ORAHS 2013 CONFERENCE

39th International Conference of the EURO Working Group on Operational Research Applied to Health Services (ORAHS)

Operational Research (O.R.) for New Challenges in Healthcare Services

7-12 July 2013

Koc University, Istanbul, Turkey

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Contents

WELCOME

Dear ORAHS 2013 Participant,

We are delighted to welcome you in Istanbul for the 39th annual meeting of the European Working Group on Operational Research Applied to Health Services! It is a great honor for us that the ORAHS community will be meeting in Turkey for the first time. We hope that it will be a very memorable and enjoyable conference both scientifically and socially.

The theme of this year's conference is "OR for New Challenges in Health Care Services". During the conference opening, local plenary speakers composed of policy-makers, academicians and practitioners will present insights on the recent reforms in the Turkish health system. Our keynote speaker, Professor William P. Pierskalla will discuss the new forces that reshape the global health systems, demanding major changes in OR research and education. Another panel consisting of leading academicians and practitioners will further discuss the opportunities and challenges in healthcare delivery, and what operational research can offer.

This year, there are some slight modifications to the traditional format of the ORAHS meetings. Similar to the previous meeting, there is no hospital tour planned. Instead, there will be three tutorial talks on a variety of topics. We hope that these sessions, in addition to the oral and poster presentations and discussion panels, will improve the conference experience by providing ample opportunities for learning, interaction and discussion. We also follow the last year practice in terms of distributing the Proceedings in digital form with USB memory sticks.

Besides an enriching scientific programme, we offer an exciting social programme. A visit to Istanbul is not complete without a Bosporus boat tour where you can have an impressive view of the city highlights, a trip to the Old Town and the Grand Bazaar, and a dinner by the sea. We also planned to allow for some free time to enjoy Istanbul as you wish.

We also would like to thank EURO for the generous support they provided, Koç University for hosting our conference and supporting us in many different and valuable ways, Özyeğin University for the conference bags, notebooks and pens, Mado for Turkish sweets, and Asterya for their support in the organization.

With our best wishes for a very fruitful and wonderful stay in Istanbul!

Tuğba Çayırlı, Murat Günal, Evrim Güneş, Lerzan Örmeci, and Yaşar Özcan

ORGANISING COMMITTEE

Yaşar A. Özcan	Tuğba Çayırlı	E.Lerzan Örmeci	Evrim D. Güneş	Murat M. Günal
Virginia Commenwealth University	Özyeğin University	Koç University	Koç University	Turkish Naval Academy

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KOÇ UNIVERSITY

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CONFERENCE INFORMATION

Conference Venue

The campus of Koç University is compact and all facilities can be reached on foot. See page ix for a map of campus.

All parallel sessions will take place in the Social Sciences Building (SOS) in rooms **SOSZ21**, **SOSZ27**, **SOS103** and **SOS104**. The opening session on Monday morning and the keynote talk on Tuesday morning will take place in the auditorium in the Engineering Building (room **ENGZ50**), which is a short stroll from the SOS building. Tutorials and the panel on Thursday will take place in room **SOSB07**. Poster session will take place in the corridor leading to rooms **SOS103 - SOS104**. All rooms will be signposted during the conference.

Registration

Participants can register either at the welcome party on Sunday in Fuat Pasa Hotel or between 09.00-11:00 on Monday morning by the Engineering Auditorium, where the opening session will take place. Registration desk will be open by **SOS103-SOS104** throughout the conference for any assistance you may need, or for late registrations.

Getting Around Istanbul

Istanbul is a very large city with all modes of transportation used to get around. Apart from public buses, trains and trams, the most common means of transportation are taxis, ferry boats, mini buses, and sea buses.

Tickets for public transportation: Istanbul Kart (Istanbul Card, please see below) is in essence an all-round public transportation boarding pass in Istanbul. It is worth getting one if you plan to use (the advantages of) public transportation multiple times during your stay in Istanbul. It's a contactless or RFID (Radio-frequency identification) card for public transportation fare payment. It has the exact same size as a regular credit card, so it fits perfectly in your wallet. The card is pre-paid in TL (Turkish Lira) and easily rechargeable. In mini busses, which are perhaps unique to Istanbul, the payment is given to the driver in cash.

Istanbul Kart


Waving the Istanbul Kart before the reader on a bus

Where to Get an Istanbul Kart
The easiest way to get the Istanbul Kart is at major transit stops such as the airport, Taksim, Eminönü, Sultanahmet, Beyazıt/Kapalı Çarşı (Grand Bazaar), etc. To buy an Istanbul Kart, you need to pay a non-refundable 10 TL fee (for the actual card and the service), and of course an amount of your choice to load onto the card.

How to Reload the Istanbul Kart
To reload the card, you can either go to newsstands and small shops (look for the phrase **Akbil Dolum Noktası**) which offer this service, use self-service special purpose machines at major transit stations. The machines accept notes of 5, 10, 20, and 50 TL and have instructions in multiple languages.

Conference Transportation

All shuttles will depart from the Sevgi Gonul Auditorium entrance of the Social Sciences Building. Shuttle stop will be signposted.

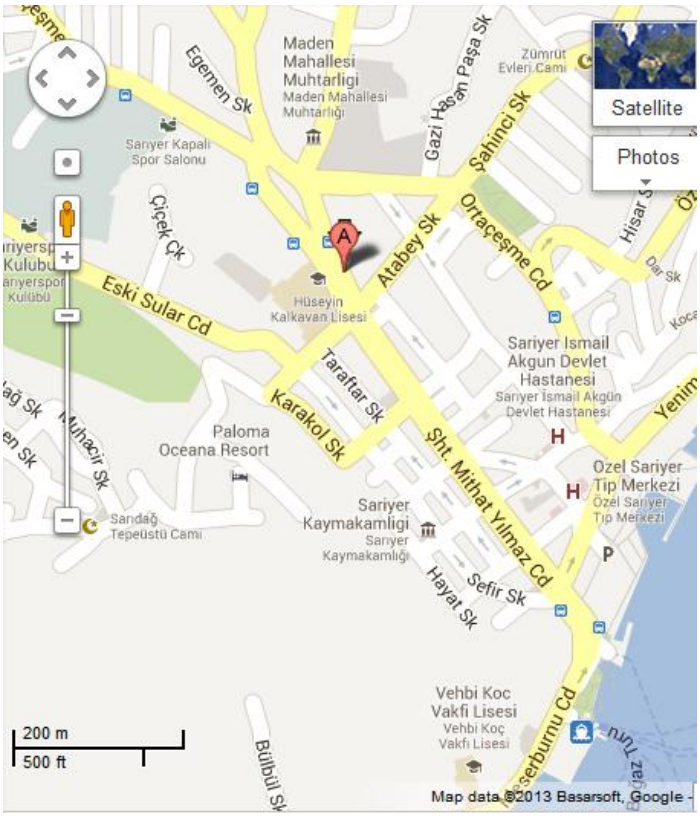
To reach the campus from Fuat Pasa Hotel:
We will provide shuttle busses between Fuat Pasa Hotel and campus in the morning and evening. The Shuttle Schedule is as follows;

ORAHS Shuttle Schedule to from Fuat Paşa Hotel

	Fuat Paşa departure	KU Campus departure
July 7th Sunday	19:00	16:00
July 8th Monday	08:50	18:00
July 9th Tuesday	08:50	17:30
July 11th Thursday	08:50	18:30
July 12th Friday	08:50	14:30

To reach the campus from Sarıyer:

There are *mini busses* leaving from the end of the Sehit Mithat Yılmaz Street (no: 86, see Map below), for a 1.75 TL per trip. Taxi is a quick and affordable alternative, which costs around 15 TL from Sarıyer to campus.



To reach campus from Taksim (or any other location on the metro line):

Take the metro direction to "*Hacıosman*", get off at the last stop (Hacıosman). Take the bus (see the schedule below), or take a taxi (costs about 25 TL).

Koç University (KU) Shuttle Schedule to/from Hacıosman Metro Station (TL 3.00 to be paid in cash)

KU CAMPUS DEPARTURE	HACIOSMAN METRO DEPARTURE
	9:00
9:30	10:00
10:30	11:00
16:30	17:00
17:30	18:00
18:30	19:00
19:30	
	22:00
	0:15

Public Bus Schedule to/from Metro Station (to be paid by Istanbul Kart)

Hacıosman Metro Station Departure	Koç University Departure
06:45	07:30
07:30	08:10
08:15	09:00
09:05	09:45
09:40	10:35
10:30	11:20
12:05	12:55
13:45	14:30
15:20	16:05
16:15	16:55
17:00	17:45
17:45	18:40
18:35	19:35
20:20	21:00
21:40	22:20

Lunches and Refreshment Breaks

Lunches, every day except for Wednesday, will be served in the yard of the Social Sciences Building. Coffee Breaks will take place by the rooms **SOS103-SOS104**.

Furthermore, participants can use the university cafeteria located in the Student Center (see Campus Map on page ix) which serves breakfast, lunch and dinner. There is also a food court with several options for meals and snacks in the Student Center, where most services are open between 08:30-19:00 with the exception of a 24-hour open canteen.

Payment in all restaurants and cafes can be done by cash or by credit card. Also there are vending machines in each building, which work with Turkish Lira coins.

There is a supermarket on campus which is open every day between 09:00-19:00.

Internet Access
Free Wi-Fi is available to all participants. You can collect login information at the registration desk.

Computer Support
A computer and a printer will be available in room CAS Z09 (CAS is the building of College of Administrative Sciences, which is next the Social Sciences building).

Poster Display
Posters will be on display in the corridor next to rooms **SOS103-SOS104** from Tuesday afternoon to Thursday afternoon. Poster presenters can hang their posters on the display location before Tuesday noon. Dedicated poster session will be on Tuesday between **14:00-15:30**, where participants will have a chance to speak with the poster presenters who will be standing by their posters.

Tutorials
There will be three tutorial sessions in total; each one scheduled in one of the three afternoons. Tutorial sessions will be held in room **SOSB07**. Please see the scientific programme for detailed information on tutorials.

Accompanying Person's Programme
Accompanying people will join the scientific delegates for the social programme of the conference. In addition, optional tours are offered. Please see the conference website for more information, and if interested, register at the registration desk.

Share your ORAHS 2013 Photos:
We have created a Picasa Web Album to share photos made during the conference. Below are the login details:
website: http://picasaweb.google.com
login: orahs2013@gmail.com
password: istanbul2013

Emergency Contacts
You can contact the local organizing committee on:

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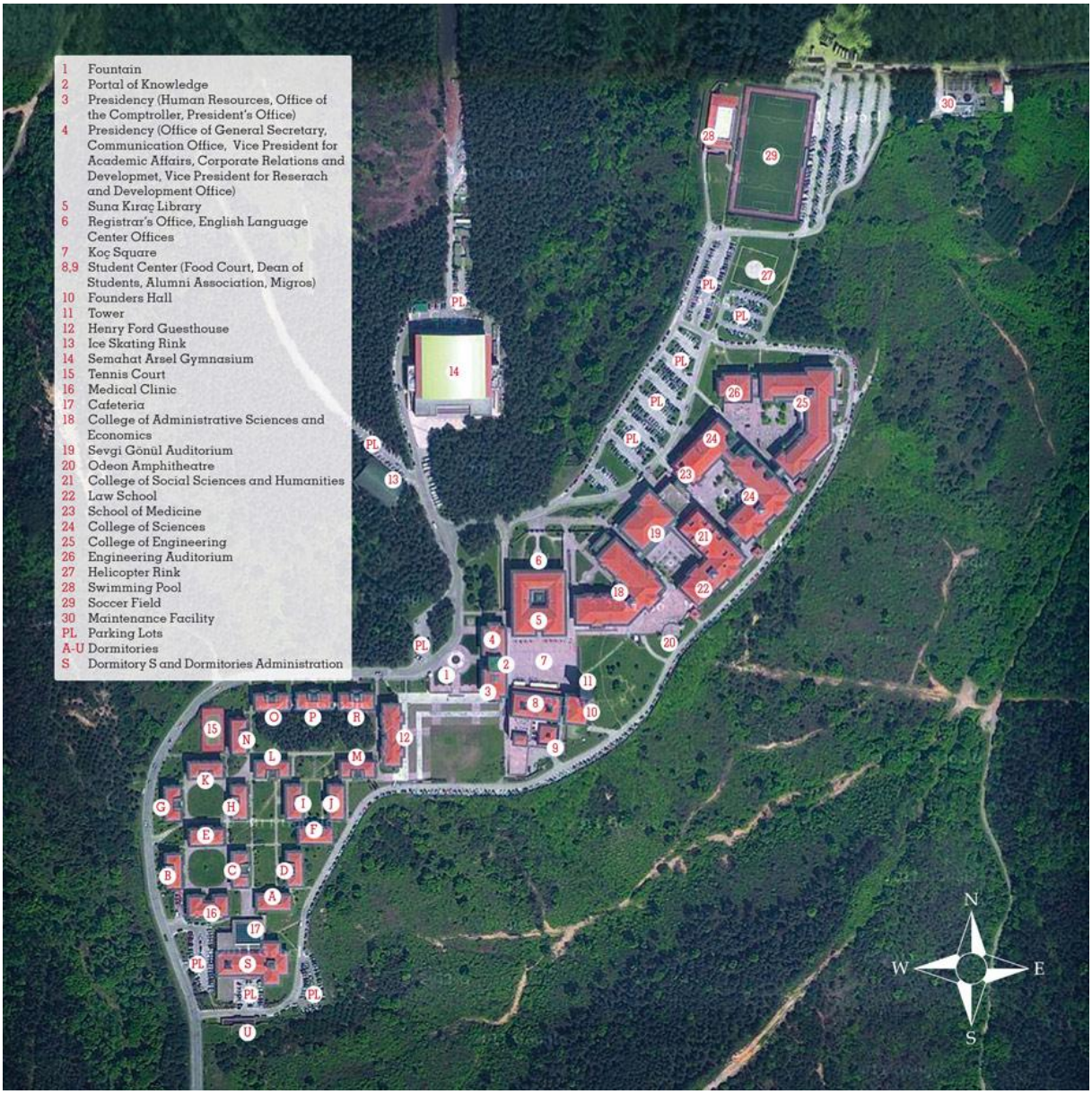
Campus Map


1 Fountain
2 Portal of Knowledge
3 Presidency (Human Resources, Office of the Comptroller, President's Office)
4 Presidency (Office of General Secretary, Communication Office, Vice President for Academic Affairs, Corporate Relations and Developmet, Vice President for Reserach and Development Office)
5 Suna Kıraç Library
6 Registrar's Office, English Language Center Offices
7 Koç Square
8,9 Student Center (Food Court, Dean of Students, Alumni Association, Migros)
10 Founders Hall
11 Tower
12 Henry Ford Guesthouse
13 Ice Skating Rink
14 Semahat Arsel Gymnasium
15 Tennis Court
16 Medical Clinic
17 Cafeteria
18 College of Administrative Sciences and Economics
19 Sevgi Gönül Auditorium
20 Odeon Amphitheatre
21 College of Social Sciences and Humanities
22 Law School
23 School of Medicine
24 College of Sciences
25 College of Engineering
26 Engineering Auditorium
27 Helicopter Rink
28 Swimming Pool
29 Soccer Field
30 Maintenance Facility
PL Parking Lots
A-U Dormitories
S Dormitory S and Dormitories Administration
N
W
E
S

SOCIAL PROGRAMME

07 July Sunday Welcome Reception
Drinks and light snacks at Fuat Pasa Hotel, between 16:00-19:00.
All conference participants are invited to attend the Welcome Reception.

08 July Monday Boat Tour
Boat leaves at 20:00 from Beşiktaş, shuttles at 19:00 from KU Campus, 19:15 from Fuat Pasa Hotel
Sail up the Bosphorus, the waterway between Europe and Asia, passing under the suspension bridges and viewing Ottoman summer palaces, waterside mansions, Galata Tower, historical peninsula, Maiden's Tower, Dolmabahçe Palace, Çırağan Palace, Rumeli Fortress, Beylerbeyi Palace and modern villas which line the European and Asian coasts. Dinner will be served during the tour.

09 July Tuesday Optional Dinner
@19:30 in Tarabya Alimento Restaurant
Per person: €30
Dinner in Alimento Restaurant in Tarabya by the Bosphorus, located 4.3 kms south of Fuat Pasa Hotel. If you would like to attend, we would kindly request that you register at the registration desk latest by Monday evening.

10 July Wednesday Guided Tour
Shuttle leaves at 9:00 from KU Campus, at 9:15 from Fuat Pasa Hotel, returns at 16:30**.**
HIPPODROME, BLUE MOSQUE, TOPKAPI PALACE, GRAND BAZAAR.
We will meet at the shuttle stop and drive the old city. First, we will visit the Hippodrome where once upon a time 100,000 specters watching at the chariot races and the gladiator fights were performed on monumentalized courtyard of the building. Then, we will continue the Blue Mosque famous for its delicate blue ceramic tiles one of the master pieces of Ottoman Empire. We will visit Topkapı Palace. It is built on one of the seven hills of Istanbul. These huge complexes command views of the Sea of Marmara, the Bosporus and the Golden horn. Then, we will visit the Grand Bazaar. It is the oldest and the largest covered market place in the world which is situated in the center of the city. After visiting the Grand Bazaar, there will be optional shopping opportunity before finishing the tour. A lunchbox will be served in the end.

11 July Thursday Gala Dinner 20:00-23:00
Shuttle departs from Campus at 19:00 and from Fuat Pasa Hotel 19:15, returns at 23:00.
The gala dinner will be at Yıldız Hisarı Restaurant. For those who want to use their own transport, please consult at the registration desk for directions.

Program for ORAHS 2013

	Sunday July 7	Monday July 8	Tuesday July 9	Wednesday July 10	Thursday July 11	Friday July 12
9:30 - 10:00		Registration and Coffee/Tea	Parallel Sessions 3	Old City Tour	Parallel Sessions 5	Parallel Sessions 8
10:00 - 10:30						
10:30 - 11:00		Conference Opening				
11:00 - 11:30		Panel Discussion [1]	Coffee/Tea		Coffee/Tea	Coffee/Tea
11:30 - 12:00			Keynote Talk [3]		Panel Discussion [5]	Business Meeting
12:00 - 12:30						
12:30 - 13:00		Lunch	Lunch	Lunch	Lunch	Lunch
13:00 - 13:30						
13:30 - 14:00						
14:00 - 14:30		Parallel Sessions 1	Poster display and Coffee/Tea	Free Time	Parallel Sessions 6 [6]	
14:30 - 15:00						
15:00 - 15:30						
15:30 - 16:00		Coffee/Tea	Parallel Sessions 4 [4]		Coffee/Tea	
16:00 - 16:30	Welcome Party	Parallel Sessions 2 [2]				
16:30 - 17:00					Parallel Sessions 7	
17:00 - 17:30						
17:30 - 18:00						
18:00 - 18:30						
18:30 - 19:00						
19:00 - 19:30		Bosphorus Boat Tour	Dinner by the Bosphorus (optional)		Conference Dinner	
19:30 - 20:00						
20:00 - 20:30						
20:30 - 21:00						
21:00 - 21:30						
21:30 - 22:00						

(1) Panel Discussion 1: *Healthcare Reform and New Challenges in Turkish Healthcare System and Operational Research*
Prof. Dr. Şevket Ruacan (Dean of Medical School at Koç University)
Dr. Hacer Özgen Narcı (Head of Healthcare Management Department at Acıbadem University)
Prof. Dr. Sabahattin Aydın (Rector of İstanbul Medipol University)
(2) Tutorial Session 1: *Healthcare Logistics*
Prof. Dr. Stefan Nickel (Karlsruhe Institute of Technology Institute of Operational Research)
(3) Keynote Talk: *New and Old Forces Are Shaping Major Changes in Health Care Delivery Presenting Great Opportunities for OR in Health Care*
Prof. Dr. William P. Pierskalla (Distinguished Prof. Emeritus and Dean Emeritus at UCLA and Ronald A. Rosenfeld Prof. Emeritus at the University of Pennsylvania)
(4) Tutorial Session 2: *Health Policy Modeling*
Prof. Dr. Margaret Brandeau (Stanford University)
(5) Panel Discussion 2: *Future of Healthcare: Challenges for Operational Research*
Prof. Dr. William P. Pierskalla (The Anderson School at UCLA & The Wharton School, Univ. of Pennsylvania)
Prof. Dr. Yasar Ozcan (Department of Health Administration, Virginia Commonwealth University)
Prof. Dr. Marion Rauner (School of Business, Economics and Statistics, University of Vienna)
Prof. Dr. Mike Pidd (The Management School, Lancaster University)
Tom Bowen (The Balance of Care Group, U.K.)
(6) Tutorial Session 3: *Stochastic Disease Modeling and Chronic Disease Management*
Prof. Dr. Mariel Lavieri (University of Michigan)

SCIENTIFIC SCHEDULE

Monday July 8th

10:30	Conference Opening	Room: Eng Auditorium

10:30-10:40 Organizing Committee
10:40-10:50 Fikri Karaesmen, Dean of College of Engineering, Koc University
10:50-11:00 Sally Brailsford , Chair of ORAHS

11:00-12:30	Panel Discussion	Room: Eng Auditorium

Healthcare Reform and New Challenges in Turkish Healthcare System and Operational Research
Moderator: Prof. Dr. Yaşar Özcan
Prof. Dr. Sabahattin Aydın (Rector of Istanbul Medipol University)
Prof. Dr. Hacer Özgen Narcı (Head of Healthcare Management Department at Acıbadem University)
Prof. Dr. Şevket Ruacan (Dean of Medical School at Koç University)

14:00-15:30 Session 1

1A Public Health Policy Room: SOS Z21	**1B Operating Room Planning & Scheduling (1)** Room: SOS Z27	**1C Cancer Treatment Planning** Room: SOS 103	**1D Modeling Length of Stay** Room: SOS 104
Brian P Reddy An MCDA approach to prioritising public health interventions: A knowledge-based approach to reducing tobacco prevalence in South Yorkshire	**Elena Tànfani** Robust solutions for the advance surgery scheduling problem	**Siqiao Li** Operation management of radiotherapy treatment: Literature review	**Sally Brailsford** The effect of outlying patients to clinically inappropriate wards
Joe Viana Whole systems modelling of social care in Hampshire in the United Kingdom	**Addis Bernardetta** An online-offline approach to the OR planning problem under uncertain surgery duration	**Mehmet A Begen** Reducing wait times and improving treatment planning process for radiation therapy	**Maria Guzman Castillo** Understanding patient length of stay: A finite mixture approach
Sonia Vanderby Can improved appointment booking policies effectively improve patient access while also reducing imaging costs?	**Inês Marques** A bicriteria heuristic approach for an elective surgery scheduling problem	**Alexander Scherrer** Software assisted decision making in breast cancer therapy planning	**Adele H Marshall** The discrete conditional phase-type distribution for modelling patient length of stay in hospital in Italy
Onur Uzunlar A preliminary study to optimally locate the clinical video telehealth units within veterans affair white river junction area	**Serhat Gul** Dynamic scheduling of surgeries under uncertainty	**Arturo E. Pérez Rivera** Preventing delays in radiotherapy by allocating linac capacity in advance	

16:00-17:30	Session 2		
	2A Performance Evaluation Room: SOS Z21	**2B Disease Modeling and Policy** Room: SOS Z27	**2C Tutorial 1** Room: SOSB07
	Marion Sabine Rauner Efficiency of rescue departments of the Austrian Red Cross: A data envelopment analysis benchmarking study	**Melike Hazal Can** A dynamic simulation model for insulin resistance and Type II diabetes in the context of obesity	**Stefan Nickel** Healthcare Logistics
	Tomi Malmström Effects of patient case-mix to operational performance of ED	**Brian Dangerfield** Use of a model for setting an achievable public health target: The case of childhood obesity in the UK	
	Guilan Kong Integrated performance assessment of orthopedics care from medical quality and efficiency dimensions	**Elvan Gokalp** Dynamic modeling of peritoneal dialysis and its implementations in children with chronic renal failure	
	Martin Utley Notes on a shambles	**Janette McQuillan** Using system dynamics to determine the long term management consequences for coronary heart disease patients	

PANEL DISCUSSION: Healthcare Reform and New Challenges in Turkish Healthcare System and Operations Research

Room: Eng Auditorium **Moderator:** Prof. Yasar Ozcan **11:00-12:30**

Sabahattin Aydın graduated from the School of Medicine of Istanbul University, Turkey and received his medical specialization in urology from Thrace University, Greece. Professor Aydın became the Deputy Undersecretary of the Ministry of Health in 2003 and worked as the coordinator of the Health Transformation Program in Turkey. He was mainly responsible for the design and monitoring of recent health reforms. He played an active role in the preparation and implementation of various projects, including pharmaceuticals pricing policy, the family practitioner scheme, performance-based payment system and granting greater autonomy to hospitals. He was a member of the interministerial drafting group for the establishment of universal health insurance. He also played an active role in the preparation of the Ministry of Health's strategic plan. He was an executive board member of WHO between 2006 and 2009. He was also elected as an alternate member of the Regional Search Group 2004 and is an active member of the latest Regional Search Group (2009) for the WHO Regional Office for Europe. Recently he was the adviser to Minister of Health and adviser to the President of Istanbul University. He is now the President of Istanbul Medipol University.

