange programs. The tools developed in this project directly supports the Portuguese Institute for Blood and Transplantation Services.

#### 2 - A Hindsight Cut-off Boundary for Metabolic Syndrome Criteria

Huifen Chen, Professor, Chung-Yuan University, Industrial and Systems Engineering Dept., 200 Chung-Pei Road, Chung-Li, Taiwan - ROC, huifen@cycu.edu.tw, Chien-Hua Wu, Tien-Mu Hsiao, Hui -Hon Lin

Metabolic syndrome (MetS) is defined by a set of interrelated factors that increase the risk of stroke and diabetes mellitus (DM). Despite several different definitions of MetS that exist, definitions to better identify patients at risk are still needed. We construct an ellipsoid cut-off boundary for MetS criteria, whose size depends on hindsight data. Using data from Taiwan Landseed Hospital, we compare this hindsight boundary with the 2001 NCEP and 2009 consensus definition (IDF and AHA/NHLBI). Our results show that the hindsight boundary provides a plausible odds ratio between MetS and stroke/DM.

#### 3 - A Multi-State Disease Progression Model of Type 2 Diabetes Mellitus

Jeng-Huei Chen, Assistant Professor, National Chengchi University, Department of Mathematical Sciences, No. 64, Sec. 2, Zhi Nan Rd., Wenshan District, Taipei, Taiwan - ROC, jhchen@nccu.edu.tw, Ming-Yen Lin, Hsing Luh, Shuang Zhu, Li-Jen Cheng, Li-Chia Chen

In this study, a disease progression model for type 2 diabetes mellitus is constructed based on a dataset with large sample size. It could simulate major diabetes-related complications, including myocardial infarction, ischaemic heart disease, congestive heart failure, stroke, nephropathy, retinopathy, amputation and death. The time-to-event and transition information among type 2 diabetes-related complications offered by this model is helpful for the development of better management strategies.

#### 4 - Whole Disease Modeling to Aid Survival Analysis on Chronic Hepatitis B Virus Infection

Hsing Luh, Professor, National Chengchi University, Department of Mathematical Sciences, No. 64, Sec. 2, Zhi Nan Rd., Wenshan District, Taipei, Taiwan - ROC, sl@nccu.edu.tw, Jenghuei Chen, Shin-Yu Chen

This paper presents a methodological framework extending the existing natural history of hepatitis B virus (HBV) prognosis progression model on chronic infection. Especially, we focus on the age-dependent nature of annual incidence rates for transitions between symptoms. We consider that the disease progression is originally described by a Markov model, and propose a method to approximate the HBV progression with data from the life table. This resulting model is established based on conditional probabilities which are excerpted from the clinical data. For example, by our model with estimation of a HBV patient at age 25, the remaining life expectancy and the standard deviation of the remaining life expectancy of the patient is 39.073 years and 17.785 years, respectively. Furthermore, this patient has 10.24% probability of death or transplantation within 15 years because of HBV infection. Numerical results show that the proposed model can be applied to obtain a more realistic life expectancy, the survival probabilities at specifically initial ages, and mortalities from various initial symptoms to death. This system-level approach referred to as whole disease modeling can provide a consistent mathematical infrastructure for the economic evaluation of virtually any intervention across a disease pathway.

## TC07

07- Kansas City

### Outpatient Operations

Contributed Session

Chair: Christopher Stromblad, Innovation Analyst, Operations Research, Geisinger Health System, 100 N. Academy Ave., Danville, PA, 17822, United States of America, ctstromblad@geisinger.edu

#### 1 - Responding to Traveling Veterans' Seasonal Demands for Healthcare Services

Shahed Al-Haque, Massachusetts Institute of Technology, 77 Massachusetts Avenue, Bldg. E38-610, Cambridge, MA, 02139, United States of America, salhaque@mit.edu, M. Erkan Ceyhan, Deborah Nightingale

In collaboration with the Veterans Health Administration, we investigate the impact of traveling veteran seasonality on the delivery of services at the VA Bay Pines facility in Florida. Through statistical modeling, this research provides operations management strategies that enable more effective allocation of resources to improve clinic operations and meet the demands of traveling veterans.

#### 2 - Stochastic Programming Model for Capacity Allocation for MRI Examinations

Na Geng, Assistant Professor, Shanghai Jiao Tong University, 800 DongChuan Road, Shanghai, China, gengna@sjtu.edu.cn

To reduce the waiting time of patients with higher priority (class 1), the paper proposes a stochastic programming model to allocate the capacity of MRI between two classes of patients. The objective is to minimize the weighted waiting time of all the patients, the unused time slots penalty, and the degrading penalty. Experiments show that the waiting time of patients of class 1 can be reduced with slightly increase the waiting time of other patients and unused time slots ratio.

#### 3 - Scheduling Physicians to Outpatient Clinics at Geisinger Health System

Christopher Stromblad, Innovation Analyst, Operations Research, Geisinger Health System, 100 N. Academy Ave., Danville, PA, 17822, United States of America, ctstromblad@geisinger.edu, Priyantha Devapriya

Scheduling clinic and procedure time for providers involves a variety of complex constraints. In this study a multi-objective MIP was developed to compare operational and strategic decisions for a given service line to assign providers clinic days and procedure days. This tool will be used by the schedulers and leaders of the organization for optimizing objectives while scheduling and planning for business development.

## TC08

08- Kane

### Community Health

Contributed Session

Chair: George Miller, Institute Fellow, Altarum Institute, 3520 Green Court, Suite 300, Ann Arbor, MI, 48105, United States of America, george.miller@altarum.org

#### 1 - Collaborative Network Models between Specialty and Rural Hospitals via Telemedicine

Balaraman Rajan, PhD Candidate, University of Rochester, Simon School of Business, Carol Simon Hall, Rochester, NY, 14620, United States of America, balaraman.rajan@simon.rochester.edu, Rajeev Ramachandran, Abraham Seidmann

In this paper we analytically investigate the collaborative impact of telemedicine between the regional medical centers and the local community hospitals around them. We analyze the impact of telemedicine penetration on various models of competition, and collaboration. Our results explain how telemedicine can lead to either increased competition amongst hospitals serving the same general region, or to a mutually beneficial collaboration resulting in improved economic and clinical outcomes.

#### 2 - Enlighten Analytics: Enabling Analytics for Community Behavioral Healthcare Providers

Jason Luellen, Manager of Analytics: Research and Technology, Centerstone Research Institute, 44 Vantage Way, Suite 280, Nashville, TN, 37228, United States of America, jason.luellen@centerstone.org, Nathan Nehrt, Russell Galyon, Roger Jackson, Thomas Doub

Many behavioral healthcare providers are missing the potential for analytics to enhance care quality and safety while improving operational efficiency and reducing cost due to limited financial and technical resources. Enlighten Analytics, developed by the research arm of Centerstone, a large, non-profit community behavioral healthcare provider, gives other behavioral healthcare providers access to sophisticated analytics without significant cost or investment in technical expertise.

#### 3 - Adverse Events Generated from the Use of Infusion Pumps: Statistical Figures from Brazil and USA

Flavio Fogliatto, Professor of Engineering, Federal University of Rio Grande do Sul, Rua Osvaldo Aranha, 99 sala 615, Porto Alegre, 90035190, Brazil, fogliatto@producao.ufrgs.br, Francisco Kliemann, Leria Holsbach

The use of health services by the population is not optional but a necessary condition for recovery and prevention of health, demanding proper use of medical devices. The objective of this research is to identify the main causes of adverse events generated in healthcare from the use of infusion pumps. For that we conducted a study in three steps. First, a database from the Technical Surveillance Unit of the Brazilian Health Surveillance Agency, comprised of medical devices' malfunction reports, was mined. The analysis included the years 2006 to 2011 covering a total of 1,971 reports, 251 of them concerning infusion pumps. Next we analyzed 29,451 reported adverse events concerning infusion pumps that were received by the North American Food and Drug Administration in the year 2010. We finally generated statistics on the two datasets, and concluded on their main characteristics.

#### 4 - Exploring the Relative Cost-Effectiveness of Community-Based Versus Clinical Preventive Services

George Miller, Institute Fellow, Altarum Institute, 3520 Green Court, Suite 300, Ann Arbor, MI, 48105, United States of America, george.miller@altarum.org

We investigate the assertion that community-based efforts to prevent medical conditions are generally more cost-effective (and more often cost saving) than clinical preventive services. We present limited empirical evidence for the assertion, discuss some of the technical difficulties in assessing the value of community prevention efforts, describe an analytical structure that is being developed as a tool for establishing such value, and illustrate use of the tool.

## TC09

09- McHenry

### Patient Flow Models

Cluster: Healthcare Operations Management

Invited Session

Chair: Retsef Levi, Professor, Massachusetts Institute of Technology, Sloan School of Management, 30 Wadsworth Street-Building E62-562, Cambridge, MA, 02142, United States of America, retsef@mit.edu

#### 1 - Information Sharing and Coordination for Pareto Improvement of EDs on Patients' Wait Time

Hung Do, Assistant Professor, University of Vermont, School of Business Administration, Burlington, VT, 05405, United States of America, hdo@uvm.edu, Masha Shunko

One method to decrease Emergency Department (ED) crowding is using central control of ambulance traffic to balance the load between the EDs. This problem has been addressed in emergency medicine and OM literature from the average wait time perspective. We contribute to this stream by focusing on the impact of load balancing on the stochastic properties of the queues. We propose a family of coordination policies under which the wait time at each ED is stochastically smaller and less variable.

#### 2 - Triage and Patient Flow Design in Hospital Emergency Departments

Soroush Saghafian, Arizona State University, Phoenix, AZ, United States of America, Soroush.Saghafian@asu.edu, Wallace Hopp, Mark Van Oyen, Jeffrey Desmond, Steven Kronick

Most emergency departments (ED's) use urgency-based triage systems that classify and prioritize patients almost exclusively based on urgency. We propose an augmented triage system for ED's which incorporates both patient complexity and urgency. Using a combination of analytic and simulation models calibrated with hospital data, we find that the new triage system significantly improves both patient safety and operational efficiency. To gain further benefits, we next present innovative ED patient flow designs that effectively utilize the information collected at triage.

### 3 - Optimal Design of Post-Discharge Treatment Plans for Combatting Readmissions

Jonathan Helm, Assistant Professor, Indiana University, 1275 East Tenth Street, Business School, Room 680, Bloomington, IN, 47405, United States of America, helmj@indiana.edu, Jon Stauffer, Adel Alaeddini

Hospital readmission is a serious healthcare issue costing \$15 billion dollars per year, of which it is estimated \$12B was potentially preventable. Proper post-discharge management has been shown to reduce readmission rates. We use OR to optimize post-discharge treatment plans by determining (1) what days a follow-up organization should be open, (2) how many resources to allocate to each specialty at the follow-up organization, (3) when to schedule patients leaving the hospital for a follow-up.

### 4 - On the Access-Throughput Spiral Effects in Large Academic Centers

Retsef Levi, Professor, Massachusetts Institute of Technology, Sloan School of Management, 30 Wadsworth Street, Building E62-562, Cambridge, MA, 02142, United States of America, retsef@mit.edu, Bethany Daily, Ulrich Schmidt, Peter Dunn, Benjamin Christensen, Cecilia Zenteno

We demonstrate empirically and statistically the surprisingly adverse impact of patient flow disruptions from ICU to regular bed floors in large academic hospitals. We call this the Access-Throughput Spiral Effect.

## TC10

10- Cook

### Organ Transplant Waitlist Models

Cluster: Healthcare Scheduling

Invited Session

Chair: David Stanford, Professor, University of Western Ontario, Dept. of Statistical & Actuarial Science, 1151 Richmond St. N., London, ON, N6A 5B7, Canada, stanford@stats.uwo.ca

#### 1 - Accept/Decline Classifiers for the Liver Simulated Allocation Model

Sang-Phil Kim, Research Associate, University of Minnesota, 111 Church St. SE, Minneapolis, MN, 55455, United States of America, ksp@umn.edu, Diwakar Gupta

Simulated Allocation Models (SAMs) are used to evaluate the impact of proposed allocation policies on the distribution of organs, waitlist statistics, and post-transplant outcomes. A key module in SAMs is a classifier that determines whether a matched candidate under a specific allocation policy will accept or decline an offered organ. The classifier needs to produce realistic results based on donor, candidate, and policy attributes. We report ongoing efforts to train different classifiers for liver candidates, challenges encountered, and solutions proposed.

#### 2 - Addressing Waiting Time Inconsistencies in Transplantation

David Stanford, Professor, University of Western Ontario, Dept. of Statistical & Actuarial Science, 1151 Richmond St. N., London, ON, N6A 5B7, Canada, stanford@stats.uwo.ca, Natasha Chandok, Vivian McAlister, Jung Min(Clara) Lee

Studies of wait times for transplantation have revealed a common pattern: recipients of blood type O wait on average substantially longer than blood type A. This situation arises in many countries, and the phenomenon has come to be known as the "blood type O problem." I will present a hybrid policy in which O-to-B and A-to-AB cross-blood-type transplantation is allowed while the rest are barred, thereby providing access to each patient to roughly half of the available supply. We establish that the fraction of needed cross-transplantation is ensured to be small.

#### 3 - A Priority Queue Model with Abandonments for Organ Transplantation

Steve Drekic, Associate Professor, University of Waterloo, Statistics and Actuarial Sciences, Waterloo, ON, Canada, sdrekic@uwaterloo.ca, Douglas Woolford, David Stanford

In many jurisdictions, organ allocation for transplantation is done on the basis of the health status of the patient, either explicitly or implicitly. This talk presents a self-promoting priority model which takes into account changes in health status over time. In this model, most patients arrive as "regular" customers to the queue, but once the health of a patient has degraded, their status is promoted to "priority" to reflect the increased urgency of the transplant. We model the queueing system as a level-dependent quasi-birth-and-death process. The steady-state joint queue length distribution as well as the marginal delay distributions for each queue are computed via the use of matrix analytic techniques. Performance measures such as the mean and distribution of the time until transplant are obtained. At the of submitting the abstract, it is our hope to be able to present numerical illustrations based upon real waitlist data from a liver transplant waitlist in a region of Canada.

## TC11

11- Dupage

### Modeling Methods and Applications in Hospital Performance Improvement

Cluster: Improving Hospital Operations

Invited Session

Chair: Shinyi Wu, Assistant Professor, University of Southern California, 3715 McClintock Ave., GER 240, Los Angeles, CA, United States of America, shinyiwu@usc.edu

#### 1 - A Systems Approach to Improve Bedside Patient Rescue (BPR) on Hospital Floor

Xiaolei Xie, Research Assistant, University of Wisconsin-Madison, 1513 University Ave., 3247 Mechanical Engineering Bldg, Madison, WI, 53706, United States of America, xxie6@wisc.edu, Jeanne Huddleston, Yue Dong, Jingshan Li, Thomas Rohleder, Colleen Swartz

In this paper, a systems approach is presented to improve operations related to bedside patient rescue (BPR) process. A five-module (triage, patient, floor, RRT and ICU) framework is proposed to systematically study the correlations and interactions among all the factors related to BPR. Under this framework, simulation model using ARENA has been developed, which provides a quantitative tool for medical professionals to improve BPR process.

#### 2 - An Agent-Based Model to Study Health System

Pai Liu, University of Southern California, 240 GER, Los Angeles, CA, 90007, United States of America, liup04@gmail.com

We proposed an agent-based model to study the US health delivery system and payment model. Our model includes interacting agents representing the key players in the health system. The agents would respond to the policy by changing their behaviors. This model can serve as a tool for decision makers to test different policy designs and scenarios to understand the complexity and mitigate the risks involved with this new approach.

