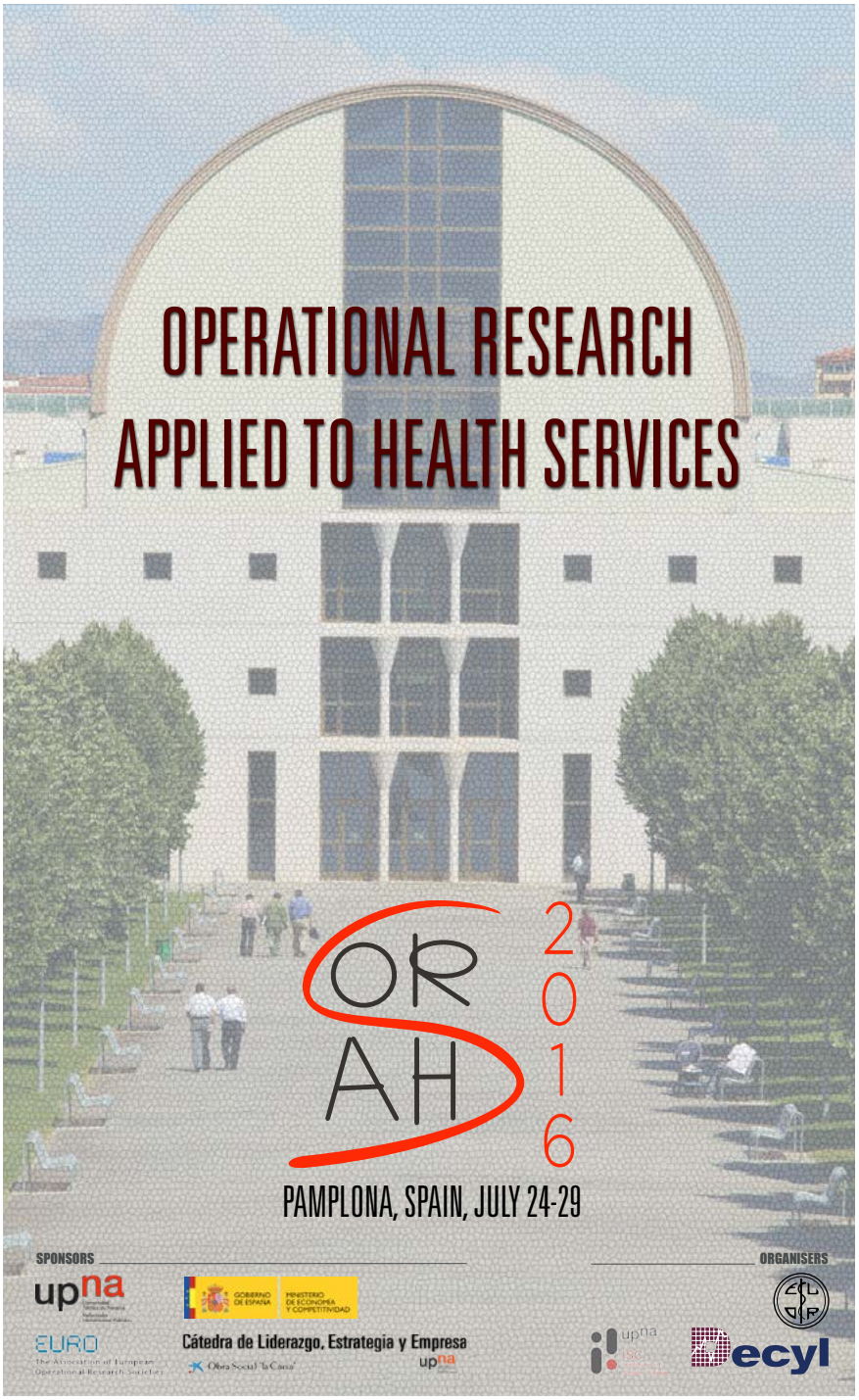
OPERATIONAL RESEARCH
APPLIED TO HEALTH SERVICES
SORAH
2016
PAMPLONA, SPAIN, JULY 24-29
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WELCOME TO ORAHS 2016 CONFERENCE

On behalf of the ORAHS 2016 organizing committee, I am delighted to welcome you to the 42nd Operational Research Applied to Health Services conference at the Public University of Navarre in Pamplona, Spain. I am sure that Pamplona is an excellent choice for hosting the ORAHS conference. Pamplona combines modernity and tradition, it is easy and safe to get around the city center and visit the many monuments that give testimony of a rich and long history. It is the first city that the pilgrimage route of Santiago passes through.

The conference theme is «*Finding better health-care decisions in new oceans of health data*». New medical devices have open a new era of information in healthcare and set healthcare systems in a path of rapid changes in the delivering of services to patients. Decision makers and operational research analysts have big challenges ahead to make an intelligent use of this information to create new efficient and high quality healthcare environments. During the conference, we will discuss different ways to achieve this objective. According with this new framework for healthcare decision making, three plenary conferences will be held: Computational Medicine and Big Data Analytic (*Eva K. Lee*, Georgia Institute of Technology, USA), Key Performance Indicators and their Optimal Performance (*David Standford*, Western University, Canada) and Enabling Context Aware Environments: Towards Smart Health Provisioning (*Francisco Falcone*, Smart Cities Institute-UPNA, Spain).

Contributed talks have been organized in nine parallel sessions which allocate 91 works, each one assigned to a time slot of half hour. In addition there are other 20 works presented in the modality of poster. A total of 265 researchers have participated as authors of research works presented in the ORAHS 2016 conference. To encourage the participation of young researches and facilitate their interaction with senior researchers a poster competition for

PhD. students will be organized. Besides, there are two special sessions, one about teaching Operational Research to practitioners and other about the risk control and management in the *Encierro*.

Along with this rich scientific program there is a pleasant social program that includes among others a guided visit to Pamplona (churches, cathedral, museums, Camino de Santiago...) and one day tour to the sea side and the Pyrenees of Navarre.

As a conference chair of ORAHS 2016, I know that the success of the conference depends ultimately on the many people who have worked with us in planning and organizing both the scientific program and the social and cultural activities. In particular, we thank our sponsors who have helped us to organize a week plenty of academic, cultural and social activities for all participants. Finally, recognition should go to the Local Organizing Committee members who have all worked extremely hard for the details of important aspects of the conference program, social activities and answering many requests of participants.

Fermín Mallor

COMMITTEES

ORGANIZING COMMITTEE

- Fermín Mallor Giménez (Conference Chairman)
- Elena Abascal Fernández
- Alba Mª Agustín Martín
- Cristina Azcárate Camio
- Francisco Ballestín González
- Javier Belloso Ezcurra
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- Mª Luisa Eraso Goicoechea
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- Ignacio García Lautre
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- Teresa León Mendoza
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- Irene Paniello Alastruey
- Guzmán Santafé Rodrigo
- Adrián Serrano Hernández
- Camelia Trandafir
- Henar Urmeneta Martín-Calero

From left to right: A. Serrano, J.A. Moler, C. Azcárate, E. Abascal, F. Mallor, M. Cildoz, I. García Lautre, J. Faulin, C. García Olaverri.

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Jan M.H. Vissers (Netherlands)

USEFUL INFORMATION AND GUIDELINES

CONFERENCE VENUE

The ORAHS 2016 Conference will take place at the Universidad Pública de Navarra. See Figure 1 for a simplified version of the University Campus, highlighting the buildings related with the conference. The conference will take place in «El Sario» building and the lunches will be served every day of the week in the «dinning room» of the University. Some participants are lodged in the Residence of the University, next to the «El Sario» building, where the conference takes place. Those lodged out of the campus may arrive by bus. Lines 1, 6, 9 and 11 stop close to the conference venue and the bus stops are indicated on figure 1.

Figure 1: Campus of the Public University of Navarre- UPNA.

EL SARIO BUILDING

All parallel sessions take place in El Sario building in rooms A.4, A. 501, A.502, A. 503 and a high capacity room for plenary sessions. In the secretary office is the registration desk. All the rooms are in the ground floor of the building, next to the main corridor where the coffee breaks and the poster display take place. See the location of the rooms in figure 2.

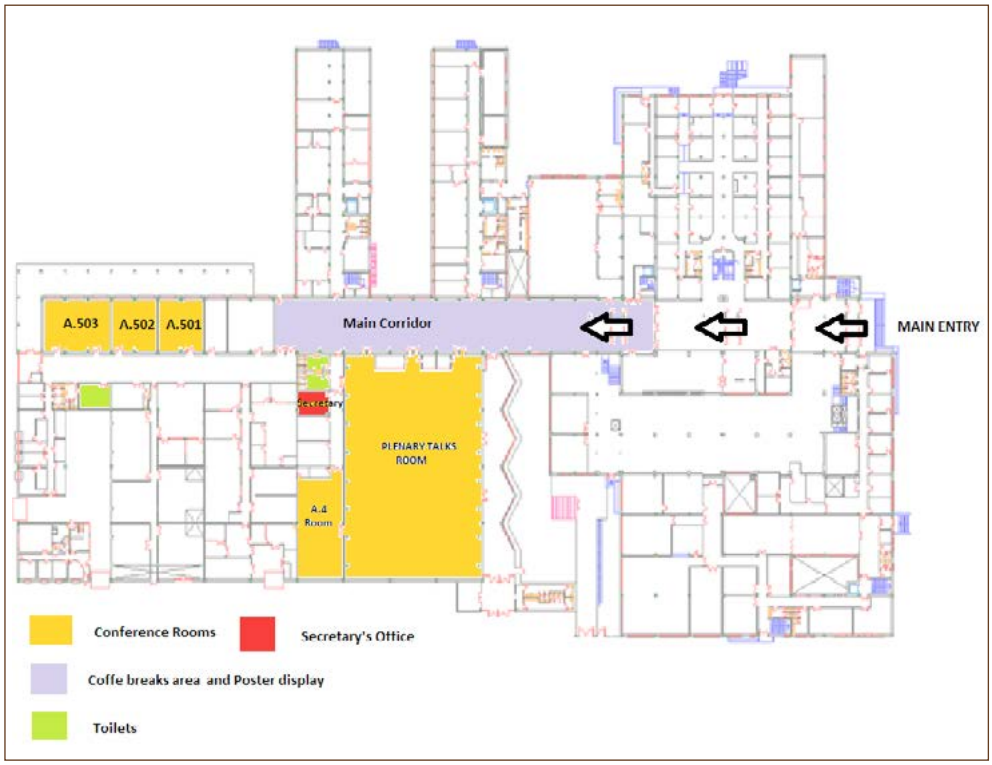

Figure 2: Ground floor plane of El Sario building. Conference rooms.

GETTING AROUND THE CAMPUS

The Public University of Navarra Campus is located to the south of the city at the end of the Arrosadía area. It is in an open landscape, crossed by the modest Sadar river, the banks of which are thick with leafy white poplars characteristic of this part of the city. The area is well served by public transport. Figure 3 presents a bird's eye view of the Campus and some spot points mark some buildings and places of interest for the conference participants.

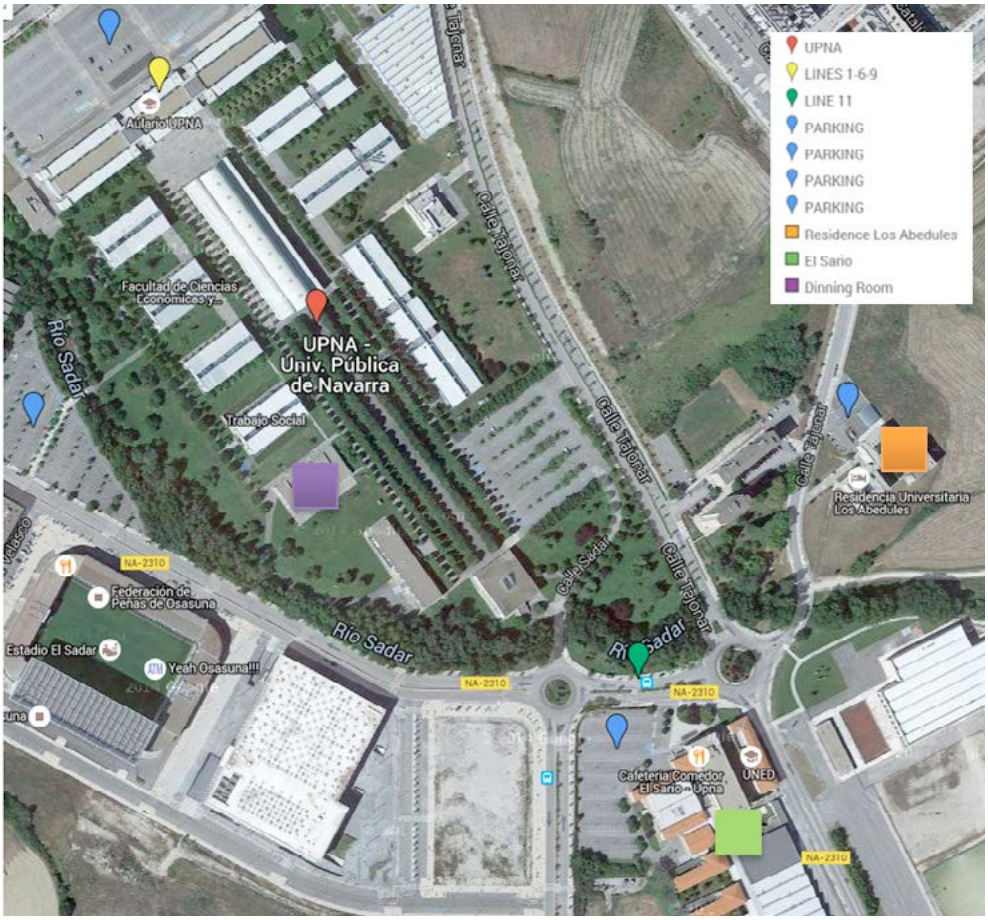

Figure 3: Campus of the Public University of Navarre- UPNA: bird's eye view

HOTELS LOCALIZATION AND MAIN SQUARES

Hotels which are recommended in the website are in 2 areas.

Area 1 corresponds to the old town and around. The reference point is «Plaza del Castillo» (see figure 4) which is considered the core of the city, where people meet and enjoy the charm atmosphere here and in the streets around which use to be full of bars, restaurants, shops and people enjoying their time.

Figure 4: Area 1: old town and surrounding area.

Area 2 corresponds to San Juan district. This place is the modern part of the city, the reference point is Yamaguchi Park (see figure 5), a place also full of life with bars, cafeterias and cinemas. Old town is 30 minutes walking distance from «Plaza Yamaguchi». There is also a good connection by bus and taxi (see bus stops in figure 5).

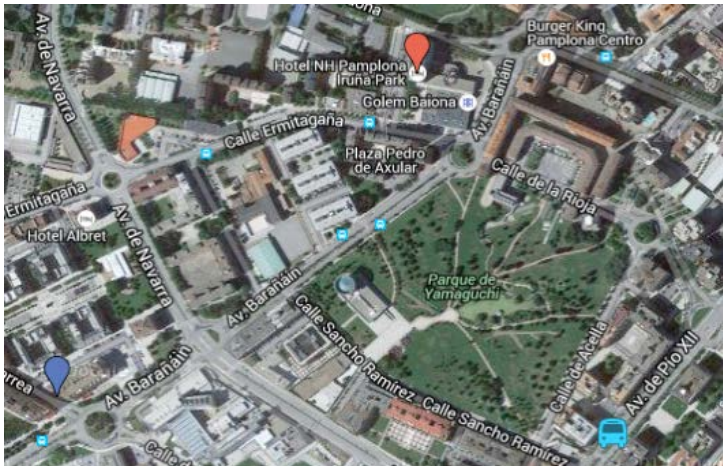

Figure 5: Area 2: Plaza Yamaguchi and surrounding area.

Hotel NH Pamplona Iruña Park
Mendebaldea Suites

HOW TO ARRIVE TO EL SARIO BUILDING

If you are accommodated in the residence, you only have to walk following the map (see Figure 1 or Figure 3) where both the Sario building and the residence are marked.

If you are accommodated in a hotel, there are two ways to arrive to the Sario building, by bus or by taxi.

By Taxi

It is the easiest way. You have to call (948 35 13 35) and indicate where you are. They send you a taxi in more or less 5 minutes.

The taxi fare from the City center to the Sario building is around 7-10 Euros depending on the hour of the day and the location of the hotel.

By Bus

Pamplona has 25 bus lines of public transport. That service is in good condition and the bus fare is 1.35€ for one way ticket (tickets are bought to the bus driver).

If you are accommodated in Area 1 (see figure 4), you must take the line 11 at the beginning of the Zaragoza Avenue (see the bus stop in figure 6) and it stops next to the El Sario building (see figure 1).

If you are accommodated in Area 2, you must take the lines either 18 or any 4 (there are several 4s but all of them stop in «Plaza Príncipe de Viana»). When you are in «Plaza Príncipe de Viana», you must transfer to the bus stop in Zaragoza Avenue (see figure 6). There you take the line 11.

Figure 6: Bus stop of the line 11 in Zaragoza Av.

REGISTRATION DESK

The registration desk will be located in El Sario building, in the Secretary office of the conference (see figure 2). The Secretary office will be open throughout the Conference daily from 9:00 to 13:00 and from 15:00 to 17:00.

POSTER DISPLAY

The posters will be displayed in the main corridor of the ground floor of the «El Sario» building (see figure 2). Two poster sessions are scheduled on Tuesday (from 11:00 to 12:00 and from 16:00 to 17:00). The posters will be displayed until the end of the conference.

INTERNET ACCESS

Wi-Fi access is available throughout the whole conference. In order to access Wi-Fi, please check the credentials at the information panels in the Secretary office.

In addition, the Public University of Navarre belongs to the eduroam network, so you may use this wireless in the whole campus if your institution is also an eduroam member (https://www.eduroam.org).

COMPUTER SUPPORT

A computer will be available in the Secretary Office for the free use of the participants.

SOCIAL PROGRAM

Welcome Reception

On Sunday 24, from 18:00 to 20:30, we will be glad to receive you in the «Sala de Armas» building in the Citadel of Pamplona. Here you may register to the conference and meet your colleagues while enjoying some tapas, soft drinks and local wine and beer.

City tour

On Monday 25, starting at 19:00 in Plaza del Castillo, we will discover the main touristic sites of Pamplona. The tour includes the visit to the Cathedral and, also, its museum and cloister which is a wonder of the gothic art in the 14th century.

Cellar visit and wine tasting

On Tuesday 26, starting at 19:00, some buses will take the attendees in the main entry of «El Sario» building to visit the Otano cellar, in Echauri, a small village close to Pamplona, where a wine tasting session will be offered.

Day tour

On Wednesday 27 the whole day will be devoted to the social program. Starting at 9:00, some buses will take the attendees in the main entry of «El Sario» building to visit San Sebastian city, one hour away from Pamplona, where the traditional boat tour will take place. We will have lunch in Astigarraga in a «sidrería», a traditional basque restaurant. In the afternoon we will return back to Pamplona but, before, we will visit the botanic park of «Señorío de Bertiz».

Conference dinner

On Thursday 28, starting at 20:00, the conference dinner will take place in the restaurant of Baluarte, one of the biggest congress centre in Spain. Located in the centre of Pamplona, Baluarte stands on a key site between the liveliest shopping and leisure area of the city and the Citadel, a 16th-century fortress that has been converted into a delightful park.

GUIDELINES FOR SESSION CHAIRS

The session chair will be in the room 10 minutes before the beginning of the session in order to welcome the speakers and to verify their presence. Please, check that all speakers are there and that they have loaded and tested their presentations on the PC in the room. The session chairs must control that the schedule is fulfilled so they must guarantee that each session begins and ends on time. To allow participants to switch between sessions, in case of speakers who do not show up, the given schedule should still be maintained.

GUIDELINES FOR SPEAKERS

In order to fulfill the timetable planned in the conference and allow a good progress of the conference sessions, the speakers are encouraged to follow the following guidelines:

- Bring your presentation on a USB pen. The software installed on the PC is for standard office set up. It will not be possible to use the speaker's laptop.
- Ensure to be punctual for your presentation time slot. This will allow to follow the schedule and, so, facilitate session jumping of the audience to move between parallel sessions.
- Meet your session chair in the scheduled room 10 minutes before the beginning of your session in order to upload the presentation in the PC. There will be members of the organization on site at all times to assist with any technical difficulties or to help as necessary. If you anticipate needing assistance of this kind, please, contact a member of the organizing committee at the Secretary office in advance.
- Presentation slots are 30 minutes per talk. The general rule is to use 20-25 minutes for each presentation and reserve 5-10 minutes for questions and discussion. Session Chairs are instructed to be strict with time keeping in order to ensure the timely running of the sessions and the Conference.

GETTING AROUND PAMPLONA

Tapeo

One of the most famous activities in Pamplona is the «tapa». This is a small dish that accompanies the drink at any bar.

The principal streets for take a tapa are «Estafeta», «San Nicolás» and «Navarrería».