Şevket Ruacan graduated from Hacettepe University Faculty of Medicine in Ankara,Turkey. He received postgraduate training in biochemistry and pathology at University of Pennsylvania and New York University. He served as the Dean of Medical School and Director of Institute of Oncology at Hacettepe University and as member of Higher Education Council and Executive Board member of Scientific and Technical Research Council of Turkey. More recently he was on the Executive Board of Interacademy Medical Panel and Association of Asian Science Academies. Since 2009 he is the founding Dean of the new medical school at Koç University,Istanbul.

Dr. Özgen Narcı is currently serving as head of the Department of Health Management at Acıbadem University, with M.S. in Health Institutions Management, Hacettepe University and PhD. in Health Services Organization and Research, Virginia Commonwealth University, USA. Her research interests include efficiency, health financing especially out-of-pocket payments and competition. Her work is focused on productivity and technical efficiency in the health care sector in general and the dialysis market in particular, financial catastrophe and poverty impacts of out-of-pocket expenditures and hospital competition-efficiency relationship. She has published in, among others, prestigious journals related to health care management such as Health Affairs, Health Services Research, Social Science and Medicine, Health Policy and Health Care Management Science. She has been involved in several national and international projects as project manager or researcher.

Yasar A. Ozcan, Ph.D. Specialties are mathematical modeling applications in health care, health care information systems, and general statistical applications. His scholarly work is in the areas of health systems productivity, technical efficiency, financial efficiency, and effectiveness for health care providers. More specifically, his specialty is focused on creating benchmarks for physicians and other health care providers using Data Envelopment Analysis (DEA). Dr. Ozcan served as Interim Executive Director, Office of International Education, Virginia Commonwealth University. He is founding Editor-in-Chief of Journal of Health Care Management Science and past-president of Health Care Applications Section of Institute for Operations Research and Management Science (INFORMS).

Session 1A: Public Health Policy MON-1A

Room: SOS Z21 **Chair**: Onur Uzunlar **14:00-15:30**

1- An MCDA approach to prioritising public health interventions – A 'knowledge based' approach to reducing tobacco prevalence in South Yorkshire

Brian P Reddy[1], Praveen Thokala[1], Lynsey Bowker[2], Helen Chambers[3], Alison Iliff[4], Kerry Warhurst[5]
[1]ScHARR, University of Sheffield, Sheffield, UK
[2]Public Health Division, Sheffield City Council, Sheffield, UK
[3]Public Health Division, Barnsley Town Council, Barnsley, UK
[4]Public Health Division, Rotherham Town Council, Rotherham, UK
[5]Public Health Division, Doncaster Town Council, Doncaster, UK

There are a number of options open to local governments to reduce the impact of tobacco on populations; helping smokers quit, reducing the harm smokers cause to others, increased investment in education to reduce the level of young people taking it up, increased efforts at enforcement to reduce the impact of illicit tobacco and sales to minors, and so on. In the four local health areas (PCTs) of South Yorkshire, over 90% of the total tobacco budget is spent on stop smoking services (SSSs) and there is strong evidence to show these should prove cost effective. However, tobacco prevalence levels have remained constant in South Yorkshire for a number of years. This reflects findings from the WHO, amongst others, that argue that a comprehensive approach to tobacco prevention is more likely to be successful. For a number of practical reasons it has not been as possible to gather data for the cost effectiveness of competing approaches, making it difficult to prioritize between them or even choose them ahead of SSSs which, it is clear, are having no impact on their own.
As such a 'knowledge based" rather than "evidence based" approach was constituted using MCDA techniques to revisit the aims of PCT-level public health spending on reducing tobacco harm and aligning services offered accordingly. 16 interventions (including present SSSs) were chosen for further investigation. Members of the public were consulted to identify relevant criteria to choose between them, and a broad range of stakeholder groups consulted to weight these. Representatives of the groups were brought together for a decision workshop to produce a score for each intervention. The approach allowed the ultimate decision makers to think more holistically about their aims and about which approaches may work together, rather than following a prescriptive approach shown to be unworkable.

2- Whole systems modeling of social care in Hampshire in the United Kingdom

Joe Viana[1], Kevin Andrews[2], Sally Brailsford[1]
[1]Southampton Management School, University of Southampton, Southampton, United Kingdom
[2]Adult Services, Hampshire County Council, Winchester, United Kingdom

The UK's population is ageing, and this is a key driver influencing the development of social care need. Social care in the UK (unlike healthcare, which is provided free at the point of access) is provided by a range of providers. Social care providers includes friends and family (informal care), third sector (charitable) organizations, care provided solely by local authorities, care purchased from private providers, or any combination of the above. In order to assess the demand for any provider of social care, a "whole system" approach is required, since the way the system operates will influence the demand for each provider. To this end a System Dynamics simulation model has been developed, which captures some of the complexity of the social care system. The model enables the interventions available to keep people healthier to be assessed, and shows the time it takes for people to develop social care need, the interactions between the provision of social care and hospital admission, and the impact of unmet need (i.e., those people who have a care need but are not receiving any type of social care support). This work is part of the Care Life Cycle project, a multi-disciplinary project based at the University of Southampton, whose aim is to investigate the factors affecting both the supply and the demand of health and social care in the UK, in the context of an ageing population.

3- Can improved appointment booking policies effectively improve patient access while also reducing imaging costs? Evaluating CT resource use in Saskatchewan, Canada

Sonia Vanderby[1], Sabrina K. Tang, Michael W. Carter[2]
1University of Saskatchewan, Saskatoon, Canada
[2] University of Toronto, Toronto, Canada

Computed Tomography (CT) is used to diagnose many conditions and demand has been increasing across Canada. Increased demand has led to CT imaging requisition backlogs and lengthy wait times which need to be reduced. The Province of Saskatchewan is seeking to decrease these wait times, in part by examining how CT resources are currently being utilized. Recent statistics indicate that annual exam rates ranged from approximately 2,775 to 10,004 per scanner, while 90th percentile wait times range from 2 to 43 days. These variations led to questions regarding the efficiency with which these costly resources are being used and if CT demand can be balanced effectively implemented to reduce wait times. Aiming to balance CT resources and improve access through lower wait times, while also reducing patient travel burdens, this ongoing research will evaluate Saskatchewan's CT imaging system in terms of utilization, efficiency, costs and accessibility. This allows opportunities for improvement to be identified with a particular focus on rural and remote residents. The key questions are; (1) How do utilization rates differ among CT resources within Saskatoon and how do they compare to other jurisdictions? (2) Do CT imaging demand and utilization vary among demographic and geographic populations in Saskatchewan? (3) How far do outpatients typically travel for CT imaging and how does this differ by patient's place of residence? The aim is for this information to be used to build a model for testing different appointment booking policies and compare their impact on patient access and system costs. It is hoped that booking policies can be identified that will simultaneously have a positive impact on these metrics, and potentially delay the need to acquire additional CT imaging resources.

4- A Preliminary Study to Optimally Locate the Clinical Video Telehealth Units within Veterans Affair White River Junction Area

Onur Uzunlar[1], James C. Benneyan[1], Bradley V. Watts[2]
[1]Healthcare Systems Engineering Program Northeastern University, Boston, USA
[2]VA Medical Center, USA

The Department of Veterans Affairs (VA) is the largest integrated health network in the United States with 21 Veteran Integrated Service Networks (VISNs), providing health services to American veterans. The VA aims to increase access to their services by adapting telehealth to their system. This study investigates the problem of optimally locating the Clinical Video Telehealth (CVT) units which are commonly used for telehealth encounters. An integer programming model which minimizes the average and maximum traveling distance is developed to propose a better functioning system. The effect of using Veteran Centers as potential location points is also considered and the benefits of using these centers are outlined. Results indicate that by using current locations with the current specialties operating these units, average and maximum traveling distance can be reduced by 14%. Moreover, by using the Veteran Centers average traveling distance can be reduced by 17% and the maximum traveling distance can be reduced by 14%. Other specialties are proposed alternative to the specialties providing CVT encounters currently by analyzing leading telehealth provider sites within VISN1. Minimum number of units needed to provide different coverage levels are determined and corresponding performance metrics are calculated accordingly.

Session 1B: Operating Room Planning & Scheduling (1) MON-1B

Room: SOS Z27 **Chair**: Elena Tànfani **14:00-15:30**

1- Robust solutions for the advance surgery scheduling problem

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We present an approach based on robust optimization to deal with the advance surgery scheduling problem assuming uncertain surgery times. In particular, given a surgery waiting list, a set of Operating Room (OR) blocks and a planning horizon, the considered problem consists in determining the subset of patients to be scheduled and in assigning each scheduled patient to a surgery date and OR block. Waiting time, urgency and due date of patients are considered. The goal is to minimize the penalty associated with waiting time and tardiness of patients. The possibility of allowing overtime is considered as well, and its impact is evaluated. The uncertainty is dealt with applying the cardinality-constrained robust optimization approach, which allows exploiting the potentialities of mathematical programming models without the necessity of generating scenarios. The proposed models have been tested on a set of real life based instances. The impact of different levels of required robustness is compared with regards to the penalty objective function, the number of patients operated and their tardiness. Besides, we tested the obtained solutions on a set of randomly generated realistic scenarios assuming lognormal distributions for surgery duration. Results show that the proposed robust models can be used, as the required computational time is compatible with the weekly schedule. Furthermore, the obtained robust solutions behave well in terms of OR utilization rate and number of cancelled patients.

2- An online-offline approach to the OR planning problem under uncertain surgery duration

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The Surgical Case Assignment Problem (SCAP) is a key problem in managing Operating Room and surgery wards. In the considered SCAP problem, a set of patients and the related surgery waiting list are given, together with a set of Operating Room (OR) blocks and a planning horizon. The problem asks to determine the subset of patients to be scheduled in the considered time horizon and their assignment to the available OR blocks. The aim is to minimize a penalty associated to waiting time, urgency and tardiness of patients. When the obtained solution is applied, unpredictable extensions of surgeries may reduce the available time and thus may prevent to operate all the scheduled patients. As a consequence, some of the patients must be rescheduled in the following days, and the overall solution must be updated in order to manage them. Therefore, we propose an approach combining offline and online decisions. The offline solutions are applied and modified online so as to manage new patient arrivals and patients who have been cancelled and must be rescheduled. Uncertainty in surgery duration must be considered in the offline step, so as to reduce the number of cancelled patients: we apply a cardinality-constrained robust optimization approach to model the offline scheduling problem. Tests on a set of real-based instances are carried on. We apply the proposed two-step approach on a set of randomly generated scenarios in order to assess its behavior. Besides, we evaluate the benefit of applying a robust solution rather than a non-robust one in the offline step.

3- A Bicriteria heuristic approach for an elective surgery scheduling problem

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Resources rationalization and reduction of waiting lists for surgery are two main guidelines for hospital units outlined in the Portuguese National Health Plan. This work is dedicated to a case study of an elective surgery scheduling problem arising in a Lisbon public hospital. In order to increase the surgical suite's efficiency and reduce the waiting lists for surgery, two conflicting objectives are therefore considered: maximize surgical suite occupation and maximize the number of surgeries scheduled. This elective surgery scheduling problem consists of assigning an intervention date, an operating room and a starting time for elective surgeries selected from the hospital waiting list. Accordingly, a bicriteria surgery scheduling problem arising in the hospital under study is presented. To search for efficient solutions of the bicriteria optimization problem, the minimization of a weighted Tchebycheff distance to a reference point is used. A simple heuristic procedure specially designed to address the objectives of the problem is developed. At the talk, the authors present and discuss the results of computational experiments obtained with real data from the hospital. These results are also compared with previous results obtained with single criterion versions of the problem, which showed a very fast performance of the heuristics providing good quality solutions for each of the two objectives when independently considered. The study reveals that by using the present bicriteria approach it is possible to build surgical plans with better performance levels for both criteria. This clearly shows that the surgical plans currently practiced in the hospital represent dominated solutions to the planning problem and therefore non-efficient solutions in face of the criteria considered.

4- Dynamic scheduling of surgeries under uncertainty

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Operating rooms (ORs) are responsible for a large portion of total hospital revenues and costs. Therefore, substantial cost reductions might be achieved through better management of ORs. In this presentation, we describe our study on the problem of assignment of surgeries into future days and ORs over a finite planning horizon. Decisions in our model include scheduling and rescheduling of surgeries where the latter results from cancellations that may occur on the day of surgery. We describe a multi-stage stochastic mixed integer programming formulation for the problem. In our model, the demand for surgery and the duration of surgery are random variables. The objective is to minimize three competing criteria: expected cost of surgery cancellations, waitings, and OR overtime. We discuss properties of the model and an implementation of the progressive hedging algorithm to find near optimal surgery schedules. We conduct numerical experiments using data from a large hospital to identify managerial insights related to surgery planning and the avoidance of surgery cancellations. Finally, we compare the progressive hedging algorithm to an easy to implement heuristic for practical problem instances to estimate the value of the stochastic solution.

Session 1C: Cancer Treatment Planning MON-1C

Room: SOS 103 **Chair**: Mehmet A. Begen **14:00-15:30**

1- Operation management of radiotherapy treatment: literature review

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Radiotherapy treatments are complex cares characterized by a series of treatment sessions. The operation management of radiotherapy treatment is challenging because of the following reasons: 1) multi-sessions treatment, 2) different waiting time targets for different classes of patients, 3) resource re-entrance and resource recirculation, 4) the development of radiotherapy technology, for example advanced linacs, 5) the impact of relevant stipulations and healthcare policies. In this paper, we provide a literature review and analysis based on the publications and our field observation of several hospitals in Shanghai. The existing works are classified into different categories along 3 dimensions: research content, research objective and research methods. We find that most of existing work focused on patients scheduling or resources assignment in pre-treatment process or treatment process respectively in order to minimize waiting time using often deterministic models. Uncertainties are rarely explicitly taken into account in planning and scheduling models which are often myopic. Some important issues are not addressed in the literature. For example, (i) capacity allocation with different types of linacs and different classes of patients, (ii) integrate scheduling of patients taking into account whole process, major uncertainties and most important objectives. Key assumptions of existing works are analyzed based on our field observations and discussions with physicians of several hospitals of different sizes in Shanghai. The current radiotherapy treatment process identified in hospitals of Shanghai is described for reference.

2- Reducing wait times and improving treatment planning process for radiation therapy

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According to Cancer Care Ontario (CCO), the referral to consult duration (RTC, the duration between a referral to a specialist to the time that specialist sees the patient) and the ready to treat (RTT, the time when the specialist is confident the patient is ready to begin treatment) to treatment wait times targets must be fulfilled within 14 calendar days. CCO statistics showed that London Regional Cancer Program (LRCP) consults 65% and treats 70% of patients within the target times.

We studied the radiation treatment planning process from patient referral to treatment at LRCP. We analyzed available data from hospital administration databases, interviewed stakeholders and observed processes. We prepared a process map of the radiation treatment planning and developed a discrete event simulation model to determine possible bottlenecks and reduce wait times (RTC and RTT to treatment) at LRCP.

Analysis and results identify possible bottlenecks of the system. Adding one more radiation oncologist decreases RTC wait time. Increasing the available number of treatment slots per given day reduces the RTT to treatment wait time. Adding one more dosimetrist reduces RTT time. The changes in number of other resources do not have a significant effect on wait time. A long term goal is to find the most cost effective ways to satisfy COO wait time targets and continuously improve and redesign the system.

3- Software assisted decision making in breast cancer therapy planning

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Breast cancer is the most common cancerous disease and cause of death among women. Therapy typically involves various diagnostic examinations (mammography, biopsy,) and treatments (surgery, chemotherapy). The physician decides about the individual therapy for a patient according to his medical expertise based on clinical guide lines and knowledge acquired from former patient cases. This requires the processing and utilization of large amounts of information, which is problematic in view of the permanent time pressure in clinical routine. This presentation addresses the collaborative work of mathematicians and physicians on a supporting software tool, which allows for an efficient planning of an optimal therapy for the individual patient case. The modeling uses data mining concepts. Characteristics describe data items of patient cases (menopausal state, tumor classification) and therapy options (recurrence risk …), which are essential for therapy planning, and similarity measures connect between their values. The representation of patient cases in terms of these characteristics allows for a high quality clinical documentation, and an aggregated similarity indicates the relevance of some former patient case for the current one. The specification of a therapy option contains pre-conditions (medical indications), which measure its relevance for a patient case, and post-conditions on the expected outcome (obtained diagnostic information). All specified options together thereby objectify parts of the physician's somewhat fuzzy decision tree. The decision support features, which emulate the clinical planning strategies, rely on context-sensitive search and dynamic decision trees. Automated search runs initialized with the current values of a patient case then provide the physician with the relevant therapy options and former patient cases, which are currently worth considering. The relief from extensive routine work and provision of a profound starting basis for decision making allows for improved breast cancer therapy in terms of time consumption and plan quality.

4- Preventing delays in radiotherapy by allocating linac capacity in advance

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In radiotherapy, linear accelerators (linacs) deliver radiation to patients' tumors during several daily sessions with the purpose of killing cancer cells. Approximately 50% of all patients diagnosed with cancer receive this form of treatment in their care-plan. Evidence shows that delays in the start of radiotherapy treatment can decrease tumor control and thus treatment quality. The objective of this research is to develop a planning method that ensures different patients can have prompt access to linacs, taking into account that not all types of patients can be treated on each linac and that daily inflow of new patients varies. We develop a tactical planning method to allocate linac capacity in advance. This method assumes a threshold on the number of patients from a given care-plan type that can be treated on a given linac on any day. A proper value of this threshold is found using a simulation-based heuristic algorithm. We carry out a series of experiments through a computer simulation to test the behavior of our method. We first tested 2012 data from our center, the Netherlands Cancer Institute in Amsterdam. Here, care-plans can be treated on 63% of the linacs on average, and demand occupies 89% of the capacity. Our simulation showed that with our planning method, 90% of patients from critical care-plans could access a linac in less than 0.23 days, as opposed to 1.12 days without it, without worsening the access of non-critical care-plans. We further simulated a number of scenarios where care-plans could be treated on 50% up to 75% of the linacs on average and where demand occupied up to 96% of the capacity. Even in extreme cases, our method diminished delays for the critical patients. Thus, better quality of care can be achieved by allocating linac capacity in advance.

Session 1D: Modeling Length of Stay — MON-1D

Room: SOS 104 **Chair**: Sally Brailsford **14:00-15:30**

1- The effect of outlying patients to clinically inappropriate wards

Sally Brailsford[1], Craig Roberts[1], Kiok Liang Teow[2]
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Medical outliers are patients who are placed in clinically inappropriate wards, e.g. a cardiac patient who is placed in a respiratory ward because no bed is available in the "correct" ward. The literature suggests such patients will experience longer length of stay (LOS) and poorer health outcomes. In this paper we examine the implications of outlying patients for medical staff and patients at a large hospital in Singapore. Our study uses both quantitative and qualitative methods. We use a matched propensity score approach on 11 Diagnosis Related Groups (DRGs) in four sub-specialties (General Medicine, Cardiology, Gastroenterology and Respiratory Medicine), such that each DRG is compared separately and outliers matched one-to-one with non-outliers with a similar propensity score. We also present the findings from a staff survey, which identify the practical difficulties outliers cause the staff while also examining key safety issues.

Our results were unexpected: of the four medical sub-specialties studied for the statistical analysis, three (Cardiology, Gastroenterology and Respiratory) showed no significant difference between the LOS of outliers and non-outliers for each DRG. One DRG in Cardiology and one DRG in Respiratory showed a significant difference in terms of readmission rate, with outliers recording the higher rate. For the General Medicine sub-specialty, outliers had a significantly shorter stay when compared with non-outliers and no significant difference was found between readmission rates in the two groups. We conclude by discussing ways in which the hospital might reduce the number of outliers, or if this is not practicable, then suggestions for how the problems identified in the survey could be mitigated.

2- Understanding patient length of stay: a finite mixture approach

Maria Guzman Castillo[1], Sally Brailsford[2], Honora Smith[2]
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This paper explores the role of finite mixture models in modelling patient length of stay (LoS). The aim is to develop a probabilistic model which approximates to the true underlying distribution of LoS. The concept of the finite mixture models is based on the basic idea that the distribution of a continuous variable in a large sample could consist of two or more clusters of observations with different means and perhaps different standard deviations within each sample. Therefore, the observed continuous variable can be defined as a mixture or sum of those two or more distributions with different parameters. One additional feature of the finite mixture models is that they can be extended to accommodate patient characteristics using a generalised linear model principle. These models, known as finite mixture regression models, allow patient characteristics to delineate the shape of the LoS probabilistic curve and its associated expected value. Moreover, they provide insights into the internal and external factors associated to LoS. In this paper, four different mixture of distribution (e.g. Gaussian, Lognormal, Gamma and Poisson) are fitted to data from two public hospitals in Mexico City. The best fit is then extended to account for other potential predictors of LoS such as type of diagnosis and surgical procedure, medical ward of treatment, age, gender, etc. This paper also discusses the applications of survival analysis for finite mixture models. In particular, it explores the use of the survival and hazard functions, which enhanced the interpretability and application of the models in terms of patient flow dynamics and bed occupancy management.

3- The discrete conditional phase-type distribution for modelling patient length of stay in hospital in Italy

Adele H Marshall[1], Mariangela Zenga[2], Hannah Mitchell[1]
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[2]Department of Statistics and Quantitative methods, Milano Bicocca University, Milan, Italy

The growing proportion of elderly in the population is placing increasing demands on healthcare resources across all European countries. This means a growth of the service of the healthcare system dedicated to the elderly, in particular an increase in the expenditure and admissions to hospital leading to an overall increase in patient length of stay (LOS) in hospital. In Italy in 2012, the elderly people comprised 37% of the admissions to hospital consuming near half (49%) of the LOS days. It has been estimated that in 2050 the aging population will produce an increase of 4-8% of the GDP.

The Discrete Conditional Phase-type (DC-Ph) distribution consists of two components; the conditional component which measures the inter-relationships between covariates and the survival component which models the survival distribution using a Coxian phase-type distribution. Coxian phase-type distributions are a special type of Markov model that can represent survival as a series of transient states which terminate in the one absorbing state when the event of interest has been reached.