#### 3 - Modeling and Analysis for Risk-Based Cervical Cancer Screening

Julie Hagle, University of Southern California, Industrial and Systems Engineering, Los Angeles, CA, 90089, United States of America, hagle@usc.edu, Adriana Ley Chavez

We examine the cost-effectiveness of personalized strategies for cervical cancer based on a patient's risk of acquiring HPV infection. Our analysis incorporates imperfect sensitivity and specificity of screening tests, and considers tests results as a function of the lesion status. Our finding demonstrate that risk-differentiated screening strategies are likely to result in more cost-efficient and medically effective screening than current strategies.

## TC12

12- Water Tower

### Topics in Patient Flow

Cluster: Patient Flow and Care Coordination

Invited Session

Chair: Amy Cohn, University of Michigan, 1205 Beal Avenue, Ann Arbor, MI, 48109, United States of America, amycohn@med.umich.edu

#### 1 - Analysis of Treatment Location for Pediatric Asthma Patients

Amy Cohn, University of Michigan, 1205 Beal Avenue, Ann Arbor, MI, 48109, United States of America, amycohn@med.umich.edu, Michelle Macy, Allison Cator, Joseph East, Tara Lynn O'Gara, Jason Card, Emily Burns

We model and analyze the treatment of pediatric emergency patients in the emergency department versus in the general ward. Our focus is on differences in length-of-stay, primarily as a function of fixed rounding times in the general ward. We discuss the implications of this both for the asthma patients and for general capacity utilization.

#### 2 - Patient Bed Assignments with Isolation Requirements: An OR Approach

Rubén Proaño, Assistant Professor, Rochester Institute of Technology, Gleason College of Engineering, Rochester, NY, 14623, United States of America, rpmeie@rit.edu, Michael Kuhl, Christina Cignarale

Hospital units with single and double bed rooms need to make bed assignment decisions while preventing hospital acquired infections. In order to do so, hospitals implement isolation requirements that determine the type of patients that can share a room, which result in internal movements (i.e., patient shuffles). We present an optimization based approach to ensure that the unit is used by the most critical patients, while incurring in the least number of internal movements.

### 3 - Modelling the Inpatient and Emergency Resource Utilization of Chronic Dialysis Patients

Shoshana Hahn-Goldberg, Post Doctoral Fellow, Centre for Innovation in Complex Care, 294 Mullen Drive, Thornhill, ON, L4J2P2, Canada, Shoshana.Hahn-Goldberg@uhn.ca, Dante Morra, Eric Chow, Tai Huynh, Hannah Wong

This project uses systems dynamics modeling to predict hospital utilization of chronic dialysis patients in Ontario, based on various demographic and system factors. Scenarios are tested to predict the effects of changing trends in demographics and possible policy changes to the dialysis modality targets. The results have implications for the allocation of inpatient resources.

### TC13

13- Navy Pier

#### Issues in Public Health

Sponsor: Public Programs, Services and Needs

Sponsored Session

Chair: Banafsheh Behzad, PhD Candidate, University of Illinois at Urbana-Champaign, 104 S. Mathews Avenue, Urbana, IL, 61801, United States of America, behzad1@illinois.edu

#### 1 - Modeling the Growing Cost Burden of Anti-Vascular Endothelial Growth Factors for Ophthalmologic Use

David Hutton, Assistant Professor, University of Michigan, 1415 Washington Heights, Ann Arbor, MI, 48109, United States of America, dwhutton@umich.edu, Joshua Stein, Mrinalini Tavag, Paula Anne Newman-Casey

Bevacizumab and ranibizumab are both used to treat macular degeneration and diabetic macular edema. Ranibizumab is FDA-approved, and may have higher efficacy and lower side-effects than bevacizumab, but costs are much higher. We use mathematical models of the use of these drugs for both macular degeneration and diabetic macular edema to predict the long-term impacts on public health financing for Medicare, overall health spending, and health outcomes.

#### 2 - RHEA: Agent-Based Modeling to Help Infectious Disease Control in a Health System

Bruce Lee, Associate Professor, University of Pittsburgh, 200 Meyran Avenue,, Suite 200, Pittsburgh, PA, 15213, United States of America, BYL1@pitt.edu, Sarah Bartsch, Kim Wong, Ashima Singh, Shawn Brown, Taliser Avery, Diane Kim, Susan Huang

Health systems include multiple acute and long-term care facilities and forming a complex ecosystem connected by flows of patients via transfers, admissions, and discharges. Infectious disease outbreaks and infection control measures in one or more facilities can reverberate throughout the ecosystem. RHEA (Regional Healthcare Ecosystem Analyst) is a computer modeling software tool developed to better understand the spread and control of infectious diseases in a health system.

#### 3 - Quantifying the Association Between Obesity, Automobile Travel and Caloric Intake

Banafsheh Behzad, PhD Candidate, University of Illinois at Urbana-Champaign, 104 S.Mathews Avenue, Urbana, IL, 61801, United States of America, behzad1@illinois.edu, Sheldon Jacobson, Douglas King

This paper presents a statistical model to capture the association between average adult body mass index, automobile travel, and caloric intake in the U.S. to estimate the impact of changes in diet and travel choices on national obesity rates. Multicollinearity across the independent variables was alleviated through ridge regression and partial least square regression. The statistical model concludes that small changes in travel or diet result in comparable changes in obesity.

#### 4 - Dynamic, Robust Location Decisions to Improve Cholera Treatment Accessibility in Haiti

Jessica Heier Stamm, Kansas State University, 2023 Durland Hall, Manhattan, KS, United States of America, jlhs@k-state.edu

In humanitarian and public health settings, organizations act independently to locate facilities to serve an affected population. In this decentralized, dynamic environment, accessibility may suffer in comparison to a system where a single planner locates facilities to optimize access for all. Centralized models are complicated by parameter uncertainty and efficiency - equity tradeoffs. We propose methods to address these challenges and apply them to cholera treatment facility location in Haiti.

### TC15

15- O'Hare

#### Surveillance at a Patient and a Population Level

Cluster: Medical Decision Making

Invited Session

Chair: Nedialko B. Dimitrov, Naval Postgraduate School, 1 University Circle, Monterey, CA, 93943, United States of America, ned@nps.edu

#### 1 - Evaluation of New Biomarkers for Prostate Cancer Screening

Christine Barnett, University of Michigan, 1205 Beal Avenue, Ann Arbor, MI, 48109, United States of America, clbarnet@umich.edu, James Montie, Brian Denton, Scott Tomlins, John Wei

Recent advances in the development of new biomarker tests, which physicians use for the early detection of cancer, have the potential to improve patient survival and lower the cost of treatment by catching cancer at an early stage. A simulation model will be presented that will analyze how best to use new biomarker tests during screening to increase survival and quality adjusted survival, and how to tradeoff the benefits of additional life years gained with the cost and harms of new biomarkers.

#### 2 - Simulation Optimization of the Clinical Decision-Making Process for Prostate Cancer

Daniel Underwood, North Carolina State University, Raleigh, NC, United States of America, daniel.underwood@ncsu.edu

We present a simulation-optimization model for finding near optimal strategies for prostate cancer screening and treatment, including decisions related to screening by prostate-specific antigen (PSA), treatment by radical prostatectomy, and active surveillance (AS). We discuss a simulation-optimization method for solving our problem. We present results, based on longitudinal data for a large North American population, to study how AS affects the expected benefit of prostate-cancer screening.

#### 3 - Designing the U.S. National Influenza Surveillance Network

Nedialko B. Dimitrov, Naval Postgraduate School, 1 University Circle, Monterey, CA, 93943, United States of America, ned@nps.edu, Samuel Scarpino, Lauren Ancel Meyers

The U.S. employs approximately 82 public health laboratories in a national influenza surveillance system. The system has three goals 1) to characterize the rise and fall of the annual influenza season 2) to detect novel and rare influenza viruses in the population and 3) to estimate the fraction of rare influenza over typical influenza. We present results of a research contract with the Association of Public Health Laboratories to design the national surveillance system.

**Tuesday, 3:30pm - 5:00pm**

### TD01

01- Chicago F

#### Healthcare Scheduling

Cluster: Healthcare Operations Management

Invited Session

Chair: Michael Carter, University of Toronto, 5 King's College Road, Mechanical and Industrial Engineering, Toronto, ON, M5S 3G8, Canada, mike.carter@utoronto.ca

#### 1 - Developing an OR Toolkit for Elective Surgeries: Stochastic Modeling to Improve Patient Certainty

Sherry Weaver, PhD Student, University of Calgary, 2500 University Drive NW, Calgary, AB, T2N1N4, Canada, sweaver@ucalgary.ca, Michael Carter

Effective and efficient scheduling of elective surgical patients is highly dependent upon certainty in operating room allocations, surgeon availability, and a predictable arrival rate of higher-priority patients. This certainty rarely exists and patients are often put on lengthy surgical waitlists and called once their date approaches. An improved system, using stochastic modeling and a simple Excel-based DSS for operational support is proposed and its pilot implementation described.

## 2 - Achieving User Acceptance of a Generic Simulation Model of Surgical Patient Flow

Daphne Sniekers, University of Toronto, 323 Victoria Park Ave., Toronto, ON, M4E 3S7, Canada, daphne.sniekers@utoronto.ca, Michael Carter

Demonstrating accuracy of a simulation model of a large, complex real system, such as perioperative patient flow, is bound to be challenging. The experience of validating a generic perioperative simulation-based model at six hospitals has been no exception. Despite the gaps in statistical validity, there is confidence that the model is accurate and acceptable as a decision tool. This talk will focus on how to achieve user acceptance such that there is trust in the results for decision-making.

## 3 - Variations in Computed Tomography (CT) Utilization and Access: Linear Regression Approach

Sabrina Tang, University of Toronto, 75 Emmett Ave., Toronto, ON, M6M5A7, Canada, sabrina.tang@utoronto.ca, Sonia Vanderby, Michael Carter

Increased demand for CT exams and high costs have led to long wait times in Saskatchewan. The aim is to assess the current situation and model different appointment booking policies to balance utilization, lower wait times, and reduce patient travel burdens. Data on CT utilization, patients, and population demographics will be analyzed to evaluate imbalances between geographic regions and accessibility disadvantages for remote and rural populations. The focus will be on Saskatoon Health Region.

## TD02

02- Chicago G

### Evidence Based Approaches to Resource Management in Healthcare

Sponsor: Data Mining

Sponsored Session

Chair: Artur Dubrawski, Senior Systems Scientist, Carnegie Mellon University, The Robotics Institute, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States of America, awd@cs.cmu.edu

#### 1 - Mining Patient Insurance Coverage Distribution to Determine Impact of Policy Changes

Archana Ramakrishnan, Masters Student, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA, 15213, United States of America, archanark@cmu.edu, Karen Chen, Artur Dubrawski, Ryan McDermitt

By looking at hospital admission records, we observe that temporal distributions of hospital visits by payer categories remain largely consistent. Changes in these distributions may reflect changes in policy or economy. Through stratified analysis, we aim to find patterns that will in the long-term aid hospitals strategize for changes in revenue models. In this presentation, we provide and discuss the most interesting of our results.

#### 2 - Optimizing Order Sets in the Pediatric Environment: Toward Safer and Efficient Patient Care

Yiye Zhang, Carnegie Mellon University, 4800 Forbes Ave., Pittsburgh, PA, 15213, United States of America, yiyez@andrew.cmu.edu, Rema Padman, James Levin

Physical and cognitive workload imposed on users due to poor usability of healthcare IT can be observed in the use of order sets. We develop an order set optimization platform that allows users to re-design order sets by identifying items for constituting order sets that are relevant based on historical ordering data wherein items for a single patient are often placed together or in close temporal proximity. Evaluation using real patient data indicates that this evidence-based approach improves order set quality and generalizability.

## 3 - Hospital Characteristics, Health Information Technology, and Stage 1 Meaningful Use Achievement

Jingyun Li, The University of Texas at Dallas, 800 W. Campbell Rd., Richardson, TX, 75080, United States of America, jxl097620@utdallas.edu, Indranil Bardhan

We study the characteristics of hospitals that are likely to achieve Stage 1 meaningful use. We find that acute care, for-profit and non-profit hospitals are more likely to achieve Stage 1 MU. Hospitals with EMR and those that use health IT are also likely to achieve Stage 1 MU. Our results suggest strong associations between hospital ownership, health IT and Stage 1 MU compliance.

## TD03

03- Chicago H

### Optimization and Analytics

Contributed Session

Chair: John Silberholz, PhD student, Massachusetts Institute of Technology, 77 Mass. Ave., Bldg E40-130, Cambridge, MA, 02139, United States of America, josilber@mit.edu

#### 1 - Gradient Based Direct Aperture Optimization for Ultra-Fast Radiation Therapy Treatment Planning

Mark Bangert, German Cancer Research Center - DKFZ, Im Neuenheimer Feld 280, Heidelberg, 69126, Germany, m.bangert@dkfz.de, Silke Ulrich, Peter Ziegenhein, Simeon Nill, Uwe Oelfke, Esther Wild

We present an efficient direct aperture optimization (DAO) algorithm for radiation therapy treatment planning that relies on gradient information only. It applies an ultra-fast implementation of the objective function and gradient calculation to reduce the overall runtime to a couple of seconds. According to a treatment planning study comprising eight patient cases, the resulting DAO treatment plans are close to theoretically ideal yet impracticable solutions.

#### 2 - Outcome and State Transition Modeling using a Robust IPTW Method for Adaptive Interdisciplinary Pain

Aera LeBoulluec, Graduate Teaching Assistant, University of Texas at Arlington, 2205 Hunter Place Lane, Arlington, TX, 76006, United States of America, aerakim77@yahoo.com, Robert Gatchel, Victoria Chen, Li Zeng, Jay Rosenberger

This research seeks adaptive treatment strategies for interdisciplinary pain management. Our framework employs approximate dynamic programming with state transition and outcome models estimated from actual patient data. We developed a process based on the inverse-probability-of-treatment weighted method to address endogeneity while estimating state transition and outcome models.

#### 3 - An Analytics Approach to Designing Clinical Trials for Cancer

John Silberholz, PhD Student, Massachusetts Institute of Technology, 77 Mass. Ave., Bldg E40-130, Cambridge, MA, 02139, United States of America, josilber@mit.edu, Dimitris Bertsimas, Allison O'Hair, Stephen Relyea

We present a data-driven approach for designing new clinical trials for cancer chemotherapy treatments. Our approach combines (i) construction of a large-scale database of clinical trial results, (ii) statistical modeling to predict outcomes of new drug combinations, and (iii) optimization models to select novel treatments that strike a balance between maximizing patient outcomes (exploitation) and learning new things about treatments that may be useful in the future (exploration).

## TD04

04- Scottsdale

### Mathematical Models in Cancer Therapy

Sponsor: Healthcare Applications Society

Sponsored Session

Chair: Archis Ghate, Associate Professor, University of Washington, Seattle, WA, United States of America, archis@uw.edu

#### 1 - A Mathematical Framework for the Fractionation Problem in Concurrent Chemoradiation Therapy

Ehsan Salari, Massachusetts General Hospital, 55 Fruit Street Boston, Radiatio Oncology, Francis H. Burr Proton, Boston, MA, 02114, United States of America, Salari.Ehsan@mgh.harvard.edu, David Craft, Thomas Bortfeld, Jan Unkelbach

We consider the fractionation problem for concurrent chemoradiation therapy in which the chemotherapeutic agent mainly performs as a radiosensitizer. The radiosensitization effect improves the local tumor control at the expense of increasing normal tissue complications. We incorporate this effect into the fractionation problem using an extended biologically-effective dose (BED) model to determine the optimal radiation and chemo agent dose to be administered per fraction.

#### 2 - Stochastic Modeling to Understand the Cancer Field Effect

Kevin Leder, University of Minnesota, 111 Church Street SE, Minneapolis, MN, 55455, United States of America, Kevin.Leder@isye.umn.edu, Richard Durrett, Jasmine Foo, Marc Ryser

The cancer field effect was first discussed by Slaughter in 1953. He observed that oral cancers were surrounded by abnormal tissue and had high rates of local recurrence. Since the original paper this phenomena has been observed in a variety of tumors. In this talk I will introduce a spatial stochastic model that can be used to study this phenomena. In particular I will discuss model predictions of recurrence times and the size of the cancer field surrounding the tumor.