The main tourist places are

Monument to the encierro

Town Hall

Pilgrimage route of Santiago

San Cernin Church

«Plaza del Castillo»

Citadel

SCIENTIFIC PROGRAM

ORAHS 2016 PROGRAM

	SUNDAY 24th	MONDAY 25th	TUESDAY 26th
09:00-09:30		Registration * Opening	Session III
09:30-10:00			
10:00-10:30		Plenary Eva K. Lee	
10:30-11:00			
11:00-11:30		*Coffee Break*	*Coffee Break* Poster session
11:30-12:00		Session I	
12:00-12:30			Plenary Francisco Falcone
12:30-13:00			
13:00-13:30		*Lunch*	*Lunch*
13:30-14:00			
14:00-14:30			
14:30-15:00		Session II	Session IV
15:00-15:30			
15:30-16:00			
16:00-16:30		*Coffee Break*	*Coffee Break* Poster session
16:30-17:00		Special Sessions Education/Smart	
17:00-17:30			Special Session Managing risk in...
17:30-18:00			
18:00-18:30	Registration at Citadel & Welcome Reception		
18:30-19:00			
19:00-19:30		City Tour, Visit to Cathedral, Museum & Cloisters	Cellar Visit & Wine tasting
19:30-20:00			
20:00-20:30			
20:30-21:00			
21:00-21:30			
21:30-22:00			
22:00-22:30			
22:30-23:00			

Registration will be open every day from 9:00 to 12:00 in the secretary room of the conference (El Sario building)

ORAHS 2016 PROGRAM

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San Sebastián

City visit &
Boat Tour

Astigarraga
Lunch

Natural Park</td><td rowspan="3">Session V</td><td rowspan="4">Session IX</td><td>09:00-09:30</td></tr>
<tr><td>09:30-10:00</td></tr>
<tr><td>10:00-10:30</td></tr>
<tr><td>Coffee Break</td><td>10:30-11:00</td></tr>
<tr><td rowspan="2">Session VI</td><td>Coffee Break</td><td>11:00-11:30</td></tr>
<tr><td rowspan="3">Business Meeting
Conference
closing</td><td>11:30-12:00</td></tr>
<tr><td rowspan="2">Plenary
David Stanford</td><td>12:00-12:30</td></tr>
<tr><td>12:30-13:00</td></tr>
<tr><td rowspan="3">Lunch</td><td rowspan="3">Lunch</td><td>13:00-13:30</td></tr>
<tr><td>13:30-14:00</td></tr>
<tr><td>14:00-14:30</td></tr>
<tr><td rowspan="4">Session VII</td><td rowspan="11"></td><td>14:30-15:00</td></tr>
<tr><td>15:00-15:30</td></tr>
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<tr><td>18:00-18:30</td></tr>
<tr><td rowspan="3"></td><td>18:30-19:00</td></tr>
<tr><td rowspan="12">Conference
Dinner</td><td>19:00-19:30</td></tr>
<tr><td rowspan="12"></td><td>19:30-20:00</td></tr>
<tr><td>20:00-20:30</td></tr>
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<tr><td>22:30-23:00</td></tr>
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MONDAY, JULY 25TH			
9:00-10:00	**Registration**		
10:00-11:00	**Plenary Session Eva K. Lee:** *Computational Medicine and Big Data Analytic*		
11:00-11:30	Coffee Break		
11:30-13:00	**R.4: Session I A**	**R.502: Session I B**	**R. 503: Session I C**
	Operations room planning and scheduling (I) Chair: **Inês Marques** **S1A.1** *Increasing the Robustness of Surgery Schedules against Emergency Break-ins* Mathieu Vandenberghe, Stijn De Vuyst, Herwig Bruneel, El-Houssaine Aghezzaf **S1A.2** *Capacity management for the operating room* Carla Van Riet, Erik Demeulemeester **S1A.3** *A robust optimization approach for a Surgical Case Assignment Problem: the case of a Portuguese hospital* Inês Marques, Maria Eugénia Captivo	**Modelling in Health Care (I)** Chair **Ana Monteiro** **S1B.1** *Too obvious to mention? Some simple ways in which running empirical data directly through simulation models can be used to identify flaws in models and data* Kim Rand-Hendriksen, Joe Viana, Fredrik Dahl **S1B.2** *Risk Modelling Framework for Emergency Hospital Readmission, Using Inpatient Data* Thierry Chaussalet, Mohsen Mesgarpour, Salma Chahed **S1B.3** *Planning of mental health care delivery: a location-allocation mathematical programming model* Ana Monteiro, Teresa Cardoso, Maria Santos	**Disease modelling and policy (I)** Chair **Praveen Thokala** **S1C.1** *Application of simulation modelling for effective design of stroke care system pathways* Mahsa Keshtkaran, Leonid Churilov, John Hearne, Babak Abbasi, Atte Meretoja **S1C.2** *Multscale Visualisation for Understanding of Multitrauma Spinal Cord Injury Treatment Processes* Hayden Johns, Leonid Churilov, John Hearne, Ian Mosley **S1C.3** *A comprehensive model for dementia: diagnosis, disease progression and service delivery* Praveen Thokala, Alan Brennan, Carol Brayne, Louise Lafortune
13:00-14:30	**Lunch**		

14:30-16:00	**R.4: Session II A**	**R.502: Session II B**	**R. 503: Session II C**
	Patient flow Chair Sally Brailsford **S2A.1** *Improving patient flow in a cardiology department by identifying care pathways* Jore Marynissen, Erik Demeulemeester **S2A.2** *Modelling patient flow in an orthopedic clinic* Narasimhan Ravichandran **S2A.3** *Predicting patient flow in a paediatric intensive care unit* Sally Brailsford, Peter Vermeulen, Vincent Peclard	**Home Care / LTC (I)** Chair Ettore Lanzarone **S2B.1** *The Use of Telecare to Support People with Dementia to Live Independently* Katherine Penny **S2B.2** *Modelling long-term care for older people in China* Yajie Nie **S2B.3** *An Implementor-Adversary Approach for the Nurse-to-Patient Assignment Problem in Home Care with Uncertain and Time- Related Demands* Giuliana Carello, Ettore Lanzarone, Daniele Laricini, Mara Servilio	**Emergency Department (I)** Chair Roberto Aringhieri **S2C.1** *In Through the Out Door: Understanding Increasing Rates of Pediatric Emergency Mental Health Presentations from a System Perspective* Leslie Anne Campbell, David Lovas, George Kephart, John Blake **S2C.2** *«Floating Patients» method based on scheduling algorithm for emergency department's service improvement* Guy Wachtel, Amir Elalouf **S2C.3** *Big Data supporting Public Health policies: assignment policies for a regional network of emergency departments* Roberto Aringhieri, Davide Dell'Anna, Davide Duma
16:00-16:30	**Coffee Break**		
16:30-18:00	**R.4: SS_A**	**R.502: SS_B**	
	Engaging healthcare managers and practitioners through OM/OR education Chair Erwin Hans *Participants in the discussion panel:* Angela Testi, Sally Brailsford, Michael Carter, Mariel Lavieri and Erwin Hans	**Smart Health** Chair Luis Serrano **SS_B1** *Impact of wireless technologies in healthcare environments* Silvia de Miguel, Victoria Ramos **SS_B2** *Smart Health Revisited: A Polysemic Concept Updated and Made Simple* Agusti Solanas **SS_B3** *Technological Aspects in the Implementation of Context Aware* Health Scenarios Francisco Falcone **SS_B4** *Implementation of AAL and Social Sensor Network Solutions* Luis Serrano	

TUESDAY, JULY 26TH

9:00-11:00	**R.4: Session III A**	**R.502: Session III B**	**R. 503: Session III C**
	Workforce Planning Chair Michael Carter **S3A.1** *Optimal staff distribution at blood collection sites* Sem van Brummelen, Wim de Kort, Nico van Dijk **S3A.2** *Nurses and Night Shifts: Relationship and Assignment Under Burn-Out Considerations* Chunmeng Zhou, Na Geng, Andrea Matta **S3A.3** *Forecasting the medical workforce: a stochastic agent-based simulation approach* Mário Amorim Lopes, Álvaro Santos Almeida, Bernardo Almada-Lobo **S3A.4** *Nurse Scheduling and Risk Analysis of Hemodialysis Patients* Michael Carter, Mahsa Shateri	**Health Economics and Decisions (Blood Delivering) (I)** Chair Francisco J. Santos **S3B.1** *Closing the immunization gap: the role of impact investing* Teresa León, Vicente Liern, Blanca Pérez-Gladish **S3B.2** *Avoiding Regrettable Choices versus Improving Expected Utility: Sequential Search Decisions and the Value of the Information Acquired* Debora Di Caprio, Francisco Javier Santos Arteaga, Madjid Tavana **S3B.3** *Balancing patients' needs, blood supply requirements and costs for optimal prevention of blood group alloimmunization: the «BloodMatch» project* Joost van Sambeeck, Mart Janssen, Wim de Kort, et al. **S3B.4** *Designing the blood supply chain: a location-allocation model with collection and production considerations* Andres Felipe Osorio, Sally Brailsford, Honora Smith	**Patient scheduling (I)** Chair Angel Ruiz **S3C.1** *Recursive logic-based Benders' decomposition for multi-mode outpatient scheduling* Leonardo Lamorgese, Atle Riise, Carlo Mannino **S3C.2** *A Dynamic integrated framework for Surgical Patients' Prioritization* Samira Abbasgholizadeh Rahimi, Angel Ruiz, Afshin Jamshidi, Daoud Ait-Kadi **S3C.3** *Scheduling of multidisciplinary cancer clinics* Greanne Leeftink, Ingrid Vliegen, Erwin Hans **S3C.4** *Managing intrahospital patient transportation* Valérie Bélanger, Angel Ruiz, Maxime Painchaud
11:00-12:00	**Coffee Break and Poster Session**		
12:00-13:00	**Plenary Session Francisco Falcone:** *Enabling Context Aware Environments: Towards Smart Health Provisioning*		
13:00-14:30	**Lunch**		

14:30-16:00	R.4: Session IV A	R.502: Session IV B	R. 503: Session IV C
	Disease modelling and policy (II) Chair Mariel Lavieri **S4A.1** *Endoscopy modelling* Richard Guerrero-Ludueña, Sally Rickard, Matt Hayes, Robert Radford, Caroline Powell, Sally Brailsford. **S4A.2** *Estimating the effect of the input parameters' uncertainty in the cost-effectiveness analysis of the breast cancer screening programme in the Basque country* Arantzazu Arrospide, Montserrat Rué, Nicolien T. van Ravesteyn, Mercè Comas, Myriam Soto-Gordoa, Garbiñe Sarriugarte, Javier Mar **S4A.3** *Optimal Screening for Hepatocellular Carcinoma: A Restless Bandit Model* Mariel Lavieri, Elliot Lee, Michael Volk	**Home Care / LTC (II)** Chair Patrick Hirsch **S4B.1** *Location-allocation planning of long-term care networks: Enhancing multi-objective stochastic approaches with new health policy objectives and scenario reduction techniques* Teresa Cardoso-Grilo, Mónica Oliveira, Ana Barbosa-Póvoa **S4B.2** *On the Robust Home Care Problem* Paola Cappanera, Laura Galli, Maria Grazia Scutellà, **S4B.3** *Home health care routing and scheduling: State of the art and promising future research directions* Patrick Hirsch, Christian Fikar	**Data analysis &risk management (I)** Chair Fredrik Dahl **S4C.1** *Length of Stay Outlier Detection through Cluster Analysis: A Case Study in Pediatrics* Daniel Gartner, Rema Padman **S4C.2** *Exploring Predictive risk models for integrated care: insights and challenges* Thierry Chaussalet, Philip Worrall, Salma Chahed **S4C.3** *Association between hospital occupancy and mortality* Fredrik A. Dahl, Joe Viana, Kim Rand-Hendriksen
16:00-17:00	**Coffee Break and Poster Session**		
17:00-18:00	**R.4: Special Session: Bull running in Pamplona: A methodological approach to deliver the Risk Response Plan.** Chair Javier Belloso		

THURSDAY, JULY 28TH

9:00-10:30	**R.4: Session V A**	**R.502: Session V B**	**R. 503: Session V C**
	Emergency medical services (I) Chair Marion Rauner **S5A.1** *An Intelligent Decision Support System Oriented to Attention To Patients on the street and Displacement Routing for no Common Emergencies* Lupe Toscano, Mario De Oliveira **S5A.2** *Stochastic Routing for Relief Efforts* Maria Elena Bruni, Patrizia Beraldi, Demetrio Laganà, Sarah Khodaparasti, Roberto Musmanno **S5A.3** *Management Policy Game for Mass Casualty Incidents: Simulation-Optimization Approaches Beat Human Players* Marion Rauner, Helmut Niessner, Walter Gutjahr	**Patient scheduling (II)** Chair Susan Li **S5B.1** *Revenue Management Models in Primary-Care Clinics* Zhimin Huang, Susan Li **S5B.2** *Controlling Indirect Waiting Times through Panel Management* Anne Zander **S5B.3** *Optimizing the Use of Hospital's Capacity to Reduce Patient Wait Times* Susan Li, Zhimin Huang	**Health Economics and Decisions (II)** Chair Paulus Torkki **S5C.1** *A decision-analytic approach for the optimal allocation of resources to diagnostic testing and treatment* Yrjänä Hynninen, Eva Vilkkumaa, Ahti Salo **S5C.2** *The utilization of Budget Impact Analysis for managing continuous improvement of integrated organizational models for multi-morbid patients.* Myriam Soto-Gordoa, Arantzazu Arrospide Marisa Merino, Ane Fullaondo, Igor Larrañaga, Esteban de Manuel, Juan Ignacio Igartua, Javier Mar **S5C.3** *Analyzing the drivers affecting cost of cancer: population-level results from Finland* Paulus Torkki, Riikka Leskelä, Jukka-Pekka Mecklin, Sakari Karjalainen, Suvi Mäklin
10:30-11:00	**Coffee Break**		
11:00-12:00	**R.4: Session VI A**	**R.502: Session VI B**	**R. 503: Session VI C**
	Infectious diseases Chair Margaret Brandeau **S6A.1** *Epidemic Structure and Optimal Control of HIV Epidemics Among Sex Workers* Alexander Rutherford, Brian Williams **S6A.2** *Improving the HIV Care Cascade via Mental Health Interventions: A Cost-Effectiveness Analysis* Margaret Brandeau	**Operations room planning and scheduling (II)** Chair Francisco Ballestín **S6B.1** *Different Perspectives for Surgical Case Assignment Problem: Heuristic Approaches* Catarina Mateus, Inês Marques, Maria Eugénia Captivo **S6B.2** *Calculating the improvement due to the rescheduling of elective patients* Francisco Ballestín, Ángeles Perez, Sacramento Quintanilla	**Performance evaluation (I)** Chair Liv Ariane Augestad **S6C.1** *An innovative Web-Delphi on weights to inform the construction of a EURO-HEALTHY population health index* A. Vieira, C.A. Bana e Costa, J.C. Bana e Costa, M.D. Oliveira, P. Santana **S6C.2** *Using the choice sequence in Time Trade-off as Discrete Choices – do the two stories match?* Liv Ariane Augestad, Kim Rand-Hendriksen, Mathias Barra
12:00-13:00	**Plenary Session. David Stanford:** *Key Performance Indicators and their Optimal Performance*		
13:00-14:30	**Lunch**		

14:30-16:30	**R.4: Session VII A**	**R.502: Session VII B**	**R. 503: Session VII C**
	Health Planning (I) Chair Honora Smith **S7A.1** *Supporting the implementation and evaluation of health system transformation with operational research* Gozdem Dural-Selcuk, Christos Vasilakis **S7A.2** *Locating and designing group practices for general practitioners* Melanie Reuter-Oppermann, Jost Steinhäuser **S7A.3** *Objectives, Objectives* Penelope Mullen **S7A.4** *Hub networks for hierarchical health services: efficiencies for logistics and patients?* Honora Smith	**Emergency Department (II)** Chair Guy Wachtel **S7B.1** *Decision-Making Process in Solving Overcrowding in Emergency Departments Including Budgetary Aspects* Guy Wachtel, Amir Elalouf **S7B.2** *A Simulation Analysis for Improving Patient-Physician Assignment Policies in Emergency Department Triage* Marta Cildoz, C. Azcárate, A. Ibarra, F. Mallor **S7B.3** *Reducing the overcrowding at the emergency department* Davide Duma, Roberto Aringhieri, P. Hosteins **S7B.4** *Combining Coxian phase-type distributions with discrete event simulation to model patient activity inAustralian emergency departments* Laura Boyle, Adele Marshall, Mark Mackay	**Modelling in Health Care (II)** Chair Joe Viana **S7C.1** *Incorporating semi urgent surgeries into the tactical surgery schedule* Nardo Borgman, Ingrid Vliegen, Erwin Hans **S7C.2** *Applying Gravity Model to estimate demand of public hospital beds in Singapore* Kiok Liang Teow, Kelvin Bryan Tan, Hwee Pin Phua **S7C.3** *A Hybrid Simulation Framework to reproduce and test hospital organizational changes* Michele Sonnessa, Elena Tànfani, Angela Testi, Paolo Landa, Marina Resta **S7C.4** *Flexible healthcare hybrid simulation modelling* Joe Viana, Kim Rand-Hendriksen, Tone Breines-Simonsen, Fredrik Dahl, Mathias Barra
16:30-17:00	**Coffee Break**		
17:00-18:30	**R.4: Session VIII A**	**R.502: Session VIII B**	**R. 503: Session VIII C**
	Disease modelling and policy (III) Chair Leonid Churilov **S8A.1** *Modelling the Optimal Ethnic Composition of an Adult Stem Cell Registry* John Blake, Ken McTaggart, Donna Killeen **S8A.2** *Value-Based Reimbursement Modeling for Ocular Gene Therapy in Patients with Choroideremia* Reza Mahjoub, Benoit Kudinga, C. McCabe, Tania Bubela **S8A.3** *Applications of Utley-Gallivan's consensus process for identifying a prioritised list of study questions in stroke care* Leonid Churilov	**Data analysis &risk management (II)** Chair Mathias Barra **S8B.1** *Perinatal hospital activities and healthcare pathway optimization in the Ile de France region: how to manage the full set of data for regional health authority?* Catherine Crenn Hebert, Elodie Lebreton, Chloe Poulain, Soufiane Zemrani, Claudie Menguy **S8B.2** *Senior Citizens' Potential Demand for Exercising* Jiun-Yu Yu, Pei-Yi Cheng, **S8B.3** *Confirmatory Factor Analysis with small samples – Are simulation studies matched by ecological data?* Mathias Barra, Jonas Lindstrøm, J. Saltyte-Benth	**Performance evaluation (II)** Chair Vicent Augusto **S8C.1** *The hospitals service's efficiency: a relational model with not discretional variables* Pinto Claudio **S8C.2** *Development of an NHS patient activity forecasting tool in England* Philip Worrall, Thierry Chaussalet **S8C.3** *Performance evaluation of health information systems implementation through discrete-event simulation* Vincent Augusto, Claire Pilet, Lionel Perrier, Xiaolan Xie, Saber Aloui, Pierre Biron

FRIDAY, JULY 29TH

9:00-11:00	**R.4: Session IX A**	**R.502: Session IX B**	**R. 503: Session IX C**
	Home Care / LTC (III) Chair Nadia Lahrichi **S9A.1** *Drudgery minimization in homecare planning* Thierry Garaix, Nizar Triki, Xiaolan Xie **S9A.2** *Solving a Rich Homecare Routing and Scheduling Problem with LNS.* Florian Grenouilleau, Nadia Lahrichi, Louis-Martin Rousseau **S9A.3** *A memetic algorithm for Home Health Care Routing Problem* Mohamed Cisse, Yannick Kergosien, Christophe Lente **S9A.4** *A New Decomposition Approach for Solving the Assignment and Routing Problems in Home Health Care* Nadia Lahrichi, Ettore Lanzarone, Semih Yalçındağ	**Health Planning (II)** Chair Felipe Rodrigues **S9B.1** *A New Configuration of Inpatient Beds in Hospitals* Navid Izady, Israa Mohamed **S9B.2** *Dedicated emergency beds optimize the emergency admission flow* Anton J Schneider, Peter L. Besselink, AJ Fogteloo, Paul Bilars, Ton J. Rabelink **S9B.3** *Dynamics of the Process of Care from Inpatient and its Influence on the Hospital Stay* Paula Andrea Velásquez Restrepo, Tatiana María Ceballos Acevedo, Sebastian Jaén Posada **S9B.4** *Level 2 bed planning in the London Health Science Centre in Ontario, Canada: A simulation model based on NEMS scores* Felipe Rodrigues, Greg Zaric, David Stanford, David Barret, Juddy Kojlak, Fran Priestap, Claudio Martin	**Emergency medical services (II). Miscellany** Chair Brigitte Werners **S9C.1** *Facility location and spatial data analytics in public access defibrillation* Derya Demirtas, Timothy Chan, Roy Kwon **S9C.2** *Constructing Optimal Routes for Inter-facility transfer Ambulances using the Dijkstra-based topographic-time dependent model: A Case Study of Zomba District Health Office* Elias Mwakilama, Javier Faulin, Levis Eneya **S9C.3** *A Queueing Model with Adjustable Speed of an Intensive Care Unit* Eman Almehdawe, Armann Ingolfsson **S9C.4** *Improving emergency medical services in a real-world setting* Brigitte Werners, Lara Wiesche, Pia Steenweg
11:00-11:30	**Coffee Break**		
12:00-13:00	**Business meeting: conference closing**		
13:00-14:30	**Lunch**		

CONFERENCES

PLENARY CONFERENCES

MONDAY
JULY 25

10:00-11:00
Plenary Conferences Room

COMPUTATIONAL MEDICINE AND BIG DATA ANALYTIC

Dr. Eva K. Lee

Abstract

Mathematical modeling and computational methods have long been cornerstones for advancement of business analytics in industrial, government, and military applications. They are playing key roles in advancing and transforming medicine and healthcare delivery. In particular, multi-source data system modeling and computational big data analytics and technologies play an increasingly important role in modern healthcare enterprise. Many problems can be formulated into mathematical models and can be analyzed using sophisticated optimization, decision analysis, and computational techniques. In this talk, we will share some of our successes in early disease diagnosis, precision medicine optimal treatment planning design, and healthcare operations through innovation in mathematical modeling and predictive big data analytics.

TUESDAY
JULY 26

12:00-13:00
Plenary Conferences Room

ENABLING CONTEXT AWARE ENVIRONMENTS: TOWARDS SMART HEALTH PROVISIONING

Francisco Falcone

Abstract

One of the main challenges humanity is facing is the optimal use of resources, which becomes particular interest in the case of dense urban scenarios, such as cities. The projected forecast of population settlements indicates that by 2050, nearly 70% of the inhabitants of the

world will be residing in cities. This poses serious concerns in terms of achieving sustainable urban environments. In this sense, the paradigm of Smart Cities and its extension to S mart Regions provides the required resource sustainability by means of handling multiple systems and resources in a coordinate way, such as transportation systems, waste management, water management or electric distribution systems, to name few. This leads also to the interaction and inclusion of higher -level citizen-oriented services, such as management and provision of health-oriented services in a global sense. Moreover, optimal performance can be achieved when user are enabled to interact with the surrounding environment, providing feedback as well as reactive capabilities to the overall systems. In this sense, wireless communication systems play a key role in providing seamless user real time interaction. The large increase in the number of wireless transceivers, the higher capacity demands and the new operation scenarios within the IoT framework lead to the use in the near future of Heterogeneous Network architectures, in which thorough wireless system planning and analysis is compulsory.

In this talk, we will explore the new trends and systems employed in order to provide context aware environments, as well as the challenges faced in different types of context and scenarios, from Intelligent Transportation Systems to Smart Health provisioning.

THURSDAY
JULY 28

12:00-13:00

Plenary Conferences Room

KEY PERFORMANCE INDICATORS AND THEIR OPTIMAL PERFORMANCE

David Stanford

Abstract

Health care systems often have to deal with diverse populations of patients with differing needs, acuities, and urgencies. Key Performance Indicators (KPIs) have been a popular tool for sorting out the question of urgency, by setting the standards for time to initiation of treatment for these various populations. KPI standards typically comprise a waiting time limit for treatment to begin, along with a compliance probability stating the minimum acceptable fraction of the patient class to commence treatment by the time

limit. The time limits increase as the patient acuity decreases, and in many cases the compliance probability decreases as well.

KPI standards are sometimes set due to perceived clinical need, sometimes due to a desired standard for waiting time performance, and sometimes as a mix of both. The five-category Australasian Triage Scale (ATS) and Canadian Triage and Acuity Scale (CTAS) are both examples of the last category: the needs of the highest category of patients (Resuscitation) are purely clinical, but as one works through the remaining four categories, the clinical need diminishes, replaced by the performance goal. Sometimes what constitutes urgency itself is open to debate. For example, in hip and knee joint replacement, some orthopaedic surgeons consider degree of pain suffered to be the urgent element, while others consider it to be the degree of degradation of the joint itself.