Previous research modelling the patient length of stay of elderly patients in the Lombardy region highlighted that there are many non-medical factors that can influence and prolong a patient's length of stay in hospital. This is more apparent for the elderly patient that may be awaiting support from the community or requiring further care when they leave hospital. In fact, it may be the particular hospital that the patient is admitted to, that determines their length of stay, rather than it being the medical condition or the severity of illness. This paper wishes to investigate this further by using the DC-Ph distribution to assess all elderly admissions to hospital in Italy during the 2008-2011 year period. It is hoped that knowledge of the barriers will mean timely discharge of patients in the future.

Session 2A: Performance Evaluation MON-2A

Room: SOS Z21 **Chair**: Marion Rauner **16:00-17:30**

1- Efficiency of rescue departments of the Austrian Red Cross: A data envelopment analysis benchmarking study

Marion Sabine Rauner[1], Doris Lauß[1], Margit Sommersguter Reichmann[2]
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[2]University of Graz, Graz, Austria

We performed a Data Envelopment Analysis (DEA) and a Malmquist Index Analysis for benchmarking rescue departments of the Austrian Red Cross. DEA is a comparative approach to identify performance of its decision-making-units (DMU, in this case the departments of the Austrian Red Cross) by considering various resources, determining relative efficiency by weighting the input-output-ratio. Additionally, DEA allows to identify reasons for inefficiencies and to draw conclusions. Suitable input and output variables were selected by correlation analysis. It became apparent that for example the duration for emergencies and non-emergencies is negligible as it didn't show differences in efficiency scores compared to the inclusion of duration. We disclosed a high rate for efficient rescue departments but also some oversupply in other regions. The results were partly surprising: it turned out that departments close to one or more hospitals are always classified as efficient. The close position of some departments can also lead to "oversupply" of certain regions and to being classified as inefficient. The reduction of several input variables is not possible because the health care supply has to be guaranteed. In addition, several variables can only be changed by particular units (e.g., working hours) or by whole numbers (e.g., ambulances).

2- Effects of patient case-mix to operational performance of ED

Tomi Malmström, Paulus Torkki, Miika Linna
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Emergency departments (EDs) have a wide variety of demand ranging from minor illnesses to life-threatening conditions and require immediate highly specialized treatment. Moreover, a part of the patients are treated and discharged to home as the other part is transferred to the hospital ward in some point of their care. Differences in the case-mix and 'completeness' of care provided make the comparison of operational performance measures between units difficult. The aim of the study was to develop and assess a patient case-mix measure which can be used to standardize operational performance measures of the ED.

In this study we specified a diagnosis related groups (DRG)–based case mix measure and combined it with resource consumption measures in the ED. The study was conducted using patient-level data from thirteen EDs from Finland catching over 50 % (2.9 million) of Finnish population. The data obtained from hospital information system consisted of approximately 300,000 visits.

After adjusting for hospital types, the differences between the Finnish EDs were relatively small using the conventional DRG case mix measures. However, the developed case mix adjustment model explained markedly better the variation in the performance measures. The validity of the enhanced case mix adjustment model is discussed and the effects of patient case-mix to the operational performance measures are presented.

Case-mix measure should be based on the generally accepted DRG-grouping method but the DRG-weights should be better adjusted to the ED setting.

3- Integrated performance assessment of orthopedics care from medical quality and efficiency dimensions

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Chinese government has launched a new wave of health care reform from 2009. The new reform aims to improve health care quality and patient safety, and to reduce health care costs. To achieve the goal, Chinese government has utilized health care strategies which link health care performance with allocation of health care resources such as government funding. In 2010, the Ministry of Health (MOH) of China started a round of pilot performance assessment of several clinical specialties. Based on the assessment results of each clinical specialty, MOH would award title of "National key clinical specialty" together with millions of RMB to top 10 hospitals in each assessment round. In this study, we choose orthopedics as target clinical specialty. Different from traditional subjective expert review methods to assess performance, we employed explicit indicator methods to do objective assessment. A novel evidential reasoning approach (ER) was employed to do analytics. Inpatient Medical Records Summaries (IMRS) from year 2006 to year 2009 of five top-ranked teaching hospitals in Beijing were used for deriving indicators. Various quality and efficiency indicators include hospital mortality rates, readmission rates, adverse event rates, median length of hospital stay, median hospitalization expense, and number of hospital discharges. For each indicator, based on benchmarking value calculated from sample hospitals, quantitative value was transformed into qualitative performance levels including excellent, good, average, poor, and worst with corresponding belief degrees. All indicators in different levels were aggregated via the ER approach to generate an overall performance assessment. Based on the overall assessment results generated through ER, we provided a performance rank of orthopedics in the five assessed hospitals. The performance ranking is close to the reality. We hope that the ER based performance assessment results would play a role in medical resources allocation in future.

4- Notes on a shambles

Martin Utley, Christina Pagel, Sonya Crowe
Clinical Operational Research Unit, University College London, London, United Kingdom

Following a successful collaborative research project to build a risk model for use in local monitoring of 30-day survival following pediatric cardiac surgery, we built some software to enable centres undertaking this surgery to generate variable life-adjusted display charts using the risk model.

As part of the roll-out of this tool we were keen to visit centres and explain what we saw as the strengths and limitations of such monitoring and the caveats concerning the risk model that we felt should be considered when using the software. Provision for such visits were included in the licence fee and we envisaged a period of working constructively with clinical teams to help them get the most out of what we saw as a useful tool to assist quality assurance and improvement initiatives.

Within a month of the software being released, operations had been suspended and then restarted at one centre, politicians had called for the resignation of the Medical Director of the NHS and the co-Director of the relevant National audit body had resigned. These events were accompanied by a considerable volume of media comment and speculation, little of it constructive.

In this talk I will outline what we observed as researchers peripheral to these events and what lessons we will carry forward into our future work in this and other areas.

Session 2B: Disease Modeling and Policy MON-2B

Room: SOS Z27 **Chair**: Elvan Gokalp **16:00-17:30**

1- A Dynamic simulation model for insulin resistance and type II diabetes in the context of obesity

Melike Hazal Can[1], Aybek Korugan[2], Yaman Barlas[2]
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Type 2 diabetes, is a frequently seen endocrinological disease leading to other serious health problems such as heart disease and kidney dysfunction that may eventually lead to a premature death. Insulin resistance is seen as the starting point of this disorder. Obesity, hyperglycemia (high blood sugar), hyperinsulinemia (excess levels of insulin in the blood) are the main reasons for developing insulin resistance and type 2 diabetes, ultimately. Other factors are indicated as age, gender and genetic factors. The aim of this study is to construct a dynamic simulation model that can realistically reproduce the long term behavior of developing insulin resistance and type 2 diabetes related to obesity. For this purpose, a model which shows the relationship between body weight and glucose-insulin mechanism for a healthy body is generated. In the validation part, the effect of obesity on glucose regulation is demonstrated. According to the available research on this topic, doing exercise and changes in the diet may reduce the severity of insulin resistance or even eliminate this disorder completely. Simulation experiments with the model show that different physical activity levels and dietary intakes have impact on developing insulin resistance. Yet in the long run, insulin secretion level and beta-cell dysfunctionality play a more significant role for developing type II diabetes. In conclusion, the obesity factor on insulin resistance and type II diabetes is demonstrated in the model in a major scope, by using available information and data in the literature.

2- Use of a model for setting an achievable public health target: the case of childhood obesity in the UK

Brian Dangerfield[1], Norhaslinda Zainal Abidin[2]
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Amongst the global threats to health facing the advanced economies, obesity is rapidly becoming a prime focus. This is because, in large measure, it is a condition which is a precursor for a range of more serious diseases, including diabetes and hypertension. Interest in a particular condition often results in governments and public health bodies setting targets aimed at reducing the prevalence of that condition in the general population. However, it appears that public health targets are not set by any informed background analysis but rather by what seems reasonable and is tolerable in political terms. In the UK in 2008 the then government announced that it would be striving, by 2020, to bring the obesity metrics back to those prevailing in 2000. Based upon a population-level model addressing the development of overweight and obesity in children (2-15 years), we demonstrate that the achievement of this target (in children) is highly unlikely. The model, which combines knowledge from nutrition, physical activity and body metabolism, shows that a plausible target date would be 2026 at least. Acknowledgement of the delays involved in reversing obesity trends is vital in setting sensible targets in this domain of public health. In general, models have an important role to play in the formulation of achievable public health targets.

3- Dynamic modeling of peritoneal dialysis and its implementations in children with chronic renal failure

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This study has been conducted in order to shed light on the effects of Peritoneal Dialysis (PD) treatment on the dynamic interactions between nutritional intake decisions and the physical development of children with chronic kidney failure. In the context of this study, the interrelationships between the substances such as protein, albumin, calcium, phosphate, sodium and potassium, which play major roles in developmental and vital indicators of the child-patients along with their relationships with PD treatment, have been analyzed with the help of System Dynamics methodology and Stella simulation modeling software. In order to better analyze the dynamics of PD treatment, the time unit of the model has been chosen as a day while time frame has been chosen as three years in order to better observe the differences in the growth and development of child-patients. At the end of the study, based on the constructed model, an interactive simulation game, which represents the relationship between the diet and the ratios of accumulated toxic or beneficial materials in the body, has been designed. With the help of such simulation game, it is aimed to help doctors, patients and patients' families preparing a diet and treatment recipe suitable to patients' monthly needs for a better growth and physical development.

4- Using system dynamics to determine the long term management consequences for coronary heart disease patients

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Centre for Statistical Science and Operational Research (CenSSOR), Queen's University Belfast, Belfast, United Kingdom

A progressive increase in the prevalence of long term conditions combined with an ageing population is resulting in our health care system experiencing a great deal of pressure. It is estimated that the prevalence of hypertension, coronary heart disease (CHD), stroke and diabetes amongst adults in Northern Ireland is set to rise by 30% between 2007 and 2020 (Making Chronic Conditions Count Report). It has been recognised that efforts need to be made to address these issues and ensure more effective management of our health care system if the system is to be robust and resilient enough to handle such pressures in the future. It is thought that better management of individuals living with long term conditions will lead to significant savings in the overall healthcare spend in Northern Ireland. In particular, a focus is being placed on both health promotion and prevention of complications. This study involves the development of a system dynamics model to represent patients living with CHD in Northern Ireland. System dynamics is a form of simulation modelling which allows various different interventions in terms of healthcare policy to be investigated and thus identify their effect on the long term behaviour of the system (Forrester, 1961). This study aims to investigate the way in which preventing individuals living with CHD from developing further complications will affect the prescribing spend and health and social care costs incurred. Further work will involve incorporating patient length of stay and subsequent costs incurred into the model.

Session 2C: Tutorial 1 (Stefan Nickel, Healthcare Logistics) MON-2C

Room: SOSB07 **Chair**: Murat Gunal **16:00-17:30**

Healthcare logistics addresses the efficient planning, realization and control of patient-, material- and information-flow within the healthcare sector. Therefore, the use of OR methods plays a crucial role in healthcare logistics. However, the unique feature in this field of application is to not only put emphasis upon the economic efficiency but also to take into account the quality of care and patient satisfaction. Accordingly, the medical competence is never interfered in.

Especially in hospitals, scheduling problems and inhouse logistics are of great importance. With the help of medical and technical devices patients are examined, treated and cured if possible. Hospital logistics are all technical and organizational measures that are needed to transfer patients from an initial state ("ill") into a final state (in the best case "healthy") while also regarding the corresponding goods and information. Usually, hospital processes are grown historically ("We have always done it this way."). Consequently, processes have not been analyzed critically until reforms of the health system have put increasing pressure on hospitals. Nowadays, hospitals are looking for possibilities to improve their processes. Therefore, the success of logistics concepts in hospitals lies in resource conservation for non-value-adding activities (not directly relevant for the healing process, e.g., administrative work) and high resource utilization for value-adding activities (e.g., surgery) while the personnel shall not be over-utilized (i.e., no overtime). Moreover, the interaction of appropriate logistics concepts with modern OR models allow a patient centered treatment, by respecting the needs of a patient and allowing a smoother process.

Clinical pathways should determine an optimal sequence and schedule for the patient's treatment with the objective of minimizing delays and maximizing the quality of care while taking into account resource capacities. To reach this goal, logistics aspects on different hierarchical levels as hospital layout planning (strategic), appointment planning (tactical) and patient transportation (operational) have to be integrated into the clinical pathway.

In this talk, we give an overview on how OR methods can be used in order to support process optimization in healthcare organizations. We focus on healthcare logistics applications arising in different healthcare sectors and dealing with different time scales. Examples include:

- Hospital layout planning
- Appointment planning
- Patient transportation
- Ambulance location
- Home health care. Both, OR models and numerical results will be presented.

Stefan Nickel obtained his PhD in mathematics at the Technical University of Kaiserslautern, Germany in 1995. From 1995-2003 he was first assistant and then associate professor in mathematics at the Technical University of Kaiserslautern. After a full professor position at the Saarland University (chair of Operations Research and Logistics) from 2003-2009 he became one of the directors of the Institute for Operations Research at the Karlsruhe Institute of Technology in April 2009. Stefan Nickel is also member of the scientific advisory board as well as of the management board of the Fraunhofer Institute for Applied Mathematics (ITWM) in Kaiserslautern, Germany. Since 2011 he additionally holds the positions of one of the directors of the Karlsruhe Service Research Institute (KSRI) and of the Research Center for Computer Science (FZI).

From 2008 to 2011 Stefan Nickel was the speaker of the EURO working group on locational analysis. Furthermore he coordinated the health care working group within the German OR society (GOR) from 2006 until 2008 and is a member of the board of directors of the GOR of which he is chairman since this year.
He has authored or co-authored 5 books as well as more than 100 scientific articles mainly in the area of location theory, supply chain management, health care and logistics. Moreover, he had numerous research contracts with well-known industrial companies (e. g. Lufthansa, Miele, SAP).
Since October 2006 Stefan Nickel is editor-in-chief of Computers & Operations Research and a member of the editorial board of Health Care Management Science.

Tuesday July 9th

09:30-11:00	Session 3			
	3A Healthcare Resource Planning (1) Room: SOS Z21	**3B Screening and Prevention** Room: SOS Z27	**3C Workforce Scheduling** Room: SOS 103	**3D Modeling & Optimizing in Emergency Medical Systems (1)** Room: SOS 104
	Fermín Mallor Queueing control problems: from theory to practice in health care	**Ali Akgunduz** Agent-based simulation for behaviour modeling: evaluating alternative influenza prevention strategies	**Roberto Aringhieri** Advanced Workforce Staffing in Healthcare via Hybrid Metaheuristic	**Erwin W. Hans** Design and optimization of an integrated emergency post. PART 1: Design
	Navid Izady Appointment capacity planning in specialty clinics with no-shows and cancellations: A queueing approach	**Francisco Santos Sabbadini** Multiphase model for flow management of chronic heart patients	**Aleida Braaksma** Developing and testing a computerized decision support system for daily nurse-patient assignment	**Nardo J. Borgman** Design and optimization of an integrated emergency post. PART 2: Systematic improvements using discrete event simulation
	Maartje van de Vrugt Assigning treatment rooms at the Emergency Department	**Zehra Önen** Screening policies for Alzheimer's disease	**Egbert van der Veen** A flexible iterative improvement heuristic to support creation of feasible employee schedules in self-scheduling	**Mahsa Ghandehari** A mixed integer model for allocation and routing emergency medical facilities in Large-Scale Emergencies
	David Stanford A Queueing model for deceased-donor solid organ transplantation			**Glaucio Henrique Barros** A model for sizing ambulances fleet of Fireman's operational command group for emergencies on central region of Rio de Janeiro

11:30-12:30	**Keynote Talk**	**Room:** Eng. Auditorium

New and Old Forces Are Shaping Major Changes in Health Care Delivery Presenting Great Opportunities for Operations Research in Health Care

Prof. William P. Pierskalla (Distinguished Professor Emeritus and Dean Emeritus at UCLA & Ronald A. Rosenfeld Professor Emeritus at the University of Pennsylvania)

14:00-15:30	**Poster Display**	**Room:** The corridor next to rooms SOS103-SOS104

15:30-17:00	Session 4		
	4A Operating Room Planning & Scheduling (2) Room: SOS Z21	**4B OR Methodologies for Home Care** Room: SOS Z27	**4C Tutorial 2** Room: SOSB07
	Sebastian Rachuba Impact of robust operating room schedules on stakeholders' interests	**Semih Yalcindag** Assignment and routing problems in home health care services	**Margaret Brandeau** Health Policy Modeling
	Evren Güney An efficient solution technique to solve the operating room planning problem	**Eloi Duchaussoy** Dynamic re-scheduling for home health care vehicle routing problem	
	Emine Akyol Determining the number and location of emergency medical stations in Eskisehir	**Giuliana Carello** Comparing two different objective functions in a cardinality-constrained model for the assignments in Home Care	
		Ettore Lanzarone A multilevel cardinality-constrained model for the nurse-to-patient assignment problem in Home Care	

Session 3A: Healthcare Resource Planning (1) TUE-3A

Room: SOS Z21 **Chair**: Navid Izady **9:30-11:00**

1- Queuing control problems: from theory to practice in health care

Fermín Mallor[1], Cristina Azcárate[1], Julio Barado[2]
[1]Public University of Navarra, Pamplona, Spain
[2]Hospital of Navarra, Pamplona, Spain

In this work, the bed occupancy problem in a healthcare center is considered and analyzed with queuing control techniques. Queuing theory has studied the problem of resource allocation under uncertainty to provide queue designs and control policies that optimize some measure of interest, like customer's expected waiting time. In our queuing control problem it is not possible to modify neither the arrival rate to the system nor the number of servers (we assume that patients arrive without appointment and that the number of beds is fixed). In practice, the control of the bed occupancy is addressed by slightly modifying the patient´s length of stay. This bed occupancy control is modeled as a queuing control problem by making the service time dependent on the system state. We define and solve the following control problem: to find the set of service rates that minimizes both the probability that a new arrival is rejected and the shortening of the service time. Observe that this bicriteria optimization problem aims to find the patient's length of stay that minimizes the probability of rejecting a patient and also maximizes the degree of recovery reached by patients when they are discharged. The solution of this control problem provides an optimal management policy at a process level, which needs to be interpreted in the health setting in terms of decisions concerning individual patients. In this work, we propose different ways for this practical implementation and we assess them through a simulation model. The control problem is first solved by assuming a Markovian model and then generalized by considering non-exponential distributions, frequently used to model the length of stay in health care.

2- Appointment capacity planning in specialty clinics with no-shows and cancellations: A queueing approach

Navid Izady
University of Southampton, Southampton, UK

Specialty clinics provide specialized and often complex care for patients who have been seen and referred by primary care physicians, emergency departments, or other specialists. Waiting times for access to specialty care are often substantially longer than those for primary care such that non-urgent patients must typically wait several weeks, and sometimes months, in order to be seen by a specialist. Apart from patient dissatisfaction, excessive delays might lead to adverse clinical outcomes, demoralization of specialty staff, inefficiency and rework across the health system, and possibly high rates of cancellations and no-shows. In this study, we develop two queueing models for estimating patients (indirect) waiting time as well as the size of backlog in terms of appointment capacity allocated to non-urgent outpatient visits. The first model considers the stochastic nature of demand as well as no-shows but assumes a fixed number of appointments per time unit. For this model, we derive the distribution for the size of backlog as well as patients waiting time. To account for the variability on the supply side, we extend the first model such that the number of appointments per unit of time is also a random variable. For this model we only derive the distribution for the size of backlog. The models developed enable us to investigate the capacity requirement for achieving a reasonably quick access in specialty clinics. Using illustrative data, we demonstrate how the models could be used for studying the joint impact of no-show probability, referral distribution and supply variability. We also present some counter-intuitive results with regards to the impact of no-shows on the system performance.

3- Assigning treatment rooms at the Emergency Department

Maartje van de Vrugt, Richard J. Boucherie
Department of Stochastic Operations Research, University of Twente, Enschede, Netherlands

Long waiting times at the Emergency Department may be dangerous for patients that need urgent care. Doctors with different specialties share the treatment rooms, and different specialties may have different policies in assigning patients to treatment rooms. At the ED in a Dutch hospital, two types of doctors treat most of the incoming patients: Emergency Physicians (EPs) and residents. EPs tend to stay in their treatment room with the patient, while residents tend to use multiple treatment rooms simultaneously and divide their time among these treatment rooms (Koks et al., 2012). We develop and analyze a queueing model for the waiting and sojourn times of patients in this ED.

We consider a queueing system as depicted in Figure 1. There are more treatment rooms than doctors, denoted by squares and dots respectively. Both types of doctors have their own stream of arriving patients and a finite waiting room. We assume each EP uses at most one treatment room at a time, while residents may occupy multiple at a time and treat the patients in these rooms in a round robin-fashion. Residents can be assigned extra treatment rooms, which may block EPs from seeing patients. For various sharing policies that distribute rooms over EPs and residents, by analogy with results of Litjens (2003), we develop analytical models for the patients' sojourn times conditioned on their treatment times. We obtain a fair sharing policy that aims for balancing the patients' sojourn time over the patient types.

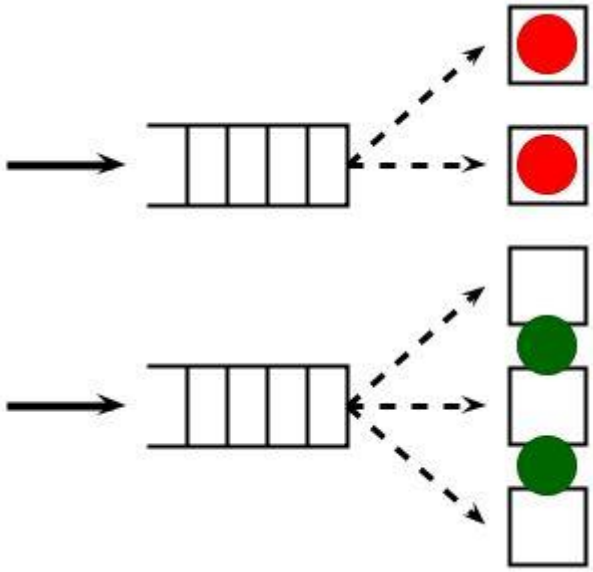

Figure 1

4- A queueing model for deceased-donor solid oOrgan transplantation

David Stanford, Steve Drekic, Douglas G. Woolford
Western University, Ontario, Canada

In many jurisdictions, organ allocation is done on the basis of the health status of the patient, either explicitly or implicitly. This paper presents a self-promoting priority queueing model which takes into account changes in health status over time. In this model, most patients arrive as "regular" customers to the queue, but as the health of a patient degrades, 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, and the steady-state joint queue length distributions 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.

Session 3B: Screening and Prevention TUE-3B

Room: SOS Z27 **Chair**: Zehra Onen **9:30-11:00**

1- Agent-based simulation for behaviour modeling: Evaluating alternative influenza prevention strategies

Elnaz Karimi[1], Ketra Schmitt[2] and Ali Akgunduz[1]
[1]Department of Mechanical and Industrial Engineering, Faculty of Engineering and Computer Science, Concordia university, Montreal, QC Canada
[2]Center for Engineering in Society, Faculty of Engineering and computer Science, Concordia University, Montreal, QC Canada

It is well established in the epidemiological literature, that individual behaviours has a significant effect on the spread of infectious diseases. Therefore, agent-based models that are able to incorporate such behaviours into simulations are increasingly being recognized as the next generation of epidemiological models. In this research, we have conducted an agent-based simulation to examine the relative importance of vaccination and social distancing, two common measures for controlling the spread of infectious diseases, with respect to seasonal influenza. Influenza, like many other infectious diseases, spreads within a population via the physical contacts among individuals. These contacts can be considered infective in terms of distance and duration. Therefore interventions such as self-isolation and physical distancing have a significant influence on the variation in the probability of contact and disease transmission process. Also, differences between individuals in terms of attributes, such as social, physical and environmental characteristics, affect the spread of a disease. Therefore we adopt a Health Belief Model to evaluate the health-related behaviours of students toward influenza in Concordia University and its effect on the spread of virus within the target population. We use an agent-based to simulate the contact network as a function of students' social behaviour within the university campus. The data required for building the daily activity patterns per individual has been gathered by surveys and the course schedules database for the Faculty of Engineering and Computer Science. We model the probability of infection for each effective contact between a susceptible and an infected individual based on the attack distance- defined as the distance between the infected and the exposed individual- and the exposure duration. To analyze the result of simulation we use a conceptual risk model to explore the potential impacts of all the behavioural variables on the spread of influenza.