#### 3 - Optimal Fractionation Schedules in IMRT for Prostate Cancer

Fatemeh Saberian, University of Washington, Seattle, WA, United States of America, saberian@uw.edu, Minsun Kim, Archis Ghate

We present an integrated optimization model to simultaneously optimize the radiation intensity profiles as well as the number of treatment sessions in IMRT. An interior point algorithm is used to solve the resulting nonlinear optimization problem. We present results for a prostate test case.

## TD05

05- Miami

### Joint Session HAS/ISIM: Healthcare Applications at Mayo Clinic

Sponsor: Healthcare Applications Society & Simulation Society

Sponsored Session

Chair: Benjavan Upatising, Research Assistant, PhD Candidate, Purdue University, Grissom Hall, 315 North Grant Street, West Lafayette, IN, 47907, United States of America, benjavan@purdue.edu

#### 1 - Determining the Ideal Size and Scheduling System for a Proton Therapy Treatment Facility

Douglas L. Berninger, Senior Principle Health System Analyst, Mayo Clinic, 200 First Street SW, Rochester, MN, 55905, United States of America, berninger.doug@mayo.edu

In developing the financial effects analysis for the Proton Beam Therapy facility, two main questions are: how many treatment rooms should be built and how many patients can be treated per day? This is complicated by the fact that there is only a single proton beam, and it can only be used on one patient at a time. In addition, there are several scheduling criteria that must be traded off when optimizing the output of the facility. MedmodelTm was used to simulate facilities ranging from 2 to 5 rooms. Excel Visual Basic was used to schedule the patients.

#### 2 - Application of Systems Engineering and Operations Research Methodology at Mayo Clinic Laboratories

Fazlollaah Amirahmadi, Systems Engineering Manager, Mayo Clinic, 3050 Superior Drive NW, Rochester, MN, 55901, United States of America, Amirahmadi.Fazi@mayo.edu

The goal of this presentation is to share some of the projects that have used discrete-event simulation, design of experiments, and optimization tools at Department of Laboratory Medicine and Pathology (DLMP). We have used discrete-event simulation to reduce patient wait time by 50% through "Desk C" area at Clinical Laboratory Services; save 400 walking hours per year for blood delivery to surgical suites at Transfusion Laboratory; reduce supply expenses by \$100,000/year at Automated Immunoassay (AIA) Laboratory; and 20% FTE avoidance because of resource reallocation at Molecular Hematopathology

Laboratory. An integer programming was used to optimize matching Clinical Laboratory Science (CLS) graduates with open positions at DLMP and applied design of experiments (DOE) to reduce test repeat rate at Molecular Genetics which resulted in annual savings of \$500,000.

#### 3 - Effects of Home Telemonitoring Between Frailty States and Death for Older Adults: An RCT

Benjavan Upatising, Research Assistant, PhD Candidate, Purdue University, Grissom Hall, 315 North Grant Street, West Lafayette, IN, 47907, United States of America, benjavan@purdue.edu, Paul Y. Takahashi, Gregory J. Hanson, Young L. Kim, Stephen S. Cha, Yuehwern Y. Yih

We conducted a secondary analysis of a Tele-ERA clinical trial at Mayo Clinic to evaluate the effect of home telemonitoring in reducing the decline in frailty states and death in older adults with comorbid health problems. Multiple logistic regression, Kaplan-Meier, and Cox proportional hazards methods were utilized to analyze frailty transition, evaluate each frailty criteria for mortality, and compute unadjusted hazard ratios, respectively.

## TD06

06- Los Angeles

### Stochastic Models in Medical Policy Making

Cluster: Medical Decision Making

Invited Session

Chair: F. Safa Erenay, Assistant Professor, University of Waterloo, Management Sciences Department, 200 University Avenue, Waterloo, ON, N2L 3G1, Canada, ferenay@uwaterloo.ca

#### 1 - Allocation Policies in Blood Transfusion

Hossein Abouee Mehrizi, Assistant Professor, University of Waterloo, Management Sciences Department, Waterloo, ON, Canada, haboueeem@uwaterloo.ca, Opher Baron, Oded Berman, Vahid Sarhangian

Red blood cells transfusion is an integral part of many treatments. Recent studies suggest correlation between receiving older blood and increased risk of adverse outcomes. The major research question is: Is there an allocation policy which can reduce the age of transfused blood without jeopardizing its availability? To answer the question, a threshold policy has been introduced. We analyze the policy using a stylized queueing model and obtain the distribution of the age of the transfused blood.

#### 2 - Improving Access to Community-Based Chronic Care Through Improved Capacity Allocation

Tingting Jiang, PhD Candidate, Northwestern University, Evanston, ID, United States of America, tingting-jiang@northwestern.edu, Karen Smilowitz, Sarang Deo, Seyed Iravani

We study a model of community-based healthcare for chronic diseases. Patients periodically access the healthcare system, influencing their disease progression and health outcomes. The provider's goal is to maximize community-wide health outcomes, subject to capacity constraint. We investigate how the provider can improve her objective through better operational decisions by implementing a dynamic resource allocation policy as opposed to a standard static allocation policy.

#### 3 - A Market Design Approach to the Adoption of Children in Pennsylvania

Mustafa Akan, Assistant Professor of Operations Management, Carnegie Mellon University, Tepper School of Business, 5000 Forbes Ave., Pittsburgh, PA, 15213, United States of America, akan@andrew.cmu.edu, Utku Unver, Onur Kesten

Adoption is an important phenomenon in the U.S. Notwithstanding the growing demand and prominence of the issue, little is known about how to operationalize child adoption, i.e., what assignment protocol needs to be employed by agencies. Inspired by our collaboration with Pennsylvania's Statewide Adoption Network, we study child adoption through the lens of operations and economics, and make recommendations for alternative systems that can ameliorate the deficiencies of current assignment plans.

## TD07

07- Kansas City

### Modeling Surgical and Operating Room Costs

Sponsor: POMS, College of Healthcare Operations Management

Sponsored Session

Chair: Vikram Tiwari, Assistant Professor of Anesthesiology, Vanderbilt University Medical Center, P.O. Box 121586, Nashville, TN, 37212, United States of America, vikram.tiwari@vanderbilt.edu

#### 1 - Making Comparisons of Surgical Case Durations among Hospitals to Identify Lower Cost Facilities

Franklin Dexter, Professor, University of Iowa, Anesthesia, 6JCP, Iowa City, IA, 52242, United States of America, franklin-dexter@uiowa.edu, Richard Epstein, Emine Bayman, Johannes Ledolter

Using several datasets, we show facilities and their anesthesia groups need to calculate statistics if price transparency (consumer-driven healthcare) were desired. Insurers and/or governments alone cannot provide cost of surgery professional information because of heterogeneity among facilities in medians and coefficients of variations of durations. Absence of cost information for patients is not due to a failure of the insurance industry and/or regulatory agencies. Insurers and/or government can though provide inferential comparisons of durations among facilities (i.e., P-values).

#### 2 - Comparison of Documented Anesthetic End Times and Claimed Extended Hours

Brian Rothman, MD, Vanderbilt University Medical Center, 1301 Medical Center Drive, 4648 TVC, Nashville, TN, 37232, United States of America, brian.rothman@vanderbilt.edu

Separate processes to document end time of medical direction and the payroll claim of overtime may lead to time differences greater than an expected 15-minute period between the two. The mean for attending physicians was 18.82 minutes, and differences increased as end times grew later. Automatically generated payroll end times could lower costs and decrease entry errors while ensuring accurate staff compensation. Further research to understand bottlenecks causing mismatches is warranted.

#### 3 - Explanation for the Near Constant Mean Time Remaining in Surgical Cases Exceeding their Duration

Vikram Tiwari, Assistant Professor of Anesthesiology, Vanderbilt University Medical Center, P.O. Box 121586, Nashville, TN, 37212, United States of America, vikram.tiwari@vanderbilt.edu, Franklin Dexter, Brian Rothman, Jesse Ehrenfeld, Richard Epstein

If an on-going case is estimated to end in 1 hour, and 45 minutes later the case has not finished, and closure has not started, previous research shows that the mean time remaining is around 1 hour, not 15 minutes. This is a direct mathematical consequence of the log-normal distributions of operating room case durations. We test the hypothesis that functionally, until closure begins, the mean time remaining is always at least as long as the mean time from the start of closure to OR exit.

## TD08

08- Kane

### EMR, EHR, HIT – Implementation Barriers and Strategies

Cluster: Rural Health

Invited Session

Chair: Larry Gamm, Director, Ctr. for Health Organ Transformation, Texas A&M Health Science Center, Health Policy and Management, Adriance-Admin., Rm. 362B, MS1266, College Station, TX, 77843, United States of America, gamm@srph.tamhsc.edu

#### 1 - Project HealthDesign: HIT in the Home Engages Patients in Self Care

Patricia Brennan, Moehlman Bascom Professor, University of Wisconsin-Madison, School of Nursing/College of Engineering, 600 Highland Avenue H6/244, Madison, WI, 53792, United States of America, pbrennan@engr.wisc.edu

Project HealthDesign, a national program of the Robert Wood Johnson Foundation, sought to design information tools to support patients' health awareness and their ability to take health action in everyday living and to integrate this awareness meaningfully into clinical care. We engaged 14 teams from around the US in a collaborative design, deployment and evaluation process. Each team engaged patient partners and health care systems to create a personal health information management tool, and evaluated the acceptability and impact of the innovation.

#### 2 - Lessons Learned about EHR Adoption by Rural Healthcare Providers

Yvonne Sanchez, Texas A&M Health Science Center, College Station, TX, United States of America, ysanchez@tamhsc.edu

A major challenge for rural health care providers' seeking to implement an EHR system is the complexity associated EHR selection and adoption, such as lack of knowledge about EHR systems, financial constraints, and uncertainty about cost and loss of office productivity while implementing an EHR. Since the implementation of the HITECH Act, with CMS' EHR incentive funds and ONC's establishment of health IT Regional Extension Centers (REC) to help providers adopt EHR, this presentation will address lessons learned by RECs in working with rural providers to adopt certified EHR technologies.

#### 3 - Improving the Selection of Electronic Medical Record Super Users: A Qualitative Study

Nicholas Edwardson, Assistant Director, Texas A&M Health Science Center, TAMU 1266, College Station, TX, 77843, United States of America, edwardson@srph.tamhsc.edu, Larry Gamm

Conventional wisdom on selecting an ideal EMR super user called for finding an individual with high computer proficiency and high peer-to-peer trustworthiness. The intention of this study was to identify additional factors that implementation leaders ought to consider when selecting EMR super users. Using social network theory, this study explored additional factors in super user selection that impacted the implementation of an EMR at a large, fully integrated multi-specialty clinic.

#### 4 - EMR Implementation in a Rural Clinic – A Mixed Method, Longitudinal Analysis Gamm

Larry Gamm, Director, Ctr for Health Organ Transformation, Texas A&M Health Science Center, Health Policy and Management, Adriance-Admin, Rm 362B, MS1266, College Station, TX, 77843, United States of America, gamm@srph.tamhsc.edu

This study reflect EMR implementation in a busy and modern rural health clinic located within a hundred yards of a critical access hospital and located in a community of several thousand near a major interstate highway. The research draws upon observations, interviews (qualitative data), and surveys (quantitative data) in three time periods over 18 months in implementing the EMR. The clinic includes 8 primary care providers, 8 nurses, 3 medical assistants, and 5 business staff members, and an administrator. Understanding the dynamics of the two way interaction between the stakeholders and the EMR change effort is critically important to the success of the proposed change. The first two waves of interviews and surveys (up through 8 months of EMR implementation) suggested slight recognition that the EMR would significantly reengineer work processes. A number of physicians noted a steep, time consuming learning curve at 8 months. Between the 8th month and 18th months growth of a widespread, but belated recognition of a need to restructure and retrain for new or redefined jobs in patient care had occurred. Nurses identified multiple expansions in their job duties with respect to entering information into the medical record and helping, at least some physicians, track the status of their orders, and communications. Some physicians reported that they were currently engaged with others in teams to improve templates and workflow. The clinic administrator discovered sometime between the 8 month and the 18 month marks that hiring, training, and other human resources functions had become much more demanding in light of changes "demanded" by the EMR. The hiring of a full-time on site EMR expert, for example, at the 15 month mark was widely heralded as a valuable addition. That training is underused until lack of it exacts a much higher price at a time the clinic "must play catch up." Purposeful reengineering of work processes in association with EMR implementation, if done, is usually done after unanticipated problems arise in the actual use of the EMR begin to arise. Staff stress associated with EMR implementation should not be viewed as a necessity, but as a preventable cost too often born by most staff, by the patient, and by the clinic. Finally, EMR implementation is too often viewed as a project and an end in itself when, instead, the focus should be on how EMR can contribute to improved processes to advance quality and efficiency of care.

## ■ TD09

09- McHenry

### **CHOIR (Center for Healthcare Operations Improvement and Research)**

Cluster: Healthcare Operations Management

Invited Session

Chair: Nikky Kortbeek, University of Twente, Academic Medical Center, Meibergdreef 9, Amsterdam, 1105AZ, Netherlands, n.kortbeek@amc.nl

#### **1 - Taxonomic Classification of Planning Decisions in Health Care: A Structured Literature Review**

Nikky Kortbeek, University of Twente, Academic Medical Center, Meibergdreef 9, Amsterdam, 1105AZ, Netherlands, n.kortbeek@amc.nl

This talk addresses the typical decisions to be made in the managerial field of resource capacity planning and control in healthcare. First, a taxonomy is presented which provides healthcare managers and OR/MS researchers with a method to identify and classify planning decisions. Second, following the taxonomy, for six care services, we provide an exhaustive specification of planning and control decisions. For each decision, we structurally review the key OR/MS literature.

#### **2 - Comparing Models for Ambulance Planning on the Strategic and Tactical Level**

Melanie Reuter, Karlsruhe Institute of Technology, Englerstraße 11, Building 11.40, Karlsruhe, 76131, Germany, melanie.reuter@kit.edu, Stefan Nickel, Johann Hurink, Theresia van Essen

Ambulance planning is done on different levels. The decision for base locations is usually made for a very long time (strategic level), but the number and location of used ambulances can be changed per year (tactical level). We present possible formulations for the problems on the different levels and discuss solution approaches that solve both levels either simultaneously or separately.

#### **3 - Assigning Treatment Rooms at the Emergency Department**

Maartje Van de Vrugt, PhD Candidate, University of Twente, Postbus 217, 7500 AE, Enschede, Netherlands, n.m.vandevrugt@utwente.nl, Richard J. Boucherie

We consider an emergency department in which two types of doctors have to share the available treatment rooms: emergency physicians (EPs) and residents. EPs occupy one room at the time, while each resident occupies multiple. Rooms are assigned according to a policy, which for example depends on the number of patients present. For both types of doctors and under various room assignment policies, we analyze the expected sojourn time of accepted patients, conditioned on their treatment time.

#### **4 - Integral Resource Capacity Planning for Inpatient Care Services**

Aleida Braaksma, University of Twente, Academic Medical Center Amsterdam, Drienerlolaan 5, Enschede, Netherlands, a.braaksma@utwente.nl, Nikky Kortbeek, Richard Boucherie, Ferry Smeenk, Piet Bakker

The challenge in decision making for inpatient care delivery is to guarantee care from appropriately skilled nurses and required equipment for patients, while making efficient use of resources. We present a stochastic analytical approach to predict bed census on nursing wards by hour, as a function of the Master Surgical Schedule and arrival patterns of emergency patients. Based on the hourly census predictions, flexible nurse staffing methods are proposed.