The common missing element for KPI systems is the fact that KPI standards represent a system of constraints, and do not indicate what the consequences of non-compliance are. A KPI system that meets its compliance could, in theory, totally ignore patients who miss their targets, in order to deploy health resources to reduce the chance of more recent arrivals missing theirs. This absurd situation is due to the fact that KPIs lack a goal to be optimized. What is needed to complete the picture is an objective which reflects the increased urgency of patients whose wait times exceed their time limit.

This plenary presentation commences with a review of several diverse areas in healthcare where KPI standards arise, so as to better identify the common elements and the differences in the assumptions and the goals. The presentation then states what seem to us to be an appropriate set of objective functions for optimal performance of a KPI system, which relate to minimizing the amount of excess waiting that occurs. We then move on to demonstrate that the Accumulating Priority queueing discipline is a well-suited discipline to aid compliance of diverse patient populations served by a common facility. The remainder of the presentation addresses what we have learned about the various objectives, and their relationship to each other, and their optimal performance. We are particularly interested in the performance of a simple Rule of Thumb which assigns priority to customers in each KPI class in inverse proportion to that class's waiting time limit.

The results to be presented are the result of a number of research projects with graduate students Na Li and Azaz Sharif, and research colleagues Peter Taylor (Melbourne), Ilze Ziedins (Auckland), and Richard Caron (Windsor, Canada). I am also deeply grateful for discussions with Martin Utley and Christina Pagel of University College London on the secondary nature of the compliance targets, and our ongoing work in that area.

SPECIAL SESSIONS

MONDAY
JULY 25

16:30-18:00
Plenary Conferences Room

ENGAGING HEALTHCARE MANAGERS AND PRACTITIONERS THROUGH OM/OR EDUCATION

Erwin Hans

Abstract

Getting healthcare managers and practitioners involved in your research is essential to take on problems that are relevant to practice, and to have a chance of actually making an impact in practice. Teaching healthcare OM/OR courses to healthcare managers and practitioners is a fun and rewarding way to get them enthused to collaborate. This session is aimed at sharing experiences of ORAHS participants who have done/are doing this in their countries, amongst each other, and with other ORAHS participants who would like to do this. The session consists of short presentations of experiences in various countries, followed by a (panel) discussion.

TUESDAY
JULY 26

17:00-18:00
Plenary Conferences Room

BULL RUNNING IN PAMPLONA: A METHODOLOGICAL APPROACH TO DELIVER THE RISK RESPONSE

Javier Belloso

Abstract

Plan Running in front of the bulls weighing over 500 kilos constitutes a risk practice for the runner and therefore a risk response plan needs to be agreed in order to mitigate the risks involved in the activity. In this talk we will introduce a Metho-

dology to approach the plan to respond to the inherent risks associated to the participation in the run, both proactive and reactively. At the same time we will try to transmit the essence and heart of the event, not only as a pure risky activity but also as an ancestral tradition that has been performed since XVII century.

We will start with images and comments of the run from inside and the AS IS situation of the stakeholders in relation with the event. Many actors are involved in the run, bulls, runners, surgeons, civil defense workers, security staff, organizers, spectators. A panel of experts in these areas will explain how they are organized in relation with the risks they are exposed.

In order to formally approach the management of the risks, we will then introduce a methodology that is well known in the Engineering applications called Failure Mode and Effect Analysis (FMEA). This will guide us in the identification of risks as well as helping in the qualitative and quantitative analysis. Depending on the risks nature, the response plan strategy will be to avoid, mitigate or even accept some types of risks as part of the essence of the event. The later are associated with the injured people during the run. We will focus in the process of attending these people and triage them in the more efficient and timely manner.

ORAL PRESENTATIONS. PARALLEL SESSIONS

MONDAY

10:00-11:00

PLENARY CONFERENCE

COMPUTATIONAL MEDICINE AND BIG DATA ANALYTIC

Eva K. Lee.

Abstract

Mathematical modeling and computational methods have long been cornerstones for advancement of business analytics in industrial, government, and military applications. They are playing key roles in advancing and transforming medicine and healthcare delivery. In particular, multi-source data system modeling and computational big data analytics and technologies play an increasingly important role in modern healthcare enterprise. Many problems can be formulated into mathematical models and can be analyzed using sophisticated optimization, decision analysis, and computational techniques. In this talk, we will share some of our successes in early disease diagnosis, precision medicine optimal treatment planning design, and healthcare operations through innovation in mathematical modeling and predictive big data analytics.

11:30-13:00

SESSION I

SESSION I A

OPERATIONS ROOM PLANNING AND SCHEDULING (I)

Chair **Inês Marques**

S1A.1

INCREASING THE ROBUSTNESS OF SURGERY SCHEDULES AGAINST EMERGENCY BREAK-INS

Mathieu Vandenberghe, Stijn De Vuyst, Herwig Bruneel, El-Houssaine Aghezzaf

Abstract

Rising healthcare costs and an aging population are placing ever higher stress and demands on European healthcare systems. As the surgery department is one of the largest cost categories in hospitals (estimated as high as 40%;

Macario et al, 1995), it is a frequent target in the search for efficiency gains. Creating robust schedules is a key component here, as the planning for elective (scheduled) patients is often disarrayed once emergency patients arrive.

To address the problem of operating room scheduling, we expand on the Break-In-Moment (BIM) problem first proposed in Essen et al, 2011. It relates to a common procedure in hospitals: as all operating rooms are often being utilized when emergency patients arrive, they must be treated in the first room that becomes available after the emergency patients arrives; «breaking into» the elective schedule. Each surgery end time is thus a potential break-in-moment (BIM), and the distance between two consecutive end times is referred to as the break-in-interval (BII).

As time is of the essence for emergency patients, it makes sense to spread these BIMs over the schedule in such a way as to minimize their expected waiting time. In the case where arrivals are time-independent, this means seeking to spread the BIMs as uniformly as possible. This leads to the basic BIM problem statement: how should one schedule a certain set of surgeries, so that the maximum BII in the schedule is minimized.

Previous work focused on a deterministic ILP formulation of the problem and proposed a variety of heuristics and local search methods; a validation of these results in a stochastic environment (with uncertain surgery times) was also shown. In contrast, we fully reformulate the problem in stochastic terms (yielding the Stochastic BIM problem; SBIM), taking into account the uncertainty of surgery times from the start. This increases the complexity of the problem, but it also makes it more robust by analyzing a variety of scenarios. As surgery times tend to show significant variance (often following lognormal distributions), this can be a strong advantage.

To solve the computationally more involved SBIM, we employ the Sample Average Approximation (SAA), a two-stage optimization technique. Rather than drawing a large amount of samples from distributions of surgery lengths and solving to optimality for this large set (infeasible in our case), SAA first solves M smaller replications of the problem, and then estimates the true optimal solution based on the M candidate solutions.

In addition, we propose heuristics to solve the SBIM problem in an acceptable timeframe.

S1A.2

CAPACITY MANAGEMENT FOR THE OPERATING ROOM

Carla Van Riet, Erik Demeulemeester

Abstract

Managing operating rooms (ORs) is a challenging task. The problem setting we research originates from a real hospital setting, where capacity is periodically assigned to surgical disciplines, patients are scheduled dynamically (i.e., at the time of their consultation) and patients are rescheduled on the day of surgery (in order to mitigate the effect of overtime).

The problem faced by the hospital is that patients are served later then their due time. Additionally, since ORs in the hospital are highly utilized, non-elective patients are disturbing the planned elective schedule. This disturbance is resolved by rescheduling actions such as OR reassignments and on-day cancellations.

This talk discusses different policies for the division of OR capacity among different surgical disciplines and patient urgency categories. We use a fixed scheduling algorithm and focus on both the use of flexibility in the capacity allocation schema and the applied access policy. Using a simulation model, we evaluate how these policies affect the ORs of the hospital over a wide range of performance measures. In addition, we compare the performance of the simulated policies with pre and post data from a university hospital after such capacity changes were implemented.

S1A.3

A ROBUST OPTIMIZATION APPROACH FOR A SURGICAL CASE ASSIGNMENT PROBLEM: THE CASE OF A PORTUGUESE HOSPITAL

Inês Marques, Maria Eugénia Captivo

Abstract

Uncertainty concerning the duration of a surgery is one major problem for the operating room planning and scheduling. Overestimating surgery durations may lead to underutilization of the surgical suite while an underestimation of the surgery durations increase the risk of cancellation of surgeries and incurs in extra work for the staff of the surgical suite. Underutilization of the surgical suite should be avoided since it represents a great inefficiency of a very expensive service and it contributes to increase the social problem of large waiting

lists in the health care sector. In the literature, the surgeries duration is often treated as a deterministic parameter, which can be disruptive to the surgical schedule obtained by a mathematical model or a heuristic approach.

This work analyses the surgical case assignment problem in a general Portuguese hospital. Deterministic mixed integer programming models were previously developed in order to consider different perspectives of the multiple stakeholders of the surgical suite. Simulations developed over the surgical schedules obtained considering average values for the surgeries' duration (deterministic approach) showed overbooked solutions: the hospital could expect an average time block occupation rate (with cleaning time) above 100%, and between 25% and 49% of the time blocks working in overtime, which would result in the cancelation 465 of surgeries. This shows that deterministic solutions can be disruptive to a smooth running of the surgical suite, and a robust approach is desired.

In this work robust optimization models are used to handle the uncertainty in the duration of the surgeries, in order to keep the surgical schedules feasible regarding the operating room capacity constraints and also the surgeons' operating time limit. The robust approach tackles the uncertain surgeries duration without the need to assume a given distribution for these random parameters, and allows to control the level of conservatism in the solutions by giving the possibility to the surgical suite planner (decision maker) to fix an upper bound on the probability for a surgical schedule to violate the uncertain constraints. In addition, this approach allows to consider uncertainty in the constraints' coefficients by solving a problem from the same class as the deterministic version (mixed integer linear programming models) with added variables and constraints. Results of computational experiences using data from the hospital will be presented and discussed. The schedules obtained are analyzed regarding quality and robustness, and are also compared with the surgical schedules performed by the hospital. The robustness of the solutions with respect to changes in the real surgery duration regarding the estimated duration is also studied. The performance of the surgical suite decreases with tighter upper bounds on the probability of violating the operating room time capacity constraints. A trade-off between the performance of the surgical suite and the robustness of the solutions can be easily leveled by this robust approach.

Finding better health care decisions in new oceans of health data (as is suggested by the conference theme) is a contribution of this collaborative work with the hospital.

SESSION I B

MODELLING IN HEALTH CARE (I)

Chair **Ana Monteiro**

S1B.1

TOO OBVIOUS TO MENTION? SOME SIMPLE WAYS IN WHICH RUNNING EMPIRICAL DATA DIRECTLY THROUGH SIMULATION MODELS CAN BE USED TO IDENTIFY FLAWS IN MODELS AND DATA

Kim Rand-Hendriksen, Joe Viana, Fredrik Dahl

Abstract

Simulation models of hospital activities have often required manual data collection, observation, and other forms of activity sampling. Due to the increasingly pervasive automatic and semi-automatic data collection in electronic journals and other computer systems, many model parameters (arrival times, transition probabilities, lengths of stay, patient characteristics) can now be estimated based on complete empirical records. Interestingly, while the literature on simulation modeling has much to say about how such models can be validated and compared to empirical data, there is a curious lack of mention of a verification procedure that should be obvious: models built to reflect and represent a reality in the form of a complete empirical record should be able to run the empirical records in question without encountering problems. Consider a maternity ward with delivery rooms, regular patient rooms, and a patient hotel (hotel-like rooms with nursing staff for low-risk patients). Most women arrive shortly before birth, and move to the patient hotel quickly after. Other patients move between rooms several times, and some occupy regular hospital both prior to and after delivery. Our aim is to model the impact of expected changes in the demographic makeup within the catchment area, and investigate the possible benefits of altering the schedules for when patients are discharged, and how empty rooms are made ready for new patients. We create a simulation model with rooms, beds, and staff based on information from the ward administration. Distributions for patient admission, length of stay, and transition between rooms are all estimated based on complete empirical records from the electronic journal system.

Before going any further, we alter the model in such a way as to allow the generation of agents (patients) directly based on the electronic record. That is, each patient in the electronic record is set to appear in the model at a time matching the record, and is set to move around and occupy resources exactly as recorded. This procedure is deterministic. If contradictions occur, such as the

occupancy reaching levels beyond what is available, we need to look for problems in the model or in the data. If the model behaves well, we can sequentially «turn on» assumed model parameters one at a time, for example enforcing the restriction on number of beds, in order to verify that all assumed parameters are able to accommodate the real record. This procedure rests on the availability of full empirical records, and on the model in question being built to accommodate those records. We assume that the lack of mention of these kinds of verification procedure in the literature is caused by the historic rarity of models in which this is possible have been relatively rare, and that procedure has been considered too obvious to mention. We present a real-world example based on models of the maternity ward in a university hospital in Norway, and show how procedures such as these have been surprisingly useful in identifying flaws in the model and errors in the empirical records.

S1B.2

RISK MODELLING FRAMEWORK FOR EMERGENCY HOSPITAL READMISSION, USING INPATIENT DATA

Thierry Chaussalet, **Mohsen Mesgarpour**, Salma Chahed,

Abstract

The objective of this study was to develop and validate a predictive risk model using a generative model and produce a feature selection framework for risk of hospital emergency readmission within a year. We carried out the development using Hospital Episode Statistics (HES), which is a routinely collected data covering hospital admissions in England. Three timeframes of inpatient data were used for training, testing and benchmarking: 1999 to 2004, 2000 to 2005 and 2004 to 2009 financial years. Each timeframe includes 20% of all inpatients admitted within the trigger year, and for training and testing each sample is spilt into two. A generative model known as Bayes Point Machine was applied, because of its well-founded improvement over other non-linear kernel classifiers, including Support Vector Machine.

The comparisons were made using precision, recall and specificity for different risk cut-offs, risk bands and top-risk segments. The constructed Bayes Point Machine with using this feature selection framework produces a risk probability for each admitted patient. The results were validated for different timeframes, sub-populations and cut-off points. At risk cut-off of 50%, the precision was 69.3% to 73.7%, the specificity was 88.0% to 88.9% and recall

was 44.5% to 46.3% across different timeframes. Also, the area under the Receiver Operating Characteristic curve was 73.0% to 74.3%. The developed framework and model performed considerably better than existing modelling approaches, with high precision and good recall.

S1B.3

PLANNING OF MENTAL HEALTH CARE DELIVERY: A LOCATION-ALLOCATION MATHEMATICAL PROGRAMMING MODEL

Ana Monteiro, Teresa Cardoso, Maria Santos

Abstract

Mental health problems currently represent one of the leading causes of disability and morbidity in many European countries. As a result, an increasing demand for mental health care is predicted for coming years across these countries. Still, the current supply of mental health care services is far from being enough to satisfy this growing demand for care, and the current economic crisis can seriously hinder the development of such supply. Within this context, planning mental health care networks currently represents a health policy priority across European countries, especially in countries with a National Health Service (NHS) where serious budget constraints are currently in place.

Different planning issues must be addressed to ensure an adequate planning of networks of mental health care services. Particularly: i) a multiplicity of services should be accounted for, including a variety of institutional services, as well as ambulatory, home-based care and rehabilitation services; and ii) the attainment of multiple planning objectives should also be ensured. Location-allocation mathematical programming models have been widely used to support health care planning in general, and have potential to be used to ensure this planning. Nevertheless, most of existing models in the literature in the area account for one single service and for a single objective. Furthermore, specific applications in mental health are still scarce.

To contribute to the location-allocation literature in the health care sector, this study proposes a multiobjective mathematical programming model to support the planning of a multi-service network of mental health care services in NHS-based countries in the medium-term. The developed model informs on services' location and capacity, while ensuring the attainment of multiple objectives, namely, the maximization of multiple dimensions of equity and the minimization of cost. Particularly, in terms of equity, the model accounts for five

equity dimensions – equity of access, equity of demand satisfaction, geographical equity, equity of service-specific utilization and equity of disease-specific utilization. These multiple objectives may be jointly considered for planning, or only part of it may be worth pursuing, depending on the planning circumstances. To deal with these multiple objectives, the ε-augmented constraint method is used. The proposed model thus provides planners with key information on: when and where to locate services and with which capacity; how to geographically distribute this capacity across services and patient/disease groups; which changes to the network of mental health care are needed over time; and how these changes impact on key equity and cost-related objectives.

The applicability of the model is demonstrated through the resolution of a case study in the Lisbon and Tagus Valley region in Portugal over the 2016-2020 period. The obtained results allow for multiple analysis: i) how to reorganize the mental health care network under different circumstances, such as when full demand satisfaction is required, when a budget constraint is in place or when specific equity targets should be attained; and ii) which equity improvements can be obtained under different circumstances, and at which costs.

SESSION I C

DISEASE MODELLING AND POLICY (I)

Chair **Praveen Thokala**

S1C.1

APPLICATION OF SIMULATION MODELLING FOR EFFECTIVE DESIGN OF STROKE CARE SYSTEM PATHWAYS

Mahsa Keshtkaran, Leonid Churilov, John Hearne, Babak Abbasi, Atte Meretoja

Abstract

It has been clinically indicated that maximum benefits in treating ischemic stroke patients can be achieved by effective and fast application of existing acute therapies aiming at dissolving the blood clot (using intravenous thrombolysis) or removing the clot from the artery. For intravenous thrombolysis, patients are expected to gain on average 1.8 days of extra healthy life for every minute of the onset-to-treatment time saved, while benefits of earlier treatment with regard to intra-arterial clot removal intervention on patients life-time is yet to be investigated.

In this study, we first report on the life-time benefits of fast delivery of intra-arterial clot treatment for stroke patients. The fact that not all hospitals are

capable of delivering intra-arterial treatment adds extra complexity to what is already a complex system of care pathways and processes. We also report on the use of multi-scale simulation modelling for effective design of stroke care system pathways with the aim of maximizing the patients' life-time benefits. This model could assist in decision support for both policy and individual clinical decision-making levels.

S1C.2

MULTSCALE VISUALISATION FOR UNDERSTANDING OF MULTITRAUMA SPINAL CORD INJURY TREATMENT PROCESSES

Hayden Johns, Leonid Churilov, John Hearne, Ian Mosley

Abstract

Traumatic Spinal Cord Injury (TSCI) is a debilitating condition which can lead to severe and long-term disability. When it occurs in a multitrauma context, a number of coexisting serious injuries can lead to uncertainty in how TSCI is managed. This uncertainty is conflated by the relative rarity of TSCI, which restricts sophisticated statistical analysis and makes TSCI processes of care harder to understand and track in the settings of a large trauma hospital.

This project uses a number of clustering methods on data collected from a major trauma hospital in Melbourne, Australia to identify both patient-level and operational aspects of acute TSCI care pathways in a multitrauma setting. These clusters are then visualised in multiscale simulation software AnyLogic, aiding decision maker interpretation and understanding of identified patterns.

S1C.3

A COMPREHENSIVE MODEL FOR DEMENTIA: DIAGNOSIS, DISEASE PROGRESSION AND SERVICE DELIVERY

Praveen Thokala, Alan Brennan, Carol Brayne, Louise Lafortune

Abstract

Introduction: Dementia is a very important concern in most countries due to increase in ageing population. In order to support efficient resource allocation, there is a need for a comprehensive economic model to allow accurate prediction of health and care demand for dementia patients.

However, there are many issues and challenges in developing such a comprehensive dementia model. There are many types of dementia (e.g. Alzheim-

er's disease) and many model possibilities. Modelling the benefits of early diagnosis of dementia is quite complicated due to lack of data; the transition between mild cognitive impairment and dementia is also an area that has been studied in detail but prediction on an individual basis remains poor.

This presentation will highlight these issues and challenges as well as potential opportunities in developing such a flexible and comprehensive long-term dementia models incorporating the most up-to-date methodologies to allow a number of cost-effectiveness evaluations.

Method(s): A comprehensive dementia model that can address diagnosis, disease progression and service delivery issues is highlighted in this presentation. A systematic review of existing dementia models was performed and data extraction was performed on the studies evaluating pharmacological interventions and diagnostic interventions. Expert opinion was sought in developing the dementia model – in particular, advice on the appropriate conditions to include in the model, key data sources and literature. Conceptual modelling was performed to finalise the structure of the model before programming in modelling software. The model was subjected to internal and external validation to ensure the robustness in predicting dementia outcomes.

Result(s): The systematic review identified 69 relevant articles evaluating pharmacological interventions and diagnostic interventions and data extraction was performed on these studies. Based on this review, Alzheimer's disease and vascular dementia were included within the 'dementia' model. The model is an individual patient-level simulation model and uses mini–mental state examination (MMSE) scores to model disease progression. Institutionalisation and mortality was also modelled. Transition probabilities were modelled based on published literature. The model incorporates diagnosis, disease progression and service delivery aspects of the patient pathway. The model takes a lifetime perspective, estimating the impact of interventions on costs, clinical outcomes, survival and quality-adjusted life years.

Conclusion(s): The results of the dementia model indicate that early diagnosis may not be cost effective, given the current evidence. The key drivers include the accuracy of the diagnosis and the effectiveness of dementia interventions. The model is highly flexible and has broad potential application to evaluate different diagnostic strategies and pharmacological/non-pharmacological interventions in dementia.

14:30-16:00

SESSION II

SESSION II A

PATIENT FLOW

Chair **Sally Brailsford**

S2A.1

IMPROVING PATIENT FLOW IN A CARDIOLOGY DEPARTMENT BY IDENTIFYING CARE PATHWAYS

Joren Marynissen, Erik Demeulemeester

Abstract

In the light of the everlasting struggle to reduce healthcare costs, a significant amount of attention in the healthcare literature has been given to optimizing the patient flow within a single hospital department. However, care is often a multidisciplinary issue with a patient requiring services from several departments. Slowly but steadily, both practice and theory seem to realize that eliminating the silos of information in hospitals is no longer optional but a true necessity if overall performance needs to be maximized. However, in order to accommodate the multidisciplinary stream of patients through individual hospital departments, one must first make sure that all departments are ready for such a paradigm altering change. In order to do so, each department needs to actively take into account the existence of the multidisciplinary flow of patients through its resources. In this presentation, we therefore limit our scope to a cardiology unit in a university hospital. This unit organizes both consultations and several function tests for inpatients as well as for outpatients. We use process mining tools to identify pathways in the current patient flow. The results are afterwards confronted with official clinical pathway guidelines and interviews with physicians. After having identified the important patient classes, we use discrete-event simulation to show the impact of reserving capacity for these patients on various performance measures such as overtime, resource utilization and the total time to serve one patient. By protecting capacity, we are able to reduce the length-of-stay (LOS) for inpatients. At the same time, outpatients can be served more efficiently with a patient undergoing all necessary tests within a single day.