2- Multiphase model for flow management of chronic heart patients

Francisco Santos Sabbadini[1], Mário Jorge F. De Oliveira[2], Antonio Augusto Gonçalves[3], Antonio Henriques De Araujo Jr[1], José Glenio M. De Barros[1]
[1]UERJ - University of State of Rio de Janeiro, Rio de Janerio, Brazil
[2]UFRJ - University of Rio de Janeiro , Rio de Janerio, Brazil
[3]UNESA - Estacio de Sá University, Rio de Janerio, Brazil

In Brazil, more than 59 million residents are suffering from at least one chronic disease. This scenario has generated a significant and growing demand on health services. This paper presents a multiphase model to manage the flow of patients with heart disease attended by medical experts. Furthermore, a database project was developed in order to support the proposed model, which will serve as an aid in the patient flow management, as well as in its monitoring. One approach to partitioning demand-oriented management of the capacity was regarded as the fundamental characteristic of this service. A discrete event simulation model was developed to serve as an instrument for the evaluation of alternatives and analysis of the proposed model. The conceptual framework considers the different levels of access required according to the stage of the patients' chronic disease. The study showed that the current system in Brazil is not integrated and has no evidence of coordination. As a result, patients are lost in the system, there is no discontinuity in the Brazilian health system stream and besides of that, as a consequence there is a loss of capacity. The model developed was applied to the outpatient health unit of the municipality of Resende, state of Rio de Janeiro. The system proposed considers 3 phases: Access, Diagnosis and Treatment. The strategic approach aims to facilitate

patient access, enabling the diagnosis and continuity of treatment and is focused on three aspects: improvement of the accessibility, prioritization of the patient care depending on its state of health and their monitoring in the treatment flow. The experimental results indicate the operational viability of the proposed system and its application for patient flow related to other chronic diseases.

3- Screening policies for Alzheimer's disease

Zehra Önen[1], Serpil Sayın[2]
[1]Graduate School of Sciences and Engineering, Industrial Engineering & Operations Management, Koç University, Istanbul, Turkey
[2]College of Administrative Sciences and Economics, Koç University, Istanbul, Turkey

Alzheimer's disease (AD) is a common type of dementia. Early symptoms are typically short-term memory loss and visuo-spatial orientation impairment. As the disease progresses there is a general decline of multiple cognitive functions that are in interaction with daily activities and make patients become very dependent on caregivers. A growing number of individuals are predicted to be suffering from this disease in the next decades. In order to limit the impact of the disease on the society, a common screening policy could be implemented so that appropriate action can be taken before the disease goes through severe stages. While at the time being there is no treatment for AD, research suggests that early intervention slows down disease progress. The aim of this work is to investigate the applicability of Markov decision process based screening models to this disease. In the preliminary model, Mini Mental State Examination test is used as the screening test. This test is widely used in practice and its validity is established in many languages and physicians are all familiar with it. Based on existing mathematical models for disease progression, we build a Markov decision process where the patient is in one of the possible health states depending on his/her test score and whether treatment has started or not. As a result, possible population screening policies will be presented and related costs and quality of life trade-offs will also be discussed.

Session 3C: Workforce Scheduling TUE -3C

Room: SOS 103 **Chair**: Roberto Aringhieri **9:30 – 11:00**

1- Advanced workforce staffing in healthcare via hybrid metaheuristic

Roberto Aringhieri[1], Bernardetta Addis[1], Marco Gribaudo[2], Andrea Grosso[1]
[1]Dipartimento di Informatica, Università degli Studi di Torino, Torino, Italy
[2]Dipartimento di Elettronica ed informazione, Politecnico di Milano, Milan, Italy

The new way of thinking and organizing the health care delivery is to focus on the patient instead of only on the facilities. A patient-centered approach to health care means to deliver a service which is "closely congruent with and responsive to patients' wants, needs, and preferences" (Laine and Davidoff 1996). Along the lines of patient-centered health care delivery, an approach to the medical workforce staffing capable to guarantee the efficiency and fairness of the delivered service becomes crucial, as pointed out in Aringhieri (2009). Usually, health care is delivered by a team composed of individuals working together sharing knowledge, experiences and skills. For instance, as reported in Auerbach (2001), an extensive literature - covering a broad range of conditions and procedures - documents superior outcomes for hospitals and physicians with higher patient volumes. The random nature of the problem requires the characterization of the team behaviour with a sort of stochastic process to have a more accurate performance evaluation under several demand scenarios. Furthermore, a good demand prevision plays a fundamental role when health care managers are interested in guaranteeing the efficiency and fairness of the provided service. We present a methodology combining Petri Nets (PN) and metaheuristics: the basic idea is to exploit PN to evaluate the team performance while a metaheuristic tries to compose the optimal set of teams. We also report how to exploit the relevant information available from the Petri Net solution in order to improve (i) the computational efficiency of the neighbourhood exploration and (ii) the global quality of the solution.

2- Developing and testing a computerized decision support system for daily nurse-patient assignment

Aleida Braaksma[1], Catharina Van Oostveen[2], Hester Vermeulen[2]
[1]Center for Healthcare Operations Improvement and Research, University of Twente, Enschede, The Netherlands
[2]Department of Quality Assurance and Process Innovation, Academic Medical Center, Amsterdam, The Netherlands

At the start of each working shift on nursing wards, nurses have to be assigned to patients. Unbalanced nurse-patient assignments induce patient safety issues and lead to stress and dissatisfaction among nurses. Reaching a balanced nurse-patient assignment can be a cumbersome and time-consuming process due to the numerous factors that play a role. The current trend towards enlarging nursing wards and merging nursing teams in order to enhance efficiency will further increase the complexity of the nurse-patient assignment process. In close cooperation with three nursing wards in the Academic Medical Center (AMC) Amsterdam, we have developed and tested a decision support system for the nurse-patient assignment process. First, a mixed-methods study was conducted to identify and assess all factors relevant for nurse-patient assignment. Second, a computerized decision support system (CDSS) was developed based on an integer linear programming model. Finally, an extended before-and-after study was conducted on three nursing wards to evaluate the performance of the system, where both logistical performance indicators and nurse satisfaction were measured. The developed CDSS enhances quality of care by inducing time savings for nurses and balancing the workload among them. It also enhances job satisfaction of nurses because it promotes fair nurse-patient assignments.

3- A flexible iterative improvement heuristic to support creation of feasible employee schedules in self-scheduling

Egbert van der Veen[1], Egbert van der Veen[2], Johann Hurink[3], Marco Schutten[4], Suzanne Uijland[1], Suzanne Uijland[4]

[1]ORTEC, Zoetermeer, The Netherlands

[2]Center for Healthcare Operations, Improvement, and Research (CHOIR), Enschede, University of Twente, The Netherlands

[3]Department of Applied Mathematics, Enschede, University of Twente, The Netherlands

[4]Department of Management and Governance, Enschede, University of Twente, The Netherlands

In self-scheduling, employees propose their own schedules to match a staffing demand specified by the employer. Since these individually composed schedules often do not perfectly match with the specified demand, the schedules have to be adapted. Our approach aims to divide the burden of shift reassignments 'fair' among employees and the algorithm parameters allow to make a trade-off between transparency of the shift reassignments and the quality of the resulting schedule. The criteria considered in the design of the approach are based on three case studies. We discuss computational results on schedules obtained from the case studies and indicate how various model parameters influence scheduling performance indicators.

Session 3D: Modeling & Optimizing in Emergency Medical Systems (1) TUE-3D

Room: SOS 104 **Chair**: Erwin W.Hans **9:30-11:00**

1- Design and optimization of an integrated emergency post. PART 1: design

Erwin W. Hans[1], Manon Bruens[2], Nardo J. Borgman[1], Carine J.m. Doggen[1], Martijn R.k. Mes[1], Ingrid M.h Vliegen[1]

[1]University of Twente, Enschede, The Netherlands

[2]Ziekenhuisgroep Twente, Enschede, The Netherlands

In the Netherlands, patients with an acute care demand outside office hours need to choose between visiting an emergency department (ED) or a general practitioners post (GPP), which is a collaboration between general practitioners. Not all of them make the right choice: Many patients that go to the ED could be helped more efficiently at the GPP. Therefore, in April 2010, the Centrale Huisartsenpost Almelo (General Practitioners post Almelo) and the emergency department of Ziekenhuisgroep Twente (hospital in Almelo) merged into one integrated emergency post (IEP), which resulted in a single access point for patients. This research aims to find the optimal process design of the IEP where the patient is provided with appropriate care, without unnecessary delays and with an optimal use of resources. This presentation focuses on the extensive patient flow analysis, data gathering, establishment of KPI's, and a patient preference study. The next presentation (PART 2) will focus on the systematic improvement of the IEP.

2- Design and optimization of an integrated emergency post. PART 2: systematic improvements using discrete event simulation

Nardo J. Borgman[1], Manon Bruens[2], Carine J.m. Doggen[1], Erwin W. Hans[1], Martijn R.k. Mes[1], Ingrid M.h. Vliegen[1]

[1]University of Twente, Enschede, The Netherlands

[2]Ziekenhuisgroep Twente, Enschede, The Netherlands

This research aims to find the optimal process design of an Integrated Emergency Post (IEP), where the patient is provided with appropriate care, without unnecessary delays and with an optimal use of resources. In an IEP a GP post closely collaborates with a hospital's ED. In this presentation we present a systematic approach, in which we use computer simulation to compare organizational interventions. This approach uses domain knowledge of the health care environment, as well as methods found in literature on design of experiments and simulation optimization to gain insights into the effects of organizational interventions like alternate staffing levels. This is done by grouping interventions, and evaluating these interventions on a per group basis. From these groups the most promising interventions are formulated, which are then evaluated for interaction effects. This gives insight in the interventions influence on performance indicators, such as patient length-of-stay, as well as the effects that interventions have on each other. With this approach several interventions showed improvements in the simulation model. Finally, we discuss how the outcomes of this research project are currently being implemented. One intervention, letting physician assistants treat both GPP and ED patients, has been trialed in a pilot study. The trial showed a decrease in GPP length-of-stay while having no negative effect on ED patients, similar to the simulation model. A second intervention, earlier admission requests for patients likely to be admitted is also scheduled to be tested in the near future.

3- A mixed integer model for allocation and routing emergency medical facilities in Large-Scale Emergencies

Mahsa Ghandehari[1], Maryam Abdollahi[2]
[1]Department of Management, University of Isfahan, Isfahan, Iran
[2]Department of Industrial Engineering, Faculty of Engineering, Njafabad branch, Azad University, Isfahan, Iran

Large-Scale Emergencies (LEMS) refer to events such as major natural disasters (e.g. earthquake) or biology attacks, which lead to tremendous demands for medical supplies in a short time period. In contrast to classic location-allocation models which emphasis on minimizing the cost of production and distribution or capture and covering the most potential customers in order to the organization to survive or increase its market share, in LEMS situations the main priority in location planning is to decrease victims or ulcerous as much as possible. In these cases, the bulk of the medical supplies would have to come from national institutions, because of limited or disrupted local health care facilities. The purpose of this paper is to propose an Allocation-Routing mathematical model and a solution approach for emergency health care facilities in Large-Scale Emergency Situations. In this model, we focus on total expected loss due to delay in mobile medical team, services and reliefs, which is defined by two OBJECTIVES**:** (i) minimizing ulcerous and victim's ratio and (ii) minimizing amount of total unsatisfied demands. The facility Allocation-Routing optimization problem is formulated by using mixed integer mathematical modeling. A solution approach is developed for the proposed model and a numerical example is solved for evaluating the resulted.

4- A model for sizing ambulances fleet of Fireman's operational command group for emergencies on Central region of Rio de Janeiro

Glaucio Henrique Barros, Fabio Batista Oliveira, Marcos Dos Santos, Mario Jorge Oliveira
Department of Industrial Engeneering, Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil

In a system of emergency care the minimization of ambulances response times and waiting in queues of patients are crucial variables. This paper presents a computer simulation model for sizing the fleet of ambulances from Fireman's Operational Command Group in meeting the demands of the Central Region of Rio de Janeiro served by Souza Aguiar Hospital where we use the software SIMUL8. Essays were performed with the gradual increase in demand to achieve optimum combinations for the quantity and types of ambulances. The model can be adapted to other scenarios and regions where in addition to diagnosing the efficiency of a system can support the decision making process of purchasing new vehicles.

KEYNOTE TALK: New and Old Forces Are Shaping Major Changes in Health Care Delivery Presenting Great Opportunities for Operations Research in Health Care

Room: Engineering Auditorium **Chair**: Tuğba Çayırlı **11:30-12:30**

Prof. William P. Pierskalla (Distinguished Professor Emeritus and Dean Emeritus at UCLA &
Ronald A. Rosenfeld Professor Emeritus at the University of Pennsylvania)

Abstract

The rate of change in Health Care delivery is increasing. The old forces of change (technology, costs, quality and demographics) are causing continually increasing pressure and change. And new forces (empowered health care consumer, health care big data explosion, life sciences knowledge explosion, demand for value by payers and patients and a rapidly growing middle class in the major markets of the newly developed and emerging countries of the world) are accelerating the very nature of what, how, where and when health care is delivered.

These changes present great opportunities and challenges for Operations Research. They mean that most of the traditional OR solutions for scheduling, planning, networks, supply chains, forecasting must be changed and restudied now due to new objectives, constraints, system changes, interactions and problem sizes. But perhaps the greatest challenges for us come from the new powerful forces emerging over the past few years. Not only do we have to attack the new problems they open up but we have to learn new paradigms, knowledge bases and languages just to understand these problems and create new OR knowledge to solve them. Our curricula, joint education and research programs, student and faculty selection will undergo stressful scrutiny and change.

I will discuss these forces in brief and spend more time on what are the implications for research and education facing health care delivery and systems/operations research/management sciences.

William P. Pierskalla, Ph.D., is a Distinguished Professor Emeritus of Decisions, Operations and Technology Management in the Anderson Graduate School of Management at UCLA. He is also the Ronald A. Rosenfeld Professor Emeritus, The Wharton School, University of Pennsylvania. He was Dean of the John E. Anderson Graduate School of Management at UCLA. He holds the A.B. in Economics and M.B.A. degrees from Harvard University, an M.A. in mathematics from the University of Pittsburgh and a M.S. in statistics and a Ph.D. in operations research from Stanford University. His current interests include operations research, operations management, issues of global competition and the management and delivery aspects of health care delivery.

Dr. Pierskalla is a member of the National Academy of Engineering (USA). He was President of the International Federation of Operational Research Societies. He is on the Editorial Advisory Boards of Encyclopedia of Operations Research & Management Science and Health Care Management Science Journal and has served on many other editorial boards. He was Vice President for Publications of the Institute for Operations Research and Management Sciences. He was President of the Operations Research Society of America, and is a past Editor in Chief of Operations Research. He is the 1989 recipient of the George E. Kimball Medal for distinguished service to the Operations Research Society of America and to the field of Operations Research and the 2005 INFORMS President's Award given to work that advances the welfare of society.

Previously he was the Deputy Dean for Academic Affairs, the Director of the Huntsman Center for Global Competition and Leadership, Executive Director of the Leonard Davis Institute of Health Economics and the

Chairman of the Health Care Systems Department at the Wharton School of the University of Pennsylvania. Prior to his positions at Wharton, he was on the faculties of Northwestern University, Southern Methodist University and Case Institute of Technology and has worked at Westinghouse Electric Corporation. He is a current board member of the Phoenix Health Systems Corp. and the Institute for Healthcare Optimization. He was a board member of the Archibald Bush Foundation (chairman 2002-2007), the Griffin Funds, the Northern Trust Bank of California, the iRise Corporation, Northern Wilderness Adventures Inc. and the Office Tenants Network Corporation. He has consulted to many business, educational and governmental organizations. He has given numerous lectures and seminars at Universities and organizations in the North and South Americas, Europe, Australia and Asia and has refereed articles in mathematical programming, transportation, inventory and production control, maintainability and health care delivery. For more information,pleasevisit
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Session 4A: Operating Room Planning & Scheduling (2) TUES-4A

Room: SOS Z21 **Chair**: Emine Akyol **15:30-17:00**

1- Impact of robust operating room schedules on stakeholders' interests

Sebastian Rachuba, Brigitte Werners
Chair of Management, esp. Operations Research, Ruhr-Universität Bochum, Bochum, Germany

Operating room schedules are regularly influenced by uncertain demands such as surgery durations or randomly arriving emergency patients. Consequently, the performance of such schedules depends on various uncertain parameters. At an offline operational planning level assignments are made without focusing on the final sequence of the patients. Additionally, a sufficient amount of time is to be reserved in order to ensure that randomly arriving emergency patients can be treated in one of the available operating rooms. The performance of an operating room schedule influences several stakeholders' interests. In particular we focus on the interests of patients, staff and management as key stakeholders. Their interests are considered simultaneously in terms of individual objective functions. We investigate the performance of schedules for operating rooms using a robust multi criteria optimization approach. First, the date for every patient's surgery is fixed in advance anticipating uncertain demand. Necessary changes of these assignments due to actual durations observed for elective and emergency surgeries are to be performed in a second step. The proposed approach balances the workload for staff and ensures simultaneously low waiting times for patients and a sufficiently high number of surgeries performed. Different robust schedules are computed using the proposed approach. Afterwards, these schedules are evaluated with respect to randomly generated demand scenarios and multiple objectives. A simulation study is performed in order to evaluate to what extend robust schedules support the interests of various stakeholders. We further investigate how significant changes in surgery durations affect the different goals considering multiple stakeholders' interests. Of particular note is that these robust schedules achieve results very close to the individual optimal values and therefore provide an excellent compromise for all scenarios.

2- An Efficient Solution Technique to Solve the Operating Room Planning Problem

Evren Güney
Istanbul Arel University, Istanbul, Turkey

The efficient planning of operating rooms is a critical issue in a hospital. The planning problem determines the set of elective patients to be operated on in each operating room in each period over a planning horizon in order to maximize the operating room utilization. In this study, a solid mathematical model is developed to formulate the problem as a mixed-integer linear programming problem. It is shown that the problem is NP-hard and for even mid-size instances the problem becomes intractable and obtaining optimal solutions within reasonable duration becomes impossible. Therefore, we propose a Lagrangean Heuristic to obtain good upper bounds on the original problem and near optimal solutions within reasonable duration. Experimental analysis is carried out on the data provided by a mid-size local hospital in Istanbul to test our model and solution procedure.

3- Determining the number and location of emerceny medical stations in Eskisehir

Emine Akyol[1], Tugba Sarac[2]
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There are presently six emergency medical stations in the center of Eskisehir and they have an average of 6.5 minutes response time to emergency cases. Reducing response time of ambulances to emergency cases increases the probability of survival of patients so it is very important. In this study,

the problem of determining the number and location of emergency medical stations to be set up in Eskisehir is considered to reduce the response time of ambulances. The mathematical model of this problem is solved by using CPLEX solver of GAMS software and obtained result is compared with the present condition.

Session 4B: OR Methodologies for Home Care — TUES-4B

Room: SOS Z27 **Chair**: Ettore Lanzarone **15:30-17:00**

1- Assignment and routing problems in home health care services

Semih Yalcindag[1,2], Paola Cappanera[3], Maria Grazia Scutella[4], Andrea Matta[2], Evren Sahin[1],
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Human resource planning in Home Health Care (HHC) services is a critical activity which the quality of the provided service depends on. The service providers have to deal with several issues in human resource planning process where the assignment problem of the operators to patients together with their routing process (i.e., deciding in which sequence each operator will visit the assigned patients) are the two most important ones. These problems can be either solved with a two-stage approach or with a joint approach. The aim of this study is to perform a comparison between the two phase approach, where the assignment decisions (first phase) and the routing decisions (second phase) are tackled in a separate (and consecutive) manner, and the joint approach, where all the decisions are taken simultaneously. Integer Linear Programming (ILP) models are developed for both approaches under different scenarios on how the requirement skills are managed. In other words, ILP models are developed based on the compatibility between patient requests and operator skills where in one case operators with different skills are managed independently and in another case all operators are managed simultaneously. Models are solved with the continuity of care assumption where only one operator can be assigned to each patient over the planning horizon with the workload balancing objective. Numerical results based on realistic problem instances are performed to show the performance of the proposed models.

2- Dynamic re-scheduling for home health care vehicle routing problem

Eloi Duchaussoy[1], Vincent Augusto[2], Maria Di Mascolo[3], Xiaolan Xie[2]
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Home health care services are growing in importance and number. They serve the double objective to reduce hospitalization costs, as well as improving patients' well-being. However, they face an important problem with admissions. They are often required to give a definitive approval within 24 hours, which includes paying the patient's domicile a visit in this short delay, as well as scheduling several other visits for treatments, nursing and coordination. Scheduling a crew of nurses for a week of visits, including travel times and time windows constraints, constitutes a so called Vehicle Routing Problem, and some methods exist to tackle it [1]. However, an admission, due to its unforeseeable nature, cannot be planned in advance. So, for each new admission, we need to re-schedule in real-time, to include the new visits, without altering the existing schedule too much. In this work, we try to solve this re-scheduling for VRP by using an Ant Colony Optimization, which had already been successfully used in VRP with similar constraints [2]. The needed proximity with the previous planning can be secured by using this previous planning to initiate the pheromones levels and by including this constraint in the quality score. Good use of the different parameters also allows using the same algorithm for the different time horizons: on-line scheduling for the admission visit, with low tolerance on planning alteration or more time-consuming in-depth research for posterior visits. So, in any case, this approach allows us to have good results in various situations.

[1] Yalçındağ, S., Matta, A., and Şahin, E. (2011). Human Resource Scheduling and Routing Problem in Home Health Care Context: A Literature Review. Proceedings of ORAHS 2011. 8-22
[2] Rizzoli, A. E., Montemanni, R., Lucibello, E., & Gambardella, L. M. (2007). Ant colony optimization for real-world vehicle routing problems. Swarm Intelligence,1(2), 135-151.

3- Comparing two different objective functions in a cardinality-constrained model for the assignments in Home Care

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[2]Istituto di Matematica Applicata e Tecnologie Informatiche, Consiglio Nazionale delle Ricerche, Milan, Italy
[3]Istituto di Analisi dei Sistemi ed Informatica, Consiglio Nazionale delle Ricerche, Rome, Italy

Human resource planning in Home Care (HC) services is a difficult task, as the provider has to deal with peculiar constraints (e.g., the continuity of care, imposing that a patient is always cared for by the same nurse) and to manage the high variability of patients' demands. Indeed, under continuity of care, one of the main issues encountered in planning HC services is the nurse-to-patient assignment. In the literature, several techniques are adopted to manage the uncertainty of the demand in the nurse-to-patient assignment problem and, recently, we solved the problem adopting a cardinality-constrained robust model. The objective function of such robust model is the minimization of the nurses' overtime costs, which arise in case nurses work for a time larger than the contractual value. In this paper, we model a new objective function for the above mentioned problem, i.e., the fairness of nurses' utilizations within the districts, and we compare the two objective functions. The performance of the two objective functions is analyzed through the application to a test case derived from one relevant HC provider operating in Italy, with the aim of evaluating the impact of the different objectives in the plans.