## ■ TD10

10- Cook

### **Capacity Management**

Contributed Session

Chair: Samuel Davis, Northeastern University, 11 Phillips St., Boston, MA, United States of America, davis.samuel.r@gmail.com

#### **1 - Preference Models for U.S. Hospital Resource Allocation**

Don Kleinmuntz, Exec VP & Chief Analytics Officer, Strata Decision Technology, 200 E Randolph St 49th Floor, Chicago, IL, 60601, United States of America, dnk@stratadecision.com

Health care reform in the U.S. poses unique challenges for hospitals and health care providers. This presentation will analyze the implications for modeling organizational preference for objectives related to cost, quality of care, and patient outcomes in the context of a decision analytic approach to resource allocation. The approach will be contrasted to approaches used in the UK and elsewhere for cost-effectiveness analysis. The discussion is informed by experience in implementing decision-analytic resource allocation models in hundreds of US hospitals.

#### **2 - A Decision Support Tool for Hip and Knee Osteoarthritis Health Service Delivery**

Sonia Vanderby, University of Saskatchewan, 57 Campus Dr., Rm. 2B37, Saskatoon, SK, S7N 5A9, Canada, sonia.vanderby@usask.ca, Deborah Marshall, AI-HS & CIHR Emerging Team

The rising prevalence of osteoarthritis is increasing the burden on already strained healthcare resources. Alberta Health Services managers lack tools to help inform difficult resource and process decisions. We present a system dynamics model developed as a decision support tool for the hip and knee osteoarthritis system. Simulating patients from disease onset through both medical and surgical management, the model provides insight into the resources needed to meet current and future demand.

#### **3 - The Inter-Relationship Between Seasonal Flu Infections, Vaccinations and Communications**

Vijay Viswanathan, Northwestern University, 1870 Campus Dr., 3rd Floor, Evanston, IL, 60208, United States of America, vijay-viswanathan@northwestern.edu, Kalyan Raman

This study examines the dynamic inter-relationships between flu vaccinations, communications and infections using a VAR Model. The study finds that increasing communication efforts had a positive impact on vaccination coverage and reversed an increasing trend in infections in the 2011-12 season. Increasing vaccination coverage also had a negative impact on infections. However, these effects were weaker in the more severe 2010-11 season. The results have important implications for public policy regarding communication efforts and vaccination coverage during seasonal flu seasons.

#### **4 - Improving Access and Patient Flow across a Multi-Specialty Safety Net Hospital**

Samuel Davis, Northeastern University, 11 Phillips St., Boston, MA, United States of America, davis.samuel.r@gmail.com, James Benneyan

Appointment access problems are ubiquitous in today's healthcare system. Our research problem is to find near-optimal trade-offs of key metrics pertaining to appointment access, patient wait time, physician utilization, and physician overtime. We use simulation and optimization to improve patient scheduling along these metrics at Boston Medical Center, an urban safety net hospital. Process and schedule improvements are made, and a tool is produced that other clinics can use to model and improve their appointment access and patient flow.

## ■ TD11

11- Dupage

### **Empirical Research in Hospital Operations**

Cluster: Improving Hospital Operations

Invited Session

Chair: Elisa Long, Assistant Professor, Yale School of Management, 135 Prospect Street, New Haven, CT, 06520, United States of America, elisa.long@yale.edu

#### **1 - Decomposing the Effect of Workload on Patient Outcomes**

Nicos Savva, London Business School, Regent's Park, London, NW1 4SA, United Kingdom, nsavva@london.edu, Stefan Scholtes, Michael Freeman

Extant literature has documented that in-patient outcomes deteriorate at high workloads. In this paper, we use data from the delivery unit (DU) of a teaching hospital to investigate two distinct mechanisms through which workload affects outcomes: (i) the amount of resources dedicated to patient care, (ii) the quality of execution given the resource provision. We estimate a model that overcomes problems associated with endogenous selection, to show evidence consistent with a reduction in the propensity of administering resource intensive treatments. We also show that outcomes deteriorate through both mechanisms.

#### **2 - Efficiency Analysis of Hospitals**

Sriram Venkataraman, Clemson University, 100 Surrine Hall, Clemson, SC, 29634, United States of America, svenkat@g.clemson.edu, Aleda Roth, Anita Tucker

This paper estimates efficiency of hospitals in the U.S. using input and output measures from publically available data sources. We estimate efficiency of hospitals in 3 dimensions: technical, quality of care and patient satisfaction. We further investigate some of the antecedents of global efficiency.

### 3 - Beyond Staffing Numbers: The Effect of Skill-Mix, Cohesion and Leadership on Adverse Events

Sandra Suelz, Universitaat zu Köln, Cologne Graduate School,  
Richard-Strauss-Straße 2, Köln, 50931, Germany,  
suelz@wiso.uni-koeln.de, Stefan Scholtes

We analyze the association between hospital nurse staffing and adverse events not only focusing on staffing numbers but also making use of team variables. Our empirical study shows that skill-mix and cohesion is relevant for the prevention of adverse events in hospitals.

## TD12

12- Water Tower

### Hospital Readmission Modeling and Analysis

Cluster: Patient Flow and Care Coordination

Invited Session

Chair: Yan Li, Research Assistant, Purdue University, 206 S. Martin Jischke Drive, West Lafayette, IN, 47906, United States of America, li528@purdue.edu

#### 1 - Reducing Readmissions: Modeling the Discharge Intervention Problem

Brandon Pope, Regenstrief Center for Healthcare Engineering,  
203 Martin Jischke Drive, West Lafayette, IN, 47906,  
United States of America, popeb@purdue.edu

The number and variety of models for predicting readmission risk has recently exploded due to attention stimulated by CMS penalties. However, the value of such a prediction is unknown, and even which decisions (if any) a risk prediction is informing is unclear. In this presentation we focus on modeling the discharge intervention problem, presenting several models and solutions of increasing complexity. We also present the details of a real-time decision support system implementation based on our discharge intervention model.

#### 2 - Decision Support Tool for Reducing Hospital Readmissions

Ramez Ayoub, Research Assistant, Purdue University,  
206 South Martin Jischke Drive, West Lafayette, IN, 47907,  
United States of America, rayoub@purdue.edu, Yan Li,  
Kathy Dale, Mark Alan Lawley

Medicare currently penalizes hospitals for excessive readmissions. To help hospitals respond, we developed a statistical model to estimate the probability of 30-day readmission in general medicine adult patients. This model forms the kernel of a decision support package to help hospitals select interventions and estimate impacts on in-patient revenue streams.

#### 3 - An Analytical Model for Gastroenterology Clinic Design

Xiang Zhong, University of Wisconsin-Madison, 1513 University Ave., Room 3235, Madison, WI, United States of America,  
Xzhong4@wisc.edu, Jie Song, Jingshan Li, Sue M. Ertl,  
Lauren Fiedler

This study is devoted to the analysis and design of the gastroenterology (GI) clinic at the new digestive health center (DHC) of University of Wisconsin Health. An analytic model of patient flow is developed and validated by the data in the existing clinic, and then used to evaluate the impact of different check-out policies (in exam room or scheduling room) on patient length of stay. It is shown that a mixed check-out process can achieve the best performance.

## TD13

13- Navy Pier

### Modeling Infectious Diseases

Cluster: International Health OR

Invited Session

Chair: Ozgur Araz, University of Nebraska Medical Center, Omaha, NE, 68198, United States of America, ozgur.araz@unmc.edu

#### 1 - Evaluating the Effectiveness of Targeted Public Health Control Strategies for Chlamydia Transmission

Monirul Islam, Assistant Professor, University of Nebraska Medical Center, Omaha, NE, 68198, United States of America,  
kmislam@unmc.edu, Ozgur Araz

Chlamydia is the most frequently reported bacterial sexually transmitted infection in the U.S. A cross-sectional survey was conducted to estimate the prevalence in the northern Douglas County. We use a compartmental transmission model to estimate the spread of chlamydia in young adults, which is also parameterized by this survey. Model based evaluation fed with community based surveys can inform public health decision making to prevent chlamydia transmission.

#### 2 - Stochastic Model of Measles Outbreaks and the Role of Community Connectivity

Kezban Yagci Sokat, Northwestern University, 2145 Sheridan Road C210, Evanston, IL, 60208, United States of America,  
kezban.yagcisokat@u.northwestern.edu, Benjamin Armbruster,  
Rebecca Wurtz

Susceptibility to measles is increasing due to decreased level of vaccination. We model the spread of measles using a stochastic simulation model. We find that while the outbreak size is larger in an inhomogeneous community (one with two subgroups), the differences are minimal. Also, the effect of the overall population size diminishes after a few hundred.

#### 3 - Statistical Evaluation of Google Flu Trends Data as a Predictor of ILI Related Emergency Department

Ozgur Araz, University of Nebraska Medical Center, Omaha, NE, 68198, United States of America, ozgur.araz@unmc.edu,  
Samantha Korpela

We performed correlation analyses to understand both temporal and spatial correlations between several predictors of ILI (Influenza-like Illness) related ED visits and ILI related ED visits data itself. We used data available for the state of Nebraska, Douglas County, the biggest county in this state, and for Omaha and Lincoln, the two major cities in the state. Google Flu Trends data performs statistically well in predicting the ILI related ED visits in Douglas County.

## TD15

15- O'Hare

### Empirical Operations in Healthcare

Sponsor: Healthcare Applications Society

Sponsored Session

Chair: Vishal Ahuja, University of Chicago, Booth School of Business, 5807 S. Woodlawn Ave., Chicago, IL, 60637, United States of America, vahuja@chicagobooth.edu

#### 1 - The Diseconomies of Pooling in Discretionary Work Settings: An Investigation of ED Length of Stay

Hummy Song, PhD Student, Harvard Business School,  
480 Morgan Hall, Soldiers Field Road, Boston, MA, 02163,  
United States of America, hsong@hbs.edu, Anita Tucker,  
Karen Murrell

We conduct an empirical investigation on the impact of pooling demand on throughput times in a discretionary work setting. We propose that the benefits of a reduction in social loafing outweigh the expected efficiency gains from pooling, which are commonly predicted by queuing theory. Using an Emergency Department's (ED) patient-level data (N = 233,781) from 2007 to 2010, we find that patients' lengths of stay were longer when the ED's work system had pooled demand, compared to when the ED had dedicated demand streams.

#### 2 - Empirical Analysis of Patient Revisit Intervals in Primary Care

Hessam Bavafa, PhD Candidate, University of Pennsylvania,  
Wharton School, Philadelphia, PA, 19104, United States of  
America, bavafa@wharton.upenn.edu, Christian Terwiesch

We study patient revisit intervals, i.e., how often patients come to their physician's office for follow up, as an important physician productivity measure. We explore the sources of variation in revisit intervals using a dataset of primary care encounters.

#### 3 - Information Diffusion and Physician Learning: Evidence from the U.S. Department of Veterans Affairs

Vishal Ahuja, University of Chicago, Booth School of Business,  
5807 S. Woodlawn Ave., Chicago, IL, 60637, United States of  
America, vahuja@chicagobooth.edu

We evaluate the changes in prescription patterns of an anti-diabetic medication during the time period when several health and safety warnings were issued related to the drug. We use the variation in the prescription patterns to study the diffusion of information and examine operational factors that promote physician learning. We employ a unique and large dataset of diabetic patients comprising of information on patient and organizational characteristics spanning five years.

**Wednesday, 8:30am - 10:00am**

■ **WA01**

01- Chicago F

**Joint Session HAS/ISIM: HIV and Networks**

Sponsor: Healthcare Applications Society & Simulation Society

Sponsored Session

Chair: Benjamin Armbruster, Northwestern University, Evanston, IL, United States of America, armbruster@northwestern.edu

- 1 - Hybrid Network Data Collection in Emerging HIV Epidemics**  
John Schneider, University of Chicago, 5841 South Maryland Avenue, Chicago, IL, United States of America, jschneil@medicine.bsd.uchicago.edu

We will discuss considerations for hybrid network data collection and analysis. Hybrid network data includes network data collected through archival or digital data such as cell phones or Facebook coupled with traditional survey data.

- 2 - P2P Text Messaging for HIV High Risk Groups: A Model of Information Spread on a Network**

Ekkehard Beck, Northwestern University, 2145 Sheridan Road, Room C220, Evanston, IL, 60208, United States of America, ekkehardbeck2015@u.northwestern.edu, Benjamin Armbruster

Text message based HIV prevention interventions are on the rise. We propose peer-to-peer (P2P) text messaging as a new HIV prevention intervention and develop an agent-based simulation model to study its impact on the spread of information in a network of men who have sex with men.

- 3 - Speeding Up Network Simulations using Discrete Time**

Benjamin Armbruster, Northwestern University, Evanston, IL, United States of America, armbruster@northwestern.edu

Network simulation models are becoming common for modeling the spread of infections. However, speed is often an issue for large populations. Choosing a discrete time simulation (DTS) over a discrete event simulation (DES) helps to remedy this problem at the cost some accuracy. We analyze and quantify the loss in accuracy for the common SI and SIS processes. Specifically we prove the DTS method for both processes converges with strong order 1, similar to Milstein's method for SDEs.

- 4 - How Risky is Risky Sex?**

Arielle Lasry, US Centers for Disease Control and Prevention, Atlanta, GA, United States of America, ftn9@cdc.gov

In estimating the risk for contracting HIV, parameters associated with the type and frequency of sex act and the preventative measures used are uncertain. Therefore, we developed a decision support tool intended for HIV-discordant couples to assess the risk of HIV transmission to the negative partner based on the couple's choices and preferences with respect to risk behaviors and preventative measures.

■ **WA02**

02- Chicago G

**Data Driven Approaches to Identify and Treat Critical Illness: Applications**

Sponsor: Data Mining

Sponsored Session

Chair: Gilles Clermont, University of Pittsburgh Medical Center, 3550 Terrace, Scaife 602A, Pittsburgh, PA, 15261, United States of America, clermontg@ccm.upmc.edu

Co-Chair: Marilyn Hravnak, Professor, School of Nursing, University of Pittsburgh, 336 Victoria Bldg, 3500 Victoria Street, Pittsburgh, PA, 15261, United States of America, mhra@pitt.edu

- 1 - using Data Driven Approaches to Improve Care: Examples Through the Eyes of the Clinician**

Marilyn Hravnak, University of Pittsburgh, 200 Lothrop, Pittsburgh, PA, United States of America, hravnakmt@upmc.edu, Karen Chen, Melissa Saul, Gilles Clermont, Artur Dubrawski, Michael Pinsky

Data from medical records and bedside monitors can be mined to inform future clinical decisions. We provide 3 examples: a) extraction of static data from a clinical and administrative database repository to assess likelihood and impact of atrial fibrillation, b) use of real-time continuous physiologic monitoring data input through an Integrated Monitoring System to enable nurses to respond to clinical instability, c) use of feature extraction from monitoring data waveforms to detect artifact.

- 2 - Predictive Modeling for Health Systems**

Jonathan Silverstein, Professor, University of Chicago, Pritzker School of Medicine, Chicago, IL, United States of America, jcs@uchicago.edu

At NorthShore, we have led Epic Systems' EMR implementation across inpatient and outpatient environments for 10 years. In addition, an industrial enterprise data warehouse is used daily for business intelligence. This talk will highlight predictive modeling in production use. Specific examples shown will include: management of antibiotic resistant microbial disease, eliminating undiagnosed hypertension, reducing readmissions, and enhanced data collection for finer grained clinical modeling.

- 3 - Outlier-Based Alerting to Decrease Medical Errors in the ICU: An Evaluation Study**

Milos Hauskrecht, University of Pittsburgh, Pittsburgh, PA, United States of America, milos@pitt.edu, Gilles Clermont, Shyam Visweswaran, Gregory Cooper

Outlier-based alerting is a data-driven approach that can, based on past data, identify unusual patient-management decisions in the electronic medical record of the current patient. Such outliers may indicate potential medical errors. We have selected 400 alerts from >33K alerts generated for >24K patient admissions. The alerts were evaluated by 18 ICU physicians. The true positive alert rate of 0.52 compares favorably to the alert rates of the existing clinical alerting systems.