S2A.2

MODELLING PATIENT FLOW IN AN ORTHOPEDIC CLINIC

Narasimhan Ravichandran

Abstract

We propose a model to manage the flow of patients in an orthopedic clinic. The clinic is owned and managed by two senior consultants. The patient mix includes regular patients with appointments and patients who report emergency. The emergency patients are treated with preemptive priority. This contributes to the increased waiting time of regular patients who visit the clinic by appointment. Liberal scheduling of patients would lead to lower utilization of consultants. The simulation model explores various scheduling options to balance the consultants utilization and patient wait time.

S2A.3

PREDICTING PATIENT FLOW IN A PAEDIATRIC INTENSIVE CARE UNIT

Sally Brailsford, Peter Vermeulen, Vincent Peclard

Abstract

The US healthcare industry has been facing rising costs for many years. The Children's Hospital of Wisconsin (CHW) in Milwaukee wished to know whether savings could be made if an observation unit were set up as an intermediate unit between the Paediatric Intensive Care Unit (PICU) and the Acute Care Unit. This arose from a concern that in future, insurance companies might refuse to pay for PICU level of care if the patient could have been safely treated elsewhere. This paper describes an Excel-based analytic tool which enables clinicians to identify patients who might be eligible for treatment outside the PICU, and then estimate the financial impact of relocating them. Data mining techniques were used to identify and group the patients/disease types selected for placement outside of the PICU, as well as key resources and tasks involved in patient care and outcomes.

The study focused on one specific reason for admission, ingestion (accidental or deliberate) of toxic substances. A list of procedures requiring PICU level of care was established through discussion with the PICU physicians, and these were used to classify patients into two groups, those who should stay in the PICU and those who could be safely treated in the observation unit. The cost analysis showed that a predicted 87% savings could be made between the current situation and the best scenario, i.e. if CHW were able to identify and relocate all eligible patients. A sub-

sequent MSc project has extended this work by using data available on admission to predict length of stay. This project also resulted in a user-friendly Excel-based tool that uses routine data from CHW information systems.

SESSION II B

HOME CARE / LTC (I)

Chair **Ettore Lanzarone**

S2B.1

THE USE OF TELECARE TO SUPPORT PEOPLE WITH DEMENTIA TO LIVE INDEPENDENTLY

Katherine Penny

Abstract

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 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.

In order to examine telecare as a service option this PhD research uses discrete event simulation (DES) to model the system, incorporating the facilitating and obstructive factors that influence telecare uptake for people with dementia. DES models take into account random variation, which is useful for capturing the variations in condition associated with dementia. They also have the advantage of being a relatively visual form of modelling, which can aid communication with stakeholders and encourage dialogue between interested parties. In turn,

feedback from key stakeholders can be built into the model design, informing elements of the modelling process, where data is not otherwise readily available.

The DES will allow individuals to be followed throughout the care system, simulating the potential experiences of hundreds or even thousands of different hypothetical telecare service users.

S2B.2

MODELLING LONG-TERM CARE FOR OLDER PEOPLE IN CHINA

Yajie Nie

Abstract

Many countries in both the developing and the developed world have been experiencing a marked demographic shift towards an ageing population. An ageing society can present challenges such as addressing a high demand for health and also social care amongst older people. Planning, delivering and financing such LTC provision for older people can be a challenge for local and national governments. Therefore, this research aims to build a model of LTC for older people in China which could be used as a policy tool to make projections of future needs for different types of LTC services for 2015 to 2024, and to investigate different LTC strategies. Such a policy tool could also facilitate policy-makers to plan LTC support services for older people more effectively in the future and thus improve the quality of life older people in China, as well as their family members. This research also informs the EPSRC Care Life Cycle (CLC) research project at the University of Southampton, which aims to build and use a suite of simulation models in order to assist UK policy-makers at the national and local level, to plan more effectively health and social care provision for future cohorts of older people, both in the UK and globally. This research is a contribution to this body of work.

S2B.3

AN IMPLEMENTOR-ADVERSARY APPROACH FOR THE NURSE-TO-PATIENT ASSIGNMENT PROBLEM IN HOME CARE WITH UNCERTAIN AND TIME- RELATED DEMANDS

Giuliana Carello, Ettore Lanzarone, Daniele Laricini, Mara Servilio

Abstract

The nurse-to-patient assignment problem in Home Care consists of assigning the reference nurse to each newly admitted patient under continuity of care.

One of the main issues in solving this problem is represented by the uncertain patients' demands, which may evolve over time. As the assignments under continuity of care are kept for a long time, this uncertain evolution may have a significant impact on the quality and the costs of the solutions when implemented. Several approaches have been proposed in the literature to account for the uncertain demands in this problem, which mainly consist of stochastic optimization, analytical policies (heuristics) and robust optimization. As far as the robust optimization is concerned, the problem has been solved exploiting the well-known cardinality-constrained approach.

However, despite the advantages of this approach, it does not allow to model a significant aspect of the problem, i.e., the fact that patient demands in consecutive time periods (e.g., the weeks) are highly correlated. Indeed, the cardinality-constrained approach allows representing each patient demand as a stochastic variable under the assumption that the demand in a given week is completely independent of the demands in the previous and the next week. Here, we overcome this problem by considering a more flexible description of the uncertainty set, and by solving the obtained model with the Implementor-Adversary approach. Briefly, in this approach, the so-called «Implementor» computes the assignments before the realization of the uncertainty, while the so-called «Adversary» fixes the worst demand evolution for that assignment. We represent each patient demand by a stochastic variable whose support is divided into a given number of equiprobable intervals. Then, the correlations between weeks are described by modeling and limiting the changes of interval between two consecutive time periods with a set of realistic rules. According to the robust optimization framework, we determine nurse-to-patient assignments on the basis of the worst-case realization of the changes under the given rules. Solutions (in terms of the provided assignments) are then applied to a set of simulated scenarios to evaluate their impact. The approach is tested on real-life data coming from one of the largest Italian public Home Care provider. Results confirm the applicability of the approach and show good results in terms of cost reduction while respecting the different continuity of care requirements associated with the patient care profiles.

SESSION II C

EMERGENCY DEPARTMENT (I)

Chair **Roberto Aringhieri**

S2C.1

IN THROUGH THE OUT DOOR: UNDERSTANDING INCREASING RATES OF PEDIATRIC EMERGENCY MENTAL HEALTH PRESENTATIONS FROM A SYSTEM PERSPECTIVE

Leslie Anne Campbell, David Lovas,George Kephart, John Blake

Abstract

Mental and behavioural disorders are highly prevalent among Canadian children and youth. Despite approximately 20% of young Canadians being affected, many of those with clinically important illness do not receive necessary treatment. Untreated or undertreated mental illness leaves children and youth vulnerable to mental and behavioural crises. Emergency Departments (EDs), designed to provide prompt treatment of acute illness, trauma, or other medical emergencies, often serve as entry points to mental health care for young patients and their families, providing safety nets when timely access to primary or outpatient mental health care is limited.

Canadian children and youth have been presenting, and returning, to EDs for mental and behavioural concerns at steadily increasing rates in recent years. This trend is of concern for several reasons. First and foremost, at the patient level, the busy ED setting combined with the cross-sectional nature of the encounter is unlikely to facilitate a complete examination or meet the complex mental health needs of young patients and their families. From a broader perspective, providing mental health care does not happen in isolation within the ED. The need for comprehensive, lengthy psychiatric assessments affects the overall capacity of the ED to meet all patients' needs. In addition to placing pressure on the ED, patients with extended ED lengths of stay are more likely to leave before receiving care and to experience dissatisfaction with health services. Given the chronicity of many mental disorders, ongoing engagement with the health care system is necessary for improved patient outcomes.

The reasons for the increasing pediatric use of the ED for mental and behavioural crises are likely numerous and complex, and may reflect growing perception of psychiatric risk (i.e., fear of negative outcomes), expected or actual improved access to better or faster care through the ED, or perceived or real difficulties with access to primary or community mental health services.

Previous studies of ED utilization, particularly among repeat users, suggest that an important contributor may be unmet health needs and lack of access to more appropriate settings.

Traditional evaluation of interventions aimed at addressing pediatric mental and behavioural crises often neglect the wider system implications, both up- and downstream. We will present an emerging program of research aimed at a system-level understanding of the contribution of poor access to primary care and outpatient mental health services to increasing pediatric ED mental health presentations and implications for patient outcomes. We will discuss opportunities and challenges in utilizing data from disparate and often incomplete sources in a Canadian Province to inform pediatric mental health services. Dynamic simulation modelling methods offer tools for estimating the consequences of health care delivery interventions in the absence of complete data while incorporating patient-, service-, and system-level interactions and outcomes in a highly complex environment.

S2C.2

«FLOATING PATIENTS» METHOD BASED ON SCHEDULING ALGORITHM FOR EMERGENCY DEPARTMENT'S SERVICE IMPROVEMENT

Guy Wachtel, Amir Elalouf

Abstract

Overcrowding in hospitals along with long length of stay, high arrival rates, budget constraints, and increasing demand for high service quality create challenges for the workflow and patient flow of hospital emergency departments (EDs). In order to prevent Overcrowding, we assume that the hospital management determines a maximal (fixed or dynamic) value for patients' length of stay and for crowding levels in the various departments, and that patients who cannot be evaluated in the ED in a timely fashion are redirected for treatment in other hospital departments. The latter approach, referred to as the «floating patient» (FP) method, was already presented in ORAHS2014 and followed by published article in Operations Research for Health Care (2015). This research proposes a development of this FP method, and a use of queuing theory models with addition of a secondary server, such as treatment chairs.

Two algorithmic approaches are designed to enable ED decision makers (specifically, in the triage) to optimally schedule evaluations for patients who are waiting for treatment in the ED. The algorithms have been developed grad-

ually and embedded in a simulation model. To build the algorithms, we first solve a problem in which the triage decision maker has full information on patients' conditions and on how long their evaluations expect to take. We then extend this problem to incorporate uncertainty as in real life scenarios: The triage decision maker needs to carry out initial examinations to obtain information on the patient's situation and, at each point in time, decides whether to continue to examine patients or to stop the process (halting rule) and «float» the remaining patients to other departments. Next, the physician determines the optimal schedule for the full ED evaluations of the examined patients.

The new addition in the current FP method is that it can deal with patients who are expected to arrive at the ED. The new technique takes into account several factors of importance: patient's severity, the uncertainty about the patient's condition, and the effect of crowding on the treatment time. We propose a Pseudo-polynomial time algorithm and a new efficient FPTAS with O((n^3)/epsilon) complexity to solve this problem. We inserted the algorithms into simulation procedures and ran simulations using empirical data. The simulation took into consideration also the crowding situation in the other departments in order to see the marginal effect of the FP method of the patients-flow in the hospital as a whole system. Implementation of the FP method is shown to reduce patients' length of stay, queues for beds in departments and the ED, and cumulative treatment time in the ED. These improvements reflect a better balance of work-rate and crowding between the ED and the other departments.

At the time of the presentation a first major application of our FP method combined with the use of treatment chairs as secondary server is about to be applied in one of the big EDs in Israel. We discuss first notes from the building process of the method and algorithms to the applications in practice

S2C.3

BIG DATA SUPPORTING PUBLIC HEALTH POLICIES: ASSIGNMENT POLICIES FOR A REGIONAL NETWORK OF EMERGENCY DEPARTMENTS

Roberto Aringhieri, Davide Dell'Anna, Davide Duma

Abstract

A defining characteristic of today's data-rich society is the collection, storage, processing and analysis of immense amounts of data. This characteristic is cross-sectorial and applies also to healthcare. Big Data is generated from

an increasing plurality of sources and offers possibilities for new insights, for understanding human systems at the systemic level to develop personalised medicine, prevent diseases and support healthy life.

The Emergency Department (ED) is responsible to provide medical and surgical care to those patients arriving at the hospital in need of immediate care. At the regional level, the EDs system can be view as a network of EDs cooperating to maximize the network outputs (number of patients served, average waiting time...) and outcomes in terms of the provided care quality.

Many EDs, especially those serving a large amount of people, complain about the large number of non-urgent patients usually transported by the Emergency Medical Service (EMS) ambulances. Further, EMSs usually do (or can) not take into account the ED workload level when assigning and transporting a patient to an ED.

In this talk we discuss how quantitative analysis based on big data in healthcare can provide a tools to evaluate the assignment policies by ambulances to the regional network of emergency departments: the basic idea is to exploit clusters of EDs in such a way to distribute the workload among them. We present a simulation model of the ED regional network of the Regione Piemonte, Italy. The model is powered by the knowledge provided by the analysis of regional big data.

16:30-18:00

SPECIAL SESSIONS

SS_A

ENGAGING HEALTHCARE MANAGERS AND PRACTITIONERS THROUGH OM/OR EDUCATION

Chair **Erwin Hans**

Participants in the discussion panel:
Angela Testi, Sally Brailsford, Michael Carter, Mariel Lavieri and Erwin Hans

Abstract

Getting healthcare managers and practitioners involved in your research is essential to take on problems that are relevant to practice, and to have a chance of actually making an impact in practice. Teaching healthcare OM/OR courses to healthcare managers and practitioners is a fun and rewarding way to get

them enthused to collaborate. This session is aimed at sharing experiences of ORAHS participants who have done/are doing this in their countries, amongst each other, and with other ORAHS participants who would like to do this. The session consists of short presentations of experiences in various countries, followed by a (panel) discussion.

SS_B

SMART HEALTH

Chair **Luis Serrano**

SS_B1

IMPACT OF WIRELESS TECHNOLOGIES IN HEALTHCARE ENVIRONMENTS

Silvia De Miguel-Bilbao, Victoria Ramos

Abstract

The significant progress in wireless technologies has caused a great growth of personal communications. There has been a significant impact due to the rapid expansion of mobile communications and wireless networks for voice, picture and video transfer, internet access and other data transfer applications. The development of wireless communications has affected almost every day-to-day activities, such as household activities, occupational, leisure, sports, displacements, healthcare activities, and even human relationship, which has caused an increasing interest in ubiquitous communications.

In particular, in healthcare environments, the growth of wireless communication systems has improved the efficiency of patient care and health management. It must be highlighted the following scenarios of applicability of wireless networks in healthcare environments:

- Hospital management networks: the network infrastructure of hospitals not only provides typical data transfer services (intranet, email, web connectivity, corporate hospital services, etc.), but it also provides a wide variety of medical applications, such as: storage, patient information treatment and processing, images and video transfer, access to medical records, etc.
- Networks of homecare, and telecare services: an intrinsic feature of mobile applications is the ubiquity, being possible the assistance and patient care avoiding the associated costs, as patient movement. Be-

longing to this type of networks, it is worth noting portable devices of telemetry to monitor vital parameters: heart rate monitor, pulsioximeter, scales, etc., provided with Wi-Fi or Bluetooth (BT) wireless communication interfaces, being possible to transmit an alarm to the central server when an abnormality is detected.

– Ubiquitous healthcare networks: patient care is performed regardless the location of the patient. Personal area networks (PANs) are formed by telemetry sensors, and a device that acts as a gateway or router, such as a smart phone that collects information from the sensors to send it to the control center. This type of networks provide patient care in an outdoor environment, and can be considered as a smart health (sHealth) solution: personal and environmental sensors works together, and eHealth solutions fusions with the smart city facilities and services.

The new systems of communication based on emerging wireless technologies facilitate interaction between people, objects together, and between people and objects, anywhere and anytime. New concepts have been coined, such as internet of things (IoT) and machine-to-machine (M2M).

On the other hand, the expanding of the use of new communications applications based on wireless technologies has involved the increase of the levels of electromagnetic fields (EMF) in healthcare environments. EMF are generated by a great range of radiation sources, such as electrical equipment, personal communication devices, office equipment and consumer products. The use of wireless communications affects the electromagnetic environment, and as consequence, there is an implicit need to assure the safety of patients, professional and general public, as well as the correct working conditions of electric and electronic equipment and electromedical devices. The new wireless healthcare systems require the assessment of the impact of exposure levels to ensure the compliance with the established standards of protection of the health.

SS_B2

SMART HEALTH REVISITED: A POLYSEMIC CONCEPT UPDATED AND MADE SIMPLE

Agusti Solanas

Abstract

The terms Smart Health or Smart Healthcare are understood differently within research communities depending on their background, scope, and areas of

expertise. At a given time, the term «smart» was a buzzword able to confer an aura of cutting-edge technology to almost every imaginable noun, namely smart transportation, smart grid, smart economy, smart society, smart city, and so on. Some of those nouns have been adopted by research communities and some others have even become commonly used. For example, the term Smart City is relentlessly used by politicians and administrators, even when some of them do not know, and only imagine, what it actually means.

As a result of this loose utilisation of the adjective «Smart», research communities coined similar or even identical terms that, in the best case had similar meanings but were mostly disjoint in the worst. After about two years from the consolidation of the Smart Health paradigm there are still several (understandable) misconceptions about its meaning and scope, and there is a need for a thorough review that helps to build a unified, consistent and widely accepted view.

In this article, we explore the diverse faces of the polyhedral concept of Smart Health and we suggest a unifying definition. Moreover, we analyse the current state of development of the concept, its opportunities, its challenges, and its interactions with the emerging and hot topic of the Internet of Things, which promises unlimited connectivity amongst billions of (let me say it) «smart» and «not-so-smart» objects and devices, from «smart watches» to «smart diapers». Also, we briefly introduce the concept of Cognitive Healthcare as the evolution of Smart Healthcare within cognitive environments and discuss its technical and societal challenges.

SS_B3

TECHNOLOGICAL ASPECTS IN THE IMPLEMENTATION OF CONTEXT AWARE HEALTH SCENARIOS

Francisco Falcone

Abstract

One of the key elements to enable context aware environments is the capability to provide seamless communications on the move, anytime and anywhere. Wireless communication systems are one of the primary tools in order to achieve full connectivity, at different communication scales, from biomedical signals coupled to a local gateway device to real time interconnectivity with health/social specialist. Multiple wireless communication systems can be involved in a heterogeneous network architecture, in which ergonomics, batery

time, required bandwidth and latency are some of the issues to be analyzed in order to provide adequate service levels.

Moreover, interoperability is compulsory in order to guarantee operation whilst allowing simple user operation. In this work, multiple wireless communication systems and their application to specific health scenarios will be presented, in order to highlight potential benefits as well as limitations. An overview of future solutions, such as D2D integration within 5G networks will also be presented.

SS_B4

IMPLEMENTATION OF AAL AND SOCIAL SENSOR NETWORK SOLUTIONS

Luis Serrano

Abstract

One of the main goals within health systems is to achieve sustainability whilst increasing quality of living of users. In this sense, multiple solutions have been envisaged in order to implement e-health/m-health platforms, which enable Ambient Assisted Living environments. Moreover, an extension to AAL platforms can be proposed, in which not only tele-monitoring of biomedial signals is performed, but also behavioral parameters of users are taken into account. In this context, a new solution, termed as Social Sensor Networks is proposed, in which a combination of devices (infrastructure embedded as well as wearable) is employed in order to correlate biomedicial signals with user behavior pattern estimators, such as water usage, energy usage or location as a function of time.

In this work, the result of several research projects leading to AAL and Social Sensor Networks will be presented, in which the technical background as well as the potential benefit of the solution will be described.

TUESDAY

09:00-11:00

SESSION III

SESSION III A

WORKFORCE PLANNING

Chair **Michael Carter**

S3A.1

OPTIMAL STAFF DISTRIBUTION AT BLOOD COLLECTION SITES

Sem van Brummelen, Wim de Kort, Nico van Dijk

Abstract

Sanquin is responsible for the collection and distribution of blood and related blood products in the Netherlands. Especially blood collection is a labor intensive process. For every 2 to 3 blood donations, 1 working hour by a staff member at a collection site is required. This is solely the staff time that is required at the collection site for the donation, and does not including all additional activities, such as the medical check at the first visit or efforts to recruit donors. As this is a labor intensive process, it is important to use staff as efficient as possible.

Using staff efficiently is made complicated by the stochastic nature of random arrivals of donors to the collection site and arrival patterns of these donors. Donors do not come in uniformly throughout the day, but instead show clear preferences for specific times of the day. When a donor arrives, three phases can be distinguished during the blood donation process: the registration phase, the interview & test phase and the donation phase. Most staff members at blood collection sites are multi-skilled, i.e. they are able to work at each of these three phases. Sanquin does not fully exploit the advantage this flexibility could give. Staff members rarely switch between these phases during a shift. It thus seems appealing to reduce waiting times and queue lengths by optimally using this flexibility of staff members.

To this end, a Markov Decision Process has been developed that models a blood collection site. Not just the stochastic nature, but also the pattern of the arrivals has been taken into account in this model. Based on the current state of the process, at any time the model computes an optimal distribution of the available staff members over the three phases.

The optimal policy can save up to 30% on the expected total number of donors at the collection site, whilst maintaining the same number of donations within a session. Focusing on queue lengths, even larger improvements can be achieved. In addition, more practical and fairly simple policies, such as a staff distribution proportional to current queue lengths or proportional to current workloads at each of the phases, can be shown to save up to 20% on the expected total number of donors at the collection site.

S3A.2

NURSES AND NIGHT SHIFTS: RELATIONSHIP AND ASSIGNMENT UNDER BURN-OUT CONSIDERATIONS

Chunmeng Zhou, Na Geng, Andrea Matta

Abstract

Nursing service is a critical link in the health care service chains. The quality of nursing service is closely related with patient treatments, medical operation and hospital management. Personnel scheduling, especially for nursing staff in health service has received huge attention from the operations research community for more than fifty years. Nurse rostering is an NP-hard combinatorial problem determining the number of nurses and their work schedules that minimize labor expenses while considering labor rules, institutional constraints, individual preferences and labor ergonomics over different time horizons.

The nurse rostering problem is very well known in the operations research (OR) community and originated a significant number of related papers discussed also in some dedicated conferences. However, OR studies have not considered the factor of burnout level of nurses into nurse rostering planning. In the nursing community, burnout syndrome has been the heating point over the last decades. Burnout is a chronic and job-related state causing psychological and physical dysfunction within an individual. Exposed to death and illness, involved in highly stressful work environment and faced with inevitable regular shift work, nurses are more likely to suffer psychological stress and physical fatigue, which can reduce working efficacy and influence patients' nursing outcome.

Incorporating burnout into the rostering problem is the main goal of this research, which aims at a) quantifying the relationship existing between night

shifts and burnout level as measured by MBI (Maslach Burnout Inventory) b) designing methods and algorithms for nurse rostering planning considering individual burnout level of nurses. Indeed, in addition to considering the satisfaction of traditional constraints such as work regulations, patients' demand coverage and personnel preferences, the developed methods will aim at alleviating individual burnout syndrome, improving the psychological and physiological well-being of nurses while minimizing labor expenses.

Specifically, a dynamic programming model is presented to assign to nurses the number of night shifts that minimizes a cost function of the burnout state, the number of night shifts and the resource underutilization. The result of this model will represent a constraint for the rostering problem, which is not considered in this specific communication.