4- A multilevel cardinality-constrained model for the nurse-to-patient assignment problem in Home Care

Ettore Lanzarone[1], Giuliana Carello[2], Sara Mattia[3]
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Uncertainty is a common feature of many health care optimization problems, spreading from ambulance location to operation rooms planning. In this paper, we focus on the nurse-to-patient assignment problem under continuity of care in Home Care, where high uncertainty is associated to the number of visits required by patients in each time period. Several techniques are adopted to manage the uncertainty of the demand in this problem and, recently, we proposed a cardinality-constrained model. In comparison with other techniques, the main advantage of such model is to exploit the potentialities of a linear programming model rather than an analytical approach, even without the necessity of generating scenarios. However, the standard formulation of the cardinality-constrained model considers only two values of demand for each patient and each period of the planning horizon (i.e., expected and maximum demands). As a consequence, in the optimal solution, patients are not allowed to have a demand for visits lower than the expected value, and the model does not allow to include smaller demand variations, which are instead quite common, thus resulting into a too conservative solution. In order to overcome the limitations above, we propose a new cardinality-constrained model in which different levels of demands are considered, also allowing negative demand deviations from the expected value. All levels are obtained by means of probability density functions derived with a previously developed patient stochastic model. The model is developed considering the case of a large Home Care provider operating in Italy.

Session 4C: Tutorial 2 (Margaret Brandeau, Health Policy Modeling) TUES-4C

Room: SOSB07 **Chair**: Evrim Didem Gunes **15:30-17:00**

The goal of public health is to improve lives through the prevention and treatment of disease. When deciding which programs to invest in, public health decision makers face a number of challenges, including limited resources to invest among many potential programs, incomplete information about the potential effect of programs, and objectives that include not only health maximization but social, political, and cultural considerations. Despite these difficulties, public health planners must make choices about which programs they will invest in – and the quality of these choices affects the health benefits achieved in the population. This is where OR-based modeling can play a role: by providing a structured framework that uses the best available evidence, imperfect as it may be, and that captures relevant uncertainties, complexities, and interactions, OR-based models can be used to evaluate the potential impact of alternative public health programs. This tutorial discusses the range of opportunities for the application of OR models in public health, presents an overview of useful modeling approaches, and describes modeling efforts in which OR has played and can play a role in informing public health decision making. We conclude with a discussion of useful lessons for OR modelers who wish to help improve public health decision making.

Margaret Brandeau is Coleman F. Fung Professor of Engineering and Professor of Medicine (by Courtesy) at Stanford University. Her research focuses on the development of applied mathematical and economic models to support health policy decisions. Her recent work has focused on HIV prevention and treatment programs, programs to control the spread of hepatitis B virus, and preparedness plans for bioterror response. She is a Fellow of the Institute for Operations Research and Management Science (INFORMS), and has received the President's Award from INFORMS (recognizing important contributions to the welfare of society), the Pierskalla Prize from INFORMS (for research excellence in health care management science), a Presidential Young Investigator Award from the National Science Foundation, and the Eugene L. Grant Teaching Award from the Stanford School of Engineering, among other awards. She is currently a member of the Board of Scientific Counselors, a Federal Advisory Committee to the Office of Public Health Preparedness and Response of the Centers for Disease Control and Prevention. Professor Brandeau earned a BS in Mathematics and an MS in Operations Research from MIT, and a PhD in Engineering-Economic Systems from Stanford University.

Thursday July 11th

09:30-11:00	Session 5			
	5A Improving Healthcare Delivery Room: SOS Z21	**5B Modeling Infectious Diseases** Room: SOS Z27	**5C Health Economics** Room: SOS 103	**5D Operating Room Planning & Scheduling (3)** Room: SOS 104
	Jan Vissers Managed outcomes: An operations management and demand based approach to regional healthcare delivery system: Methodology and modeling issues	**Alexander R Rutherford** Estimating HIV Incidence: A mathematical modelling approach	**Reza Mahjoub** Health economic evaluation of a pay-for-performance risk-sharing agreement	**Tagi Hanalioğlu** Estimating operational and surgical team network effects on surgery durations
	Mahdi Mahdavi A comparative analysis of operations and performance of a regional stroke service in six EU countries. Model, findings and benchmarking issues	**Margaret Brandeau** HIV treatment and prevention: A simple model to determine optimal investment	**Kenan Arifoglu** A two-sided mechanism to coordinate the influenza vaccine supply chain	**Patrick Soriano** Assessing the impact of patient sequencing in stochastic operating room planning
	Tom Bowen Scenario models of healthcare process and patient outcomes	**Sarah Kok** Operational strategies for improving the HIV testing program in Vancouver, Canada	**Mónica Duarte Oliveira** Tactical planning of an equitable long-term care system under uncertain conditions	**Fabrício Sperandio** Operating room scheduling under uncertainty: An efficient simulation optimization approach
		Dionne Aleman An efficient approximation algorithm for the critical node detection problem	**Claudio Deiana Deiana** Disability and labour market outcomes: An empirical analysis across Europe	**Marzieh Soltanolkottabi** Capacity planning in operating rooms by means of centralized data envelopment analysis: Case study of Alzahra Hospital in Isfahan-Iran

11:30-13:00	**Panel Discussion**	**Room:** SOSB07

Future of Healthcare: Challenges for Operations Research

Chair: Prof. Dr. Mike Pidd

Prof. Dr. William P. Pierskalla (The Anderson School at UCLA & The Wharton School, Univ. of Pennsylvania)

Prof. Dr. Yasar Ozcan (Department of Health Administration, Virginia Commonwealth Univ.)

Prof. Dr. Marion Rauner (School of Business, Economics and Statistics, University of Vienna)

Prof. Dr. Mike Pidd (The Management School, Lancaster University)

Tom Bowen (The Balance of Care Group, U.K.)

14:30-16:00	Session 6		
	6A Decision Support Room: SOS Z21	**6B Emergency Department Modeling** Room: SOS Z27	**6C Tutorial 3** Room: SOSB07
	Jiun Yu Yu Design and operations for online-offline-integrated healthcare networks facilitators	**Dave Worthington** Implementing a combined analytical queueing and simulation-based staffing approach for A&E departments	**Mariel Lavieri** Stochastic Disease Modeling and Chronic Disease Management
	Guilan Kong Pre-hospital trauma assessment by combining multiple trauma scores	**Ruth Luscombe** Reactive scheduling to minimize tardiness of flow time targets in the Emergency Department	
	Amene Alimohammadi Rule extraction for pre-eclampsia based on Genetic Algorithm	Sima Ajami Impact of implementing scenarios' simulation on waiting time at emergency department	
	Mónica Duarte Oliveira Developing a methodology to support ICD coding using Electronic Health Record structured data: Issues and insights from an application to real-world healthcare settings	**Paula Andrea Velásquez Restrepo** Dynamics of patient care in the hospital emergency department and its effect on the overcrowding.	

16:30-18:00	Session 7			
	7A Healthcare Supply Chains Room: SOS Z21	**7B Location Problems in Health Care** Room: SOS Z27	**7C Patient Scheduling** Room: SOS 103	**7D Healthcare Resource Planning (2)** Room: SOS 104
	Sultan Turhan Vendor managed inventory via SOA in healthcare supply chain management	**Dirk Degel** Dynamic ambulance location providing suitable coverage for time-dependent demand	**Zheng Zhang** Simulation-based optimization of surgery appointment scheduling	**Eylül Damla Gönül** A system dynamics model for the analysis of hospital laboratory capacity
	Nazaré Rego Evaluating segmented health care supply chain strategies	**Derya Demirtaş** Optimizing the deployment of public access defibrillators	**Michael Samudra** Implications of switching from a to-day to a to-week patient scheduling strategy, an application at the UZ Leuven	**Tolga Tezcan** Determining the optimal configuration of hospital inpatient rooms in the presence of isolation patients
	Cigdem Gurgur Health care product procurement in dual supplied systems	**Soheil Davari** The bi-objective equitable preventive healthcare network design	**Atle Riise** Operational activity scheduling in a hospital laboratory	**Asli Ozen** Modeling hospital-wide patient flows using simulation
	Yannick Kergosien A Benders decom-position based heuristic for a combined transportation and scheduling problem in chemotherapy production		**Yuwei Lu** Elective inpatient admission with delay announcement	**Mario Jorge Ferreira De Oliveira** A visual platform for Hospital Admission

Session 5A: Improving Healthcare Delivery THURS-5A

Room: SOS Z21 **Chair**: Jan Vissers **09:30-11:00**

1- Managed Outcomes: an operations management and demand based approach to regional healthcare delivery system. Methodology and modeling issues

Jan Vissers, Mahdi Mahdavi, Sylvia Elkhuizen
Institute of Health Policy and Management, Erasmus University Rotterdam, Rotterdam, Netherlands

Managed Outcomes is a 3-year project financed by the EU 7e Program Framework for Health, performed in 2010-2012 by a consortium of universities and consultancy organizations. The objective of the project is to improve the performance of regional provider networks in delivering health care services by investigating the relationships between demand for services, the processes of service delivery and outcomes. The basic assumption underlying this project is that patient centered well-organized delivery systems contribute to a better health performance. This approach was tested for four demanding health care system challenges (diabetes type 2, stroke, hip-osteoarthritis and dementia) in case studies in six EU countries (Finland, Germany, Greece, The Netherlands, Spain and United Kingdom). The methodology used by Managed Outcomes is a combination of modeling health services and assessing the performance of the system from the perspective of the provider and the user. The modelling of services is based on principles of service operations management. The backbone of the approach is an operational model of the service delivery system, which describes in a structured way the relationships between the demand for services by the population in the area, the services that are required to fulfill the demand, the availability of these services at provider service points in the network, the patient journey that is followed by the patient through the network, the requirements of these services for the resources of providers, the costs of these resources and the reimbursement of the services delivered. The presentation will first introduce the Managed Outcomes project by providing some background information. Then we present the methodology developed by Managed Outcomes for describing, analyzing and comparing regional health service delivery systems. We will end with some issues encountered during the modelling.

2- A comparative analysis of operations and performance of a regional stroke service in six EU countries. Model, findings and benchmarking issues

Mahdi Mahdavi, Jan Vissers, Sylvia Elkhuizen
Institute of Health Policy and Management, Erasmus University Rotterdam, Rotterdam, Netherlands

Stroke services represent one of the cases investigated in the Managed Outcomes project, a 3-year project financed by the EU 7e Program Framework for Health. The objective of the project is to improve the performance of regional provider networks in delivering health care services by investigating the relationships between demand for services, the processes of service delivery and outcomes. See other abstract for information on Managed Outcomes and methodology. We applied the methodology of Managed Outcomes to stroke services in a case study in six EU countries (Finland, Germany, Greece, The Netherlands, Spain and United Kingdom). We derived a specific operational model from the generic model of Managed Outcomes and we used this model for description and analysis in the six case studies. This description of the delivery system is complemented with information on the operations management practice. The aspects covered relate to the planning models used at different levels, the collaboration between the partners along the delivery chain, the responsibilities and structure, the improvement and organizational development, the IT support and information management, and the innovation of services and organization. For the measurement of the performance of the delivery system a distinction is made between the provider perspective and the user perspective on outcomes. For the provider perspective data were extracted from information systems regarding service performance and clinical performance. For the user perspective a survey was held on the experiences of patients with the service delivery and satisfaction with the services,

their perceived health status and the satisfaction with their health. In the presentation we will first elaborate the operational model for stroke. Then we present the results of applying this model to six instances in EU countries. We will end with some issues encountered during the comparative analysis.

3- Scenario models of healthcare process and patient outcomes

Tom Bowen
The Balance of Care Group, United Kingdom

The central objective of the EU funded (FP7) 'Managed Outcomes' project was to explore how healthcare outcomes and cost-benefits are affected by the efficiency with which services are organised, produced and delivered. Better knowledge of these relationships is crucial in order to support more effective use of available resources in the future. A case study approach was adopted, with four care processes being studied, related to diabetes, stroke, hip osteoarthritis and dementia. For each case study, extensive data collection from providers and service users in six European countries was analysed to generate operational, economic and scenario models of care processes. Results from the scenario modelling will be presented, demonstrating how process management impacts on patient outcomes. As common elsewhere, our process-outcome models were based on external estimates of demand. New 'idealised design' approaches to modelling demand in terms of processes could help deliver improved outcomes for future service developments.

Session 5B: Modeling Infectious Diseases THURS-5B

Room: SOS Z27 **Chair**: Dionne Aleman **09:30-11:00**

1- Estimating HIV Incidence: A Mathematical Modelling Approach

Alexander R Rutherford[1], Ali Nadaf[1], Bojan Ramadanovic[2], Krisztina Vasarhelyi[3], Benita Yip[4], Art Poon[4], Richard Liang[4], Richard Harrigan[4], Ralf Wittenberg[1], Julio S Montaner[4]

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[4]BC Centre for Excellence in HIV/AIDS, Providence Healthcare, Vancouver, Canada

An important measure of the success of public health strategies for containing the HIV/AIDS epidemic is incidence, the rate of new infections in the population. However, the rate of new positive tests is not necessarily a good measure of incidence, because an HIV infection may be asymptomatic for as long as eight years. We present a new method for estimating incidence, which utilizes public health data along with viral genetic data obtained from viral load tests of infected individuals. Our approach is to first estimate the time series for the fraction diagnosed of the HIV-positive subpopulation and then compute the incidence time series from it. A compartmental disease transmission model is used to obtain a differential equation for the fraction diagnosed of the HIV-positive subpopulation. For any given values of the transmission rate, the reduction in the transmission rate caused by behavioural change upon diagnosis, and the fraction diagnosed at an arbitrary reference time, this differential equation is solved using Euler's method. The population-level viral genetic distance at time t is defined as the average over all individuals tested at t of the minimum viral genetic distance from each test at t to all tests before t. If this genetic distance approaches zero, then the fraction diagnosed approaches one. Likewise, if it approaches infinity, then the fraction diagnosed approaches zero. A two-parameter family of functions is used to model this behaviour. The optimal parameter values are calculated by using tabu search to minimise the sum of the squared differences between the two time series for the fraction diagnosed. Finally, bias caused by the choice of reference time used to solve the differential equation model is eliminated by doing a Monte Carlo simulation over randomly chosen reference times. This method is applied to the HIV epidemic in British Columbia, Canada.

2- HIV Treatment and Prevention: A Simple Model to Determine Optimal Investment

Margaret Brandeau
Stanford University, Stanford, California, USA

Funds for HIV control fall far short of the estimated need and, despite ongoing efforts, HIV remains a significant problem in the United States (US) and worldwide. Public health decision makers must determine how to best invest limited resources in HIV treatment scale up and prevention programs. This paper presents a simple model for determining the optimal mix of investment in HIV treatment and prevention, given a fixed budget. We incorporate estimates of secondary health benefits accruing from HIV treatment and prevention and allow for diseconomies of scale in program costs and subadditive benefits from concurrent program implementation. We use a cost-effectiveness framework that considers incremental cost and two objectives, maximizing quality-adjusted life years gained or HIV infections averted. We develop methods of linearly estimating health benefits and costs that account for epidemic effects of prevention and treatment. We illustrate our model with the examples of preexposure prophylaxis (PrEP) and community-based education (CBE) compared with antiretroviral therapy (ART) for men who have sex with men (MSM) in the US. For MSM in the US, we find that it is optimal to invest in ART before PrEP, and to invest in CBE before scaling up ART. Subadditivity of benefits does not affect the optimal resource allocation for relatively low implementation levels but diseconomies of scale may lead to lower investment in a program than when there are no diseconomies. Our model provides a simple yet accurate means of determining optimal investment in HIV prevention and treatment. Our example analysis demonstrates that HIV budgets are often best spent on the program that offers the greatest "bang for the buck."

3- Operational Strategies for Improving the HIV Testing Program in Vancouver, Canada

Sarah Kok[1], Krisztina Vasarhelyi[1], Alexander R. Rutherford[2], Rolando Barrios[3], Reka Gustafson[3], Julio Montaner[1]
[1]BC Centre for Excellence in HIV/AIDS, Vancouver, BC, Canada
[2]The IRMACS Centre, Simon Fraser University, Burnaby, BC, Canada
[3]Vancouver Coastal Health Authority, Vancouver, BC, Canada

In Canada, many HIV-positive people remain undiagnosed until late in the course of infection. This leads to delayed treatment initiation, which both compromises the health of the infected individual and increases the likelihood of HIV transmission. Therefore, a timely and efficient HIV testing program is imperative in combatting the HIV epidemic. In this project, we explored ways to optimize the HIV testing program in Vancouver, Canada. We produced a detailed operational model of the testing program within a previously developed system dynamics model of the entire Continuum of HIV Care. This operational model is coupled with an HIV transmission model to allow tracking of the spread of HIV infection in the population. The combined operational/transmission model is programmed using simulation software iThink. The main data sources for the model include publically available reports, published literature, and data provided by Vancouver Coastal Health Authority, BC Centre for Disease Control and the BC Centre for Excellence in HIV/AIDS. The model was validated against best available data on the number of individuals on treatment, the percentage diagnosed in AIDS phase and HIV prevalence. We used this model to evaluate resource allocation strategies within the overall HIV testing program in Vancouver. Evaluated scenarios included increasing testing in selected programs, finding the optimal mix of HIV testing programs using both existing and additional resources, and the effect of improved engagement in care on the testing program. Preliminary results suggest routine HIV testing of all patients admitted to hospitals can reduce HIV incidence, assuming a realistic cost ratio of risk-based tests to routine HIV tests. Using 5-year cumulative incidence as the measure of interest, the optimal percentage of existing resources allocated to routine testing ranges from 20% to 40%, for a cost ratio of 3:1 to 5:1, respectively.

4- An Efficient Approximation Algorithm for the Critical Node Detection Problem

Mario Ventresca, Dionne Aleman
Department of Mechanical and Industrial Engineering, University of Toronto, Toronto, Canada

The objective of the critical node detection problem (CNDP) is to fragment a graph by removing a small subset of vertices such that the induced subgraph contains minimum pairwise connectivity. There are a wide variety of important practical applications where the CNDP finds application, from drug discovery to our motivating application of pandemic disease mitigation. In this talk we present a polynomial-time algorithm that achieves a constant factor approximation ratio to the expected optimal objective value of the CNDP. Our algorithm is straightforward and is based on derandomizing a randomized rounding of the solution to the linear programming relaxation of the CNDP integer programming formulation. We present benchmarking and real-world results, in comparison to optimal solutions, to highlight the effectiveness of the algorithm.

Session 5C: Health Economics — THURS-5C

Room: SOS 103 **Chair**: Monica Duarte Oliveira **09:30-11:00**

1- Health Economic Evaluation of a Pay-for-performance Risk-sharing Agreement

Reza Mahjoub, Fredrik Odegaard, Greg Zaric
Richard Ivey Scool of Business, Western University (Formerly: The University of Western Ontario), London ON, Canada

Development of new pharmaceutical drugs has become increasingly costly. However, the incremental benefit or effectiveness is often small and uncertain. One mechanism to offset some of the uncertainties surrounding new and costly drugs is Health-Based Pay-for-Performance Risk-Sharing agreements. In this paper, we examine a risk-sharing contract between a payer and a pharmaceutical firm. The basis of the contract is that the pharmaceutical firm has to rebate a portion of the sales from patients that do not respond to the drug. The objective of the paper is to identify the conditions under which the rebate rate and evaluation time are mutually beneficial, i.e. where both the payer and pharmaceutical firm have incentives to introduce the new drug. We investigate how different classifications regarding rebates for non-respondent patients impact the two parties. The analysis of the contract performance is based on an underlying patient-level disease progression model. Based on published data from a Phase 2 clinical trial of an oncology drug, we empirically estimate disease progression parameters, and conduct numerical analyses of the risk sharing agreement. Our results indicate that: 1) there are trade-offs in choosing the evaluation time for both parties, such that its optimal value is not easily identifiable; 2) The payer is better off under one specific type of risk-sharing agreement in most practical circumstances and 3) the evaluation times beneficial to both parties are sensitive to the proportion of the rebate that the payer missed collecting

2- A Two-Sided Mechanism to Coordinate the Influenza Vaccine Supply Chain

Kenan Arifoglu
University College London, London, United Kingdom

We model the influenza (flu) vaccine supply chain as a decentralized system consisting of rational (self-interested) consumers and a monopolist manufacturer with an uncertain production process. We develop a two-sided coordinating mechanism which counteracts two main sources of inefficiency in the flu vaccine supply chain, namely, the rational consumer behavior and uncertain yield. On the demand side, the two-sided mechanism proposes tax/subsidy payments between the social planner (e.g., government) and consumers which depend on the realized yield. In some cases, the two-sided mechanism reduces the demand by making vaccination more costly through tax subsidy payments, e.g., higher sales tax on flu vaccine and higher tax exemptions for all consumers. On the supply side, the two-sided mechanism requires a transfer payment between the social planner and manufacturer which is also contingent on the realized yield. The transfer payment on the supply side is not independent from demand-side factors such as infection and vaccination costs. The two-sided mechanism requires the social planner to intervene but has a balanced budget, and also it can allocate the social welfare between consumers and the manufacturer arbitrarily. Using estimates from the literature, we conduct a numerical analysis and find that our two-sided mechanism reduces social costs up to 75%. We also find that mechanisms coordinating only one (demand or supply) side but failing to account for the inefficiency on the other side (the uncertain yield or rational consumer behavior) defeat their own purposes and increase social costs in some cases.

3- Tactical planning of an equitable long-term care system under uncertain conditions

Teresa Cardoso[1], Mónica Duarte Oliveira[1], Ana Barbosa-Póvoa[1], Stefan Nickel[2]
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European countries are currently facing an increasing demand for Long-Term Care (LTC), with LTC planning ranking high in the health policy agenda of these countries. Satisfying that increasing demand requires an adequate supply of LTC services, but most healthcare systems across Europe are still ill-equipped to meet this challenge. Departing from a structuring of key uncertainties and of policy options inherent to the reorganization of a network of LTC services, this study proposes a stochastic approach for planning the delivery of LTC services. In particular, a stochastic multi-objective and multi-period mathematical programming model is proposed for supporting the medium-term planning (both in terms of location selection and capacity planning) of the entire range of LTC services (institutional, home-base and ambulatory services) when several equity and cost related objectives are pursued and while considering the impact of uncertainties affecting the LTC sector. The model considers uncertainty associated with the number of individuals in need and with the intensity of resources that these individuals will require, as measured by the length of stay for institutional LTC services. The model is used to analyze the reorganization of the LTC network under an uncertain environment, when a wide range of inter-related policy decisions are to be made by combining: i) making changes to the budget available for coming years, ii) allowing the conversion of acute hospitals into LTC units, iii) allowing the transfer of acute care resources to the LTC sector and iv) changing the LTC provision paradigm. The applicability of the proposed model is demonstrated through a case study in Portugal

4- Disability and Labour Market Outcomes: An Empirical Analysis across Europe

Claudio Deiana
University of Essex, Essex, United Kingdom

This paper investigates the relationship between limitation in daily activities and labour market outcomes in twenty-six European countries using the European Union Statistics on Income and Living Conditions dataset (2007-2009). Matching techniques are used in order to control for the non experimental nature of the data. The empirical analysis uncovers a significant causal effect of health on the labour outcomes. Individuals who incur an adverse health shock are significantly more likely to leave their fulltime job and transit either into unemployment or inactive status according to the country-specific social security system. The pooled effect for all Europe is negative nevertheless the estimates dipper across countries, with the largest (smallest) effect respectively in Romania (in Finland) while the Mediterranean countries register an average drop of about thirteen per cent. I argue that these discrepancies are explained through the heterogeneity in social security systems across Europe. Empirical results demonstrate that those countries who register a higher level of integration disability policy have the smallest effect in terms of drop out of fulltime job.