■ **WA03**

03- Chicago H

**Dynamic Optimization of Clinical Treatments**

Sponsor: INFORMS Optimization Society

Sponsored Session

Chair: Alexander Gutfraind, University of Illinois at Chicago, FDA/CBER, School of Public Health, Chicago, IL, 60612, United States of America, agutfraind.research@gmail.com

- 1 - Administering Antibodies for Seasonal Infections – A Dynamic Programming Approach**

Alexander Gutfraind, University of Illinois at Chicago, FDA/CBER, School of Public Health, Chicago, IL, 60612, United States of America, agutfraind.research@gmail.com, Alison P. Galvani, Lauren Ancel Meyers

Palivizumab, an antibody for RSV infections, costs the healthcare system some \$1.35 annually. The customary protocol uses injections every 30 days. Based on data from 18 sites around the country, we show that an optimized protocol can save up 20% on cost or improve the effectiveness of the treatment.

- 2 - Quantile Interactive Q-Learning**

Kristin Linn, North Carolina State University, 5109 SAS Hall, 2311 Stinson Dr., Raleigh, NC, 27695, United States of America, kalinn@ncsu.edu, Leonard Stefanski, Eric Laber

A dynamic treatment regime (DTR) consists of decision rules that operationalize clinical decision-making by recommending treatments over time. Methods for estimating optimal sequential rules such as Q- and IQ-learning aim to maximize the expected value of the response. Our proposed method, Quantile Interactive Q-learning (QIQ-learning), extends Q- and IQ-learning to handle optimization of quantiles of the distribution of the final clinical outcome. We derive the form of the QIQ-learning optimal policy for the two-decision setting and propose estimators for the optimal rules at each stage.

- 3 - Biological-Driven Dose Escalation in Cervical Cancer Treatment**

Fan Yuan, Georgia Institute of Technology, Industrial & Systems Engineering, Atlanta, GA, United States of America, fyuan3@isye.gatech.edu, Eva Lee

This work is joint with Rush University Medical Center. We describe a tumor-control-probability(TCP) based treatment planning framework for PET image guided dose escalation high-dose rate brachytherapy for cervical cancer. Using real patient cases, robustness of the planning is tested, and plan quality, TCP, and potential outcome significance are evaluated.

## ■ WA04

04- Scottsdale

### Joint Session HAS/MDPM: Policy and Decision Making in Disasters and Public Health Emergencies

Sponsor: Healthcare Applications Society & Medical Decision and Policy Making

Sponsored Session

Chair: Eva Lee, Professor and Director, Georgia Institute of Technology, Atlanta, GA, United States of America, evakylee@isye.gatech.edu

#### 1 - Analysis of Large-Scale Medical Countermeasure Dispensing: Multi-Modality and Cost-Effectiveness

Ferdinand Pietz, CDC, Atlanta, GA, United States of America, Eva Lee

This study is performed to better understand the feasibility and resource requirements to carry out large-scale medical countermeasure dispensing operations in the event of a biological attack. We perform cost-effectiveness analysis on multi-modality dispensing strategies. The presentation will focus on anthrax and pandemic flu scenarios across large US metropolitan areas.

## ■ WA07

07- Kansas City

### Surgical Operations

Contributed Session

Chair: Thomas Sexton, Professor and Associate Dean, Stony Brook University, College of Business, 317 Harriman Hall, Stony Brook, NY, 11794-3775, United States of America, Thomas.Sexton@stonybrook.edu

#### 1 - Solving the Operating Room Scheduling Problem using Mathematical Programming

Pablo Rey, Universidad Diego Portales, Av. Ejercito 441, Santiago, Chile, pablo.rey@udp.cl, Guillermo Durán, Patricio Wolff

The scheduling of surgical interventions impacts directly on the number of patients that can be treated with given operating room resources. In addition to the timetabling aspect, operating room scheduling methods must determine the order in which patients should be treated as a function of their relative priorities. In this paper, four methods for solving this problem are proposed and compared. Improvements in operating room utilization rates ranged from 10% to 15% over current manual techniques.

#### 2 - An Inpatient Bed Demand Prediction Tool for Surgical Smoothing

Ronald Dravenstott, Intermediate Innovation Analyst, Operations Research, Geisinger Health System, 100 N. Academy Ave., M.C. 30-65, Danville, PA, 17822, United States of America, rwdravenstott@geisinger.edu, Priyantha Devapriya, David Franklin

Facilitating patient flow is imperative and difficult in a hospital with high patient occupancy. A decision support tool applying Monte Carlo Simulation has been developed to predict the inpatient bed demand from surgical and medical patients four days into the future. We created a user-friendly tool for administrators to predict and mitigate potential bed shortages before they occur.

#### 3 - Dynamic Surgery Assignment of Multiple Operating Rooms with Planned Surgeon Arrival Times

Xiaolan Xie, Professor, Shanghai Jiao Tong University, 800 DongChuan Road, Shanghai, China, xie@emse.fr, Na Geng, Zheng Zhang

This paper addresses the multi-OR dynamic surgery scheduling with random durations and planned surgeon arrival times. We propose a multi-stage stochastic programming model by allowing scheduling revision at all surgery completion events. A two-stage stochastic programming approximation is proposed and solved by two look-ahead strategies and valid inequalities. A lower bound is proposed based on perfect information. An efficient algorithm is also proposed for determining surgeon arrival times. Numerical results show the value of dynamic scheduling and the value of proactive decisions.

#### 4 - Optimal Block Scheduling for the Operating Room Suite: from Tactical to Strategic Planning

Thomas Sexton, Professor and Associate Dean, Stony Brook University, College of Business, 317 Harriman Hall, Stony Brook, NY, 11794-3775, United States of America, Thomas.Sexton@stonybrook.edu, Melissa Dolan, Herbert Lewis, Kenneth Rosenfeld

We present a multicriteria nonlinear optimization model that allocates OR time among 15 surgical services in a major academic medical center. The model considers the probability distribution of demand and optimizes an objective that includes the medical center's financial success, its overall mission, and

community needs, thereby elevating the OR scheduling process from the tactical realm, in which utilization is the objective, to the strategic realm, in which higher level objectives dominate.

## ■ WA08

08- Kane

### Chronic Diseases: Screening and Treatment

Cluster: Medical Decision Making

Invited Session

Chair: Reza Skandari, University of British Columbia, 98 West 37th Ave., Vancouver, BC, V5Y2N1, Canada, reza.skandari@sauder.ubc.ca

#### 1 - Optimal Patient-Specific Post-Operative Surveillance for Vascular Surgeries

Peter Frazier, Assistant Professor, Cornell University, 232 Rhodes Hall, Ithaca, NY, 14853, United States of America, pf98@cornell.edu, Shanshan Zhang, Pranav Hanagal, Andrew Meltzer, Darren Schneider

We optimize the design of post-operative surveillance schedules for patients who have undergone vascular surgery. Current strategies use the same schedule of follow-up visits for all patients, even though problems tend to occur early for some types of patients, while problems tend to occur later for other types of patients. Using survival analysis and optimization, we devise patient-specific follow-up schedules and compare their efficacy and cost to existing schedules.

#### 2 - Screening for Hepatocellular Carcinoma in a Capacitated System

Elliot Lee, University of Michigan, 1205 Beal Ave., Ann Arbor, MI, 48105, United States of America, elliotdl@umich.edu, Mariel Lavieri, Michael Volk

We investigate the problem of allocating a fixed screening capacity amongst a set of patients at risk for hepatocellular carcinoma. The decision maker faces the challenge of incorporating the knowledge of each patient's risk, which is learned over time. This problem is modeled in the language of the multi-armed bandit problem, and a heuristic strategy is derived from the dynamic allocation index theorem. The performance of the heuristic is compared to other popular screening strategies.

#### 3 - Optimal Policies for Arteriovenous Fistula Creation for Patients on Hemodialysis

Reza Skandari, University of British Columbia, 98 West 37th Ave., Vancouver, BC, V5Y2N1, Canada, reza.skandari@sauder.ubc.ca, Nadia Zalunardo, Steven Shechter

To deliver hemodialysis (HD), patients need to have a vascular access. The gold standard for delivering HD is via arteriovenous fistula (AVF). Due to AVF creation failure, limited lifetime of a functional AVF, and limited places to create an AVF, patients may use an inferior access substitute called central venous catheter (CVC). We aim to characterize conditions under which the patient should or should not be referred for AVF creation, under total lifetime and quality adjusted lifetime metrics.

## ■ WA09

09- McHenry

### Application of Operations Research in Healthcare

Sponsor: Manufacturing and Service Operations Management

Sponsored Session

Chair: Saied Samiedaluie, McGill University, 1001 Sherbrooke West, Montreal, QC, H3A 1G5, Canada, saied.samiedaluie@mail.mcgill.ca

#### 1 - Admission Policies in a Neurology Ward

Saied Samiedaluie, McGill University, 1001 Sherbrooke West, Montreal, QC, H3A 1G5, Canada, saied.samiedaluie@mail.mcgill.ca

We study patient admission policies in a neurological hospital ward, where there are multiple patient types. The patients need to wait until a hospital bed is assigned to them. The patients are different in terms of level of severity and average length of stay. The problem is formulated as an average cost dynamic program. An approximation scheme to solve the dynamic programming will be presented.

## 2 - Hypertension Management: A Value of Information Approach for Blood Pressure Measurement

Manaf Zargoush, McGill University, Montreal, QC, Canada, zargoush@gmail.com, Mehmet Gumus, Stella Daskalopoulou, Vedat Verter

Hypertension is one of the most prominent risk factors for the development of cardiovascular disease (CVD), the leading cause of morbidity and mortality worldwide. In this context, accurate measurement of blood pressure is vital. In this research we model two blood pressure measurement methods as Markov Decision Processes (MDP's) and analyze the value of information (VOI) attributed to these two methods. We also identify the optimal policies under each measurement scheme.

## 3 - Surgical Sequencing with Stochastically Ordered Service Times

Yun Zhou, McGill University, 1001 Sherbrooke Street W, Montreal, QC, Canada, yzhou.zj@gmail.com, Mahmut Parlar, Vedat Verter, Shannon Fraser

In this presentation, we consider two types of surgeries with random durations. The duration of one type is stochastically shorter than the other type. We compare two simple sequencing policies in terms of the total expected patient waiting time and the expected operating room overtime. We also study a constrained sequencing problem that aims to minimize total expected patient waiting time while the expected OR overtime does not exceed a certain predetermined threshold. Two case studies are provided based on 2012 data from Jewish General Hospital in Montreal.

## ■ WA10

10- Cook

## ORAHS 2- Modeling for Planning Decisions

Cluster: International Health OR

Invited Session

Chair: Sally Brailsford, Professor, University of Southampton, Southampton Management School, Southampton, SO17 1BJ, United Kingdom, S.C.Brailsford@soton.ac.uk

### 1 - Age-Related Macular Degeneration: Combining Models Offers Health and Social Care Insights

Joe Viana, Research Fellow, University of Southampton, University Road, Hampshire, Southampton, SO17 1BJ, United Kingdom, J.Viana@soton.ac.uk, Stuart Rossiter, Andrew Amos Channon, Sally Brailsford, Andrew Lotery

We aim to create a whole system model of health and social care in the context of age-related macular degeneration (AMD), a degenerative eye condition prevalent in the elderly and treatable via injections. A traditional discrete-event simulation of the eye clinic is extended via an agent-based model of AMD sufferers' social care dynamics (with system dynamics models for sight level). This allows us to explore the combined effects of policy on clinic efficiency and social welfare.

### 2 - Dynamic Location of Ambulances Considering Time-Dependent Demand

Sebastian Rachuba, Research Assistant, PhD student, Ruhr University Bochum, Universitaetsstrasse 150, Bochum, 44801, Germany, sebastian.rachuba@rub.de, Brigitte Werners, Dirk Degel, Lara Wiesche

The efficient use of available resources such as ambulances is crucial for high quality medical services. We developed a mixed-integer linear program in order to locate and re-locate ambulances during the day. Demand and travel times are modeled time-dependent and thus explicitly for all time periods. The number of parallel occurring emergencies is derived from existing data records in order to determine a required degree of multiple coverage. Calculations show that the new approach leads to high quality solutions with respect to coverage and cost criteria.

### 3 - An Iterative Simulation-Optimization Approach for Hospital Layout Planning

Ines Arnolds, Karlsruhe Institute of Technology, Englerstr. 11, Building 11.40, 2 OG, RM 204, Karlsruhe, D-76131, Germany, ines.arnolds@kit.edu, Stefan Nickel

Most layout models are based on deterministic data, but usually patient and personnel flows are uncertain. We present an iterative simulation-optimization approach to find a robust hospital layout that performs well under uncertain flows. First, a deterministic MIP is solved. Second, a generic discrete-event simulation model is applied. Third, the layout is improved heuristically. With this approach, we take into account the influence of strategic layout decisions on the operational performance.

## 4 - Machine Learning Approaches for Early DRG Classification of Inpatient Services

Daniel Gartner, Technische Universität München, TUM School of Management, Arcisstr. 21, München, 80333, Germany, Daniel.Gartner@wi.tum.de, Rainer Kolisch, Daniel B. Neill, Rema Padman

This study examines the applicability of machine learning methods for classifying diagnosis-related groups (DRGs) of inpatients for upstream planning and better resource allocation. We evaluate different techniques on hospital data from the year 2011 containing more than 16,000 inpatient records. Results indicate that, depending on the available information, up to 79.5% accuracy can be achieved for elective patients (before admission). Moreover, more than 65% accuracy can be achieved for all (elective and non-elective) patients on the day of admission which outperforms current practice.

## ■ WA18

18- Northwestern

## Scheduling and Patient Flow for Healthcare OR

Cluster: Healthcare Scheduling

Invited Session

Chair: Jivan Deglise-Hawkinson, University of Michigan, Industrial and Operations Engineering, Office 2811, Ann Arbor, MI, 48105, United States of America, jivan@umich.edu

### 1 - Flexible Nurse Staffing Models under Patient Volume Uncertainty and Cost Implications of Flexibility

Kibaek Kim, Northwestern University, 2145 Sheridan Rd., C210, Evanston, IL, 60208, United States of America, kibaek.kim@u.northwestern.edu, Sanjay Mehrotra

Limited budget for full-time equivalent nursing positions compels hospital operations managers to efficiently utilize nursing staffs without loss of care quality. We present a nurse-staffing model to find the optimal staffing levels and patterns of full-time/part-time nurses for different care units and nurse float pool. We further analyze the cost implications of using part-time nurses and float pool nurses.

### 2 - Appointment Scheduling with Follow-Up Visits

Yichuan Ding, University of British Columbia, 4735 W. 4th Ave., Vancouver, BC, V6T1C3, Canada, daniel.ding@sauder.ubc.ca, Chinghua Chen, Mayank Sharma, Diwakar Gupta

Properly modeling outpatient arrivals helps physicians make better decisions regarding panel sizing and appointment scheduling. This paper models the patient follow-up phenomenon and investigates its effect on appointment scheduling. By formulating the problem as a Markov Decision Processes, we concluded that the optimal scheduling policy is of a control-limit type, and the optimal daily booking-limit decreases as days move towards the future.

### 3 - Modeling Selective ICU Admission Based on Mortality Risk

Jeff Kritzman, PhD Pre-Candidate, University of Michigan, Industrial and Operations Engineering, Ann Arbor, MI, 48109, United States of America, jefkritz@umich.edu, Jivan Deglise-Hawkinson, Mark Van Oyen, Jonathan Helm

Intensive care units (ICUs) are highly utilized hospital wards that drastically improve the outcomes for medically needy patients. Some patients require treatments only available in an ICU, but who else should be admitted to the ICU? How do we control the admission to do the greatest good for the greatest number? Our partner hospital has pioneered a patient Mortality Risk Metric (MRM) that we use for improved ICU admission control.