S3A.3

FORECASTING THE MEDICAL WORKFORCE: A STOCHASTIC AGENT-BASED SIMULATION APPROACH

Mário Amorim Lopes, Álvaro Santos Almeida, Bernardo Almada-Lobo

Abstract

Starting in the 50's, health care work-force planning became a major concern for researchers and policy makers, since an imbalance of health professionals may create a serious insufficiency in the health system, and eventually lead to avoidable patient deaths. As such, methodologies and techniques have evolved significantly throughout the years, and simulation, in particular system dynamics, has been used broadly. However, tools such as stochastic agent-based simulation offer additional advantages for conducting forecasts, making it straightforward to incorporate microeconomic foundations and behavior rules into the agents. Surprisingly, we found no application of agent-based simulation to healthcare workforce planning above the hospital level. In this paper we develop a stochastic agent-based simulation model and apply it to the Portuguese physician workforce. Moreover, we study the effect of variability in key input parameters using Monte Carlo simulation, concluding that small deviations in emigration or dropout rates may originate disparate forecasts. We also present different scenarios reflecting opposing policy directions and quantify their effects using the model.

S3A.4

NURSE SCHEDULING AND RISK ANALYSIS OF HEMODIALYSIS PATIENTS

Michael Carter, Mahsa Shateri

Abstract

Kidney failure patients require dialysis treatment 3 times a week until a suitable donor is found. During dialysis, nurses monitor several patients at once, but when complications occur, a nurse must be available quickly to attend to the problem and restart dialysis. This paper provides a model to determine the minimum staffing levels required in order to deliver safe, effective care.

SESSION III B

HEALTH ECONOMICS AND DECISIONS (BLOOD DELIVERING) (I)

Chair **Francisco J. Santos**

S3B.1

CLOSING THE IMMUNIZATION GAP: THE ROLE OF IMPACT INVESTING

Teresa León, Vicente Liern, Blanca Pérez-Gladish

Abstract

Immunization prevents 2 to 3 million deaths annually. However, approximately 1 in 5 children worldwide has not access to routine immunizations for preventable diseases, such as diphtheria, pertussis and tetanus. In 2012, the World Health Assembly supported the Global Vaccine Action Plan 2011-2020 (GVAP) including six strategic objectives: all countries commit to immunization as a priority; individuals and communities understand the value of vaccines and demand immunization as both their right and responsibility; the benefits of immunization are equitably extended to all people; strong immunization systems are an integral part of a well-functioning health system; immunization programs have sustainable access to predictable funding, quality supply and innovative technologies and, country, regional and global research and development innovations maximize the benefits of immunization. As remarked by the World Health Organization, only 1 out of these 6 strategic objectives is currently on track: the introduction of new or underutilized vaccines in low- and middle-income countries. The objective of this work is to show how impact investing can be an adequate instrument to reach one of those strategic objectives: sustainable access to predictable funding, quality supply and innovative technologies.

The Global Impact Investing Network (GIIN) defines impact investments as «those investments in companies, organizations and funds that are intended to generate social and environmental impacts and to achieve a financial return». In recent years there has been a significant acceleration in the market growth of impact investing. This market provides capital from private sources to address many pressing global challenges such as access to basic services as health. Governments have, therefore, an essential role in supporting the development of this market by improving the risk/return profile of investments through access to credit facilities, tax credits or subsidies or defining the regulation of the supply of investments, provision of technical assistance to investing private companies and co-financing.

Policy makers, regulatory bodies and national decision makers should base their decision making processes on multiple criteria. These criteria are, by nature, imprecise, ambiguous and uncertain. In this work, we will develop a decision making tool within the framework of multiple criteria decision making and Fuzzy Logic, which will allow project selection for impact investing focusing on the reduction of immunization gap, the lemma of the World Health Week 2016 drawing attention over the urgent necessity of improving vaccination coverage. In particular, we will use multiple criteria decision making methods for the ranking of investing alternatives, such as the Technique for Order of Preference by Similarity to Ideal Solution, TOPSIS. In our opinion, impact investing can play a key role in the reduction of immunization gap offering suitable strategies for both, governments and private investors.

S3B.2

AVOIDING REGRETTABLE CHOICES VERSUS IMPROVING EXPECTED UTILITY: SEQUENTIAL SEARCH DECISIONS AND THE VALUE OF THE INFORMATION ACQUIRED

Debora Di Caprio, **Francisco Javier Santos Arteaga**, Madjid Tavana

Abstract

Most real-life decisions are made with imperfect information regarding the available choice alternatives and there is often some opportunity for the decision maker (DM) to acquire additional information in order to increase the quality of his decision. Given the increasing number of alternatives to choose from, DMs must carefully select the information acquired so as to make sound decisions that they do not regret in the future. This selection process includes

everyday life decisions but it must be particularly accurate when considering health-related choices.

Consider a rational DM who must acquire a finite amount of information sequentially about a set of alternatives whose attributes are grouped in two differentiated categories. For example, one can think of the potential benefits and risks associated with a given treatment and its different alternatives or those associated to the choice of a hospital or a given medical specialist.

We study the sequential information acquisition process of a rational DM when facing a set of different health- related alternatives involving potential regret. This process is determined by the capacity that information has to prevent a DM from regretting his current decision. That is, after acquiring an observation, the DM has to recalculate the probability of improving upon the alternatives already observed with the next observations available. Then, he must consider the value that the following piece of information has in determining his choice. Three different definitions of information value will be considered, leading to three different potential scenarios. A piece of information is valuable if:

- It induces a reversal in the choice of the DM. That is, if after acquiring the information the DM chooses an alternative different from the one he would have chosen without it.
- It allows the DM to confirm the suitability of his choice – over a randomly chosen alternative – or to improve upon it.
- It allows the DM to choose without any regret. For example, given three possible choice alternatives, information is valuable if it prevents the DM from either choosing an alternative that turns out to be worse than any of the other two, or rejecting an alternative that turns out to be better than the others.

We construct two real-valued functions determining the decision of how to allocate each available piece of information. The information acquisition process of the DM depends on the potential value of the information acquired, his attitude towards risk and his subjective preference for either preventing regret or improving the expected utility derived from a given alternative.

We provide several numerical simulations to illustrate the main properties of the resulting information acquisition incentives determining the behavior of the DM. The model can be easily extended to account for the reception of signals on the distribution of the characteristics defining the different alternatives. In this case, the effects derived from the provision of reassuring information by hospitals and health specialists on the information acquisition and choice behavior of DMs can be easily analyzed.

S3B.3

BALANCING PATIENTS' NEEDS, BLOOD SUPPLY REQUIREMENTS AND COSTS FOR OPTIMAL PREVENTION OF BLOOD GROUP ALLOIMMUNIZATION: THE «BLOODMATCH» PROJECT

Joost van Sambeeck, Mart Janssen, Wim de Kort, Ellen van der Schoot, Masja de Haas, Marian van Kraaij, Rianne Koopman, Henk Schonewille, Jessie Luken, Anne van Dongen, Katja van den Hurk, Puck de Wit, Barbera Veldhuisen, Anske van der Bom

Abstract

Although red blood cell transfusions are lifesaving and can be considered as safe, adverse events cannot be avoided completely. Of these adverse events, alloimmunization (the formation of antibodies as a result of incompatible blood transfusions) is the most frequent. Whilst completely antigen matched donor blood would nullify the alloimmunization risk, this is practically infeasible because of the >300 known blood group antigens. Current matching policies require matching for a limited number of antigens only, and are applied for specific patients groups with a higher risk of alloimmunization. These policies have evolved over time based upon expert opinion aimed to reduce antibody development against those antigens for which (serious) lloimmunization complications most frequently occurred.

An optimal matching strategy for controlling the risk of alloimmunization would balance alloimmunization complications and costs, whilst fulfilling practical limitations of the blood supply chain. Since any matching strategy will either directly or indirectly affect all components of the blood supply chain, an integrated approach is required to establish an optimal matching strategy. Such an integrated model should incorporate costs of donor recruitment, donor blood typing, inventory management, logistics, patient blood typing, and alloimmunization complications in transfusion recipients. Besides costs the effects of transfusion complications on patients' health should also be taken into account. As the current matching strategy has been guided by transfusion incidents without systematically considering all consequences of such strategies, room for improvement is very likely.

The integrated blood management model will increase transparency in costs and effects of various matching strategies for blood transfusion, which is expected to contribute to an improved efficiency in blood transfusion practice.

S3B.4

DESIGNING THE BLOOD SUPPLY CHAIN: A LOCATION-ALLOCATION MODEL WITH COLLECTION AND PRODUCTION CONSIDERATIONS

Andres Felipe Osorio, Sally Brailsford, Honora Smith

Abstract

Different topologies of the blood supply chain can be found around the world. The design of the network might depend on factors such as geography, policies, costs, and service levels; however, developed countries have aimed to centralise facilities such as production centres. This centralisation has occurred together with the creation of distribution centres, to maintain the service level, as well as meeting distance and time constraints. A large body of literature exists concerning location-allocation problems in general; however, only few publications deal with the blood supply chain. Furthermore, most of the location-allocation models in the blood supply chain have not considered important aspects, such as collection and production alternatives and multiple products that might have an impact on the optimal design of the network. To support decisions such as location, allocation, capacity definition and collection and production strategy, a mixed-integer linear programming is proposed. This model includes multiple constraints such as capacity, demand fulfilment and distance covering. The model seeks to optimize total cost of designing the complete blood supply chain. The proposed methodology is evaluated using actual information from Colombia.

SESSION III C

PATIENT SCHEDULING (I)

Chair **Angel Ruiz**

S3C.1

RECURSIVE LOGIC-BASED BENDERS' DECOMPOSITION FOR MULTI-MODE OUTPATIENT SCHEDULING

Leonardo Lamorgese, Atle Riise, Carlo Mannino

Abstract

Efficient outpatient scheduling is becoming increasingly important for the overall cost effectiveness and treatment efficiency of a hospital. We consider a class of multi-mode appointment scheduling problems, with variable resource availability and resource setup times. These problems frequently arise in hospital outpatient

clinics, and they are typically hard to solve. We present an exact method based on a recursive logic-based Benders' decomposition, where each subproblem is formulated as an integer linear program. We show how such a decomposition can be designed to fully exploit the daily structure of these problems, while at the same time addressing the symmetry issues that arise from having many appointments with similar resource and time requirements. Novel valid inequalities are also added to strengthen each master problem. We demonstrate the efficiency of the overall approach through a case study from a gastroenterology clinic at the University Hospital of Northern Norway, using real-life data. The computational results show that the recursive, three-level, decomposition solves the most complex real-life test instances to optimality in less than 5 minutes. The method drastically outperforms the corresponding two-level decomposition, which fails to solve all but one of these test instances within the 1 hour time limit.

S3C.2

A DYNAMIC INTEGRATED FRAMEWORK FOR SURGICAL PATIENTS' PRIORITIZATION

Samira Abbasgholizadeh, Rahimi, Angel Ruiz, Afshin Jamshidi, Daoud Ait-Kadi.

Abstract

Waiting list management and appropriate patients' prioritization can play an important role in diminishing undesirable outcomes, such as patients' injury or mortality. Several researchers stressed the need for an interdisciplinary and collaborative research to explore systematic and precise prioritization framework. We seek to answer that call by proposing a general and integrated framework able to prioritize patients in complex dynamic systems, taking into account multiple decisional criteria, considering both medical staff and patient's opinions, risks, uncertainties and incomplete information.

In particular, this study reviews current patients' prioritization systems and presents a three-steps decisional framework in an attempt to overcome their limitations. The first step establishes relative importance among the selected criteria and risks, structuring them according to the stakeholders' objectives. In the proposed framework, a Fuzzy – multi-criteria decision making technic (MCDM) approach is proposed to determine the weights of different criteria and risks by considering several health professionals' opinions. It should be noted that, in order to handle the associated uncertainties in mapping of decision maker's qualitative and quantitate judgments, fuzzy logic is

used to accept semantic evaluations or assessments. The second step focus in the assessment of patients and it is done at the arrival of the patient. Patient assessment is performed on every criterion and risk situation elected in Step 1. It is worth mentioning that our framework proposes a Group-decision making approach (GDM) to integrate the evaluation of several experts on each criterion and risk to produce a patient's score. Then, a Min-Max regret approach is used to produce a ranking of the patients. The third step deals with the dynamics and evolving aspects of the waiting list system. This step is performed frequently (once a week or every two weeks) according to the rate of arrivals

and departures of patients to the list. It uses two dynamic factors, namely Delay Ratio and Risk-criteria score, aiming to capture the evolution of patients to update their position in the list if required. Last, a Risk-Delay matrix is used to visually support decision making.

The new framework has been implemented in the Orthopedic Surgery Ward, Shohada University Hospital, Iran, and very promising results have been achieved. In particular, surgeons that participated in the study concluded that the method is able to produce precise and reliable prioritization, and it is more effective than the currently used prioritization method.

S3C.3

SCHEDULING OF MULTIDISCIPLINARY CANCER CLINICS

Greanne Leeftink, Ingrid Vliegen, Erwin Hans

Abstract

One third of the Dutch population will be diagnosed with cancer during their life. Due to advanced diagnostic tools, the ageing population, and an increase in patients with comorbidity, cancer diagnostics becomes more and more complex. Furthermore, the timeliness of cancer care is of increasing interest of patients, care providers, and society. Traditionally after a diagnosis is given by a surgeon, patients get an invitation to come to the hospital on another day for appointments with referring specialists to discuss their treatment plan. Currently, many hospitals start multidisciplinary clinics to assure timely care. In such a clinic, multiple specialists with different backgrounds work together as a team. These clinics are designed in such a way that a patient can visit both the radiotherapist and medical oncologist before deciding about his or her preferred treatment, and visit the nurse practitioner afterwards for aftercare, all at the day of diagnosis and depending on the patient's need.

The planning of these multidisciplinary clinics asks for flexibility of all involved specialists. The referring specialists have to treat their own, regular patients next to the multidisciplinary patients. Since it is unknown when the multidisciplinary patients arrive, a balance between appointments and empty spots for multidisciplinary patients should be found. Since the appointment schedule of the diagnosing specialist determines the referral rate to the referring specialists, their appointment schedules should be jointly optimized.

The objective of this study is to develop a blueprint appointment schedule for the initial specialist and the referring specialists, in order to optimize the waiting time for the patients and the utilization and overtime of the specialists. We show this problem can only be analytically solved for small problem instances. Therefore, we develop a novel local search heuristic to handle real-life instances, for the joint optimization of the two appointment scheduling phases.

We apply this methodology to a case study of the Hepato-Pancreato-Biliary (HPB) clinic of a large academic hospital in the Netherlands. Results show a trade-off between patient waiting time and specialist performance of multidisciplinary clinics.

S3C.4

MANAGING INTRAHOSPITAL PATIENT TRANSPORTATION

Valérie Bélanger, Angel Ruiz, Maxime Painchaud

Abstract

Clinical pathways consist of a sequence of heterogeneous medical activities that can be performed at several locations within the health system. Along his/her pathway, the patient having limited mobility often requires to be transported from one location to another for diagnosis or therapeutic reasons. If transportation is needed between units in the same building, patients are generally transported by trained personnel using stretchers or wheelchairs. On the other hand, if transportation is needed between buildings of a same institution, patients are rather transported by ambulances. In all the cases, patient transportation activities need to be planned carefully in order to maximize (1) patient confort and well-being, (2) efficiency in the use of the granted ressources (stretchers, vehicles, etc.), and (3) the reliability of medical activities' execution (e.g. schedule of operating theaters or magnetic resonance imaging services).

Throughout a day, transportation requests having different priority levels and requirements arrive in real- time. Only few of them are known in advance,

which complicates the decision-making process. At the moment a request is received, the time at which it is treated and its exact duration are also uncertain, being affected by several decisions. Among these decisions, we can mention the patient transportation process, the policies to rule priorities between requests, the number of resources dedicated to patient transportation, and the allocation of requests to available ressources. The objective of a patient transportation system should be to ensure that each patient is at the right place at the right time, and properly prepared so all the medical activities can be performed without any unwanted delay. Intrahospital transportation planning is therefore a very challenging problem that needs to be addressed carefully.

In this study, we focus on intrahospital transportation of inpatients having limited mobility, and present the practical context of a canadian hospital. More precisely, this study proposes a dispatching and scheduling strategy that takes into account medical requirements while maximizing patient comfort and transport efficiency. To do so, we first review common practices with respect to patient transportation including specific management problems, and analyze intrahospital transportation needs in a practical setting.

Secondly, we propose a dispatching and scheduling strategy to support the planning of transportation activities in a highly dynamic and uncertain context. Finally, we propose a simulation tool to analyze and compare the performance of the proposed strategy.

11:00-12:00

POSTER SESSION (I)

12:00-13:00

PLENARY CONFERENCE

ENABLING CONTEXT AWARE ENVIRONMENTS: TOWARDS SMART HEALTH PROVISIONING

Francico Falcone

Abstract

One of the main challenges humanity is facing is the optimal use of resources, which becomes particular interest in the case of dense urban scenarios, such as cities. The projected forecast of population settlements indicates that by 2050, nearly 70% of the inhabitants of the world will be residing in cities. This poses

serious concerns in terms of achieving sustainable urban environments. In this sense, the paradigm of Smart Cities and its extension to Smart Regions provides the required resource sustainability by means of handling multiple systems and resources in a coordinate way, such as transportation systems, waste management, water management or electric distribution systems, to name few. This leads also to the interaction and inclusion of higher -level citizen-oriented services, such as management and provision of health-oriented services in a global sense. Moreover, optimal performance can be achieved when user are enabled to interact with the surrounding environment, providing feedback as well as reactive capabilities to the overall systems. In this sense, wireless communication systems play a key role in providing seamless user real time interaction. The large increase in the number of wireless transceivers, the higher capacity demands and the new operation scenarios within the IoT framework lead to the use in the near future of Heterogeneous Network architectures, in which thorough wireless system planning and analysis is compulsory.

In this talk, we will explore the new trends and systems employed in order to provide context aware environments, as well as the challenges faced in different types of context and scenarios, from Intelligent Transportation Systems to Smart Health provisioning.

14:30-16:00

SESSION IV

SESSION IV A

DISEASE MODELLING AND POLICY (II)

Chair **Mariel Lavieri**

S4A.1

ENDOSCOPY MODELLING

Richard Guerrero-Ludueña, Sally Rickard, Matt Hayes, Robert Radford, **Caroline Powell**, Sally Brailsford

Abstract

Context: One of the strategic aims of Wessex Cancer Network is to increase early detection of cancer and thereby reduce premature mortality. Our endoscopy modelling work supports planning to meet future demand for endoscopy services in Wessex.

Outcomes: Wessex-wide activity currently utilises approximately 70% of existing capacity (range from 41% to 94% across hospitals). A 5 year projected increase of 28% (due to population growth, new FOBT screening programme) could be accommodated within Wessex.

Achievements: Development of a computer-based Endoscopy Service Planning Tool for providers (a 'what if' scenario analysis).

Colorectal cancer diagnostic pathway modelled.

Wessex endoscopy activity, capacity and future demand quantified (by endoscopy unit and CCGs). Planned impact 2016-18:

Wessex wide model: Supporting a major NHS transformational project across Wessex, aiming to describe the activity, capacity and demand of all diagnostic services supporting cancer patient pathways.

Across provider model: Undertaking detailed modelling of services for all endoscopy providers in Wessex in order to manage future demand, improve patient experience and resource utilisation.

S4A.2

ESTIMATING THE EFFECT OF THE INPUT PARAMETERS' UNCERTAINTY IN THE COST-EFFECTIVENESS ANALYSIS OF THE BREAST CANCER SCREENING PROGRAMME IN THE BASQUE COUNTRY

Arantzazu Arrospide, Montserrat Rué, Nicolien T. van Ravesteyn, Mercè Comas, Myriam Soto-Gordoa, Garbiñe Sarriugarte, Javier Mar

Abstract

Since 1996 screening mammograms have been done in a biennial basis to women aged 50 to 69 in the Basque Country (Spain). Based on epidemiological observations and simulation techniques it is possible to extend observed short term data into anticipated long term results. In addition, such a mass preventive intervention must be evaluated also in economic terms to warrant that the allocated resources are a worthwhile investment for the entire population. The aim of this study was the evaluation of the breast cancer early detection programme in the Basque Country from 1996 to 2011 in terms of probabilistic cost-effectiveness analysis and the probabilistic sensitivity analysis.

A discrete event simulation model was built to represent the natural history of breast cancer in women invited to the breast cancer screening programme in the Basque Country. The disease progress was described in three main states: healthy, preclinical and clinical. We estimated for lifetime follow-up the total

cost of BC (screening, diagnosis and treatment), as well as quality-adjusted life years (QALY), for women invited to participate in the evaluated programme during the 15-year period in the actual screening scenario and in a hypothetical unscreened scenario. The probabilistic feature of the model was based on varying the main variables randomly at the same time. Uniform distributions were adopted to vary time between successive invitations and the mean duration of the pre-clinical phase, Beta distributions for sensitivity and specificity of the programme and Dirichlet was the distribution selected for the detection stages classification in screen-detected cancers were the variables we varied in the probabilistic sensitivity analysis. Therefore, we were able to examine the effect of joint uncertainty in these variables through cost-effectiveness plane and calculate the expected value of perfect information.

The actual screening program involved a mean cost of 1,123 million Euros and provided 6.7 million QALYs over the lifetime of the target population, resulting in a gain of 10,110 QALYs for an additional cost of 22.3 million Euros, compared with the unscreened scenario. Thus, the incremental cost-effectiveness ratio was 2,209€/QALY. All the model runs in the probabilistic sensitivity analysis resulted in an incremental cost-effectiveness ratio lower than 10,000€/QALY. The expected value of perfect information associated to a 5,000€/QALY threshold was a population opportunity loss of 163,620€. Cancer stage distribution in screendetected cancers was the variable with greater impact on the final incremental cost-effectiveness ratio.

The BC screening programme in the Basque Country proved to be cost-effective during the evaluated period. No addition research on the main parameters was necessary. These results confirm the epidemiological benefits related to the centralised screening system and support the continuation of the programme.

S4A.3

OPTIMAL SCREENING FOR HEPATOCELLULAR CARCINOMA: A RESTLESS BANDIT MODEL

Mariel Lavieri, Elliot Lee, Michael Volk

Abstract

We model the problem of screening a population at risk for liver cancer when resources are limited and each patient's disease evolves stochastically over time. Using a restless bandit model, we derive an optimal policy for this prob-

lem and discuss insights into what characterizes more effective screening. We then compare the performance of the optimal policy against current screening practices in a simulation built upon historical patient data.

SESSION IV B

HOME CARE / LTC (II)

Chair **Patrick Hirsch**

S4B.1

LOCATION-ALLOCATION PLANNING OF LONG-TERM CARE NETWORKS: ENHANCING MULTI-OBJECTIVE STOCHASTIC APPROACHES WITH NEW HEALTH POLICY OBJECTIVES AND SCENARIO REDUCTION TECHNIQUES

Teresa Cardoso-Grilo, Mónica Oliveira, Ana Barbosa-Póvoa

Abstract

Improving the delivery of long-term care (LTC) is currently a top policy priority across European countries. This is mainly motivated by the growing number of elderly and chronic patients and by a weakening of family support structures, and is especially recognized as relevant in the context of National Health Service-based countries that are facing high budget constraints.