Session 5D: Operating Room Planning & Scheduling (3) THURS-5D

Room: SOS 104 **Chair**: Tagi Hanalioglu **09:30-11:00**

1- Estimating operational and surgical team network effects on surgery durations

Enis Kayış[1], Tagi Hanalioğlu[2]
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In this study we explore the problem of surgery duration estimation, which is an essential ingredient in effective management of operating rooms (OR). ORs are one of the most critical resources in hospitals. OR scheduling is a challenging and critical problem that affects patient throughput, revenue, and outcomes, as well as patient and staff satisfaction. There are often conflicting multiple objectives, each with inherent uncertainties. Predicting the surgery duration as accurately as possible is one of the key prerequisites of good OR schedules. Various estimation models have been proposed in the literature for estimating surgery duration. Factors such as patient severity, procedure type, surgeon's estimate, time of day are found to be significant for the estimation. Team composition and the previous common experiences of team members are considered to have significant impacts on surgery duration. However, current literature on team composition is limited in validating this hypothesis. One of the main contributions of this study is to consider the impact of operational factors (such as sequence of the surgery, time of day, etc.) and past mutual and individual experiences of surgery team (e.g., surgeons, anesthesiologists and nurses) on the surgery duration from historical operational data. We combine the known significant factors (such as procedure name, surgeon…) with the ones that have not been considered before to create a more accurate and robust model to improve current estimation methods. Our methodological contribution is to employ elastic net method to select the most significant variables out of hundreds of possible predictor variables. In order to mitigate the low stability problem of elastic net method, we employ K-fold method and bootstrap algorithms to select the best adjustment parameters. Finally, we develop a novel clustering algorithm to identify procedures that have a high sensitivity to operational and team network effects.

2- Assessing the impact of patient sequencing in stochastic operating room planning

Roberto Aringhieri[1], Paolo Landa, Patrick Soriano, Elena Tànfani[2], Angela Testi[2]
[1]Department of Computer Science, University of Turin, Torino, Italy
[2]University of Genova, Genova, Italy

This study deals with the stochastic surgery process scheduling problem. Given a hospital departments made up of different surgical specialties which share common resources, such as operating theatre and beds, we jointly focus on the "advance scheduling" and "allocation scheduling" problem. In the advance scheduling phase, the operational decision addressed is that of assigning a surgery date and operating room (OR) allocation to the patients scheduled to be operated on. The second sub-problem solves a scheduling phase which determines the sequence and resource allocation of procedures in each OR and day. The main concern of this paper is to evaluate the impact of considering in the solution approach the patient sequencing inside the blocks when dealing with stochastic surgery durations. The advance scheduling problem is firstly formulated by a chance-constrained stochastic model that allows us to consider the variability of surgery durations by means of individual probabilistic capacity constraints for each OR block. The solution approach starts by an OR plan obtained by a straightforward greedy algorithm that allocates patients inside the OR blocks. Afterwards, through a Monte Carlo simulation, a large number of scenarios consisting in a collection of patient operating times are generated. Neighbourhood search are then applied to retain the solution into feasibility with respect to the scenarios previously generated. The goal of the whole approach is to determine a robust OR plan. The results from the solution framework are tested on a set of real based instances varying the search criteria, the operating time distributions parameters, as well as the critical overtime probability level.

3- Operating Room scheduling under uncertainty: an efficient simulation optimization approach

Fabrício Sperandio, Bernardo Almada Lobo, José Borges
INESC-TEC, Faculty of Engineering, University of Porto, Porto, Portugal

Operating Room (OR) scheduling is subject to strong uncertainty, which comes from multiple sources, such as: surgery duration variability, emergency/urgency arrivals, cancellations and delays. These unexpected events disturb the execution of the plan, causing low utilization of resources, low quality of service and additional costs. In order to prevent such problems, researchers and OR managers rely on proactive and reactive approaches. The proactive approach consists in using a stochastic optimization model to devise robust surgery schedules which can resist the effects of uncertainty. However, the high computational cost of combining combinatorial and stochastic problems takes researchers to apply simplified models. We propose a Simulation Optimization (SO) approach using a Genetic Algorithm and a Discrete Event Simulation model considering multiple sources of uncertainty. In the ORAHS 2012 we presented preliminary results showing that this approach is able to devise schedules which can perform better than schedules generated by traditional deterministic approaches. This year we focus on integrating more advanced SO methods, namely statistical ranking & selection procedures and meta-models, to reduce the computational cost so that the approach can be used in practice. In order to evaluate the results, real world data from a Portuguese hospital is used. This approach has a potential to smooth the execution of the plan, reducing the impact of unexpected events. As a result, surgical departments become more efficient, and are able to reduce costs without compromising quality of care.

4- Capacity planning In Ooperating rooms bBy means of centralized data envelopment analysis: Cases of Alzahra hospital in Isfahan-Iran

Marzieh Soltanolkottabi[1], Saeedeh Ketabi[2]
[1]Department of Industrial Engineering, Isfahan University of Technology, Isfahan, Iran
[2]Department of Management, University of Isfahan, Isfahan, Iran

In recent years providing health services to patients has becoming increasingly important and countries spend a large number of their GDPs on health services. In this environment application of managerial approaches will lead to the more efficient use of resources. Hospitals absorb a large share of public health expenditures; therefore, considerable savings in health cost can be achieved through the improving their efficiency. Since operating theatre has the hospital's largest cost and revenue, it has significant role in the performance of the hospital as a whole. In the past decades, a large body of literature on the management of operating rooms has evolved. One field that is of particular interest is operating room (OR) planning. The first phase in OR planning is to determine the number of OR times allocated to each surgical service or surgeon. In this study, centralized data envelopment analysis is used to allocate the limited resource of OR times to different surgeons. We considered that there is a centralized decision maker (Operation theatre manager) who supervises all surgeons. This centralized OR capacity planning model, while interested in the efficiency of the services, is also concerned with the overall consumption of the different inputs and the overall production of their outputs. It is also shown by the centralized DEA model how extra OR blocks can be assigned to surgeons. The model has been solved for data of operating theatre of Alzahra Hospital in Isfahan, Iran.

PANEL DISCUSSION: Future of Healthcare: Challenges for Operations Research

Room: SOS B07 **Moderator:** Prof. Mike Pidd **11:30-13:00**

Prof. Mike Pidd (The Management School, Lancaster University)
Prof. William P. Pierskalla (The Anderson School at UCLA & The Wharton School, Univ. of Pennsylvania)
Prof. Yasar Ozcan (Department of Health Administration, Virginia Commonwealth Univ.)
Prof. Marion Rauner (School of Business, Economics and Statistics, University of Vienna)
Mr.Tom Bowen (The Balance of Care Group, U.K.)

William P. Pierskalla, Ph.D., Distinguished Professor Emeritus of Decisions, The Anderson School at UCLA & The Wharton School, Univ. of Pennsylvania.

Please see short bio at the Keynote section.

Yasar A. Ozcan, Ph.D. Professor, Department of Health Administration, School of Allied Health Professions, Virginia Commonwealth University.

Please see short bio at the Keynote section.

Marion S. Rauner is Associate Professor, Department of Innovation and Technology Management, University of Vienna, Austria. She received an MBA in Business Informatics, a Ph.D. in Social and Economic Sciences, and her Habilitation in Business Administration, all from the University of Vienna, Austria, and an MBA in Business Administration from Vienna University of Economics and Business Administration, Austria. During the academic year 1999/2000, she was a visiting assistent professor at Standord University, Department of Management Science and Industrial Engineering. She was ranked 27 in the Handelsblatt ranking of professors for management under 40 years for German-speaking countries in 2009. Professor Rauner's research interests include international health care systems, disease policy modeling, operations research in public health, evaluation and management of healthcare technologies, and disaster management. Her refereed research has been published in a wide variety of journals, including European Journal of Operational Research, Journal of the Operational Research Society, Computers & Operations Research, OR Spectrum, Central European Journal of Operations Research, IMA Journal of Management Mathematics, Socio-Economic Planning Sciences, Health Policy, Health Care Management Science, International Journal of Healthcare Technology and Management, and International Journal of Technology Management. Furthermore, she is furthermore member of eight advisory boards of international journals and has co-edited seven special issues. Professor Rauner was awarded the Young, Talented Scientists Award of the Vienna Municipal Government, the Pharmig Prize for Health Economics, the Dr. Maria Schaumeyer Prize, the Kardinal-Innitzer-Prize 2003 as well as the best paper award at the

GOR-Working Group "Simulation and optimization of complex systems" - "Fuzzy systems, neuronale networks und artifical intelligence" together with Siemens AG, Corporate Technology. She also received several teaching awards from 2001 - 2013 at the University of Vienna for teaching innovation and technology management as well as for co-ordination and teaching the secialization of health care management. She has also supported the Austrian sick fund for occupational injuries in optimally allocating prevention budgets since 2001. Her professional memberships include the EURO Working group on OR Applied to Health Services, the Austrian and German Operations Research Societies, and the Austrian Society for Health Economics (executive board member). She was President of the Austrian Operations Research Society from 2006-2012 for which she has coordinated the working group "Operations Research applied to Health Services" since 2004.

Mr. Tom Bowen (The Balance of Care Group, U.K.) has degrees in Mathematics and Operational Research, and an extensive background in the fields of healthcare planning and information systems spanning over 25 years. After analytical and management posts in both the Department of Health and the NHS, he has been operating in consultancy for the NHS and in other European countries for the last ten years. UK projects have ranged from national policy work and key infrastructure projects to extensive work with local Trusts, health authorities, PCTs, local authorities and partner organisations on a variety of planning and informatics issues.
Tom has extensive experience of developing service plans for patient groups with chronic care needs, in particular services for older people. He has been involved with developing and applying the Balance of Care approach for several years, originally when working as an analyst at the Department of Health, then more recently through the activities of the Balance of Care Group.
He continues to maintain an interest in healthcare systems in other countries, and has undertaken consultancies in a number of other countries including Latvia (on the future funding of its health service), Turkey (hospital capacity planning) and for the European Commission, where he led a project on the impact of population ageing on health care costs.

Michael Pidd, Ph.D., is a Professor of Management Science at Lancaster University in the UK. He has an engineering degree from Brunel University, a Masters in OR from Birmingham University and a PhD in Management Science from Lancaster University. He has a long-standing interest in the ways that models are built and used in management science. This is seen in his soleauthored books: Computer simulation in management science (now in its 5th edition) and Tools for thinking: modelling in management science (working on a 3rd edition), both published by John Wiley and in use in many countries, as well as edited works and numerous papers. He is a firm believer than the most interesting things happen on the boundary between theory and practice and also that this can be great fun. His current interests include the improvement of healthcare through modelling, including whole hospital simulation models of hospital performance, and the links between hard and soft methods in OR. Most of his recent applied work has been in the public sector. Within Lancaster University he has served as Head of the Management Science Department and as Research Dean in the Management School. He has served as President of the Operational Research Society and as Chair of the Committee of Professors in OR. Through 2008 he has Chaired the national RAE panel assessing research quality across all subjects in all the UK's business schools, so may not have so many friends in 2009.

1- Design and operations for online-offline-integrated healthcare networks facilitators

Jiun Yu Yu
Department of Business Administration, National Taiwan University, Taiwan

Healthcare services are facing several challenges such as soaring costs and inappropriate allocation of resources. To respond to these challenges, the well-known management guru Clayton Christensen proposed three types of business models for healthcare service innovation: Solution Shops, Value-Adding Process Business, and Facilitated Networks. Although the impact of the first two types of business models are well discussed in the literature, the managerial implication of the third one is generally overlooked. In this study, organizations that facilitate interactions and resource exchanges among their participating entities in the healthcare system are referred to as "Healthcare Networks Facilitators (HNFs)". National Multiple Sclerosis Society (US) and the website PatientsLikeMe.com are two examples. Offline/physical network business models, such as rail transportation and postal services, have been operating successfully long before the emergence of the internet, on which numerous online/virtual business models are developed inspiringly in the past decade. Several attempts at developing innovative pure online HNFs have been made since the beginning of this century, including Google Health and Microsoft HealthVault, but only a few of them are still running now. On the other hand, the advantage and power of virtual community seems not well understood by traditional offline HNFs. This study aims to investigate the design and operations for online-offline-integrated HNFs so that innovative healthcare services that are unlikely to be delivered in the past can be enabled now. The main research methods are case analysis and system dynamics. This study proposes a framework which is expected to provide managerial guidance for HNFs. The framework includes four main actors – healthcare network facilitator, network members, partners, and the general public – and five major interrelated components – Awareness, Accessibility, Membership Management, Resource Management, and Trustworthiness. This study finds that the synergy between offline and online networks can enhance the impact of HNFs.

2- Pre-hospital trauma assessment by combining multiple trauma scores

Guilan Kong[1], Xiaofeng Yin[2], Tianbing Wang[2], Shuai An[2], Boaguo Jiang[2]
[1]Medical Informatics Center, Peking University, Beijing, China
[2]Peking University People's Hospital, Beijing, China

Pre-hospital trauma assessment is important in trauma care. Accurate pre-hospital trauma assessment could help pre-hospital medical workers to send victims to proper hospitals or trauma centers to receive proper trauma treatment. In the past four decades, many trauma scoring systems have been developed for this purpose. In china, frequently used pre-hospital trauma scoring systems include pre-hospital index (PHI), trauma index (TI), and Glasgow coma score (GCS). PHI comprises four components: systolic blood pressure, pulse, respiratory status, and level of consciousness. Consciousness assessment in PHI is glancing. GCS defines the level of consciousness in more details according to three parameters: eye-opening, best verbal response and best motor response. TI assess trauma from the following dimensions: region of body injured, type of injury, cardiovascular status, central nervous systems status, and respiratory status. Though each scoring system has its advantages, no one tool can guarantee high sensitivity and specificity. In this study, we proposed to use PHI, TI, and GCS in an incorporated way to assess pre-hospital trauma. The decision tree we employed can be shown as in Figure 1. We used hundreds of second hand trauma data to validate the composite approach. The results show that the assessment results generated by the composite approach are close to the reality. In the next step, we would implement a computerized decision support system for pre-hospital trauma assessment based on the composite approach.

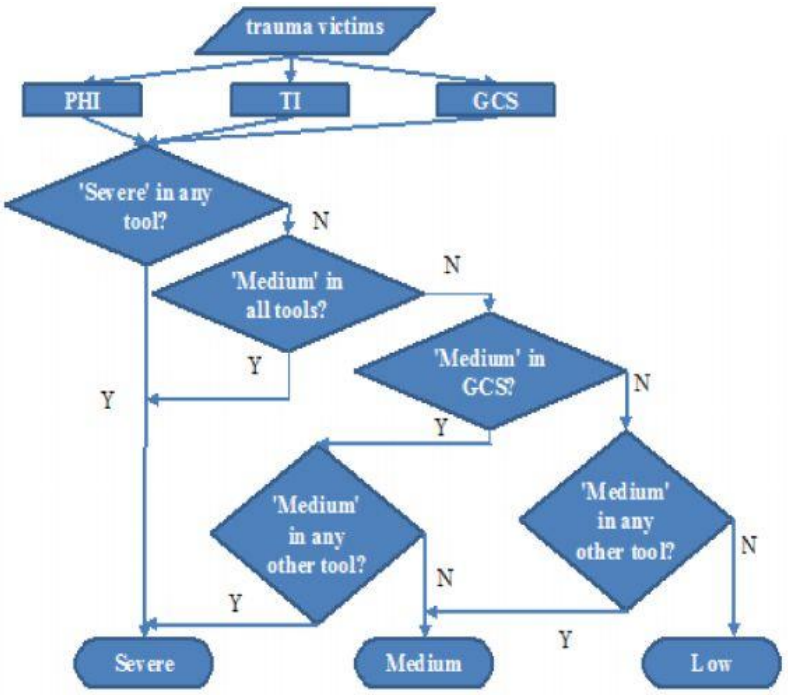

Figure 1

3- Rule extraction for pre-eclampsia based on Genetic Algorithm

Amene Alimohammadi[1], Nasrollah Moghaddam Charkari[2], Mahdi Ashrafi[1]
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In this work, data about pregnant women with pre–eclampsia and mothers without pre-eclampsia were studied in order to determine the rules of the disease with the help of Genetic Algorithms and to obtain understandable knowledge on the disease areas. Information about the disease, including 543 cases was divided in three categories: healthy, low risk and high risk group. After pre-processing, Genetic Algorithms have been used for rule extraction of pre-eclampsia. The three rules with the help of Genetic Algorithms (for each disease class, a rule) for pre-eclampsia have been extracted.

4- Developing a methodology to support ICD coding using Electronic Health Record structured data: issues and insights from an application to real-world healthcare settings

José Carlos Ferrão[1], Mónica Duarte Oliveira[2], Filipe Janela[1], Henrique M G Martins[3]
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[3]Centro de Investigação e Criatividade em Informática, HFF, Amadora, Portugal

Clinical coding is a common ground for most healthcare providers, being required to index patient episode data using the International Classification of Diseases (ICD) for reporting and billing purposes. The growing implementation of electronic health records (EHR) has motivated authors to develop methods to support this process, yet these approaches are based on text processing and, therefore, lack generalizability amongst languages and depend on the quality of narratives. This study aims firstly to propose a methodology to develop prediction models to support clinical coding using

structured EHR data and, secondly, to discuss key issues related to the use of structured data and to the construction of prediction models based on real-world hospital data. In order to build a predictive model, the clinical coding process was first structured in order to define a set of variables as a basis for developing prediction models. This step was streamlined with adaptable queries and allowed for mapping the information stored in the EHR database in its raw format into a data matrix in which episodes are expressed according to a certain set of variables defined by the data model. Then, using a supervised learning paradigm, historical data from 3842 episodes occurring in the Department of Internal Medicine of a large public hospital in Portugal were used to develop prediction models with the aim of predicting the ICD codes to be assigned to each episode, using decision tree learning algorithms optimized for each code through cross-validation. Preliminary results show the relevance of developing methods using structured EHR data to support clinical coding. A refined analysis to assess model behavior for different episode types has identified key information with relevance for predicting ICD code assignment and raised issues and provided feedback to inform the strategic management of EHR systems.

Session 6B: Emergency Department Modeling THURS-6B

Room: SOS Z27 **Chair**: Dave Worthington **14:30-16:00**

1- Implementing a combined analytical queueing and simulation-based staffing approach for A&E departments

Dave Worthington[1], Navid Izady[2], Claire Worthington[3]
[1]Management Science Department, Lancaster University, Lancaster, UK
[2]School of Management & Mathematics, University of Southampton, Southampton, UK
[3]Lancashire Business School, University of Central Lancashire, Preston, UK

Izady and Worthington (2012) describes a method for determining staffing levels in accident and emergency (A&E) departments which combines analytical results for time-dependent infinite server networks with simulation, in an iterative scheme. Applying the approach in a typical A&E department in 2011 suggested that significant improvements could be made with respect to performance targets, without any increase in total staff hours. However the hospital chose not to adopt the recommended approach. The hospital recently decided that it wished to use the approach and requested that models be updated and recalibrated, and then used to recommend staffing levels, to develop shift patterns and to generate rosters – by the end of June 2013. This talk will describe this implementation project, highlighting the additional challenges over and above the technical challenges of the modelling work.

Izady N and Worthington D, 2012, 'Setting Staffing Requirements for Time Dependent Queueing Networks: The Case of Accident and Emergency Departments', European Journal of Operational Research, vol 219, Issue 3, pp531-540.

2- Reactive scheduling to minimize tardiness of flow time targets in the Emergency Department

Ruth Luscombe, Erhan Kozan
Mathematical Sciences School, Queensland University of Technology, Brisbane, Australia

The Emergency Department (ED) operates as a non-terminating system with new patients arriving at random. The process of ED care is made up of several treatment tasks designed to assess, stabilize and treat the presenting condition of the patient. Each patient requires a set of tasks and each task requires access to some ED resources i.e. staff, treatment spaces and equipment. The challenge with ED care is to allocate the scarce resources to patient tasks according to their urgency and treatment needs. The aim of this paper is to improve the efficiency of ED patient flow under scarce resource constraints through an online task scheduling model. ED task scheduling is formulated as a Resource Constrained Project Scheduling Problem (RCPSP) due to the limited availability and capacity of resources and precedence relationships between tasks. The objective is to minimise tardiness in accordance with flow time targets for ED patients. Binary integer programming and constraint programming are combined to formulate the RCPSP. In the online environment the assignment and sequencing decisions need to be revised in response to new information. A reactive scheduling approach is used to respond to new information. Rescheduling is triggered by uncertain events such as patient arrivals and resource disruptions. Schedule repair heuristics are used to update the ED schedule in response to trigger events. A comprehensive sensitivity analysis is presented and demonstrates that high quality ED schedules can be obtained in real-time.

3- Impact of implementing scenarios' simulation on waiting time at emergency department

Sima Ajami[1], Saeedeh Ketabi[2]
[1]Health Information Technology & Management Department, Isfahan University of Medical Sciences, Isfahan, Iran
[2]Department of Management, University of Isfahan, Isfahan, Iran

Crowded Emergency Department (ED) affects the quality of medical care. It not only reduces access to medical care services but also delays time rescue of patients. Simulation is one of the decision supporting techniques that analyzes risk factors and strategies in decision-making. The aim of this research was to determine impact of implementing scenarios' simulation on waiting time at the Ayatolahkashani ED after one year. This study was analytical intervention in which data collected by forms and observations. Population included the patients who received services in the ED in May 2009. Researchers have been collected data which were according to findings of a research entitled "Waiting Time in ED by Simulation" Ayatolahkashani Hospital in 2008, for 1092 patients during 17 days at ED in 2009. For data analysis, SPSS, and simulation model were used. In this study, after implementing some scenarios which proposed by first research during 2008 (phase-one), after one year, distribution of patients' arrival time and patients' service times along with related parameters for each work center measured and compared with phase-one. Results after applying modifications showed service time in the Ear Nose Throat (ENT) and Neurosurgical dramatically reduced as well as other services. Health care managers, in the ED are usually physicians who are not familiar with principals of management. Hence, they need simple tools for logical decision-making. Operation research methods such as simulation are suitable for them.

4- Dynamics of patient care in the hospital emergency department and its effect on the overcrowding: An application to the "IPS UNIVERSITARIA", seat Leon XIII Clinic of Medelling-Colombia

Paula Andrea Velásquez Restrepo[1], Juan Sebastián Jaén Posada[2], German Gonzalo Gonzalez Echeverri[3]
[1]Department of planning, IPS UNIVERSITARIA, Clínica León XIII of Universidad de Antioquia, Medellín, Colombia
[2]Department of Industrial Engineering, Universidad de Antioquia, Medellín, Colombia
[3]Health services Sundireccion, IPS UNIVERSITARIA, Clínica León XIII of Universidad de Antioquia, Medellín, Colombia

The Hospital Emergency Departments (HEDs) play a fundamental role, saving lives. Despite being one of the basics of health care to the population, are still arguing about its function and structure, becoming an important focus of study for researchers. Among the problems in the HED is overcrowding that affects millions of patients each day. In this research, we reviewed literature which helped reconstruct the history of the study of the problem of overcrowding of the HEDs, possible causes arising out this problem and starting from this. The research focused on obtaining new knowledge of the variables and relationships, focusing on evaluating the dynamics of the process in the HEDs urgent patient care, integrating the different variables that influence crowding it. Arose the need for a study incorporating all the variables of the problem of overcrowding of the HEDs: increasing patients demand, the time of care, diagnosis and treatments for care for the patient, the ability of the nursing staff and beds of service of emergency in contrast to the demand, times of auxiliary hospital services such as: diagnostic tests, tests of clinical laboratory, consultation for specialist doctor, times of observation of the patient and the availability of beds in the hospital. Thus, this work provides value from the methodological point of view that comes from the classical approach to the dynamics of systems. It was built a simulation model on the basis of variables and the relationships in the literature, which we checked with the medical staff, in order to build a micro-world that serves as a learning basis for decision-making when it comes to implementing policies that seek to alleviate the problem of overcrowding in the HEDs.