### 4 - An Optimization-Based Approach to Capacity Planning for Clinical Research Operations

Jivan Deglise-Hawkinson, University of Michigan, Industrial and Operations Engineering, Office 2811, Ann Arbor, MI, 48105, United States of America, jivan@umich.edu, Mark Van Oyen, Blake Roessler

Clinical trial protocols demand complex coordination of physical and human resources over time for each participant. A clinical research unit site must service many trials. We develop a novel stochastic planning model that uses forecasting and optimization to select the highest scientific value from the portfolio of candidate trials while meeting participant access and overtime metrics. We also optimize the daily participant booking reservation strategy, and the daily staffing coordination plan.

Wednesday, 10:30am - 12:00pm

## ■ WB01

01- Chicago F

### Healthcare Services

Sponsor: Healthcare Applications Society

Sponsored Session

Chair: Alex Mills, Assistant Professor, Indiana University, Kelley School of Business, Bloomington, IN, United States of America, millsaf@indiana.edu

#### 1 - Nurse Staffing Ratios: A Case for Higher Quality Care

David Cho, Indiana University, Kelley School of Business, 1309 E. Tenth Street, Room 752-48, Bloomington, IN, 47405-1701, United States of America, ddcho@indiana.edu, Kurt Bretthauer, Edwin Coe, Jan Schoenfelder

Despite the considerable attention given to healthcare in operations management and operations research, there has been limited effort to take advantage of results from the medical, nursing, and healthcare services literature to make the research more patient and nurse oriented. Thus, we present a nurse staffing model that incorporates patient outcomes, nurse burnout, and costs when making hospital capacity planning decisions such as patient-to-nurse ratios and usage of float and agency nurses.

#### 2 - Analysis of Skilled Nursing Facility Admission Control using Event-Based Dynamic Programming

Xiaoyang Yu, PhD, Indiana University, Kelly School of Business, 107 S. Indiana Ave., Room 736-5, Bloomington, IN, 47405-7000, United States of America, xy9@indiana.edu, Jonathan Helm

Skilled nursing facilities (SNF) are a major bottleneck to discharging patients from hospitals in a timely manner. These facilities typically have two main sources of patients: hospital and community. High utilizations at SNFs force a choice of which patients to admit and which to delay. We develop an event-based dynamic programming approach to optimize admission control at the SNF that seeks to balance the needs of hospital, SNF, and community.

#### 3 - Improving ED Patient Flow: Multi-Class Admit Prediction Models at Triage

Shanshan Qiu, Research Assistant, Wayne State University, 4815 Fourth St., Detroit, MI, 48202, United States of America, dy5145@wayne.edu, Ratna Babu Chinnam, Alper Murat

To predict inpatient bed demand from ED, we propose a multi-class classification model that predicts the target admit ward for the patient using information readily available right at triage. It overcomes the shortcomings of extant binary prediction models that lack the ability to predict the target admission ward to facilitate timely coordination and reduces patient waiting times and boarding.

## ■ WB02

02- Chicago G

### Hospital Operations

Sponsor: Healthcare Applications Society

Sponsored Session

Chair: Lerzan Ormeci, Koc University, Istanbul, 34450, Turkey, lormeci@ku.edu.tr

Co-Chair: Evrim Didem Gunes, Koc University, Istanbul, Turkey, egunes@ku.edu.tr

#### 1 - Stabilizing Patient Flows and Inpatient Bed Usage

Rene Bekker, VU University Amsterdam, De Boelelaan 1081, Amsterdam, Netherlands, r.bekker@vu.nl

The central topic of this presentation is to show the merits of stabilizing patient flows in order to avoid peaks in demand. We consider the impact of (reducing) variability in the patient care process, or clinical pathways, by applying the Queueing Network Analyzer adapted to health care. Moreover, we propose a refined admission scheduling approach to stabilize the usage of inpatient beds. The mathematical models are illustrated with a case study on cardiac patients.

#### 2 - Adaptive and Anticipative Decisions in Operating Room Rescheduling

Sakine Batun, Assistant Professor, Middle East Technical University, Department of Industrial Engineering, Ankara, 06800, Turkey, sakine@metu.edu.tr, Brian Denton, Andrew Schaefer

We consider a stochastic multi-OR scheduling problem where the initial schedule is revised at a prespecified time during the surgical day. We formulate the problem as a SMIP that minimizes the sum of the fixed cost of opening ORs and the expected overtime cost. For our numerical study, we consider a special case where rescheduling decisions are made under perfect information. We use our model to estimate the value of adaptive and anticipative decisions in OR rescheduling.

#### 3 - Operations Management Approaches in Perioperative Flow

Erkan Ceyhan, Lahey Clinic, Boston, MA, United States of America, Mehmet.E.Ceyhan@lahey.org, Patricia Roberts, Stephen Demers

We apply advance operations management techniques to (1) improve patient outcome, (2) reduce patient delays, (3) maximize efficiency of operating room, and (4) provide surgeons optimum access to OR. Initial results of following projects are presented: identifying key metrics and translating them to daily operations, monitoring OR metrics & same day surgery cancellations by statistical process control, and patient flow of perioperative services.

#### 4 - Modeling the Effect of a Nurse as a Transmitter on Hospital Acquired Infections

Lerzan Ormeci, Koc University, Istanbul, 34450, Turkey, lormeci@ku.edu.tr, Evrim Didem Gunes, Önder Ergönül

We analyze the role of bed adjacency in hospital acquired infection dynamics in an intensive care unit (ICU). In the context of ICUs, this coincides with the role of the nurse as an agent. The analysis is carried on a data set which includes the patients' age, sex, admission and discharge dates, length of stay, Apache II score, and colonization/infection test results. Then, we develop and numerically analyze a Markov chain model which represents the interactions between a nurse and patients.

## ■ WB03

03- Chicago H

### Big Data in Healthcare

Sponsor: INFORMS Optimization Society

Sponsored Session

Chair: Leila Zia, Stanford University, Huang Engineering Center, 475 Via Ortega, Stanford, CA, United States of America, leilaz@stanford.edu

#### 1 - Making the Case for Case Management

David Anderson, University of Maryland, Robert H Smith School of Business, College Park, MD, 20742, United States of America, danderson@rhsmith.umd.edu, Margrét Bjarnadóttir

One of the key questions in case management is which patients to enroll, and most programs target current high-cost patients. However the real potential is including lower cost patients at high risk of future high healthcare costs. Identifying these patients is a hard classification task. In this study we infuse classical classification models with association rules to identify and include higher order interactions. We demonstrate the potential of association rules for classification and derive an upper bound on the predictive performance.

#### 2 - Innovations in Big Data Analytics: Medical Decision Making

Eva Lee, Professor and Director, Georgia Institute of Technology, Atlanta, GA, United States of America, evakylee@isye.gatech.edu

This work is joint with Emory Vaccine Center. In this talk, we will describe a big data analytic approach multi-disciplinary involving immunology, genomics and bioinformatics to predict the immunity of a vaccine without exposing individuals to infection. This approach addresses a long-standing challenge in the development of vaccines—that of only being able to determine immunity or effectiveness long after vaccination and, often, only after being exposed to infection.

#### 3 - Predicting Colorectal Cancer Mortality

Leila Zia, Stanford University, Huang Engineering Center, 475 Via Ortega, Stanford, CA, United States of America, leilaz@stanford.edu, Margret Bjarnadottir

We build prediction models for colorectal cancer mortality over a horizon of 30 days to 5 years after hospital discharge considering comprehensive medical, socio-economical, geographical and hospital related data. We use two major California data-sets along with modern statistical methods such as classification trees and regularized logistic regression. We report the most important predictors and assess the quality of the prediction models, the key considerations for medical decision makers.

## ■ WB04

04- Scottsdale

### Modeling for Optimization of Healthcare Delivery

Sponsor: Healthcare Applications Society

Sponsored Session

Chair: Julie Ivy, Associate Professor, North Carolina State University, 111 Lampe Drive, Raleigh, NC, 27695-7906, United States of America, jsviv@ncsu.edu

#### 1 - Optimal Control of an Emergency Room Triage and Treatment Process

Gabriel Zayas-Caban, Cornell University,  
206 Frank H.T. Rhodes Hall, Cornell University, Ithaca, NY, 14853,  
United States of America, gz63@cornell.edu, Mark Lewis

Patient care may consist of two phases: triage and treatment. These are often carried out by one medical provider. We consider how to prioritize the work by the provider to balance initial delays for care with the need to discharge patients in a timely fashion. We model this process as a single server two-stage tandem queue. After service in the first station, patients may leave the system. Otherwise, they join the second station where they may abandon prior to treatment. We use sample path arguments and Markov Decision Processes to determine the optimal dynamic schedule for the server.

#### 2 - A Data Visualization Approach to Obesity Counseling by Primary Care Physicians

Harriet Nembhard, Professor, Pennsylvania State University,  
College of Engineering, 360 Leonhard Building, University Park,  
PA, 16802, United States of America, hbn2@psu.edu, Jennifer  
Kraschnewski, Dominic Amirtharaj, Ting Lei, Samuel Ridout,  
Kathryn Ridout, Hyojung Kang

Rates of weight counseling in primary care have significantly declined despite increased rates of overweight and obesity in the United States. We propose a data visualization intervention that integrates Gestalt principles and motivational interviewing with the United States Preventive Services Task Force (USPSTF) guidelines on obesity counseling.

#### 3 - Impact of Mode of Delivery Disutility on VBAC Decision Making Considering Mother and Child Outcomes

Karen Hicklin, North Carolina State University, Raleigh, NC,  
United States of America, kthickl@ncsu.edu, Vidyadhar Kulkarni,  
Meera Viswanathan, Evan Myers, Julie Ivy

In the U.S. over 4 million births occur each year and almost one in three deliveries is a cesarean delivery making it the most common major surgical procedure. Cesarean delivery is associated with both maternal and neonatal risks and can cause complications in subsequent pregnancies. We model the trade-off between cesarean section and trial of labor considering both mother and child outcomes as a function of disutility associated with mode of delivery for a patient with a prior cesarean section.

#### 4 - Personalized Biopsy Referral Decision Modeling in the Presence of Breast Cancer Regression

Fan Wang, University of Arkansas, 4207 Bell Engineering Center,  
Fayetteville, AR, 72701, United States of America,  
fxw005@uark.edu, Shengfan Zhang

Mammography screening, although effective in reducing mortality, has high false-positive rates. Biopsy is performed to verify the presence of cancer after positive mammograms. We develop a discrete-time finite-horizon Markov decision process model to determine optimal biopsy referral policies that maximize women's life expectancies. Our model incorporates individual's breast cancer risk factors and clinical history of breast cancer and allows the possibility of spontaneous disease regression.

## ■ WB07

07- Kansas City

### Healthcare Operations

Sponsor: Healthcare Applications Society

Sponsored Session

Chair: Pengyi Shi, Georgia Institute of Technology, 765 Ferst Drive, Atlanta, GA, 30332, United States of America, pengyishi@gatech.edu

Co-Chair: Jim Dai, Georgia Institute of Technology, Atlanta, GA, United States of America, dai@gatech.edu

#### 1 - Nursing Home Staffing: Gaining More Insight into Scale and Skill-Mix Efficiencies

Dennis Moeke, AVANS University of Applied Sciences,  
Onderwijsboulevard 215, Den Bosch, Netherlands,  
d.moeke@avans.nl, Lineke Verkooijen, Ger Koole

Care workers account for a significant proportion of the total health expenditure in nursing homes and are by far the largest controllable resource. Therefore determining the appropriate number and type of care workers required plays an important role in the search for more efficiency. This study used the scheduling data of a Dutch nursing home to provide insights in how and why 'scale of scheduling' and the enlargement of care workers' jobs (blending tasks of different qualification levels) effect the number and type of staff required to meet the preferences (in terms of day and time) of nursing home residents.

#### 2 - Panel Sizing and Appointment Scheduling in Outpatient Medical Care

Christos Zacharias, New York University, Stern School of Business,  
44 West 4th Street, New York, NY, 10012, United States of  
America, czachari@stern.nyu.edu, Mor Armony

We study the joint problem of determining the panel size of a medical practice and the number of offered appointments per day, so that patients do not face long backlogs and the clinic is not overcrowded. By capturing many features of the healthcare system (balking, no-shows, walk-ins, random services), we model the two time scales involved in accessing care: out-of-clinic and in-clinic waits. We show that an open-access policy is optimal and provide guidelines for a clinic's desired panel size.

#### 3 - A Two-Time-Scale Approach to Time-Varying Queues for Hospital Inpatient Flow Management

Pengyi Shi, Georgia Institute of Technology,  
765 Ferst Drive, Atlanta, GA, 30332, United States of America,  
pengyishi@gatech.edu, Jim Dai

We model the patient flow from the emergency department to inpatient wards as a time-varying queue. One novel feature of the model is that each patient's service time is endogenous and non-iid. We develop a two-time-scale approach to analyze the model and evaluate strategies such as inpatient discharge policy.

## ■ WB08

08- Kane

### Modeling Cancer Behavior, Screening, and Treatment

Cluster: Medical Decision Making

Invited Session

Chair: Ayca Erdogan, Stanford University, 1201 Welch Road Mc 5488, Stanford, CA, 94305, United States of America, serdogan@stanford.edu

#### 1 - A New Approach for Predicting the Severity of Prostate Cancer Based on Biopsy Results

Arthur Swersey, Yale University, Box 208200, New Haven, CT,  
06520-8200, United States of America, arthur.swersey@yale.edu,  
Johannes Ledolter, Rodney . Parker

The effectiveness of PSA screening for prostate cancer continues to be hotly debated with all sides agreeing that overtreatment is a major problem. We develop a simulation model of the prostate biopsy procedure and use probability modeling to devise an effective decision rule for deciding whether to treat, based on the amount of cancer found on biopsy. This rule results in a high rate of detection and treatment of important tumors, while minimizing the treatment of insignificant ones.

## 2 - Prostate Cancer Screening Rules: A Comparison of Deterministic and Agent Based Model Approaches

Alana Reiter Guiney, University of Michigan, Health Management & Policy, M3048 SPH II, Ann Arbor, MI, 48109-2029, United States of America, aguiney@umich.edu

Prostate cancer is diagnosed using the low accuracy Prostate Specific Antigen test. This study compares a deterministic compartmental model to an agent-based model (ABM) of the same system to determine if there are more insights to be gained by allowing stochasticity into the behavior of individuals. The two approaches yield equivalent results in terms of financial and health costs. The ABM approach can easily expand to include more information rich agents to interact with screening rules.

## 3 - A Microsimulation Model for Lung Cancer Natural History and Screening for Early Detection

Ayca Erdogan, Stanford University, 1201 Welch Road Mc 5488, Stanford, CA, 94305, United States of America, serdogan@stanford.edu

We present a microsimulation model for the natural history of lung cancer and the effects of screening. The disease progression in the absence of screening is modeled based on survival data from SEER. A screening program is simulated using data from a single arm clinical study. The model closely predicts the results of the study and estimates the effect of screening compared to the simulated hypothetical noscreening arm. The model can be used to simulate different screening trials for further investigation.

## WB09

09- McHenry

### Challenging Decisions in Pharmaceutical Supply Chains

Sponsor: Manufacturing and Service Operations Management  
Sponsored Session

Chair: Hui Zhao, Assistant Professor, Pennsylvania State University, Smeal College of Business, 419 Business Building, University Park, PA, 16802, United States of America, huz10@psu.edu

#### 1 - Effects of Competition on PBM Profitability in Drug Distribution: Rebates and Price Spreads

Yixuan Xiao, PhD Student, Washington University in St. Louis, One Brookings Drive, Campus Box 1133, St. Louis, MO, 63130, United States of America, xiaoy@wustl.edu, Panos Kouvelis, Nan Yang

We model the competition among pharmacy benefit managers (PBMs) for the patronage of a client organization. Each PBM selects a list of prices to be charged to the client for each branded or generic drug (price decision) and a formulary list that assigns branded drugs to preferred or non-preferred tiers (formulary decision). Drug manufacturers offer rebates to PBMs for drugs on preferred tier. We show the existence of a pure Nash equilibrium on prices and formulary decisions, and study the impact of model primitives. We apply our model to study the impact of PBM mergers for PBMs and the client.