Location-allocation models based on mathematical programming have been shown to be central to support health care planning in general, and LTC planning in particular. In order to be useful in practical settings, such models need to account for the attainment of multiple policy objectives and for the uncertainty associated with the demand and supply of care. Nevertheless, most location-allocation studies in health only consider a small number of objectives, mostly restricted to some equity or cost dimensions. Furthermore, when it comes to the treatment of uncertainty, sensitivity analysis appears as the most commonly used approach. Although stochastic programming models based on scenario planning have also been used in a few studies, their use is seen as prohibitive due to the associated high computational times.

This study contributes to location-allocation planning literature by proposing a multi-objective stochastic mathematical programming model to support the planning of a multi-service network of LTC, both in terms of services'

location and capacity planning, which accounts for: i) a wide range of health policy objectives – further to the maximization of equity of access, socioeconomic equity, geographical equity and equity of utilization and to the minimization of cost, it considers the maximization of health and wellbeing; ii) the impact of uncertainty on planning decisions (namely, uncertainty in the number of individuals in need and in the length of stay of LTC services) through the use of alternative scenario reduction techniques that enable a faster resolution of the stochastic model. In particular, two scenario reduction techniques previously used in general location-allocation literature are explored and compared with a new approach, the Morphol-KMG method. While existing techniques reduce scenario trees strictly based on scenarios' probabilities and/or differences in scenario values, the Morphol-KMG method combines existing scenario reduction methods with scenario planning, thus capturing meaningful information (and fostering the involvement) from experts.

Particularly, this new method ensures that the most representative and plausible scenarios (according to the experts' opinion) are kept in the reduced scenario tree and are considered for planning purposes.

The proposed model has been applied to the LTC network of the Great Lisbon region in Portugal. Its implementation requires the modeling of health and wellbeing improvements to be achieved through LTC provision, with the EQ-5D questionnaire and the ICECAP instrument being used. Results show that the pursuit of health and wellbeing objectives are not in line with equity and cost improvements; and that accounting for uncertainty has a high impact on planning decisions and that using alternative scenario reduction techniques has a high potential to improve the models' computational performance.

S4B.2

ON THE ROBUST HOME CARE PROBLEM

Paola Cappanera, Laura Galli, Maria Grazia Scutellà

Abstract

In this paper we study the Home Care Problem under uncertainty of data.

The term Home Care Services refers to medical, paramedical and social services that must be delivered to patient homes and that represent an alternative to hospitalization. Indeed, the ever increasing age of population and the

consequent need to reduce hospitalization costs while providing patient-centered services, compel medical care units to rely on efficient design of Health Care Services. This topic is relatively new and it represents a very challenging application in Operations Research.

Although the Home Care problem literature is reasonably broad, very few works address the issue of uncertainty in the problem data.

Our goal is to fill this gap, by considering the Home Care problem where caregiver-to-patient assignment, scheduling of patient visits, and caregiver routing are taken into account jointly over a weekly time horizon, and patient demand is subject to uncertainty.

In particular, we use the cardinality-constrained robust framework proposed in the literature to extend in an original manner our joint approach which is referred to as the nominal problem in this study. To the best of our knowledge this is the first time that a robust framework is applied to the Home Care problem, when several kinds of decisions are simultaneously addressed over a multiperiod horizon. More generally, this is the first time that a cardinality-constrained robust framework is applied, in the proposed form, to complex vehicle routing problems such as the one arising in Home Care applications.

The nominal problem we refer to is defined on a complete network where each node corresponds to a patient and an extra node represents the depot. A set of skilled caregivers is given along with their availability in the planning horizon considered (typically a week). The nominal problem asks to (i) assign patients to caregivers guaranteeing the continuity of care and matching the skills of requests and caregivers, (ii) scheduling patients' visits during to the week according to predefined scheduling patterns, (iii) determine a route for each operator in each day of the planning horizon that starts and ends at the depot and respects the workday duration. The objective is to balance the workload among caregivers.

In the robust counterpart, instead, at the moment of planning, skilled requests are classified in «certain» requests and «uncertain» requests: for the former ones we know for sure that they will need to be served, while the latter might be cancelled during the week. At one extreme, if only certain requests are taken into account, service disruptions may arise when uncertain requests occur; at the other extreme, all the requests, both certain and uncertain, are considered in the planning giving rise to a very conservative approach. Our approach aims at trading-off these two extreme solutions and addresses the

case where at most a given number of uncertain visits occurs in each day of the planning period, for each operator. Finally, computational results on real life instances coming from an Italian health care provider are presented and discussed.

S4B.3

HOME HEALTH CARE ROUTING AND SCHEDULING: STATE OF THE ART AND PROMISING FUTURE RESEARCH DIRECTIONS

Patrick Hirsch, Christian Fikar

Abstract

This talk aims at providing a comprehensive overview of current work in the field of home health care (HHC) routing and scheduling with a focus on considered problem settings. Moreover, it presents an outlook on promising future research directions, which is also based on the knowledge of practitioners in HHC organizations.

In industrialized countries, the demand for HHC services is expected to rise significantly during the next years. The main reasons for that are an increased life expectancy, changing family structures, and the trend to grow old at home. Nevertheless, the planning of HHC services is still done manually in most HHC organizations, since suitable decision support tools are missing. This results in high organizational efforts and potentially sub-optimal solutions. These facts underpin the need for an efficient planning of HHC services. HHC routing and scheduling problems have gained substantial interest over the past years. They consider a wide range of regulative and operational constraints as well as diverse objectives. Their formulations and solution procedures differ substantially in literature, since the problems originate from different national and regulatory settings. Important constraints in HHC include time windows, skill levels, working- and break time regulations, precedence, synchronization, uncertainty, or continuity of care. HHC staff may use different modes of transport like bike, bus, tram, metro, or car, which can also be combined. The literature presents solution methods for single- and multi-period HHC routing and scheduling problems that are based on heuristics, metaheuristics, matheuristics, and exact approaches.

Together with partners from HHC organizations, the authors identified promising future research directions. These include stochastic HHC routing and scheduling on a daily basis, integrated multi-stage multi-period planning, multimodality and mode of transport choices, as well as sustainability considerations. Besides, researchers can build on publicly available test instances for some published HHC routing and scheduling problems to develop new solution methods.

SESSION IV C

DATA ANALYSIS &RISK MANAGEMENT (I)

Chair **Fredrik Dahl**

S4C.1

LENGTH OF STAY OUTLIER DETECTION THROUGH CLUSTER ANALYSIS: A CASE STUDY IN PEDIATRICS

Daniel Gartner, Rema Padman

Abstract

The increasing availability of detailed inpatient data is enabling the development of data-driven approaches to provide novel insights for the management of Length of Stay (LOS), an important quality metric in hospitals. This study examines clustering of inpatients using clinical and demographic attributes to identify LOS outliers and investigates the opportunity to reduce their LOS by comparing their order sequences with similar non-outliers in the same cluster. Learning from retrospective data on 353 pediatric inpatients admitted for appendectomy, we develop a two-stage procedure that first identifies a typical cluster with LOS outliers. Our second stage analysis compares orders pairwise to determine candidates for switching to make LOS outliers similar to non-outliers. Results indicate that switching orders in homogeneous inpatient subpopulations within the limits of clinical guidelines may be a promising decision support strategy for LOS management.

S4C.2

EXPLORING PREDICTIVE RISK MODELS FOR INTEGRATED CARE: INSIGHTS AND CHALLENGES

Thierry Chaussalet, Philip Worrall, Salma Chahed

Abstract

In the UK, the National Health Service (NHS) has published its strategic five-year forward view of outlining multiple delivery models which are aimed at improving care and driving productivity by aligning and integrating hospital care, social care, community care, mental health and primary care. The intention is that the NHS, its commissioners and providers will cooperatively design services based on a model of cohort specific integrated care with their own exemplars, risks, benefits and transition cost. As a result of such changes, there is a growing need to increase understanding of the local patient population and in particular, how those in specific risk groups can be identified earlier and more proactively managed.

In this paper, we perform a structured review of the academic and grey literature on predictive risk tools for social care utilisation, as well as admission and readmission to general hospitals and psychiatric hospitals. This is the first phase of a project in partnership with Docobo Ltd and funded by Innovate UK, in which we seek to develop novel predictive risk tools and dashboards to assist commissioners in Clinical Commissioning Groups with the triangulation of the intelligence available from routinely collected data to optimise integrated care and better understand the complex needs of individuals.

S4C.3

ASSOCIATION BETWEEN HOSPITAL OCCUPANCY AND MORTALITY

Fredrik A. Dahl, Joe Viana, Kim Rand-Hendriksen

Abstract

In 2015, a study reported increased mortality in German hospital wards when these had high occupancy rates («Stress on the Ward: Evidence of Safety Tipping Points in Hospitals», Kuntz et al, 2015). One conclusion in this study was that mortality rates appear uninfluenced by occupancy rates up to 92.5% of maximum capacity, but increases rapidly beyond this threshold value.

A methodological challenge lies in the fact that the causal links may be different from the ones assumed. For instance, hospital wards experiencing

high occupancy may more readily discharge the healthiest patients, so that the observed increase in mortality could be due to sicker patients. The study attempts to control for such effects, but they may still be present.

We try to reproduce the German study, using Norwegian data, and will improve upon the methods used, so as to remove more potential sources of error. For each hospital ward, we will calculate the number of patients (the occupancy) for each day in the period of observation. As in the German study, we will use the maximum observed occupancy for each ward as a measure of maximum capacity. Hence, we can measure occupancy over time as a percentage of maximum capacity. This will be the main explanatory variable in our study, and the objective is to determine how this relates to mortality for the admitted patients. We will consider three outcome measures: Mortality while admitted to the ward, 30-day mortality and 90-day mortality.

The first of these is included to replicate the German study, while the other two are more important for estimating the true impact of ward occupancy. For in-ward mortality, we will use regression models for the probability of death for each day, as in the German study. For 30- and 90-day mortality, we will use Cox- models. We will reproduce the German analyses of possible tipping points, but also investigate linear and non-linear associations between occupancy and mortality. In all the models, we will attempt to control for patient mix, as represented by their primary and secondary diagnoses, combined with age and sex. We will represent variation between wards by use of random and/or fixed effects in our regression models.

Additionally, we will include time-related explanatory variables for days of the week, time of year, and time trends. Through use of modeling and simulation, we will investigate the opportunities for avoiding mortality through sharing of resources capacity between hospital wards.

We will use data from the Norwegian Patient Registry from 2009 through today. For each patient stay at a somatic hospital ward, the dataset will contain information on hospital, ward, date of admittance and discharge, the age, sex, and diagnoses, as well as discharge status (dead/alive), and date of death for patients dying within 90 days of discharge.

At the time of writing, we have access to data for Akershus University hospital only, and we plan to present preliminary results.

16:00-17:00
POSTER SESSION (II)

17:00-18:00
SPECIAL SESSION

SS_C
BULL RUNNING IN PAMPLONA: A METHODOLOGICAL APPROACH TO DELIVER THE RISK RESPONSE PLAN

Chair **Javier Belloso**

Abstract

Running in front of the bulls weighing over 500 kilos constitutes a risk practice for the runner and therefore a risk response plan needs to be agreed in order to mitigate the risks involved in the activity. In this talk we will introduce a Methodology to approach the plan to respond to the inherent risks associated to the participation in the run, both proactive and reactively.

At the same time we will try to transmit the essence and heart of the event, not only as a pure risky activity but also as an ancestral tradition that has been performed since XVII century.

We will start with images and comments of the run from inside and the AS IS situation of the stakeholders in relation with the event. Many actors are involved in the run, bulls, runners, surgeons, civil defense workers, security staff, organizers, spectators. A panel of experts in these areas will explain how they are organized in relation with the risks they are exposed.

In order to formally approach the management of the risks, we will then introduce a methodology that is well known in the Engineering applications called Failure Mode and Effect Analysis (FMEA). This will guide us in the identification of risks as well as helping in the qualitative and quantitative analysis. Depending on the risks nature, the response plan strategy will be to avoid, mitigate or even accept some types of risks as part of the essence of the event. The later are associated with the injured people during the run. We will focus in the process of attending these people and triage them in the more efficient and timely manner.

THURSDAY

9:00-10:30

SESSION V

SESSION V A

EMERGENCY MEDICAL SERVICES (I)

Chair **Marion Rauner**

S5A.1

AN INTELLIGENT DECISION SUPPORT SYSTEM ORIENTED TO ATTENTION TO PATIENTS ON THE STREET AND DISPLACEMENT ROUTING FOR NO COMMON EMERGENCIES

Lupe Toscano, Mario De Oliveira

Abstract

The medical professionals who give response in not common emergencies nowadays not only have to face emergencies like floods, earthquakes, extreme cold, etc. they have to face terrorist assault inside the urban area too, so the Emergency Attention To Patients on the street and to get your target on the city quickly became now the difference between live or dead. It is inside this context that the engineering must contribute developing models in order to support medical or paramedical rescue teams. They need to give in a few seconds a rapid, efficient and effective response. In this paper has been modeled the paramedic interaction with the patient on the street as well as an special intelligent model for displacement of the rescue units.

The paramedic attention to patient was modeled by discreet event simulation and the rescue unit displacement by an intelligent routing algorithm implemented in language C. The routing algorithm has interactive knowledge bases for the data searching and a searching intelligent with specific heuristic for the emergency scene. It is important remark that the routing algorithm is a specific model in order to face displacements when a dramatic change has happened very quickly on the route and it is impossible to use conventional routes or take care of the data network.

These models provides a satisfactory vision of the emergency focus on attention to patient on the street and the displacement planning of the rescue units across the city as well as the return to the hospital. Finally we can conclude that rescue teams could use this tool first in the instant of the emergency and get a rapid, efficient and effective response on time and the emergency will be hard supported.

S5A.2

STOCHASTIC ROUTING FOR RELIEF EFFORTS

Maria Elena Bruni, Patrizia Beraldi, Demetrio Laganà, Sarah Khodaparasti, Roberto Musmanno

Abstract

In the last decades, several disasters have caused worldwide millions of victims. Seismic and flood events have affected an enormous number of people. It is therefore evident the need to address the challenge associated with managing a humanitarian relief chain.

An efficient coordination and management of disaster operations, which are the set of activities that are performed before, during, and after a disaster, might prevent loss of human lives, reduce material, economic and environmental losses. An important logistical issue in disaster management is the determination of transportation routes for providing first aids, rescuing people and saving lives. A large number of destination nodes, geographically spread out over the disaster region should be reached in a time effective fashion since the arrival time clearly has an impact on mortality and morbidity.

The aim of this talk is to study a stochastic version of a routing problem arising in the context of disaster management in which the travel times are uncertain and the objective function minimizes the arrival time at nodes. It is easy to recognize that this interesting variant allows to address many real-life situations, where travel speed is not constant since depends on many factors among which roadway capacity and traffic fluctuations.

We study the problem under ambiguity supposing that only the first and the second moment of the probability distribution of the travel times are known.

The introduction of the uncertainty leads to additional severe computational difficulties that need to be addressed from a computational standpoint.

We present tailored heuristic solution approaches able to efficiently solve the problem. Preliminary computational results are presented and discussed.

S5A.3

MANAGEMENT POLICY GAME FOR MASS CASUALTY INCIDENTS: SIMULATION- OPTIMIZATION APPROACHES BEAT HUMAN PLAYERS

Marion Rauner, Helmut Niessner, Walter Gutjahr

Abstract

Due to an increasing number of mass casualty incidents, their high complexity and uniqueness, decision makers of emergency medical services need Operations Research-based policy models for training emergency staff on planning and scheduling at the incident site. We develop a discrete event simulation policy model which is applied by the Austrian Samaritan Organization. By calculating various realistic emergency scenarios from small, simple, urban ones to rather big complex, remote mass casualty ones, our policy model helps enhance the quality of planning and outcome. Furthermore, the organization of an advanced medical post can be improved in order to decrease fatalities as well as quickly treat and transport injured individuals to hospitals.

First, we have analyzed the status quo and derived policy implications for balanced strategies to manage staff of ambulance services for maximizing quick treatment of patients and fast evacuation from the incident site as well as for minimizing the number of fatalities. Second, we conducted an experiment using a realistic predetermined disaster scenario in which players acted as on-site commanders to decide on sending staff to triage, to different treatment rooms for care and on-site transportation, as well as to transportation to hospitals. From these experiments, we derived reasonable benchmark results for our disaster scenario. Next, we combined our simulation management policy game with advanced optimization approaches to further improve scheduling on-site. The simulation-optimization approaches outperformed human players. Furthermore, advanced policy implications for incidence commanders could be derived.

SESSION V B

PATIENT SCHEDULING (II)

Chair **Susan Li**

S5B.1

REVENUE MANAGEMENT MODELS IN PRIMARY-CARE CLINICS

Zhimin Huang, Susan Li

Abstract

Improvement of primary-care clinics has been a priority for many years. Various operations research models have been developed in the literature to improve primary-care efficiency. Primary-care clinics continue to survive and provide quality, indispensable services, only if they recover and profitably reinvest the revenue generated by the wide range of services they provide to a wide range of patients. As waiting times for elective physicians are known to be increasing and waiting queues are piling up, solutions are sought to decrease the waiting times while maintaining an acceptable quality service. For a given clinic, if it schedules too many appointments in advance, capacity shortages problem will arise. If it schedules too few appointments, the patients' wait time will increase, patients and primary care physicians will be mismatched, and the possibility of unused clinic slots is increased. We utilize Markov process and revenue management to develop an optimization model deciding how to allocate the available slots between walk-ins (same-day appointments) and regular patients (advance booking) who may have a preference for both the slot time and their primary care physicians in a given clinic. A numerical example is constructed to illustrate how to implement our model.

S5B.2

CONTROLLING INDIRECT WAITING TIMES THROUGH PANEL MANAGEMENT

Anne Zander

Abstract

Indirect waiting times or access times of patients are an important indicator for the quality of care of a physician. They are mainly influenced by the panel, i.e., the group of patients regularly visiting the physician. The panel is composed of patients with different time demands dependent on their health status. Over

time those demands change, e.g., older patients need more care and patients might also leave the panel. A panel has an expected total time demand per time period. The challenge is to match this demand with the time capacity of the physician now and in the future such that a service level with respect to the indirect waiting time can be assured, e.g., on average patients should not wait longer than 2 weeks to get an appointment. To this aim we use an M/D/1/K/N queueing model including no-shows and the possibility for rescheduling in order to connect the total time demand of the panel with the distribution of indirect waiting times. Here, we assume that panel patients do not make new appointments if they already have an appointment at some time in the future. A service level concerning the distribution of the indirect waiting time can then be transformed into an upper bound on the total time demand of the panel. Having determined this upper bound we manage the panel such that its time demand matches this upper bound now and in the future. To do so, we define criteria to measure the value of a given panel and present integer linear programs to determine optimal panels, the mix of patients to be integrated to reach an optimal panel and to decide about admission for a specific patient request to enter the panel. We use simulation to see if using the queuing model together with the panel management programs yields the expected results with respect to the predefined service level regarding the indirect waiting time. The model can help physicians to decide on a total time demand bound of their panel and to manage the panel in order to maintain a predefined service level with respect to indirect waiting times.

S5B.3

OPTIMIZING THE USE OF HOSPITAL'S CAPACITY TO REDUCE PATIENT WAIT TIMES

Susan Li, Zhimin Huang

Abstract

Hospitals throughout the world face long and increasing wait times for medical services. Excessive delays may be detrimental to patients' health. As a result, there is growing public and patient pressure on hospitals to reduce wait times to acceptable levels. In order for hospitals to continue surviving, solutions are needed to decrease the waiting times while maintaining an acceptable quality service. This paper develops several optimization methods which provide hospital management with insights into the causes for excessive wait

times and the relationship between wait times and capacity. We will show the significant benefits that can be achieved by applying our methods to health-care management. We will provide a numerical example to illustrate the use of our methods to optimize the scheduling of patients with multiple priorities. The study shows that by applying our approaches, wait time targets can be achieved with the use of hospital capacity.

SESSION V C

HEALTH ECONOMICS AND DECISIONS (II)

Chair **Paulus Torkki**

S5C.1

A DECISION-ANALYTIC APPROACH FOR THE OPTIMAL ALLOCATION OF RESOURCES TO DIAGNOSTIC TESTING AND TREATMENT

Yrjänä Hynninen, Eeva Vilkkumaa, Ahti Salo

Abstract

When choosing how to treat a patient, it is important to diagnose the patient's state of health correctly. The likelihood of a correct diagnosis can often be increased by carrying out multiple diagnostic tests. However, from a societal point of view, such tests consume resources which could otherwise be allocated to treatment. Therefore, it is important to allocate resources between testing and treating such that the benefits resulting from better-informed treatment decisions can be expected to offset the negative impact of decreasing the amount of resources for treatment.

The optimal allocation of resources is challenging because it requires the optimization of testing and treatment strategies across the entire population of patients. In particular, it is necessary to define (i) how to divide this population into different risk segments, (ii) how to allocate resources to each risk segment, and

(iii) which tests and treatments to carry out to each segment within these resources. If there are multiple tests, treatments, and testing stages, solving this optimization problem quickly becomes computationally challenging.

We present a decision analytic approach for the optimal allocation of resources between diagnostic testing and treatment. For this purpose, we develop a model for the identification of testing and treatment strategies that

maximize the expected net health benefit for the population subject to limited resources. In particular, we first model the strategy for each risk segment separately by a decision tree in which the risk is updated based on test results using Bayesian methods. The segment-specific non-dominated strategies (i.e., those that maximize the net health benefit at a given cost level) are then solved for different cost levels using dynamic programming. Second, we use zero-one integer linear programming to identify those non- dominated strategies for each risk segment that together maximize the net health benefit of the whole population when this benefit is obtained by integrating the segment-specific benefits over the distribution of these segments in the population.

Our approach helps (i) segment the population and plan which tests and treatments to use for each risk segment at different cost levels, (ii) identify what the optimal allocation of resources between testing and treatment is at different cost levels, and (iii) understand how changes in the level of total resources affect the net health benefit of the population. Such results can be used to support the cost-benefit analysis of adopting new testing or treatment technologies, and provide information for decisions about the appropriate level of investment into the care of a particular disease. Moreover, our model can be used to support clinical decision making by providing suggestions for tests and treatment actions for individual patients. For this purpose, the model could be integrated with a patient data system to establish a platform and to produce automated decision recommendations.

S5C.2

THE UTILIZATION OF BUDGET IMPACT ANALYSIS FOR MANAGING CONTINUOUS IMPROVEMENT OF INTEGRATED ORGANIZATIONAL MODELS FOR MULTI-MORBID PATIENTS.