Stochastic disease modeling and chronic disease management

Mariel Lavieri
University of British Columbia, Vancouver, Canada

Through examples from my ongoing work, I illustrate how operations research models may guide management of chronic disease patients. The main decisions considered include screening, monitoring and treatment. The presentation will start with patient-level models and then move into resource allocation and planning. Key to the models developed is the incorporation of the individual patient's disease dynamics into the parameterization of the stochastic models of the disease state evolution. The role of data used for model creation and validation is described. I shall conclude the talk by describing my experience working with clinicians as well as discuss steps taken from model conception to acceptance by the medical community.

Dr. Lavieri is an Assistant Professor in the Department of Industrial and Operations Engineering at the University of Michigan. She has bachelor's degrees in Industrial and Systems Engineering and Statistics and a minor in String Bass Performance from the University of Florida. She holds a Masters and PhD in Management Science from the University of British Columbia. In her work, she applies operations research to healthcare topics. Her most recent research develops dynamic programming, stochastic control, and continuous, partially observable state space models to guide screening, monitoring and treatment decisions of chronic disease patients. She has also developed models for health workforce planning which take into account training requirements, workforce attrition, capacity planning, promotion rules and learning. Dr. Lavieri is the recipient of the Bonder Scholarship (for her potential in making a significant contribution to the field of applied operations research in health care services), and an honorary mention in the George B. Dantzig Dissertation award. She also received the Pierskalla Award for the best paper presented in the Health Applications Society at INFORMS.

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Session 7A: Healthcare Supply Chains THR-7A

Room: SOSZ21 **Chair**: Cigdem Gurgur **16:30-18:00**

1- Vendor managed inventory via SOA in healthcare supply chain management

Sultan Turhan[1], Özalp Vayvay[2]
[1]Department of Computer Engineering, Galatasaray University, Istanbul, TURKEY
[2]Department of Industrial Engineering, Marmara University, Istanbul, TURKEY

As the management of supply chain gains an important role for the companies in order to be competitive in the market, healthcare sector also has effected from this wave. The main difference between the healthcare supply chain management and the other sectors are the key elements. In healthcare sector, pioneers must do highly accurate job because, in this sector, cost of an error may be someone's life. In healthcare sector, "Right product must be in the right place at the right time" is really a must. This paper shows a new modelling approach of healthcare supply chain in order to ensure this mandatory accuracy by using vendor managed inventory (VMI) technique. The core theme of this paper is that, to provide the best kind of process systems by using service oriented architecture patterns to model vendor managed inventory in order to ensure an effective management in healthcare supply chain management.

2- Evaluating segmented health care supply chain strategies

Nazaré Rego[1], João Claro[2], Jorge Pinho de Sousa[2]
[1]INESC TEC (formerly INESC Porto)/ Escola de Economia e Gestão, Universidade do Minho, Minho, PORTUGAL
[2]INESC TEC (formerly INESC Porto)/ Faculdade de Engenharia, Universidade do Porto, Port, PORTUGAL

In the last decades, academics and managers have presented arguments and examples to support the idea that companies should not apply a "one-size-fits-all" strategy to manage multi-product supply chains. However, it may be challenging to link the desired supply chain capabilities – e.g., low cost, speed, high quality and/or flexibility, safety – to the actual operational processes and resources that are in the sphere of decision makers. A hospital supply system provides a great variety of the services and products through a network of diverse and relatively autonomous services, and must assure a high service level, as the occurrence of stock-outs can, in extreme situations, threaten the patients' life. Additionally, the various stakeholders involved in the decision process often have different perspectives of what "good" system performance is, and individuals' reactions to the system state (namely, to the information they obtain about that state) highly influence subsequent system performance. In this work, we partition the myriad of pharmaceutical and medical items that flow through the supply chain of a hospital system composed by three neighbour hospitals into a practicable number of homogeneous groups (clusters/segments), in terms of the capabilities they need/require from the hospital system supply chain. Although we focus our analysis on the items supply chain, the results of our analysis show that the segments obtained are closely related to the specific types of services provided. Afterwards, we suggest different supply chain operations strategies in order to fit the requirements of the specific supply chain segments identified, and evaluate these strategies using simulation models that take into account the influence of individuals' behaviour/decisions on the outcome of the different strategies.

3- Health care product procurement in dual supplied systems

Cigdem Gurgur
Department of Management & Marketing, Doermer School of Business, Purdue University, Indiana, USA

We consider supplier selection and quantity allocation decisions for a health care organization that may purchase a number of unbundled and refurbished products under stochastic demand. There are a set of suppliers available in the market. Some suppliers offer only brand new products. These are more expensive than the used ones, but can be delivered any time and in any quantity. Some suppliers offer only refurbished products. These products are certified by the regulator. Thus, there is no uncertainty about their quality. However, suppliers do not sell these separately, but in bundles, i.e. each bundle consists of a variety of products with different quantities and bundles are sold as a package. If the health-care organization accepts to purchase a specific bundle from a supplier, it purchases the whole package, which may involve products it does not use or the quantities exceeding its need. The advantage of purchasing refurbished bundles is that they are much cheaper than brand new ones. Our model is general enough to consider a pricing structure without any bundling discount on individual items to account for situations wherein the buyer finds it beneficial to only buy an individual item in the family from a supplier despite the offer of price discount for a family of items. The setting also addresses situations where the buyer is able take advantage of bundling discounts offered by a supplier. The fixed cost structure deals with a variety of costs in a practical scenario, including any overhead incurred by the buyer towards establishing and maintaining a relationship with a supplier that is independent of the number of items sourced from the supplier. We adopted simulated annealing because of its ability to quickly combine and evaluate strategic purchasing schemes. We used data from a large healthcare provider to test implications of our study.

4- A Benders decomposition based heuristic for a combined transportation and scheduling problem in chemotherapy production

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This study is an extension of an earlier work on planning and tracking chemotherapy production for cancer treatment in the Biopharmaceutical units of a French hospital complex. In the previous work, a decision making software for production planning was developed, where only the scheduling problem was considered without taking into account the delivery problem. However, this part is important because only one person is available to deliver the drugs in the hospital services and the drugs are not available at the beginning of the day, but throughout the day. Some destination services are near (they can be reached by foot), although other ones are far and require the use of a car. In order to improve the quality of service, the routing part can be improved taking into account the parameter of delivery in the production planning. For example, finishing together the all production of chemotherapy drugs that have the same destination service could avoid useless roundtrip. Therefore, we are interested in solving the combined transportation and scheduling problem. We consider n independent jobs (chemotherapy drugs) that have to be scheduled on m uniform parallel machines. Then, the products must be delivered to the patients. This step can be modeled by a multi-trip vehicle routing problem in which only one delivery man can make more than one trip and the objective to minimize is the maximum lateness. In addition to traditional constraints that link the two problems, some hard constraints related to chemical stability are added to the whole problem, making it difficult to solve. We propose a Benders decomposition based heuristic that allows finding feasible solutions and a lower bound on the problem. Numerical tests will be presented to assess the efficiency of our approach.

Session 7B: Location Problems in Health Care THR-7B

Room: SOS Z27 **Chair**: Dirk Degel **16:30-18:00**

1- Dynamic ambulance location providing suitable coverage for time-dependent demand

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Chair of Management, esp. Operations Research and Accounting, Ruhr-University Bochum, Bochum, GERMANY

Providing and securing public access to high quality Emergency Medical Services (EMS) is one of the key task of a health care system. Considering a limited budget, the available resources have to be used efficiently in order to ensure a high quality coverage. EMS-vehicles have to be re-positioned so that emergencies can be reached within a legal time frame. To reach a suitable coverage flexible ambulance locations such as hospitals or voluntary fire departments can be especially helpful. Empirical studies have shown temporal and spatial variations of emergency demand as well as variations of travel times during a day. A required constant degree of coverage will either underestimate or overestimate actual demand. In order to handle these variations time-dependent model parameters have to be taken into account. Therefore a new mixed-integer linear program is formulated which explicitly represents time-dependent demand and travel times. Based on large empirical data sets it is shown that the proposed dynamic model outperforms existing static models. We study the number of ambulances necessary to ensure a required degree of coverage. An investigation of the number of parallel emergencies provides detailed information to calculate the required degree of multiple coverage. In fact, we identify customized limitations for the degree of coverage for every demand node. Changing the fleet size and ensuring a number of re-locations as low as possible lead to a decrease of operating costs. The degree of coverage, the number of re-locations and the fleet size are considered to be major performance indicators. An evaluation using real-world data from 2010 and 2011 clearly points out that considering time-dependent travel times and time-dependent demand the approach outperforms existing solutions. Overall, the proposed approach leads to a high quality solution with respect to coverage and cost criteria.

2- Optimizing the deployment of public access defibrillators

Derya Demirtaş, Timothy C. Y. Chan, Roy H. Kwon
Department of Mechanical & Industrial Engineering, University of Toronto, Toronto, CANADA

Out-of-hospital cardiac arrest is a significant public health issue. The treatment for cardiac arrest, namely, cardiopulmonary resuscitation and defibrillation, is very time-sensitive. Public access defibrillation programs, which deploy automated external defibrillators (AEDs) in public areas for bystander use in an emergency, reduce the time to defibrillation and improve survival rates. In this work, we develop models to guide the deployment of AEDs in public settings. Our models generalize the maximal covering location problem and are motivated by real-world views on AED usage during a cardiac arrest emergency. We formulate three mixed integer nonlinear models and derive either equivalent integer linear reformulations or easily computable bounds. We also provide detailed analysis of the AED deployment schemes recommended by the models using geographical information systems software. Computational results using real cardiac arrest and AED data from Toronto, Canada demonstrate the application of the proposed models. We find that most cardiac arrest coverage is derived from deploying AEDs in urban and often high-risk areas. Efforts that improve the ability of bystanders to locate and retrieve AEDs, such as raising public awareness, improving signage, and technological innovations that guide lay responders to the closest AED, have the potential to increase cardiac arrest coverage by approximately 60%.

3- The bi-objective equitable preventive healthcare network design

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Preventive healthcare programs provide services such as breast cancer screenings, osteoporosis screenings, and colonoscopies to public. The effectiveness and efficiency of these programs are heavily dependent on the level of client participation. This paper addresses the bi-objective problem of designing a preventive healthcare network considering balking clients, budget constraints, and a fair distribution of facilities in the network. The two objectives are to maximize the minimum utility and to maximize participation levels. Clearly, due to the congestion in the system, customers do not wait indefinitely. This means that a ratio of clients do not enter the system (balking), leave the system (reneging) and never return again. Needless to say, this is unwelcome for policy makers and may decrease the participation levels considerably. The problem becomes aggravated considering the influence of "word-of-mouth". Therefore, the effect of these customers in the participation levels is included in the objective function. Besides, in order to be fair in providing services and contrary to all the publications hitherto, we remove the constraint on the minimum workload of facilities. Instead, we define a budget and K possible levels for capacity of each facility. Like this, each facility is modeled as an M/M/sk queuing model in which sk is an integer decision variable which takes lower values for less populated zones and higher values for populated zones. This leads to more equity in providing services, especially in problems where population density is not homogeneous. Since the model is nonlinear, we will propose a bi-objective local search procedure to solve it and analyze the model's sensitivity to its parameters.

1- Simulation-based optimization of surgery appointment scheduling

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Appointment scheduling (AS) is a popular topic in health care system because it often has large uncertainties. In the appointment system, a patient arrivals in conformity with his/her appointment and will be served until the arrival and a server is released. Due to uncertainties of service durations, the patient's waiting and server's idling often occur. A key issue of AS is to reduce the expected operating cost by setting an appropriate arrival time for each patient. Recently, it has emerged several papers considering the optimization of arrivals and sequencing of patients. Most of them formulated the AS problem as LP or MILP models based on sample average approximation (SAA), and several important insights are derived. However, they all concentrated on a single server system. In this paper, we consider a more realistic model which has *m* identical and exchangeable servers; patients are served in a pre-determined order but are flexible to any server. Our aim is to proactively optimize the arrival times for patients under a widely used FCFS dynamic assignment strategy. This system is common in many health care services, e.g. a clinic and an operating theatre. We formulate the AS problem as a simulation based optimization model to avoid integer variables of assignments. Compared to MILP model, this model can provide a continuous and differentiable cost function. Thus, we are able to compute gradients exactly using a simple and efficient recursion and propose a stochastic gradient algorithm accordingly. Indeed, our approach is often faster than SAA-based algorithm and can solve realistic-sized instances efficiently. The results show it obtains significant performance improvements relative to the arrival times produced by heuristic under deterministic durations. We also provide several managerial insights based on experimental results.

2- Implications of switching from a to-day to a to-week patient scheduling strategy, an application at the UZ Leuven

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In most hospitals there are some patients who receive surgery later than required. As their health condition can potentially quickly worsen, they are exposed to a health risk. In order to improve the current situation, the lateness of patients has to be, firstly, quantified and, secondly, the responsible mechanism has to be understood, namely the patient scheduling process. We analyzed the percentage of patients being served late in Belgium's largest hospital, the UZ Leuven. At the hospital, an elective patient is associated with one of five due time intervals within which the patient has to be served. We analyzed the lateness of patients across disciplines using all data from 2012 and 22 ORs. We tried to understand many of the different aspects related to the scheduling process, which knowledge we then included into a simulation model. We investigated from the data: patient arrival patterns, the relation between estimated and realized surgery durations, rescheduling mechanisms and the allocation patterns of emergencies. We also used the model to investigate the effects of switching from the current scheduling practice of assigning surgeries directly to slots (OR and day) to a two-step procedure, where patients are scheduled to a surgery week first and only in a second step to slots. Our results suggest that in case of the two-step procedure it is very important to allow patients with shorter due times to break into the already fixed weekly schedule. Additionally, it is important that in the second step of the scheduling procedure, in the within week scheduling, the due time is considered. We conclude that improving patient scheduling can help to decrease the amount of patients served too late. As a next step, we try to develop a sound scheduling schema, which allows to further decrease the number of patients served to late.

3- Operational activity scheduling in a hospital laboratory

Atle Riise, Oddvar Kloster, Leonardo Cameron Lamorgese, Torkel Andreas Haufmann
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Most hospitals have laboratories that perform different diagnostic examination procedures on medical or surgical patients. For these laboratories, activity scheduling problems arise for both admission planning and short-term (re-)scheduling. As a case study, we consider a gastroenterology laboratory at the University Hospital of North Norway. The laboratory's admission planning involves choosing a room, a doctor, equipment, and a time for each elective patient. Some time slots are reserved for urgent or emergency care patients. Based on the resulting admission schedule, the short term scheduling step considers the inclusion of urgent/emergency patients, using the reserved time slots. These patients come from other units in the hospital, and typically become known with a couple of days' notice. Short term re-scheduling is also performed in response to stochastic events during the day of execution, such as no-shows, delays and unexpected changes in resource capacity. Although admission planning and short term (re-)scheduling differ in some aspects, they consider the same treatment activity schedule and have a common fundamental problem model. We present this model as an extension to the multi-mode resource constrained project scheduling problem with generalized time constraints (MRCPSP/Max), which is NP-hard. The problems include multiple projects (one per patient), project disjunction constraints, and multiple resource availability intervals. Both problems involve re-scheduling, and their objective is to minimize deadline violation, maximize resource utilization, and minimize disruption with respect to the existing schedule. We propose a meta-heuristic algorithm for solving the two scheduling problems. Experiments are presented based on real hospital problem instances, and we show that the algorithm produces good results compared to objective lower bounds. We discuss these results and propose directions for further research.

4- Elective inpatient admission with delay announcement

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Elective inpatients have to blindly wait long time until being hospitalized which caused severe patient dissatisfactions. We believe hospitals can benefit a lot, just as call-centers do, by taking into account offering delay information to improve customer satisfaction. Delay announcement is expected to free patients from blind and long waiting, to allow potential patients to decide immediately whether to wait or to abandon, and hence to improve both the hospital effectiveness and the patient satisfaction. However, elective inpatient admission system is totally different from call-center, which blocks us from directly applying call-center findings. First of all, in order to free patient from lengthy waiting, it should be assumed that patient can neither balk nor be admitted before the announced delay once he/she accepts the delay and enters the queue. Besides, 3 additional differences exist: 1) patients require multiple treatments during their hospitalization; 2) service times differ in magnitude from call-center; 3) length of stay of patient hospitalization is not memoryless and depends highly on the availability of key resources needed for the treatment. To study the elective inpatient admission issue, we propose a formal "patient admission with delay announcement" (PADA) model to describe the whole process of elective inpatient admission. We also build an original "multi-stage treatment" (MST) model to represent the routes and rules of patients treatment process and resource requirements during the hospitalization of patients. Other key components of the formal model include impatience of patients, bed capacity, and key resource capacity. Our work shows that system performances of the PADA problem is significantly different from call-center, hospitals can benefit a lot from making delay announcement, and it is a challenge to effectively offer delays in the PADA system.

Session 7D: Healthcare Resource Planning (2) THR – 7D

Room: SOS 104 **Chair**: Yuwei Lu **16:30-18:00**

1- A system dynamics model for the analysis of hospital laboratory capacity

Zeynep Ocak, Eylül Damla Gönül
Yeditepe University, İstanbul, TURKEY

This article explores the initial work performed on the development of system dynamics model that will be used to simulate the dynamics of various factors impacting the utilization of hospital laboratory capacity. Facing a staff capacity and/or equipment constraint an hospital can explore number of strategies: (1) hiring new staff,(2) working overtime (3) outsourcing the work to an outside laboratory. Each of these options have downsides: If overtime work is preferred, the performance of overtime staff may deteriorate due to tiredness leading to lack of productivity and quality. If a hiring strategy is adopted, the performance from the new hires are expected to be low due to inexperience and training period, which impacts again both productivity and quality. Finally, if the laboratory work is decided to be outsourced, the impact it may have on cost and quality must be fully investigated. Thus, at this preliminary research work, a dynamic model is employed (1) to study the impact of these strategies on laboratory work quality, productivity and cost; (2) to simulate the hospital laboratory utilization process.

2- Determining the optimal configuration of hospital inpatient rooms in the presence of isolation patients

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We study the optimal configuration of hospital in-patient rooms with private and semi-private rooms when some of the patients have infectious diseases and need to be isolated. We assume that the demand is random and seasonal. We propose a computationally efficient solution procedure that is based on a stochastic program that uses asymptotic approximations for the system performance under different admission policies and show its accuracy for large systems. 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.

3- Modeling hospital-wide patient flows using simulation

Asli Ozen[1], Hari Balasubramanian[1], Joan Roche[2], Patricia Samra[2], Haiping Li[2], Todd Fairman[2], Mike Ehresman[2]
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One of the most important resources in a hospital is inpatient beds. We used patient admission rates, surgery schedules, bed placement rules, length of stays and capacity information from Baystate Medical Center (BMC) Springfield, MA to develop a simulation based optimization model to improve capacity allocation of inpatient beds. Our goal with our nursing collaborators in BMC is to provide guidelines on how hospitals should manage their inpatient bed capacity in the presence of demand and length of stay (LOS) variability. We analyzed all of the inpatient population of Baystate Medical Hospital from May 2010 to April 2011, consisting of around 47000 patients. We develop a simulation

model in C# that considers different patient demand sources, LOS and unit requirements. We sample from different patient sources and depending on these MDC categories patients LOS and admit values are sampled. We focus on queue sizes and the waiting times as the two main outcome measures. We have proposed using early discharge policies in order to alleviate bed congestions. Late discharges are typically the result of the timing of rounds, poor discharge planning, lack of coordination with the patients' family members and delays resulting from post-acute care facilities. The motivation is to make timely discharges rather than, as the name implies, premature ones. Results show some benefits of using an early discharge policy. In order to simulate a realistic scenario, we only discharged patients (1) from units that are highly utilized (over 85% utilized units); (2) within certain hours of the day (9AM-12PM); (2) who have less than 6 hours to their discharge time; and (4) whose LOS within the range of what is medically accepted value for that specific MDC. This will be implemented via planning the discharges of tomorrow from today so that the "simple" discharges will happen before noon.

4- A visual platform for hospital admission

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An examination of the early OR studies on Hospital Admission (HA) permits a classification of efforts according to different problem areas. It is possible to trace by the 1960's the growing interest in the admission problem or, at least, in the components of it. Most of the first studies focus on the census variability, prediction and control. The stochastic models have been used mostly to study variability and prediction. The optimization models have been used chiefly for designing admission policies and to exercise control over the census. Complex problems which may not be treated analytically have been studied experimentally by simulation. Several attempts have been made to improve the HA of some public hospitals in the municipality of Rio de Janeiro. The research topics includes: I) Pre-hospital services such as call centres, rescue operation, ambulance service and transfers; II) Hospital services such as the entrance layout, reception, triage, risk evaluation, medical care, surgery, ancillary services and pharmacy operation. Most models focus on the flow of patients, reduction of waiting times and configuration of human and material resources, in order to achieve an adequate treatment according to the severity of the case. The most important entities involved in the hospital admission process are the patient, the medical staff and the administrator. It can be argued that in the cause of better functioning of the system the different views of the admission process need to be taken into account in the drawing up of any modified procedure. The aim of this paper is to present a review of the recent OR contributions on HA and to propose a visual platform to support the implementation of new hospital facilities. The interactive virtual fashion of the platform is intended to reduce the gap between theory and practice.

Friday July 12th

9:30-11:00	Session 8		
	8A Process Improvement and Quality Room: SOS Z21	**8B Statistical Methods in Healthcare** Room: SOS Z27	**8C Modeling and Optimizing in Emergency Medical Systems (2)** Room: SOS 103
	Martin Andrew Pitt How do we know we are helping? – Towards a framework for the evaluation of operational research in healthcare	**Inad Nawajah** Estimating patient demand progression in Home Care: a Bayesian modeling approach	**Claire Reeves** A generic ambulance scheduling and rostering methodology for metropolitan ambulance services
	Kudret Demirli Improving patient flow with lean methodology: A case study at the Montreal General Hospital Colorectal Department	**Fanwen Meng** Modeling patient waiting time via a transformed piecewise distribution using general phase-type distributions	**Julie Leanne Vile** Managing time-varying and prioritised demands when setting staffing requirements for Emergency Medical Services (EMS) in Wales
	Cheryl Voake Modelling the value of transferring ENT/Audiology secondary care services into a primary setting	**Stefano Alderighi** Assessing the correlation of individual characteristics on cost and length of genetic clinical pathways: a regression analysis approach	**Omar El Rifai** Stochastic scheduling in an Emergency Department
			Malika Babes Coloring a graph by a multi-agents system

11:30-12:30	**Business Meeting**	**Room:** SOSB07

1- How do we know we are helping? – Towards a framework for the evaluation of operational research in healthcare

Martin Andrew Pitt
Medical School, University of Exeter, Devon, UK

Successful implementation of Operational Research (OR) in healthcare has been at best patchy with few published papers outlining how, or even if, outputs have been applied in healthcare practice. Rarer still are publications which provide a proper evaluation of any impact from an OR application. The increasing importance of demonstrating impact from OR research emphasises the need both to understand and evaluate how the application of OR can contribute to changing health systems. This presentation will provide a clear rationale for the evaluation of OR in healthcare and argue for an approach that goes beyond simple testimonials from stakeholders towards a more empirical basis for the assessment of impact. This is a significant challenge given the complex and dynamic nature of healthcare and it is clear any evaluation framework needs to define and account for the many different dimensions by which OR interventions can affect healthcare organisation (e.g. communication, understanding, process change, clinical change, cost savings, improved effectiveness etc). Against this background a mixed method eclectic approach is likely to be most fruitful however there remain significant challenges in determining how change can best be measured and assessed, which metrics to use, and how impact can be attributed to a specific intervention within a constantly changing system.