#### 2 - An Analysis of Drug Shortages: Inventory Management and Contract Designs

Justin Jia, Purdue University, Krannert School of Management, 403 W. State Street, West Lafayette, IN, 47907, United States of America, jia16@purdue.edu, Hui Zhao

Drug shortages have recently been a critical problem faced by the pharmaceutical industry. In this study, we investigate the reasons for the shortages, derive the optimal inventory policies for drug manufacturers, and design efficient contracts to mitigate the shortages. Our analysis captures key characteristics of drug shortages: frequent manufacturing disruptions, uncertain recovery duration from disruption, limited buyers' patience, low redundancy in capacity, and weak failure-to-supply clauses.

#### 3 - Pharmaceutical Capacity Planning for Multiple Drugs

Hiroko Okajima, Pennsylvania State University, Smeal College of Business, 426A Business Building, University Park, PA, 16802, United States of America, huo104@psu.edu, Susan Xu, Hui Zhao

We investigate dynamic trade-offs among investments in dedicated capacity, flexible capacity and outsourcing in capacity planning for multiple drugs. While dedicated capacity is cheap, flexible capacity allows for pooling of demand risk across drugs and outsourcing reduces capital investments. We characterize complementary-substitute relationship between outsourcing and flexible capacity and develop a simple staged capacity expansion strategy to support a manager's decision making.

## WB10

10- Cook

### Healthcare Policy and Finance - II

Contributed Session

Chair: Vikrant Vaze, Member Research Staff, Philips Research North America, 345 Scarborough Road, Briarcliff Manor, NY, 10510, United States of America, vikrant.vaze@philips.com

#### 1 - Hospital and Surgeon Report Cards and Patient Sorting

Tae Jung Yoon, Northwestern University, Kellogg School of Management, 2001 Sheridan Rd., Evanston, IL, 60208-2001, United States of America, taejung-yoon@kellogg.northwestern.edu

Demand-side informed choice behavior and supply-side gaming behavior after the report-card release have been presumed by previous studies, but they have not been identified separately. In this paper, I empirically examine both across-hospital and within-hospital patient sorting mechanisms induced by the cardiac surgery report cards in New Jersey. I find that patient severity of illness, traveling costs, admission sources, and provider capacity status affect patient sorting. Controlling for these factors, I show that patient informed choice and provider gaming behavior separately affect patient sorting across hospitals after the report-card release. For within-hospital patient sorting, I find that admitted patients via cardiology departments are sorted better based on their severity for cardiac surgery within the hospital.

#### 2 - Hospital Safety Culture's Role in Reducing Central Line Associated Bloodstream Infections (CLABSI)

Jason Richter, Doctoral Candidate, The Ohio State University, 2274 Collins Dr., Columbus, OH, 43085, United States of America, richter.97@osu.edu, Ann Scheck McAlearney

A change to safety culture may foster the attainable elimination of CLABSI. Statistical significance in baseline and change analysis offers robust evidence that improvements in organizational learning and management support for safety are associated with a reduction in CLABSIs; hospitals should primarily focus on these areas. Given that the CLABSI mortality rate is as high as 25 percent, the average hospital may avoid one unnecessary death each year through elimination of CLABSIs.

#### 3 - Frictions, Contract Design and Time-to-Sell in Markets for Technology

Manuel Hermosilla, PhD Candidate, Northwestern University, Kellogg School of Management, 2001 Sheridan Road, Evanston, IL, 60208, United States of America, m-hermosilla@kellogg.northwestern.edu

To take advantage of productive efficiencies and reduce time-to-market, transactions in markets for technology should occur earlier on in the technology's development. However, substantial contracting delays are commonly observed, suggesting that frictions may play a relevant role. Focusing on the market for developing biopharmaceuticals, I develop a structural model that characterizes two prominent types of imperfections, innovator-based adverse selection and moral hazard. Results crystallize the intuition that compounds with low privately observed quality are more likely to enter the technology market than their high quality counterparts, and conditional on doing so, more likely to do it sooner, highlighting the role of the adverse selection problem. While non-contractible innovator effort is estimated to significantly impact developmental success, contract design successfully aligns incentives for its provision, reducing the burden of the moral hazard problem.

#### 4 - Modeling and Assessment of Total Financial Risk in Healthcare Facilities

Vikrant Vaze, Member Research Staff, Philips Research North America, 345 Scarborough Road, Briarcliff Manor, NY, 10510, United States of America, vikrant.vaze@philips.com, Saeed Bagheri, Hanqing Cao

With the evolving regulatory and reimbursement landscape of healthcare industry, the management of total financial risk to the healthcare facilities has become more complicated. Variations in different aspects of performance of a hospital, e.g. in-hospital mortality rates, readmission rates, length of hospital stay, patient charges etc., contribute to the overall risk. We develop statistical models of hospital outcomes using public data. A number of interesting relationships are presented and results are validated against HospitalCompare results.

## ■ WB11

11- Dupage

### Empirical Studies on Hospital Operations

Cluster: Healthcare Operations Management

Invited Session

Chair: Nicos Savva, London Business School, Regent's Park, London, NW1 4SA, United Kingdom, nsavva@london.edu

#### 1 - Patients without Patience: A Priority Queuing Simulation Model of the Intensive Care Unit

Elisa Long, Assistant Professor, Yale School of Management, 135 Prospect Street, New Haven, CT, 06520, United States of America, elisa.long@yale.edu

As demand for intensive care unit (ICU) beds increases, improving patient throughput is needed. Using 12 months of data for Yale-New Haven Hospital, we estimate the impact of bed census levels on patients' length of stay—separated into service and non-service times—controlling for key patient characteristics. We use these empirical findings to construct a multi-class priority queuing model with state-dependent service rates, to simulate different bed allocation policies currently under consideration.

#### 2 - Point-of-care Testing: Improving ED Performance through Process Redesign

Nicole DeHoratius, University of Chicago, 15345 SW Lark Lane, Beaverton, IL, 97007, United States of America, Nicole@DeHoratius.com, Esther Chen, Lijie Song, Thomas Lee, Tava Olson

Hospital EDs typically rely on central labs to analyze patient samples for the purposes of diagnosing and treating patients. Point-of-care testing (POCT) is a process redesign that shifts analysis of samples from central lab to ED. We use a queuing model to generate hypotheses about how POCT affects operational performance (e.g., service time, waiting time, and quality of care). This research is unique in identifying the impact of POCT across test and no-test patients, and attendant system-wide benefits that can be attained through ED process redesign.

#### 3 - Hurry Up and Wait: Differential Impact of Load on Patient Length of Stay

Jillian Berry Jaeker, Harvard Business School, Wyss Hall, Soldiers Field, Boston, MA, 02163, United States of America, jjaeker@hbs.edu, Anita Tucker

High work load, from high patient censuses, impacts patient LOS, but prior OM studies have found conflicting results regarding direction. Thus, it is difficult to predict load's effects on productivity a priori, inhibiting effective capacity management in high load systems. We categorize load at 283 hospitals into current patient census (congestion) and incoming patients, decomposing the latter into its levels of pressure and predictability, and quantify the magnitudes and directions of change on LOS.

## ■ WB18

18- Northwestern

### Challenges in Sudden Cardiac Arrest: Perspectives from Physicians

Cluster: International Health OR

Invited Session

Chair: Brittany Megan Bogle, Northwestern University, 2145 Sheridan Road, Evanston, IL, 60208, United States of America, BrittanyBogle2015@u.northwestern.edu

#### 1 - Video Self-Instruction Improves Knowledge about CPR and AED among Police Officers

Adriana Segura, age.segura@gmail.com

The goal of this study was to quantify the effect of video self-instruction (VSI) on knowledge and attitudes among Chicago Police Department officers about cardiopulmonary resuscitation (CPR) and automated external defibrillators (AEDs). Officers were exposed to a 10-minute VSI on CPR and AEDs. Knowledge and attitudes were assessed before and after the intervention with an online survey. VSI can significantly improve positive attitudes toward and knowledge of CPR and AEDs among urban law enforcement.

#### 2 - Operations Issues Involved in Planning for the Chicago Marathon

George Chiampas, Medical Director, Bank of America Chicago Marathon, Chicago, IL, United States of America, gchiampas@comcast.net, Mike Nishi, Sanjay Mehrotra, Karen Smilowitz

"With the use of enhanced technology, tracking and implementing Unified command processes for public health safety during large scale events is becoming "Best Practices." Real time and accurate information allows greater decision capabilities in planning and implementation in large and small scale incidents.

#### 3 - iRescu: Bridging New Tech, Social Media & Saving Lives - A Novel System for CPR/AED Management

Nadine Levick, EMS Safety Foundation, New York, NY, United States of America, nlevick@attglobal.net

There are 1,000 U.S. deaths daily from out of hospital cardiac arrest. Existing strategies have had little impact on bystander effectiveness in 30 years. iRescu bridges social good, new tech, cloud based data, community engagement, crowd sourcing, geolocation, gamification, public health and safety to address these gaps in the chain of survival. Designed as a global platform that is sustainable, scalable and translatable, iRescu has 3 basic modes: Emergency response, Train and AED management.

#### 4 - Predicting Lifetime Risk of Sudden Cardiac Death

Brittany Bogle, PhD Candidate, Industrial Engineering, Northwestern University, 2145 Sheridan Rd., Room C210, Evanston, IL, 60201, United States of America, brittanybogle@u.northwestern.edu, Donald Lloyd-Jones

Competing lifetime risk is the total cumulative risk of developing a disease of interest which adjusts for the competing risk of other competing diseases and causes of death. In our study, we examine the competing lifetime risk of sudden cardiac death from large cohort study through an adjustment of Kaplan-Meier for competing risk. We explore important risk factors through penalty norm techniques, including Lasso Regularization, and compare these to traditionally used clinical risk factors.

## Wednesday, 1:30pm - 3:00pm

## ■ WC01

01- Chicago F

### Healthcare Analytics in the CMS Systems Engineering Innovation Center

Cluster: Healthcare Data Analytics

Invited Session

Chair: James Benneyan, Professor, Northeastern University, 253 Richards Hall, Boston, MA, 02115, United States of America, benneyan@coe.neu.edu

#### 1 - The CMS Innovation Center and Healthcare Systems Engineering Demonstration Project

James Benneyan, Professor, Northeastern University, 253 Richards Hall, Boston, MA, 02115, United States of America, benneyan@coe.neu.edu, Vinod Sahney

As part of the 2010 Patient Protection and Affordable Care Act, Congress created the Center for Medicare and Medicaid Innovation (CMMI), with \$10 billion in funding to experiment with innovative concepts that might broadly improve the "triple aim" of better care processes, improved population health, and lower national costs. We describe several CMS/CMMI initiatives, including an \$8 million Scalable Healthcare Systems Engineering demonstration grant to create a system of regional extension centers across the U.S. to produce a measureable and scalable impact on health, care, and cost. The overall objectives are to foster much greater use of industrial and systems engineering in healthcare, visibility and demand for these professions, and pipelines of formally and experientially trained healthcare industrial engineers at a larger scale and pace by several orders of magnitude. We discuss the current status of this initiative, example projects, and experiential and formal education programs.

#### 2 - Care Continuity in Primary Care Resident Scheduling

Rachel Miller, Northeastern University, Healthcare Systems Engineering Institute, Boston, MA, United States of America, r.miller@neu.edu, Serpil Mutlu, Sue Freeman, James Benneyan

An important problem in primary care and family medicine is care continuity, with evidence this produces better outcomes, wellness and prevention, trusting provider-patient relationships, and lower system utilization, also with significant investments nationally in primary care residency programs to develop family care practitioners. The logistics of scheduling and managing a primary care residency program introduces complexities different from those in a hospital setting, with current approaches being mostly manual. We describe recent work to develop a scheduling methodology for primary care resident teams in a way that maximizes the number of patients who are able to see either their specific primary care provider (PCP) or a familiar resident on the PCP's team based on the PCP team concept and seeking to maximize weighted session coverage of all teams. Preliminary testing results will be reported.

### 3 - Modeling the Connectedness and Spread of Improvements across Healthcare Networks

Dayna Martinez, Northeastern University, Boston, MA, United States of America, d.martinez@neu.edu, Corey Balint, Amanda Bell, Nicholas Adrianas, James Benneyan

The poor spread of proven improvements across healthcare systems is a ubiquitous problem in many contexts. We describe ongoing work to better understand the spread of improvement across healthcare systems. As one approach, several efforts exist to develop formal and informal healthcare quality improvement networks through which improvement and innovation information can flow. We use a combination of social network mapping tools and agent-based simulation models to study the structure of several healthcare improvement networks and understand how improvements flow across these systems, similar to epidemiologic models, and what interventions can maximize spread and network quality. Several national and regional examples and ongoing work will be described.

### 4 - The CMS Innovation Center Healthcare Systems Engineering Summer Fellowship Program

Laura Hyde, Northeastern University, Boston, MA, United States of America, hyde@neu.edu, James Benneyan

For industrial and systems engineers to have greater impact on health care, familiarity and experience working within health systems may be required. To facilitate this, we describe a summer healthcare systems engineering fellowship program funded as part of a CMS Innovation Center grant to Northeastern University's Healthcare Systems Engineering Institute. Partnering with dozens of Boston-area health systems affiliated with our institute and 2 federally-funded centers, this program allows undergraduate and graduate students across the U.S. to join ongoing projects in order to gain hands-on experience applying systems engineering methods to a variety of problems. Summer fellows work for 8 to 12 weeks on applied or research projects aligned with their interests, mentored by a senior doctoral student, healthcare practitioner, and faculty coach. Several students have gone on to pursue research topics in their home universities related to their summer projects. Examples of past projects, program logistics, and impact-to-date will be described.

## WC02

02- Chicago G

### Patient Flow Models for Resource Allocation

Cluster: Healthcare Operations Management

Invited Session

Chair: Jackie Griffin, Northeastern University, 360 Huntington Ave., Boston, MA, 02115, United States of America, ja.griffin@neu.edu

#### 1 - A Queueing-Based Measure to Evaluate Responsiveness to Multi-Class Customers in Healthcare Delivery

Elham Torabi, University of Cincinnati, Lindner College of Business, 2925 Campus Green Dr., Cincinnati, OH, 45221-0130, United States of America, torabiem@mail.uc.edu, Michael Magazine, Feng Mai, Uday Rao, Yann Ferrand, Craig Froehle

In health centers with multi-priority patients, dedicating resources to different priority groups can increase responsiveness to some while increasing delays for others. Using queueing theory, we develop a surrogate performance measure to compare different resource flexibility strategies. We apply the model to allocate ORs among elective and emergency surgeries.

#### 2 - Resource Planning for Mental Health Services Delivery

Ayten Turkcan, Assistant Professor, Northeastern University, 360 Huntington Avenue, Boston, MA, 02115, United States of America, A.Turkcan@neu.edu, Laura Myers, Brad Doebbeling, Stephanie Adams

Mental health services are frequently resource limited. We modeled the inpatient and outpatient mental health care system at a VAMC. Our simulation model incorporated patient population characteristics, comorbidity, treatment patterns, patient flow, and care needs based on diagnosis and severity. Experts validated the simulation model, and provided usability feedback. Our model is a resource allocation tool for capacity planning decisions and to improve quality measures and timely access.

#### 3 - Patient-Bed Assignment Policies in Hospital Systems

Jackie Griffin, Northeastern University, 360 Huntington Ave., Boston, MA, 02115, United States of America, ja.griffin@neu.edu, Pinar Keskinocak

To alleviate overcrowding in hospitals, hospitals may implement policies that address the management of patient arrivals through the redirection of patients to other hospitals. We model the hospital unit as a Markov chain and develop type-specific threshold policies for patient assignment while simultaneously addressing three distinct objectives.