Myriam Soto-Gordoa, Arantzazu Arrospide, Marisa Merino, Ane Fullaondo, Igor Larrañaga, Esteban de Manuel, Juan Ignacio Igartua, Javier Mar

Abstract

Introduction: An integrated care approach supported by information and communication technologies is being deployed in the

Basque Country, to best respond to the complex needs of multi-morbid patients. Our statistical analysis carried out in Donostialdea County demonstrated that the profile of resource consumption has not shown the expected changes. The fact that no significant differences were found indicates that the

aim of maintaining stability in multi-morbid patients has not been achieved. However, this is just a static view of the situation two years after the initial deployment. Although necessary, this information is not enough to assess the efficacy of the intervention since the way in which health care is organized is considered as a unitary actor, either adapting to the environment or remaining inert. The objective of this work was to apply budget impact analysis (BIA) adapted to the local context to develop a tool within the PDCA cycle to manage continuous improvement in integrated interventions over the long term.

Methods: Discrete Event Simulation (DES) was used to estimate the budget impact of a new integrated intervention – which included the use of electronic prescriptions and new provider roles, including reference internist, hospital liaison nurse, and advanced skills nurse – from 2012 to 2020. Simulation helped us delimit the impact of the integrated health-care intervention according to the organizationally defined goals by comparing both scenarios (Plan).

Resource consumption data used to populate the model –traditional health care – was obtained from administrative databases. A Delphi study was performed to determine the extent to which integrated health-care systems could avoid patient decompensation, which was measured as Accident and Emergency and hospitalizations avoided. This economic analysis assumed a reduction in emergencies by 10% during 5 years.

Comparing the real costs with those that would have incurred under conventional care and with the objective integrated care determined whether the trend was positive (Check).

Results: The simulation model showed that, by considering ageing of the population, the multi-morbid patient population in Donostialdea will increase by 8% by 2020. As the target population is larger and older, conventional health-care costs will have increased by 21%. If interventions could successfully reduce emergency costs annually by 2%, this budget would decrease 18%, with cumulative savings of over 500,000 euros in the study period.

Discussion: PDCA cycle, together with statistical analysis, is a well-known tool for management, but to our knowledge, our work is the first to demonstrate the capacity of BIA as a complementary tool in managing integrated health-care models. Using DES to represent the care process and natural history of multi-morbid patients, we can forecast the economic burden associated with this population. Integrating simulation modeling and statistical analysis within the PDCA cycle helped the continuous improvement of changing the

organizational model to achieve deployment of complex interventions within integrated health-care organizations. The four stages described in the PDCA cycle mirror the scientific experimental method of formulating a hypothesis, collecting data to test the hypothesis, analysing and interpreting the results, and making inferences to iterate the hypothesis

S5C.3

ANALYZING THE DRIVERS AFFECTING COST OF CANCER: POPULATION-LEVEL RESULTS FROM FINLAND

Paulus Torkki, Riikka Leskelä, Jukka-Pekka Mecklin, Sakari Karjalainen, Suvi Mäklin

Abstract

Objective: The incidence of cancer has increased 20 % in last ten years in Finland. In addition, the rapid development of treatment methods and technology build pressure for cost increase. The main objective is to analyze the changes in total costs of cancer in Finland between 2009 and 2014 to enable more accurate prediction of the costs in the future. The objective is to recognize the most important drivers of cost and to build the operational model: how these drivers affect the total costs. The changes in treatment and management methods behind the cost drivers are identified.

Methods: The cost and service usage data of treatment, screening, disability, sickness leave, rehabilitation and other reimbursements were obtained from national registers. We selected two hospital districts to analyze the changes in cost and methods of cancer care in more detail. The data from hospital districts included cost-per-patient and cost-per service data and interviews of the medical doctors and nurses. The hospital data enabled analyzing the costs of specific procedures and examinations per patient and diagnosis group to build the operational model. We combined the analysis with the predictive incidence data to estimate the future costs.

Results: The preliminary results show that there have been significant changes in the cost drivers. The share of surgical treatment and medication costs have increased whereas the share of inpatient care has decreased. The cost of sickness leaves increased 2 % per year but the disability pensions decreased by 1 % per year.

Conclusions: The measurement of healthcare should be focused in total cost of specific health problems and cost of patient episodes. Understanding the cost drivers and their effects on total costs enables allocative efficiency.

Currently, the hospitals have budgetary constraints limiting the optimization of total costs. In further study, the outcomes of the cancer care will be included to analyze the cost-effectiveness. Using the operational model in cost prediction increases the accuracy.

11:00-12:00

SESSION VI

SESSION VI A

INFECTIOUS DISEASES

Chair **Margaret Brandeau**

S6A.1

EPIDEMIC STRUCTURE AND OPTIMAL CONTROL OF HIV EPIDEMICS AMONG SEX WORKERS

Alexander Rutherford, Brian Williams

Abstract

Delivery of health services and disease prevention among sex workers presents many challenges. They often live at the margins of society and do not have access to adequate levels of health care. Prevalence of sexually transmitted diseases is usually very high in sex workers. In this talk, we will focus on HIV epidemics and the unique structure of these epidemics among sex workers in uncontrolled environments. These environments include street-based settings or «hot spots» near areas where there are many migrant workers. This social environment leads to a specific sexual network structure and presents unique challenges for epidemic control. Two case studies will be examined in this talk: (i) female and transgender street-based sex workers in Panama City; (ii) female sex workers in hotspots near the Carletonville gold-mining complex in South Africa.

Compartmental models of sex worker populations are two-population models in which clients provide the link for horizontal transmission from sex worker to sex worker. We have developed compartmental models for the HIV epidemic in female and transgender sex workers in Panama City. There are approximately 17,000 female sex workers and 300 transgender sex workers in Panama City. In 2010, HIV prevalence was 1.4% among nonregistered female sex workers, who work primarily in a street-based setting, and 37.6%

among transgender sex workers. Panama has adopted a policy of Treatment as Prevention, to combat the HIV epidemic. This entails an expanded program of testing and treatment with antiretroviral therapy to prevent new infections. Our modelling analysis demonstrates that a treatment program target to sex workers would be more effective at containing the epidemic, than a non-targeted program applied to clients in the general population.

The sexual network for heterosexual sex work has the structure of a bipartite graph, with one set of vertices corresponding to the female sex workers and the other the male clients. In an uncontrolled environment, clients often choose sex workers randomly. We show that this behaviour implies a sex worker degree distribution that has the form of a Poisson distribution. Relatively little detailed data exists for the structure of sex worker networks. One of the most detailed studies to date is the Carletonville-Mothusimpilo Project [Williams, et al. 2000], which collected data on sex workers near the Carletonville gold-mining complex in South Africa. At the time of the study, this was the largest gold mine in South Africa, employing approximately 75,000 workers. The study found that in 1999, HIV prevalence among sex workers was 70% working in hotspots near the mining complex was 70% and that prevalence among miners was 29%. The study collected detailed data on sexual contacts for sex workers, which we used to calculate the degree distribution for this community of sex workers. We found that the degree distribution fits well to a Poisson distribution. Implications of this network structure for optimal epidemic control will be discussed in the talk.

S6A.2

IMPROVING THE HIV CARE CASCADE VIA MENTAL HEALTH INTERVENTIONS: A COST-EFFECTIVENESS ANALYSIS

Margaret Brandeau

Abstract

Effective treatment of human immunodeficiency virus (HIV) greatly reduces infectivity of treated individuals and thus can help reduce the spread of the disease. To achieve this goal, effective care delivery programs are needed. Two key challenges in improving HIV care are reducing loss from care and increasing adherence to ART among persons who remain in care. Developing effective and cost-effective approaches to improve these parts of the HIV care cascade

are critical. In this study, we focus on one potential opportunity for improving the HIV care cascade, namely improving mental health care for HIV-infected individuals. Increasing evidence points to high prevalence of mental illness among persons living with HIV. We develop a microsimulation model of patients flowing into and through the care cascade, taking into account the natural history of HIV and major depressive disorder (MDD). We consider three interventions aimed at improving the diagnosis and treatment of MDD among HIV-infected individuals. We instantiate the model with data from Uganda. However, our findings are relevant to other countries in sub-Saharan Africa.

SESSION VI B

OPERATIONS ROOM PLANNING AND SCHEDULING (II)

Chair **Francisco Ballestín**

S6B.1

DIFFERENT PERSPECTIVES FOR SURGICAL CASE ASSIGNMENT PROBLEM: HEURISTIC APPROACHES

Catarina Mateus, Inês Marques Maria Eugénia Captivo

Abstract

The surgical suite has multiple and powerful stakeholders. In a public hospital, the government wants to achieve some social measures like the number of patients in the waiting list, number of days in the waiting list,or percentage of patients that are treated after the clinically acceptable period. The administration of the hospital wants to achieve those goals in order to avoid high contractual penalties; they also desire a high efficiency level of the surgical suite, not only because this is a highly costly service with a high influence in many other relevant services in the hospital (e.g., wards) but also because the number and complexity of the surgeries performed represent a significant hospital funding source. However, surgeons often schedule surgeries according to their agenda and their capacity to remember all their patients. When a systematic system to select and schedule the patients to be operated in a given week is not available, the surgeons will tend to select the patients that they remember the best (e.g. those patients more recently consulted or those patients that pressure the surgeon).

This can bring a sort of LIFO strategy to manage the waiting list for surgery, which may undermine the government guidelines.

The hospital under study has a central surgical suite with 11 ORs (1 dedicated to urgent cases) shared by 11 surgical services. The surgical suite is opened all working days from 8h to 21h divided into morning (8h-15h) and afternoon (15h-21h) shifts. The OR time is allocated to the surgical services according to a pre-specified master surgery schedule; each service appoints its elective patients to its assigned time block, OR and day (block scheduling strategy) in a one-week planning horizon.

This work emerges from a close collaboration with a large and publicly funded Portuguese hospital. The aim is to propose a systematic approach to help the surgical planner in the scheduling of elective surgeries, in order to optimize the use of the available surgical resources and improve equity and access to operated and waiting patients. The decisions to be taken are twofold: select patients to be scheduled in the planning horizon from the large waiting list for surgery; and assign a day, an operating room and a time block to the selected patients. A systematic system to select and schedule the patients to be operated in a given week is under development, trying to consider the different stakeholders' perspectives for a surgical case assignment problem and avoiding the manually procedures currently in use at the hospital as well as to try to reduce the adverse influence exerted by the surgeons in the management of the patients in the waiting list and in the scheduling process. Here we present the heuristics that were already developed and tested to be included in the system. The results, using data from a Portuguese hospital, will be analyzed and discussed. A comparison with the optimal values obtained using a Mixed Integer Linear Programming model for the same problem will also be presented.

S6B.2

CALCULATING THE IMPROVEMENT DUE TO THE RESCHEDULING OF ELECTIVE PATIENTS

Francisco Ballestín, Ángeles Pérez, Sacramento Quintanilla

Abstract

The management of operating rooms is a key factor in a hospital. This work deals with the problem of selecting and scheduling elective patients for several operating rooms. An elective patient is a patient whose surgery can be planned in advance. The opposite concept is the urgent patient. The methodology followed and the solution methods proposed in this work are useful for those hospitals that dedicate some sessions of some operating rooms only for elec-

tive patients and do not mix elective with urgent patients in the same session. This paper has arisen from a project we have been developing in recent years with a large local hospital. It is an important hospital in Valencia (Spain), with more than 1000 rooms, 45 operating rooms and more than 6000 employees. The methods proposed can be applied to most hospitals with the mentioned characteristic.

In this kind of hospital, an initial schedule with the patients who are going to be operated on in a certain planning period (one or two weeks) is calculated several days before the planning period. The patients are chosen from a dynamic waiting list according to some objective function. The scheduled patients are assigned to a specific session and to a specific day within the schedule. There is some information about the patients, which includes the day of admission in the list, the operation needed, the duration of the operation and other important restrictions that limit the sessions in which the operation can be performed. An example may be the specific doctor who has to perform the operation. The information may also contain a priority for each operation that defines a (soft) due date for it. In the present study we consider the duration to be a constant value.

Once the initial or tentative schedule has been calculated, scheduled patients are informed of their upcoming operation. Also the surgeons are notified and the required resources for the operations are reserved.

However, a few days before the planning period, the tentative schedule is revised since some of the planned operations may not take place due to different reasons. In addition, new patients will have arrived on the waiting list and become eligible to be scheduled. Therefore, a new and final schedule is calculated, something which can be called the rescheduling phase. This paper assumes that the tentative schedule has already been calculated and focuses on the building of the final schedule. Specifically, we analyse the improvement attainable in the objective function thanks to the rescheduling phase, as a function of the characteristics of the instance and the number or importance of the changes made in the tentative schedule. We test different objective functions typically used to calculate the schedule of elective patients.

SESSION VI C

PERFORMANCE EVALUATION (I)

Chair **Liv Ariane Augestad**

S6C.1

AN INNOVATIVE WEB-DELPHI ON WEIGHTS TO INFORM THE CONSTRUCTION OF A EURO-HEALTHY POPULATION HEALTH INDEX

A. Vieira, C.A. Bana e Costa, J.C. Bana e Costa, M.D. Oliveira, P. Santana

Abstract

Multidimensional indices have been used in multiple contexts and for multiple purposes in the health sector. Two well-known indices are the ones to rank health systems by the World Health Organization, and to appraise the health of the communities in the American Health Ranking (by the United Health Foundation).

Typical challenges in index construction in the health context are: What are the best indicators to include in such a model? Should one combine different types of indicators (for instance health outcomes with health determinants, or physical and mental health)? For aggregation purposes, how should weights be defined?

How should one combine available data and scientific evidence with the views of experts and stakeholders? Despite the common use of indices, several studies have identified common pitfalls in the methods used to build health indices and the relevance of developing sound methods to assist that task.

This study is developed within the context of the EURO-HEALTHY project – in the scope of the H2020 framework – with an aim of «Shaping EUROpean policies to promote HEALTH equitY». The core of EURO- HEALTHY is the construction of a population health index (PHI) that will be first used to evaluate population health across European regions, and then as a means to analyse health and health inequities in Europe and to appraise which policies have the highest potential to improve health and health equity. An instrumental objective is that the PHI reflects the views and perspectives of a diversity of experts and stakeholders spread across Europe, and that involves them in the PHI building through innovative approaches.

The EURO-HEALTHY PHI has been designed to follow a MACBETH socio-technical approach that is grounded on multicriteria value measurement theory. This study describes the design and implementation of a Web- Delphi process to collect experts and stakeholders views on the weighting of the indica-

tors. Specific objectives for the Delphi process were: the use of a technological platform to engage experts and stakeholders in the process; the use of a sound and friendly questioning protocol to obtain participants' value judgments on the weights; and to get insights from participatory processes, particularly the Delphi method, through the analysis of data stability, eventual opinion change, and behavioural and motivational influences on weight judgements.

In line with those objectives, in this presentation we describe the preparation, design, implementation and evaluation of an innovative Web-based Delphi, as well as present the results from applying it with 61 experts and stakeholders across Europe in March and April 2016. In particular, we describe the sound and friendly questioning protocol – as framed by the MACBETH socio-technical approach –, the Delphi design (including type of first round, total number of rounds, type of feedback), the implementation on the web-platform and an evaluation of the Delphi results.

Based on the results, we draw conclusions on the usefulness of the Delphi method for collecting weights information to build a PHI, in particular on issues related with data stability, eventual opinion change, and behavioural and motivational influences on weight judgements.

S6C.2

USING THE CHOICE SEQUENCE IN TIME TRADE-OFF AS DISCRETE CHOICES – DO THE TWO STORIES MATCH?

Liv Ariane Augestad, Kim Rand-Hendriksen, Mathias Barra, Akershus

Abstract

Background: The EQ-5D is the most used instrument for measuring quality-adjusted life-years worldwide. The questionnaire describes health along 5 dimensions, each at 5 levels, for a total of 3125 unique health states. Time trade-off (TTO) is the de facto gold-standard methodology for eliciting health utilities for EQ-5D health-states. Since TTO requires face-to-face interviews, and is taxing on participants, there is a growing interest in the use of discrete choice experiments (DCE) as DCE methodology is regarded as less demanding and less costly. Importantly, TTO consists of a series of discrete choices. The aim of this study was to explore the agreement between health-state values from TTO, and estimated by inferring DCE values from TTO responses.

Methods: TTO-values for 10 EQ-5D-5L health states were collected from 202 study participants. From these, mean values were calculated for each

of the 10 health states. Next, the same data was treated as a series of discrete-choices. The TTO-data was collected using a non-standard procedure called «non-stopping TTO», meaning that all respondents answered all possible TTO questions for all 10 health states. Each strict expression of preference was recorded as a DC-choice. For indifference (an option native to TTO-methods, but not to DCE-methods) a random draw was used.

After removing 69 incomplete responses (3.4%), we generated 42922 discrete choices. Each DC-pair consisted of (A) 10 years in an impaired health-state compared to (B) a shorter life without impairment (for Better-Than-Death (BTD) states); or (A) a mix of impaired health and no impairment compared to (B) immediate death (for Worse-Than-Death (WTD) states.)

We estimated simple binary logit/probit models to estimate latent (health-) utility under the assumption that respondents are utility-maximizers subject to an IID-error term. The latent utility for each choice-situation was thus modeled as

$$Y = (t*DA - (b*HSV)*DA) - t*DB*DD + \text{error}$$

where t is a parameter for the value of time without morbidity (1 QALY/Year), DA and DB are the durations of choice A and B respectively, HSV is a dummy vector indicating which reduced health state figures in choice A, and b is a vector of parameters to be estimated and later interpreted as the disutility of spending time in the corresponding reduced health state. Hence A is chosen whenever Y>0 as this corresponds to A having greater utility than B. In addition, each health-state was characterized as BTD or WTD, and was included in the model by the dummy DD. For comparison, we computed average elicited TTO-utilities for each of the health-states.

Results: The logit-model achieved the highest observed maximum likelihood. The estimated DCE-utilities agree well with the TTO-utilities for health states with low utility (close to 0). However, states with high TTO-utilities are not matched by their DCE counterparts; and even exceed 1 – inconsistent with the QALY-model. Conclusion: The values estimated using the inferred discrete choices did not match the scale of the corresponding TTO values. Implications for the prospect of combining TTO and DCE when assigning health-utility values are discussed.

12:00-13:00

PLENARY CONFERENCE

KEY PERFORMANCE INDICATORS AND THEIR OPTIMAL PERFORMANCE

David Stanford

Abstract

Health care systems often have to deal with diverse populations of patients with differing needs, acuities, and urgencies. Key Performance Indicators (KPIs) have been a popular tool for sorting out the question of urgency, by setting the standards for time to initiation of treatment for these various populations. KPI standards typically comprise a waiting time limit for treatment to begin, along with a compliance probability stating the minimum acceptable fraction of the patient class to commence treatment by the time limit. The time limits increase as the patient acuity decreases, and in many cases the compliance probability decreases as well.

KPI standards are sometimes set due to perceived clinical need, sometimes due to a desired standard for waiting time performance, and sometimes as a mix of both. The five-category Australasian Triage Scale (ATS) and Canadian Triage and Acuity Scale (CTAS) are both examples of the last category: the needs of the highest category of patients (Resuscitation) are purely clinical, but as one works through the remaining four categories, the clinical need diminishes, replaced by the performance goal. Sometimes what constitutes urgency itself is open to debate. For example, in hip and knee joint replacement, some orthopaedic surgeons consider degree of pain suffered to be the urgent element, while others consider it to be the degree of degradation of the joint itself.

The common missing element for KPI systems is the fact that KPI standards represent a system of constraints, and do not indicate what the consequences of non-compliance are. A KPI system that meets its compliance could, in theory, totally ignore patients who miss their targets, in order to deploy health resources to reduce the chance of more recent arrivals missing theirs. This absurd situation is due to the fact that KPIs lack a goal to be optimized. What is needed to complete the picture is an objective which reflects the increased urgency of patients whose wait times exceed their time limit.

This plenary presentation commences with a review of several diverse areas in healthcare where KPI standards arise, so as to better identify the common

elements and the differences in the assumptions and the goals. The presentation then states what seem to us to be an appropriate set of objective functions for optimal performance of a KPI system, which relate to minimizing the amount of excess waiting that occurs. We then move on to demonstrate that the Accumulating Priority queueing discipline is a well-suited discipline to aid compliance of diverse patient populations served by a common facility. The remainder of the presentation addresses what we have learned about the various objectives, and their relationship to each other, and their optimal performance. We are particularly interested in the performance of a simple Rule of Thumb which assigns priority to customers in each KPI class in inverse proportion to that class's waiting time limit.

The results to be presented are the result of a number of research projects with graduate students Na Li and Azaz Sharif, and research colleagues Peter Taylor (Melbourne), Ilze Ziedins (Auckland), and Richard Caron (Windsor, Canada). I am also deeply grateful for discussions with Martin Utley and Christina Pagel of University College London on the secondary nature of the compliance targets, and our ongoing work in that area.

14:30-16:30

SESSION VII

SESSION VII A

HEALTH PLANNING (I)

Chair **Honora Smith**

S7A.1

SUPPORTING THE IMPLEMENTATION AND EVALUATION OF HEALTH SYSTEM TRANSFORMATION WITH OPERATIONAL RESEARCH

Gozdem Dural-Selcuk, Christos Vasilakis

Abstract

Health and social care systems in the developed world are struggling to keep up with rising demand for their services. As a result of increasing life expectancies and lower birth rates, population structures in developed countries change in a way that the proportion of elderly people is higher than ever before. In addition to an ageing population, lifestyles and expectations of people also evolve over time. These factors together create additional pressures on health

and social care systems both in operational and financial terms. Against this backdrop, it is not surprising that many have called for significant transformation in the way services are planned and delivered in the National Health Service (NHS) in England. In the influential Five Year Forward Plan published in late 2014 for example, it is stated that NHS aims to transform into a proactive and preventive care delivery system that operates in an efficient way.

As part of this effort a nationwide transformation plan has been initiated in England with a number of hospital trusts chosen to be the pioneers of this initiative. Yeovil District Hospital (YDH) is one of these sites in the stream of «Integrated primary and acute care systems». Under this transformation scheme, the hospital has introduced a different care pathway for those complex patients with three or more comorbidities, who were deemed to take the advantage of improved integrated care most. Accordingly, the hospital has setup a complex care hub to co-ordinate and manage the health of these complex patients. The complex care hub initiative is designed to give the opportunity to act proactively for this group of patients in a timely fashion. Having implemented the first phases, hospital management aims to evaluate the initiative on a range of metrics including lower admission rates, shorter hospital length of stay and higher patient satisfaction.