2- Improving patient flow with lean methodology: A Case study at the Montreal General Hospital colorectal department

Jonathan Rodriguez, Kudret Demirli
Concordia University Department of Mechanical and Industrial Engineering, Montreal, Quebec, CANADA

Quebec healthcare institutions are facing an increase in patients' request and asked to do more with less, impacting the healthcare staff by working harder and longer shifts. Despite efforts, waiting lists keep growing in numbers resulting in patients waiting long periods of time for a specific treatment. Most of the resources channeled into healthcare to improve operations are absorbed by the non-value adding activities. Lean methodologies, originally developed in the manufacturing industry, offer an alternative to do more with less, by eliminating waste (non-value adding activities). Lean focuses efforts on eliminating activities that do not add value from the patient perspective and builds more efficient processes to perform an activity. This paper proposes the use of Lean methodologies to improve the patient flow throughout the colorectal department at the Montreal General Hospital located in Montreal, Quebec. After rigorous data collection and analysis, the current processes of the department are mapped by the use of value stream mapping tool and analyzed. An improved patient flow is proposed by following the Lean principles. The proposed system lead to an improved patient flow by reducing the patient Lead time significantly; up to 25% in short procedures, 20% in colonoscopies and 10% in surgeries. In addition, the proposed system resulted in an increase in the capacity of the common flow and colonoscopy loop by 20 patients per week and 60 patients per week, respectively.

3- Modelling the value of transferring ENT/Audiology secondary care services into a primary setting

Cheryl Voake[1], Paul R Harper[1], Alun Tomkinson[2], Maureen Fallon[2], Vincent A Knight[1], Janet E Williams[1]

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[2]Cardiff & Vale University Health Board, Cardiff, UK

Large numbers of patients regularly travel long distances to receive treatment for ear conditions and the provision of hearing aids. The key objective of this study is to model the demand reduction on secondary care facilities, resulting in improved waiting times and fewer no shows, by transferring ear nose and throat (ENT) and audiology services into a community setting. This will in turn ease pressure on the ambulance service and improve quality of care, including patient experience, through quick and relatively stress-free care, while saving time and costs for patients. This project is supported and funded by The Health Foundation as part of its annual Shine programme. It is piloting a self-contained satellite community facility close to patients' homes, within a local GP practice, that will enable 5,000–7,000 people to receive care outside of a secondary care setting. It is being run by the University Hospital of Wales, which treats a large number of patients, many of whom are older and travel some distance, often transported by carers or in ambulances, to receive treatment for ear conditions, hearing loss and hearing aids. Parking is a significant problem, and the hospital can be a complicated and confusing place for individuals to negotiate. Modelling the patient experience will include estimating quality improvement and cost reductions for the patient and the local health economy. As well as shifting secondary care hearing services into a primary care setting, the team is developing a more generic new model for planning service redesign more accurately and ensuring better informed decision making, using a multi-criteria decision analysis approach. We expect the project to have a significant impact on individuals with hearing loss and the health service community, with wider learning for other services.

1- Estimating patient demand progression in Home Care: a Bayesian modeling approach

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Home Care (HC) service consists of providing care to patients at their own home, without the necessity of bringing them to hospitals or nursing homes. This service allows a high quality of life for the assisted patients and, at the same time, a cost reduction for the health care system. Planning human resources is a difficult task and, for a good quality of planning, a knowledge of future demands for visits from patients is required. In the literature, several studies deal with stochastic models for representing patient conditions in health care systems but, to the best of our knowledge, few works deal with HC service and Bayesian approaches have not been considered in the HC context, yet. The aim of this paper is to propose a methodology for estimating and predicting the demand for care by HC patients in terms of number of visits (N) required in a defined time slot. Patients are characterized by a Care Profile (CP) which varies along with the time secondary to a periodic revision or sudden variations in health state. Our approach considers the joint distribution of N and CP over time as a conditional distribution of N given CP, times the marginal of the CP; in addition, the transition between CPs is regulated by a non homogeneous multistate Markov Chain. The proposed model is developed and validated considering the data of one of the largest HC providers in Italy. We obtain the posterior densities of model parameters through MCMC simulation and predict the number of visits from patients in future time slots. Results show the applicability of the approach in the practice and a good quality of the predicted number of visits.

2- Modeling patient waiting time via a transformed piecewise distribution using general phase-type distributions

Fanwen Meng[1], Kiok Liang Teow[1], Chee Kheong Ooi[2], Bee Hoon Heng[1], Kannapiran Palvannan[1], Seow Yian Tay[2]
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Waiting times in hospitals can affect patient satisfaction and quality of care. Patients often need to wait due to various reasons, such as limited capacity, variable demand, and inefficient operations management. This has been recognized by hospital managers as a challenge in health services management. The objective of this study is to analyze the new mean waiting time and its variance if the emergency department (ED) patients who waited beyond a threshold had their wait shortened. We used phase-type (PH) distribution to approximate the consult waiting time of ED patients from a 1,200-bed acute hospital in Singapore. Assuming that a policy was implemented to accelerate the long-waiting cases such as putting in temporary additional resources, we transformed the original waiting distribution to a piecewise distribution. In particular, one discontinuous and one continuous piecewise distribution were investigated. In our numerical study, the threshold was set as the 95th percentile, 75th percentile, mean, and median of the waiting time data. We established closed-form formulae for mean and variance of the transformed piecewise distribution, respectively. From here, we estimated the mean waiting time together with the variance for the various scenarios. For a given mean waiting time, we also evaluated the corresponding value of the threshold. Hospital managers can consider this approach of using PH distribution to fit the original waiting distribution, and piecewise distribution to approximate the new distribution where long-waiting patients are cleared with additional resources (doctors, nurses, and support staff). The expected reduction in waiting time

and variance reduction can be predicted using this approach without actual trials. The estimated mean waiting time can then help managers to plan for capacity, such as space and manpower.

3- Assessing the correlation of individual characteristics on cost and length of genetic clinical pathways: a regression analysis approach

Stefano Alderighi, Paolo Landa, Elena Tànfani, Angela Testi
DIEC, Università degli Studi di Genova, Genova, ITALY

The research question herein addressed is the importance of individual characteristics of the patients in explaining cost and length of Clinical Pathways (CPs) for risky pregnancy. Firstly, a one year data collection has been carried out in a genetic Department of an Italian Hospital sited in Ferrara in order to collect the information related to the care paths followed by pregnant patients, which enter the Department willing to understand whether their children are likely to be affected by a genetic disease. With the collaboration of physicians we associated one of the fifteen identified CPs to each patient. The final dataset collects the main individual characteristics of patients i.e., age, country of origin, previous pregnancies, diagnosis exams etc., the followed CP and the total cost of delivered examinations and visits. The tool we implement to investigate this topic is regression analysis. We firstly evaluate the correlation between individual characteristics on length and tariffs, by running simple OLS models. We then assess how these same characteristics influence both the probability of being subject to a specific clinical pathway. This analysis is done by firstly running binary choice models linked to any single clinical pathway and then by creating a clinical pathway qualitative variable and running a multinomial logit. We find indeed that individual characteristics have effects on the above variables and we are able to make inference about their absolute magnitude and relative importance.

Session 8C: Modeling & Optimizing in Emergency Medical Systems (2) FRI-8C

Room: SOS 103 **Chair**: Claire Reeves **09:30-11:00**

1- A generic ambulance scheduling and rostering methodology for metropolitan ambulance services

Claire Reeves, Erhan Kozan
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A new approach for optimising ambulance scheduling and crew rostering as an integrated model is formulated. The model presented here directly schedules resources to fulfill demand requirements and applies rostering rules as constraints. This allows the model to optimise resources over an entire planning period using a single integer programming model based on flexible job shop scheduling techniques. The initial model assumed ambulances are dispatched from static locations and finds the minimum number of ambulances required to fill optimal schedules across a planning period. This model is then improved by including relocation and reassignment of ambulance vehicles during each shift, creating a more realistic situation where ambulances may be dispatched from more than one location. These models also improve the literature by including ambulance staff overtime as a variable for the first time. We also consider the effects on time to complete a job caused by the decision of the hospitals to which patients are transferred. Factors affecting choice of hospital are complex and include accessibility, specialist services, emergency department status and miscellaneous preference. Data obtained a metropolitan ambulance service is analysed to provide a case study to test the models. This case study presents a network of cooperating ambulance stations and hospitals that are able to share resources.

2- Managing time-varying and prioritised demands when setting staffing requirements for Emergency Medical Services (EMS) in Wales

Julie Leanne Vile, Jonathan Gillard, Paul Harper, Vincent Knight
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For patients requesting Emergency Medical Service (EMS) assistance for a life-threatening emergency, the probability of survival is strictly related to the quickness of assistance. As both demand for, and public expectation of, EMS is escalating in the Western world, the provision of an efficient service is a significant challenge for many nations. A particular difficulty for planners is to allocate often limited resources whilst managing increasing demand for services, in a way to ensure high levels of geographical coverage and attain key performance targets. Motivated by case studies investigating the operation of the Welsh Ambulance Service Trust (WAST), this presentation summarises how we have developed an array of forecasting, queueing theory, stochastic modelling and optimisation techniques to analyse priority service systems subject to demand that is of an urgent nature, cannot be backlogged, is heavily time-dependent and highly variable. The techniques are ultimately integrated into a user-friendly workforce capacity planning tool that may be independently operated by WAST planners to predict future demand, set staffing levels and optimise rosters. In this talk, we focus on the queueing theory section of our research. When performing transient analysis of system behaviour, previous works have incorporated preemptive or exhaustive service disciplines at shift boundaries; yet we note that it is inappropriate to apply these disciplines at artificially imposed shift boundaries (i.e. those created for the purpose of obtaining minimum staffing requirements for short periods that later inform the development of a shift schedule). We accordingly define instantaneous transitions that map the change in the composition of customers at novel `dummy' boundaries, where excess staff may leave the system, new staff may join and a set of base staff serve customers without interruption. Application of the methodology to WAST illustrates how it may be used to recommend staffing levels that satisfy government performance targets.

3- Stochastic Scheduling in an Emergency Department

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Overcrowding in emergency departments (ED) is manifest through excessive patients waiting time. Excessive waiting times has been linked to both health concerns and increased stress for employees. In order to alleviate overcrowding in emergency departments, a correct utilization of available resources is crucial. To this end, human resource scheduling has been the topic of many research papers in emergency departments. However, to capture the detailed structure of the system, most studies focus on an approach combining heuristics and simulation. This paper proposes an optimization scheduling model that strategically allocates human resources in the ED. The optimization model is based on a queuing system that captures the inner system dynamics of the ED. In addition, multiple resources are considered and scheduling is done simultaneously to account for their inherent interactions. Consequently, given a fixed staffing level, the model finds the optimal combination of shifts so as to minimize the total patients waiting time. In order to capture the uncertainties in emergency departments, the scheduling model uses non-stationary stochastic arrival rates and stochastic service times. The system's parameters are defined using admissions data from the university hospital center in Lille (France). The primary aim of the study is to provide EDs with a robust cyclic schedule to be used under varying conditions. To this end, different scheduling hypotheses are tested and evaluated against the feasibility of the resulting schedules. The solutions are then validated using a simulation model that replicates the structure of the optimization model and serves to introduce further complexity.

4- Coloring a graph by a multi-agents system

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Graph coloring problem is a simple problem with its statement: given a set of nodes in a graph, assign them identifiers called colors, so that two adjacent nodes do not have the same identifier. It is difficult if not impossible to solve this problem since it is NP-complete. It is a daily application: all the problems of planning, to cite only those, can be formalised as the search for a graph coloring. The approaches applied to "resolve" this problem are considerable and with variable performances. We deal with this problem because we want to incorporate it into the allocation of frequencies in mobile telephony. Our approach stands conventional approaches, since a multi-agent system is associated to join our network where an agent is a node. Our agents will be instantiated at the same time, which contributes to the speed of resolution. They consult their messages via a shared memory. Violation of the constraints of neighbourhood is easily supervised and the system stops if the network is coloured in a correct way (no violation) and with the smallest number of color; an optimization problem is then indirectly resolved.

1- Symptoms of relocation stress syndrome in older adults with type 2 diabetes

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Empirical evidence suggests that that up 55% of older adults 60 years or older will likely relocate to a nursing home. Relocation stress syndrome maybe a contributing factor to increases in morbidity and mortality in this population. A retrospective, medical record review was conducted to determine whether newly relocated older adult patients with Type 2 diabetes that exhibited symptoms of relocation stress syndrome have poorer glycemic control than newly relocated older adults with Type 2 diabetes that did not exhibit symptoms of relocation stress syndrome. The framework for this study is based on concepts from the Roy's Adaptation model (RAM). A convenient sample of 100 residents from 7 long-term care facilities in Midwestern United States was drawn from a medical record review. All residents with a diagnosis of Type 2 diabetes at admission, 60 years or older and cognitively intact were included. Knowledge gained from this study may assist nurses in identifying patients at risk for poor glycemic control and care plans may be developed to address ways to promote positive adaptations during transitions. There was a statistically significant change in A1C levels at baseline and 6 months ($t = 49.82$, $df = 99$, $p = <.05$). Glycemic levels among the residents improved in 6 months from their admission into the long-term care facility. A statistically significant change was also found in the number of observed relocation stress symptoms from baseline and 6 months ($t = 8.02$, $df = 99$, $p = <.05$). Data analyses however, did not find a significant relationship between these two variable improvements.

2- Modelling long-term care of old people in China

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The population in most developing and developed countries is ageing. Ageing societies raise issues of increased demand for Long Term Care (LTC). In response to these issues, policy-makers in western countries have devoted considerable attention to the planning and provision of LTC for older people. However, in China, a developing country with a vast ageing population, research on LTC has only recently started and is confronting many serious challenges. One such challenge is the lack of data; however a key issue for China is declining fertility and the impact of the "one child policy", which has resulted in a severe imbalance between the numbers of young adults and their elderly dependent relatives. Against this background, research is under way as part of the EPSRC-funded Care Life Cycle Research Programme based at the University of Southampton. This research will focus on developing a system dynamics simulation model for LTC of old people in China, and using this model to facilitate the planning of LTC provision from a policy perspective. The following three key research questions will be addressed: 1.What are the key socio-economic and demographic factors that will impact on changes in demand and supply of LTC, such as gender; occupation; marital status; living arrangements; disability and disease; economic resources; family care; health care and other forms of social care? 2. What are the relationships between these factors? 3. How could these factors influence and inform local/national LTC policy? The model will help policy-makers gain insight into the LTC system, and allow them to conduct "what-if" scenarios to evaluate alternative LTC provision policies. This poster presents the context for this research, plus some of the preliminary findings from a search of the literature relating to ageing and LTC in China.

3- Scientific collaboration in biotechnology applied to human health: a network study in Brazil

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This work analyses the inter-institutional collaboration network in Brazilian science in biotechnology applied to human health and this network's temporal evolution. The population was selected from the ISI Web of Knowledge based on descriptors which incorporate a series of works that use genomic, proteomic and recombinant DNA techniques. Networks were generated from the selected data for two distinct periods: 2000-2004 and 2005-2009, while another network covered the entire ten years. The results demonstrate that there are a few strongly connected institutions (hubs) and a large number with few connections. In comparing the two periods there is a clear trend for leading institutions to concentrate on connections with new actors. This particularly occurs with the University of São Paulo (Universidade de São Paulo: USP), a pioneer in the Brazilian biotechnology field. It also reflects relatively little collaboration between institutions from the South-east and those from other regions of the country, as well as few links between national institutions and the production sector. This work aims to increase understanding of the innovation dynamic in biotechnology in Brazil, in that it supplies empirical evidence regarding the configuration of Brazilian research networks and, more specifically, of trends over time.

4- Fuzzy clustering analysis of risk factors for mortality after coronary artery bypass graft bBased on AHP method

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OBJECTIVE: Despite technological advancements, open-heart operations still carry a risk of mortality and morbidity and it is difficult to decide about appropriate protocols of treatment. To aid in the selection of patients for cardiac surgery, several risk scoring systems have been developed during the last decade. The goal of this study was to identify preoperative determinants associated with surgical mortality in patient who underwent Coronary Artery Bypass G to assist cardiac surgeons as a facilitator tool in decision making as well as patient counseling.
METHODS: We performed a literature search from 1980 to January 2013 using the MEDLINE and Science Direct database and assessed the quality of by standardized checklist. Data of the reported predictors of mortality after CABG were extracted and 22 studies met our inclusion criteria. The AHP model was developed to determine the relative importance of risk factors and the K-means clustering to group them into 3 levels.
RESULTS: Emergency state, age over 80 years and sever Left Ventricular Ejection Fraction (LVEF) proved to be the most important risk factors for early mortality after CABG and considered as core variables. So, our analysis suggests that prior to this operation, operative mortality can be best predicted by these core predictors. This information to determine appropriate intervention as well as to know predicted chances of postoperative adverse outcomes for better management and monitoring for individual patient is helpful and also, facilitates decision making.
CONCLUSIONS: We conducted that fuzzy clustering and AHP, as engineering tools, and statistics, as a branch of mathematics, has successfully detected strongest risk factors to predict mortality rate after CABG and showed the power of the engineering tools in health area.

5- Application of touch less gesture user interface to improve operating room performance based on key performance indicators

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OBJECTIVE: The growing interest in computer interface based on gesture is inspired in different area. Recently application of this methodology in healthcare systems specially operating room is becoming increasingly important because operating rooms (ORs) is recognized as the largest cost centers and the greatest source of revenues for most hospitals. The present study is focused on one application of this technology to improve performance of operating room according to key performance indicators (KPIs).
METHODS: we developed a touch less user-interface based on gestures called "MediNav" that allows the surgeon to navigate needed information in the intraoperative setting through a computer touchlessly, access to patient information from any location without leaving room to access, send medical information for Inter-department Consult of cross section as well as record voice and video simultaneously. This software implemented based on the Kinect device. To evaluate the positive impact of this technology on the performance of operating room a set of KPIs in different aspects including productivity, efficiency, responsiveness, safety and sustainability is considered.
RESULTS: This software is applied in Operating Rooms of a teaching hospital, Dr. Shariati medical center. Our result showed that the capability of this software to increase process and quality performance of operating rooms such as delay and infection, which is confirmed by surgical and non-surgical experts.
CONCLUSIONS: The presented software by using kinect 3D sensor showed that to be useful and efficient to improve some of the KPIs in operating room such as delay and throughput, decrease infection, and so on. Although the capability of this technology to another potential applications, for example voice record as well as electronic medical records remains inconclusive. Use of this application is useful to gather medical information. This information is helpful to ORs manager for recognizing bottleneck of operating theater and handles them.

6- Determining preventive dentistry service provider using fuzzy AHP/ANP and a case study for Istanbul

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Preventive dentistry; which is one of the major branches of public health, simply aims to maintain dental health avoiding the occurrence of dental diseases. This branch of dentistry also aims to ensure dental health in addition to early diagnosis for the individuals in the society to reduce the odontogenic infection based diseases through the whole body and thus to reduce the cost arisen through the treatment of these diseases. In recent years Turkey made a dynamic progress in primary health services with the implementation of "family practice" system to national health policy which provides the main motivation for this study. The complex relation between dental and total individual health includes many sophisticated variables and parameters that mostly are hard to define and analyze which also make the whole system appropriate for the usage of fuzzy logic. This study approaches to public dental health from the service provider point view as it is assumed to be the basic foundation of whole preventive dentistry. A systematic model to determine the preventive dentistry service provider is developed using fuzzy AHP and ANP that also have the ability to show the relation between the

criteria of the model. The criteria and the weighting for the criteria that are used in the study are determined via a questionnaire technique applied to dentists and specialists and making use of previous studies. To illustrate the applicability of the model, a case study is also performed in Pendik Istanbul.

7- Estimation and application of state dependent transition matrices for inpatient flow modelling

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Mathematical and computational models of hospital inpatient facilities often assume or make estimates of probabilities which govern patient transitions between various facilities within the hospital. In most cases, these transition probabilities remain static with respect to the state of the model. However, anecdotal evidence from hospital staff suggests that patient-to-ward placement decisions can be influenced by patient congestion on particular wards. Therefore, models which include state dependent transition probabilities may provide more accurate indications of bed demand, if placement decisions are indeed affected by congestion. This work is concerned firstly with estimating the extent of this effect. Since placement decisions for non-medical reasons are not flagged in the data, a statistical approach must be used. The second purpose is to show how including this effect changes the picture of bed demand for a selection of wards. By grouping placements which occur during times of similar congestion, contingency tables are constructed and then used to test the relationship between congestion and the ward where the patient is placed. The statistical power of the test is then estimated as a function of the number of placements in each table by bootstrap resampling. The results from small scale discrete event simulations show the effect of different transition matrices on bed demand for a selection of wards. These results are compared to the results generated by the transition matrices in which congestion is not accounted for. Finally, modelling the effect of congestion on patient placement is further motivated by its intended use in a real-time discrete event simulation for early detection of ward overcrowding. The usefulness of such a model is increased if it can also capture changes to bed demand caused by placement decisions made at times when the most suitable beds are scarce.

8- The use of telecare to support people with dementia to live independently

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This research is looking at the use of Telecare to meet the social care needs of people with dementia within the United Kingdom's ageing population. Dementia is not a single illness but a group of progressive symptoms that occur when the brain becomes damaged by certain diseases or conditions, such as Alzheimer's disease. Symptoms include memory loss, mood changes, problems with communication, confusion and disorientation; leading to an increased dependency on other people. The risk of developing dementia increases with age, affecting mostly people over the age of 65. According to the Alzheimer's Society (1) there are currently around 820, 000 people living with dementia in the United Kingdom; a figure that is set to rise to over one million by 2021. With this in mind the UK government is keen to explore different options to meet the increasing demand on social care services; one such option is: telecare. Telecare equipment allows remote care by automatically sending a signal to a carer, community alarm or monitoring service so that support can be called for when it is needed. Telecare can help people with dementia to maintain their independence, delaying or even eliminating the need for residential care (2). Operational Research (OR) modeling techniques will be utilized to explore the potential role of telecare in supporting care delivery. Ultimately this project will lead to the development of a discrete event simulation (DES) model which will be used to examine telecare as a care service option and will incorporate the facilitating and obstructive factors that influence telecare uptake for people with dementia. This PhD is based within the Care Life Cycle (CLC) Project which is a 5 year multidisciplinary research programme funded by the EPSRC to investigate the supply and demand of health and social care in the context of an aging society. http://www.southampton.ac.uk/clc/

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9- Dynamic Allocation of Hospital Elective Admissions

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Capacity management is of the utmost importance in the healthcare literature and can affect both the utilization level and the quality level of service. Operating rooms (ORs) are the most important revenue income centers of the hospitals (HFMA 2005) and consume a high portion of hospitals' annual budget (Gordon et al. 1998). The health condition of a patient before, during and after an operation may vary considerably, which creates a challenge in operations planning due to the limited resources like OR capacity, bed capacity, etc. In this study, we focus on the effects of bed capacity in a department of a hospital. For this purpose, we propose two models that consider the stochastic nature of patient length-of-stay durations (LOS) when the bed capacity is limited. Our aim is to provide a decision support system for hospitals on the issues of OR planning.

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