### 4 - Sizing and Scheduling Health Claims Coders under a Flexible Demand

Monica Villareal, PhD student, Georgia Institute of Technology, 755 Ferst Drive, NW, Atlanta, GA, 30332, United States of America, monica.v@gatech.edu, Pinar Keskinocak

We implemented a model that schedules about 700 coders for a company in Georgia. There is a time window for the demand completion, so solving this problem requires not only scheduling the staff but also the workload. This problem was modeled as a mixed integer program, which balances capacity constraints, preferences and utilization of the staff, supervision requirements, and demand completion. We also developed and tested heuristics for settings where an optimal solution was not available.

## WC04

04- Scottsdale

### Industry-Academic Research Partnership: Advances and Challenges

Cluster: Medical Decision and Policy Making

Invited Session

Chair: Eva Lee, Professor and Director, Georgia Institute of Technology, Atlanta, GA, United States of America, evakylee@isye.gatech.edu

#### 1 - Modeling and Optimizing Emergency Department Workflow

Eva Lee, Professor and Director, Georgia Institute of Technology, Atlanta, GA, United States of America, evakylee@isye.gatech.edu, Ruilin Zhou

The studies are joint with Grady Health Systems & Children's Hospital of Atlanta. The work addresses overcrowding of the emergency department; excessive presence of patients with non-urgent medical conditions; long wait times; decreased quality of care and patient satisfaction; unnecessarily long length-of-stay, and return/readmission of patients. Systems models and advanced computation are developed for optimal care delivery to improve performance efficiency and cost-effectiveness.

#### 2 - Rerouting Non-Emergency Patients from the Emergency Department (ED) to an Appropriate Care Setting

Kristin Schuller, schuller@tamhsc.edu, Tiffany Radcliff, Terri Menser, Jungyeon Kim

A new medical screening program that re-routes non-emergent patients age 6 to 64 from the emergency departments to an affiliated health clinic to receive care is has been implemented at a Texas hospital. All patients arriving at the ED are screened by a registered nurse in accordance with an approved protocol for triage. This study explores the impact on volume, case-mix, and revenues for both the health clinic and the ED using claims and payment information. A pre-post analysis, controlling for facility and patient characteristics, is used to analyze changes in revenues, volume, payer, and patient mix.

#### 3 - Engineering Better Emergency Department Observation Units

Kendall Sanderson, sanderson.k@husky.neu.edu, James Benneyan, Laura Hyde

Emergency department observation units (OUs) are gaining increased interest as an effective process to increase inpatient access, patient safety, and satisfaction and reducing overall costs and lengths of stay. In parallel there has not been much investigation on how to most effectively run IUs, such as patient selection, staffing, capacity sizing, and best practices. We report preliminary results of ongoing work to develop an operations research tool kit for OUs, including using capacity optimization, patient flow algorithms, staffing and scheduling, and data envelopment analysis (DEA).

#### 4 - Leveraging the Admission Process Policy to Improve Patient Flow and Quality of Care in the ED

Hyojung Kang, Pennsylvania State University, 310 Leonhard Building, University Park, PA, 16802, United States of America, HQK5116@psu.edu, Harriet Nembhard, Chris DeFlicht

The rapid transition of admitted patients from the Emergency Department (ED) to inpatient units is essential for high quality of care and efficient use of hospital resources. This research focuses on improving the patient flow and quality of care in the ED by leveraging the admission process policy. We categorize different admission processes into five major policy types. The potential impact of the admission process policy types on patient length of stay and ED throughput were analyzed using simulation. Our work also addresses the impact of the admission process on boarding patients in the ED.

## ■ WC09

09- McHenry

### Perpectives on Integrated Analytics in Healthcare

Contributed Session

Chair: Bradley Vincent Watts, Psychiatrist, Veterans Affairs, 215 North Main Street, White River Jct, VT, 05009, United States of America, [Bradley.watts@va.gov](mailto:Bradley.watts@va.gov)

#### 1 - Unstructured Health Care Big Data Analytics with Semantics

Deva Reddy, Founder & CTO, Evam Technologies, Bangalore, India, [deva@evamtec.com](mailto:deva@evamtec.com)

Majority around 80 % of the hospital unstructured data remains obsolete. Unstructured data consists of the physician prescription data, physician voice transcribed file and machine printed discharge summary along with the social media data. Current systems are unable to take value out of this ocean of unstructured big data. We provide great value in the following ways: to gain the leads to treat the patient, by integrating the patient records with the physician prescriptions and semantic social media; make unstructured data become value oriented asset; discover the data; understand the patterns and insights for clinical decisions and perform predictions; semantic inter-operability for integration; intelligent decision systems; personalization (alerts and updates, email, SMS, Tweets; follow-ups, updates, medicine consumption, research.

#### 2 - Integrated Healthcare Design Optimization through Predictive Analytics and Advanced Post Occupancy Evaluation Techniques

David Morgareidge, RTKL Associates Inc., 1717 Pacific Avenue, Dallas, TX, United States of America, [dmorgareidge@RTKL.com](mailto:dmorgareidge@RTKL.com), Hui Cai

Predictive analysis tools such as Discrete Event Simulation and Space Syntax Analysis support an optimal, integrated healthcare design approach. These rigorous and quantitative analysis techniques lead to the ideal blend of architectural space, technology, staffing, and clinical processes that achieve each client's unique clinical and financial performance objectives.

#### 3 - Differing Focus of Biomedical Research and Operations Research and Management Science

Bradley Watts, Assistant Professor of Psychiatry, Geisel School of Medicine at Dartmouth, 215 N. Main Street, White River Junction, VT, 05009, United States of America, [bradley.v.watts@dartmouth.edu](mailto:bradley.v.watts@dartmouth.edu), Julia McDougal Ronconi, James Benneyan, Erkan Ceyhan, TeChieh Chen, Brian Shiner

We hypothesized that operations research and management science (OR/MS) and traditional biomedical research (BMR) generally focus on different problems, decreasing synergy and slowing incorporation of systems engineering into healthcare. We reviewed abstracts from the INFORM's Healthcare conference (2011), and compared these to abstracts published and indexed by the National Library of Medicine, representing the biomedical literature. While complimentary in many areas, OR/MS and BMR differ importantly in areas of disciplinary focus. While BMR is relatively well-spread across most medical disciplines, OR/MS focuses on relatively few medical disciplines, potentially limiting the impact of OR/MS on the improvement in healthcare.

## ■ WC10

10- Cook

### Healthcare Policy and Finance - III

Contributed Session

Chair: Lijian Lu, PhD Candidate, Columbia University, Columbia Business School, 3022 Broadway, New York, NY, 10027, United States of America, [ll2755@columbia.edu](mailto:ll2755@columbia.edu)

#### 1 - Price Competition under Subsidization: Application to Medicare Reform

Lijian Lu, PhD Candidate, Columbia University, Columbia Business School, 3022 Broadway, New York, NY, 10027, United States of America, [ll2755@columbia.edu](mailto:ll2755@columbia.edu), Awi Federgruen

We consider price competition models, in which a significant part of the price is subsidized by a third party. We characterize the equilibrium behavior and derive comparison results for the price equilibria under alternative subsidy schemes. Applying our results to the Medicare insurance market, we estimate that implementation of various proposals, in particular the Wyden-Ryan plan, in 2010 would have enabled savings of 16.2% in the governments' costs. For beneficiaries continuing to opt for the traditional Medicare plan, the average monthly cost is roughly \$64.

#### 2 - Hedge Against Shortage: Improvement Analysis of Demand and Yield Rate Uncertainty

Hubert Pun, Western University, Ivey Business School, London, ON, Canada, [hpun@ivey.ca](mailto:hpun@ivey.ca), Mehmet Begen, Shaun Yan

A main driver for the drug shortages is the uncertain natures of the demand and of the yield. To hedge against shortages, the government should have a more precise estimation of the demand and of the yield. We analyze how the uncertainties in the demand and the yield rate impact the shortage, and the optimal efforts to reduce the uncertainties. Besides the order quantity and the number of production units, the government and the supplier also need to decide the level of effort to be exerted to reduce the variances of demand and yield rate, respectively.

#### 3 - Does Following the Rules Reduce Resource Usage? Exploring the Impact of Pay-for-Performance Programs

Dimitrios Andritsos, HEC Paris, 1 Rue de la Liberation, Jouy-en-Josas, 78351, France, [andritsos@hec.fr](mailto:andritsos@hec.fr), Christopher Tang

Within the context of cardiac care, we empirically examine whether hospital processes of superior quality also attain lower resource usage, which we measure while taking into account patient readmissions. We find that patients whose initial hospitalization occurs at a hospital with high process quality, spend on average less time in an acute care setting and hence consume less resources. Moreover, the effect of process quality appears to be direct. We then examine whether the structure of the cardiac department, moderates the observed effects of process quality on resource usage.

#### 4 - Skepticism and Credulity in the Market for Healthcare Services

Eric Schmidbauer, Indiana University, 1309 E. 10th St., BU 460, Bloomington, IN, 47405, United States of America, [eschmidb@indiana.edu](mailto:eschmidb@indiana.edu), Dmitry Lubensky

We develop a model of the doctor-patient relationship in which a biased doctor observes the true health state and sends a message that restricts the action space of the patient. The patient can accept the doctor's advice or reject it and do nothing. We find pure strategy equilibria in which both over- and undertreatment can occur. Patient skepticism about the doctor's motives lead to rejection of advice and thus undertreatment for relatively minor ailments while the doctor's messages about major treatments are heeded and result in overtreatment. Empirical findings of overtreatment may therefore hide some undertreatment. We additionally show that the ability to restrict the patient's action space results in doctor welfare that is unambiguously higher, though for patients this result only holds for relatively low levels of doctor bias.

## ■ WC11

11- Dupage

### Advances in Healthcare Delivery

Cluster: Healthcare Operations Management

Invited Session

Chair: Eva Lee, Professor and Director, Georgia Institute of Technology, 755 Ferst Drive, NW, Atlanta, GA, 30332, United States of America, [eva.lee@gatech.edu](mailto:eva.lee@gatech.edu)

#### 1 - On the Development of the Scheduling System of Operating Rooms of Aichi Medical University Hospital

Atsuo Suzuki, Professor, Nanzan University, 27 Seirei, Seto, 4890863, Japan, [atsuo@nanzan-u.ac.jp](mailto:atsuo@nanzan-u.ac.jp), Yoshihiro Fujiwara, Kana Yamamoto, Mina Ito, Chihiro Kobayashi, Takamori Imaizumi

We develop a system supporting operating rooms' scheduling. The system provides an interface to support the process to finish up scheduling. We obtain scheduling by solving the scheduling problem, formulated as integer programming. After that we modify it by hand and solve it again under the modified constraints. We iterate this until we obtain the final scheduling. A prototype is tested in Aichi Medical University Hospital and we find that the system reduces the time for scheduling.

#### 2 - OR/MS Offers Solutions to the Emergency Department Crisis

Doug Samuelson, President / Chief Scientist, InfoLogix, Inc., 8711 Chippendale Ct, Annandale, VA, 22003, United States of America, [info-logix1@aol.com](mailto:info-logix1@aol.com)

While emergency departments (EDs) in the U.S. are increasingly overwhelmed, often compromising treatment quality, a few analyses have produced dramatic improvements. "Door-to -Doc," having a doctor assess patients before performing triage to assign beds, is one good example, and simulations of patient and resource flows suggest other opportunities. But to help, OR/MS analysts need to learn medical terms and practices. (Dedicated to the Memory of David Eitel, M.D.)

### 3 - The Surgical Patient Routing Problem

Sepehr Nemat, University of Pittsburgh, Department of Industrial Engineering, 1048 Benedum Hall, Pittsburgh, PA, 15261, United States of America, sen12@pitt.edu, Oleg Shylo, Oleg Prokopyev, Andrew Schaefer

Many patients face difficulties to access medical facilities in the U.S. In this study, we propose an integrated routing and outpatient surgery scheduling model for those medical centers providing transportation assistance for the patients. The objective is to minimize the total service time cost of all the patients. Our numerical study using actual medical data shows the efficacy of a unified framework to improve the quality of services to the patients.

### 4 - Priority Queuing Models for Hospital Intensive Care Units and the Impacts to Severe Case Patients

Matthew Hagen, Georgia Institute of Technology, College of Computing, Atlanta, GA, United States of America, matthew.hagen@gatech.edu, Eva Lee

This is a joint work with Emory University. This talk reports priority strategies for intensive care units (ICU) and the effects on wait times, utilization, return rates, mortalities, and number of patients served. Five separate ICUs are analyzed. A system-based simulation-optimization model is built to capture all possible cases of patient flow. Patients are grouped into 9 different classes that are categorized by severity and length of stay.

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- MA04 Managing and Discharging Inpatients
- MA05 Joint Session HAS/SPPSN: Preferences and Risk Management in Health Care
- MA06 Population-level Models of Interventions and Disease Outcomes
- MA07 Scheduling Services in Healthcare
- MA08 Recent Advances in Proton Radiation Treatment Planning
- MA09 Optimization Models for Kidney Allocation and Transplantation
- MA10 Healthcare Scheduling and Capacity Management
- MA11 Patient Centered Models of Care
- MA12 Evidence Based Health Services Operations Research
- MA13 Medical Decision Making
- MA14 ORAHS I- What Makes a Model Useful?

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- TA08 Advances in Rural Health
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- TD08 EMR, EHR, HIT: Implementation Barriers and Strategies
- TD09 CHOIR (Center for Healthcare Operations Improvement and Research)
- TD10 Capacity Management
- TD11 Empirical Research in Hospital Operations
- TD12 Hospital Readmission Modeling and Analysis
- TD13 Modeling Infectious Diseases
- TD15 Empirical Operations in Healthcare

**Wednesday, 8:30am - 10:00am**

- WA01 Joint Session HAS/ISIM: HIV and Networks
- WA02 Data Driven Approaches to Identify and Treat Critical Illness: Applications
- WA03 Dynamic Optimization of Clinical Treatments
- WA04 Joint Session HAS/MDPM: Policy and Decision Making in Disasters and Public Health Emergencies
- WA07 Surgical Operations
- WA08 Chronic Diseases: Screening and Treatment
- WA09 Application of Operations Research in Healthcare
- WA10 ORAHS 2- Modeling for Planning Decisions
- WA18 Scheduling and Patient Flow for Healthcare OR

**Wednesday, 10:30am - 12:00pm**

- WB01 Healthcare Services
- WB02 Hospital Operations
- WB03 Big Data in Healthcare
- WB04 Modeling for Optimization of Healthcare Delivery
- WB07 Healthcare Operations
- WB08 Modeling Cancer Behavior, Screening, Treatment
- WB09 Challenging Decisions in Pharmaceutical Supply Chains
- WB10 Healthcare Policy and Finance - III
- WB11 Empirical Studies on Hospital Operations
- WB18 Challenges in Sudden Cardiac Arrest: Perspective from Physicians

**Wednesday, 1:30pm - 3:00pm**

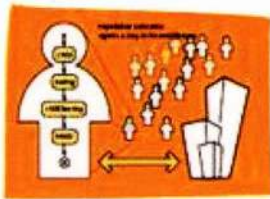
- WC01 Healthcare Analytics in the CMS Systems Engineering Innovation Center
- WC02 Patient Flow Models for Resource Allocation
- WC04 Industry-Academic Research Partnership - Advances and Challenges
- WC09 Perspectives on Integrated Analytics in Healthcare
- WC10 Healthcare Policy and Finance - I
- WC11 Advances in Healthcare Delivery



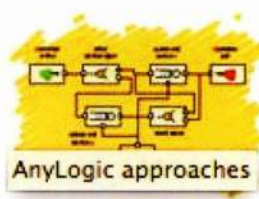
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## Multimethod Simulation Software

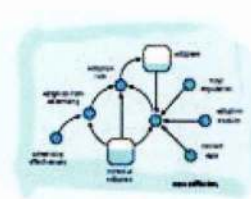
AGENT BASED  
APPROACH



DISCRETE  
EVENT



SYSTEM  
DYNAMICS



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