Under the auspices of a Researchers-in-Residence programme between the hospital and the university, a team of operational researchers works in close collaboration with hospital managers and clinicians to support the implementation, improvement and evaluation of the initiative. Specifically, we aim to provide the means for evaluating the complex care hub initiative from a systems perspective by capturing the influence of external dynamics and the volatile environment of interacting factors. For these purposes, we have constructed a system dynamics model comprising a number of interacting components including the dynamics of the local population, elective and emergency care and the new complex care hub. Having populated the input parameters of the model with estimates from empirical data, we use this model as a means to evaluate the likely impact of changes on system outcomes as well as to investigate the conditions under which the complex care hub can provide sustainable solutions within the local health economy.

S7A.2

LOCATING AND DESIGNING GROUP PRACTICES FOR GENERAL PRACTITIONERS

Melanie Reuter-Oppermann, Jost Steinhäuser

Abstract

In Germany the future lack of general practitioners (GP) will be a major challenge for the healthcare system.

In Baden-Württemberg, a federal state located in south-west Germany, around 24% of all GPs will retire in the next eight years. These almost 2000 GPs are therefore looking for a successor for their practices as well as their patients. Underlining the current situation, in the next eight years at least 500 practices will probably close as there are too little successors, leaving 750.000 patients that have to find a new GP. The main reason for that is that many newly qualified GPs are more interested in an employment or sharing a practice than having their own. Especially female doctors demand possibilities for part-time employments. With 70% of all GPs being female doctors they build the majority of future GPs. Primary health care in Germany is widely provided by GPs. Due to the demographic change rather more than less GPs will be needed in the future to provide close to home primary medical care for the German population. The «Arbeitsgemeinschaft der Obersten Landesgesundheitsbehörden (AOLG)» expects an increase of primary care demand of at least 20% in 2020 compared to 2000 and it is even more critical in rural areas.

One idea to overcome this challenge is to build new group practices of 4 (or more) GPs that allow for (part-time) employments. In this work we want to present and discuss planning problems that should be taken into account when building those practices. Arising questions that should be answered include: (1) how many practices with how many doctors are needed, (2) where should the practices be built, (3) how should the practice be designed, (4) how many medical assistants are needed and (5) how can their shifts be scheduled? While we will briefly discuss all the questions and their relations, we will focus on (2) and (3) and present suitable formulations and approaches for solving the location and layout problems. Determining the locations of the practices, current locations, possible closings and future demand must be taken into account.

Exemplary, results of a study for the administrative district of Rottweil will be presented. As patients can choose their GP freely, models can only as-

sume an assignment of patients to practices in relation to the distance. Therefore, it might be necessary for GPs to apply panel management strategies in order to level the demand. In a next step, the layout of the practices needs to be designed in order to minimize the walking distances for doctors and receptionists / medical assistants, as well as for the patients. We present layouts for potential group practices with two examination rooms per doctor and a central reception area based on a study for a large group praxis in Baiersbronn, Germany. A set of additional soft constraints needs to be taken into account that can best be tested by simulation.

S7A.3

OBJECTIVES, OBJECTIVES

Penelope Mullen

Abstract

In recent years decision making in the health service in England, and increasingly in other countries, has been dominated by the pursuit of cost-effectiveness – based on the assumption, implicit or explicit, that health is the primary, or even sole, objective of healthcare and healthcare systems. This assumption is very powerful and attractive. However, as has been demonstrated elsewhere, health-gain maximisation (QALY maximisation) can have a number of undesirable consequences, including reinforcement of inequalities and discrimination against those with rare diseases, against those with pre-existing disabilities and against those needing more costly interventions.

As a result, modifications to 'pure' QALY maximisation have been proposed, for example by attempting to incorporate equity considerations, using approaches such as weighted QALYs or adjusting funding thresholds, but without questioning the underlying assumption of the pursuit of health-gain maximisation. However, that assumption is being increasingly challenged by suggestions that health is not the sole or even primary objective.

In examining these issues, this paper proposes that there should be a clearer distinction between the objectives of health-related interventions and the objectives of healthcare systems. In the case of the latter, it is suggested that security is under-recognised as an important, and possibly primary, objective. But if security is accepted as a primary objective of healthcare systems, how can it be operationalised for use in analysis, decision making and resource allocation? In attempting to answer that question, this paper explores concepts and approach-

es such as risk, assurance, safety right to health (care) need, certainty, process utility, safety and prevention. It also examines the compatibility between 'security' and widely supported objectives, such as equity.

S7A.4

HUB NETWORKS FOR HIERARCHICAL HEALTH SERVICES: EFFICIENCIES FOR LOGISTICS AND PATIENTS?

Honora Smith

Abstract

Hub networks offer efficiencies of transportation and centralisation in many realms, such as airline travel, road transportation and internet routing. Such networks can particularly suit hierarchical services where travel to rarely-used services can be centralised and more commonly used services can be made available locally. We consider firstly a case study of the National Health Laboratory Service (NHLS) of South Africa, where a hub network is used to transport HIV/AIDS blood samples to testing laboratories. These tests are delivered in a hierarchical manner, with the majority of tests needing quick, local service, and small numbers of other tests carried out less frequently. A locational analysis approach to this problem is taken in this case study, with development of mixed integer programming models to find best locations for hubs and provision of test capacity. However the problem definition is not straight forward, particularly in terms of the objective function to be optimised and constraints on time or distance travelled. We describe several scenarios modelled, in terms of maximum travel time achieved, and close-to-optimal solutions are compared.

Moreover, for different rural/urban regions of the country, variations in travel time constraints are suggested, raising questions of equity of provision.

We secondly turn the focus to patients accessing urgent and emergency care. The UK National Health Service (NHS) is currently facing major problems of capacity planning in emergency care. Current NHS proposals are for Urgent and Emergency Care (UEC) Networks within regions, to provide care in a hierarchical fashion, from Urgent Care Centres, for urgent but non-life-threatening needs, to Emergency Centres and Major Emergency Centres. If established successfully in an integrated manner, the UEC Networks could ensure consistency of care is always available, despite resource constraints. The risk of temporary lack of capacity in one area could be mitigat-

ed by surplus in another. The question is raised as to how far the modelling methods applicable to logistics networks can be applied to flows of patients accessing urgent and emergency care. Patients exercise choice of destination, choosing both location and level of care to access in the first place. Clinicians also make decisions as to whether to treat and discharge patients locally, or to refer to more specialised services. Moreover, the current fragmentation of the NHS in terms of providers of care and budget holders is making integration of services difficult at best, although vanguards have been chosen to demonstrate possibilities for efficiencies.

SESSION VII B

EMERGENCY DEPARTMENT (II)

Chair **Guy Wachtel**

S7B.1

DECISION-MAKING PROCESS IN SOLVING OVERCROWDING IN EMERGENCY DEPARTMENTS INCLUDING BUDGETARY ASPECTS

Guy Wachtel, Amir Elalouf

Abstract

Overcrowding in hospital emergency departments (EDs) that arise from long length-of-stay (LOS) is an unfortunate common occurrence. While some factors affecting LOS are well known, there may be additional factors that have not yet been properly addressed. An understanding and analysis of these factors may help ED management to predict and to better handle overcrowding in the ED. Our goal is to show that by collecting data inside the ED we can find new factors that will help the emergency departments in general. By analyzing information systems data as well as data from patient files, real-time observations in an ED and conversations with ED staff, we have identified a number of new variables that affect patients' length of stay and ED crowding. This research presents and demonstrates a dynamic programming algorithmic method that, together with observational and statistical analysis, enables us to identify the factors affecting the patient's LOS and crowding in the ED and, on the basis of our findings, to propose means of reducing LOS and crowding. During the summer of 2012 we did several sets of empirical observations in «Bnei-Zion» hospital in Haifa, Israel, achieving data from the hospital's management system for about 1,000 patients which is regular data usually seen

in researches. In addition to the management system's data we gain full data about more than 700 patients from empiric observation (including much data as possible about patients' movement and tasks in the ED). Finally, additional 100 patients' records (out of the 700 observed) were further analyzed.

We have taken into account factors that are known to be influential, e.g., reason for arrival, occupancy in the ED, and hour of arrival, as well as factors that were explored for the first time in this research, such as patient heart rate, the number of accompanying escorts and the number and kind of tests assigned to patients (e.g., blood tests and urinalysis.

We obtained additional support for our results by interviewing ED physicians and nurses from various hospitals. The number of escorts arriving with a patient has a substantial effect on length of stay (and, obviously, on crowding in the ED). Another interesting factor influencing both length of stay and crowding is the number of tests a patient performs. Triage nurses tend to perform more tests at crowded times, suggesting that testing may be used as a means of «buying time» for ED staff. It is expected that, by taking these factors into consideration, ED efficiency can be improved.

For cases that have more than few statistically significant factors, we showed an algorithmic method that can be used even for cases that there were no observations and can be based on the physicians' experience only. If these bottlenecks situations will be efficiently treated, the average length of stay and crowding in the ED are likely to decrease. Those and more factors can be the basis for future studies.

S7B.2

A SIMULATION ANALYSIS FOR IMPROVING PATIENT-PHYSICIAN ASSIGNMENT POLICIES IN EMERGENCY DEPARTMENT TRIAGE

Marta Cildoz, Cristina Azcárate, Amaia Ibarra, Fermín Mallor

Abstract

Since the new Emergency Department of the Hospital of Navarre was built (which has 3.500 square meters of facilities that serve a population of half a million people), it emerged the need to enhance the system performance by shortening the length of stay, improving patient satisfaction and reducing physicians' work overload.

As part of a larger project, it is studied how to avoid disparities between physicians in the mild patients' circuit (A) and between medical teams work-

load in the severe patients' circuit (B). At the present time, patients in triage are assigned to physicians cyclically as they arrive to the Emergency Department which facilitates the triage nurses decision making although it leads to an imbalanced workload of the physicians.

This patient-physician assignment problem has been studied extensively in the literature by performing interventions (testing new policies by practical implementation in hospital) that contradict results of basic models of queuing theory. Our approach consider the development of a discrete-event simulation model that takes into account an accurate description of patient flow, medical and nurse procedures, and characteristics of patient (health status, seasonal patterns of arrivals, etc.). The model parameters calibration and estimation is based on a thorough analysis of real historical data associated to this new department (more than 120.000 patient cases during its first operating year).

Furthermore, this mathematical model also allows incorporating other aspects that influence the system performance, in particular, the medical team work breakdown at doctor work and nurse work, which facilitates treating patients in parallel (observed in practice).

By using this mathematical model, we compare the actual patient-physicians assignment policy with other assignment rules proposed by the medical teams who work in the new Hospital of Navarre Emergency Department (and also by the authors) with the aim of balancing physicians' workload and reducing patients waiting time.

S7B.3

REDUCING THE OVERCROWDING AT THE EMERGENCY DEPARTMENT

Davide Duma, Roberto Aringhieri, Pierre Hosteins

Abstract

The Emergency Department (ED) is responsible to provide medical and surgical care to patients arriving at the hospital in need of immediate care. For such a reason, the activity planning and the resource allocation are challenging issues because of the high variability of problem parameters: different patients (by type of symptoms, urgency, deambulation, etc) could have very different paths through the ED requiring different resources.

We analysed the case of the ED sited at Ospedale Sant'Antonio Abate di Cantù, which is a medium size hospital in Italy. The ED serves about 30000

patients per year: such patients are over 50 years old in more than 40% of cases, a third of them is over 75 years old, generally requiring a greater use of resources because of a less autonomy. Minors are about 20% of the patient population for which a dedicated path into the Pediatric Ward is provided, except for the most urgent cases.

At the triage, an urgency code is assigned to the patients. The codes 1 and 2 require an immediate intervention: the former (less than 1.5% of cases) are patients in immediate danger of death, whilst for the latter (about 15% of cases) a medical visit is needed as soon as possible. The code 3 is the most frequent (more than 60% of cases) and is assigned when some investigations or treatments are required but are not urgent. Finally, codes from 4 to 6 usually cover patients whose symptoms could be treated as primary care.

The ED has been involved in an initial analysis of overcrowding using the NEDOCS score, that is an index used in the medical literature, based on surveys at periodic intervals of time. Such surveys are about the number of available beds, the number of patients involved in some activities and their waiting times. The NEDOCS score has been already used at the ED in CantÃ[1] as a comparison criterion to assess the performance after the adoption of different strategies, such as the introduction of a visit room for the minors codes (from 4 to 6), changes to the staff rostering and the adoption of new protocols.

The aim of this preliminary work is to provide a simulation model to better investigate the behaviour of the ED under several scenarios. The simulation model will be used to provide an ex-post evaluation of the previous organization changes, and to get more insights from the analysis of new possible changes in the organization. Further, we will exploit ad hoc online methods to reduce the overcrowding. A quantitative analysis involving the NEDOCS score and other indices is then provided.

S7B.4

COMBINING COXIAN PHASE-TYPE DISTRIBUTIONS WITH DISCRETE EVENT SIMULATION TO MODEL PATIENT ACTIVITY IN AUSTRALIAN EMERGENCY DEPARTMENTS

Laura Boyle, Adele Marshall, Mark Mackay

Abstract

Hospital emergency departments (EDs) are the key access point for patients requiring urgent admission to hospital (‘Emergency departments: at the front

line', Australian Institute of Health and Welfare, 2014). The demand for emergency healthcare is rapidly increasing in line with population growth, with figures showing that between 2010-11 and 2014-15, the number of patients presenting at EDs in Australia increased by 19%, with an annual average increase of 4.5% (Australian Institute of Health and Welfare, 2015). It is therefore essential that the demand for emergency care is efficiently managed. This study aims to develop a simulation model representing activity within a major emergency department in South Australia, with the aim of formulating a tool for strategic planning.

This research develops a unique approach to modelling the flow of patients in EDs by combining discrete event simulation with Markov modelling. Discrete event simulation (DES) models the evolution of a system over time, where changes in the state of the system occur at discrete time points (Banks et al., 2010). DES has been used widely to model emergency departments as it provides a flexible method of analysing complex queuing systems and a platform for quantifying the impact of changes to the system. Coxian phase-type distributions are a special type of Markov model which represent the time until absorption of a finite-state Markov chain in continuous time (Neuts, 1981), with the advantage of representing the underlying patient flow distribution as a series of latent phases. Analysis of patient covariates can show which types of patients progress to the later phases of the model (Marshall and McClean, 2004), highlighting long-stay patients who consume a greater proportion of resources and are liable to exceed the four-hour National Emergency Access Target (Council of Australian Governments, 2011). Identification of long stay patients is important as it can result in the development of improvement strategies to increase patient flow and reduce access block.

Coxian phase-type distributions are utilised to model sections of the key patient pathways through the ED. The resultant fits are then used to populate the discrete event simulation model, which is of particular value in the modelling of emergency departments. This novel modelling technique offers greater insight into the underlying patient flow processes than standard DES approaches, considering the influence of both patient and operational system characteristics upon length of stay in the ED. Additionally, although many DES models can become quickly outdated, this model is conceptually founded on the idea of reusability and can easily be run on new data for new insights.

The simulation model has been constructed in collaboration with academics and clinicians working closely with ED. It is therefore anticipated that

the model will be used at a management level to provide a high-level understanding of patient flow through the emergency department. Further work will look at evaluating the impact of proposed scenarios and improvement strategies on the system.

SESSION VII C

MODELLING IN HEALTH CARE (II)

Chair **Joe Viana**

S7C.1

INCORPORATING SEMI URGENT SURGERIES INTO THE TACTICAL SURGERY SCHEDULE

Nardo Borgman, Ingrid Vliegen, Erwin Hans

Abstract

The planning of surgeries in the operating theater is a complex process, involving many stakeholders. Part of this complexity is caused by the arrival of (semi) urgent patients. While urgent (emergency) patients are treated as soon as possible, often in a dedicated emergency OR, a large part of patients in our collaborating hospital are semi-urgent. These patients must be seen within 2-7 days, which falls within the regular planning horizon. In practice, this means that often elective surgeries are cancelled and rescheduled in favor of semi-urgent surgeries.

In this project, we aim to incorporate the planning of semi-urgent surgeries in a tactical surgery schedule to create surgery schedules that allow for the treatment of both elective and semi-urgent patients. When creating a tactical schedule, a trade-off exists between scheduling semi-urgent and elective surgeries. When too few semi-urgent surgeries are planned, urgent patients may exceed their medically allowed waiting time, and elective surgeries must be cancelled. On the other hand, when scheduling too many semi-urgent surgeries utilization may decrease, and access time for elective patients may increase. To this end, we use a queueing approach to determine acceptable levels of offered semi-urgent surgeries, and then incorporate these into the tactical planning using a MIP, taking into account OR utilization, overtime, as well as lateness probabilities of semi urgent patients.

S7C.2

APPLYING GRAVITY MODEL TO ESTIMATE DEMAND OF PUBLIC HOSPITAL BEDS IN SINGAPORE

Kiok Liang Teow, Kelvin Bryan Tan, Hwee Pin Phua

Abstract

Singapore is a small country of about 700 sqm with 5.5 million people. As of 2015, there are a total of 6 public acute general hospitals that provide multi-disciplinary acute inpatient and specialist outpatient services and a 24-hour emergency department. The oldest hospital, Singapore General Hospital, had its beginnings in 1821, while the latest one, Ng Teng Fong General Hospital (NTFGH), opened in 2015. With ageing and population growth, Singapore has planned and built new hospitals to cater to the increase in hospital bed demand. Two more public hospitals have been announced and planned to be ready by 2018 and 2022 respectively. In Singapore, patients have the freedom of choice to use any of the hospitals.

With the opening of each new hospital, we expect it to reduce the load of some existing ones. More importantly, we also want to estimate the demand of the new ones to plan for infrastructure and manpower. This study uses Gravity Model for the above mentioned aims.

Gravity model has been used in retail and health planning. Joseph and Kuby (2011) gave a comprehensive review on Gravity modelling, including pioneered work done by Reilly (1931) and Huff (1963). Our work adopts the probabilistic approach advocated by Huff. However we differ from Biggeri et al. (2002) and Jones et al. (2011), where they used bed supply to determine hospital's mass coefficient. In our context, we believe that some hospitals are more attractive due to their longer establishment or being a tertiary hospital, rather than due to number of bed supply. We use empirical hospital admission data and patients addresses to calibrate and estimate the «mass» coefficients for each hospital directly.

In June 2015, one hospital was closed for renovation and another hospital (NTFGH) located at another place started to operate. By Sep 2015, NTFGH opened its A&E to all ambulances. We used Q1 2015 data to calibrate the mass coefficients for all hospitals and predicted their market share in last quarter of 2015. The predictions were fairly close to the actuals. Using these sets of coefficients and future demand by region, we could then estimate the future demand of the hospitals and make appropriate infrastructure and manpower planning. Further work includes monitoring the changes in the market

share and therefore the changes in mass coefficients, and understanding the contribution to the differences in the respective hospitals' coefficients.

S7C.3

A HYBRID SIMULATION FRAMEWORK TO REPRODUCE AND TEST HOSPITAL ORGANIZATIONAL CHANGES

Michele Sonnessa, Elena Tànfani, Angela Testi, Paolo Landa, Marina Resta

Abstract

This paper introduces a hybrid simulation framework able to assess the impact of organizational strategies intended to adjust the emergent and elective patient flows inside hospital systems. Citizens' needs are put in competition because elective patients, who are entitled to a surgical intervention, could delay their intervention due to unpredictable excessive arrivals of patients to Emergency Department (ED) which need an emergent hospital admission to be further needed. Besides, the boarding of emergent patients waiting to be admitted in hospital inpatient wards is a major reason of ED overcrowding.

The framework herein developed is based on System Dynamics (SD) and Discrete Event Simulation (DES) components linked in a hybrid simulation model. Flows are generated at a high level by the SD component and interact following some parameters coming from DES model, where flows are disentangled into single individuals following a detailed process-oriented pathway.

The DES component is able to assess the performance and system bottlenecks under alternative operational and tactical scenarios. Indeed, it is able to forecast the hospital resource allocation over seasonal fluctuation of patient arrivals at ED. The SD component allows to explain how some adaptive phenomena are able to put the system in equilibrium when demand varies. Behavioral aspects explain the intrinsic system adaptability and SD techniques can effectively be used to reproduce such coping mechanisms. In fact, the SD component is able to reproduce at a high level the relationships and the causal effects between emergent and elective patient flows and it can evaluate the impact of variations of the flows dynamics. As an example the increase of the rate of arrival at the Emergency Department, can trigger a reinforcing loop increasing elective waits which in turns results on further overcrowding of ED.

The hybrid model has been implemented with Anylogic® and has been applied to a real case study in order to evaluate hospital organizational strate-

gies when a change is needed: alternative bed managing rules, introduction of discharge rooms and bed capacity reallocation among different hospital stay areas.

The results of the alternative scenarios tested are compared with respect to a set of performance metrics, such as waiting times to be admitted in hospital, number of misallocated patients, number of trolleys in ED, inpatient bed occupancy rates and elective patients delayed.

S7C.4

FLEXIBLE HEALTHCARE HYBRID SIMULATION MODELLING

Joe Viana, Kim Rand-Hendriksen, Tone Breines-Simonsen, Fredrik Dahl, Mathias Barra

Abstract

At the health services research unit (HØKH), Akershus University Hospital (Ahus), we have used the commercial simulation package AnyLogic, to model the entire or parts of healthcare systems under analysis. AnyLogic is an object oriented Java based development environment, to produce a generic simple hybrid approach for combining two or more modelling techniques. Additionally we are developing a number of R (A Language and Environment for Statistical Computing) functions that transform data extracted from hospital systems into a form suitable for the type of generic models being produced in AnyLogic. The goal is ultimately to integrate R with AnyLogic so that pre analysis of hospital data and post analysis of simulation data can be carried out in R.

Six case studies will be presented to illustrate the use of this approach. The case studies are: 1) a model of the obstetrics department, 2) a model of the post-operative (PO) recovery department, 3) a model of the medical observation (MO) department, 4) a model of the intensive care unit (ICU), 5) a combined model of the PO, MO and ICU to explore the connections and feedback within these closely linked departments, and 6) a strategic level model of the UK stroke pathway guidelines as recommended by the National Institute for Health and Care Excellence (N ICE).

Cases one to five are models of actual departments at Ahus which address problems which are of interest from clinical and managerial perspectives. The cases utilise real data in terms of problem elicitation from staff as well as patient pathways, arrival patterns, process times and patient characteristics. Ahus' data acquisition unit, whom HØKH work closely with extracted from

the «distributed information and patient data system in hospital» (DIPS) and MetaVision ICU systems, the hospitals electronic health record systems. An overview of the key R functions used to transform this data into data suitable for the models will be provided.

We are seeking approval to conduct in depth modelling of stroke care in Norway, whilst we are in the process of obtaining approval, a sixth case study of the stroke pathway in the UK was developed. This is a hypothetical case study exploring the possibility of applying the hybrid modelling approach to a different level of problem. The case study investigates a wider system including hospitals, care homes, rehabilitation centres, patients' homes and carers. It is hoped that insights from the sixth case study will be used to inform the development of the Norwegian stroke model.

Each one of these projects has its own aims but utilise the same generic hybrid approach. The scope of each case study and the associated model design decisions will be presented. The key changes to the hybrid approach which has evolved with each project will also be illustrated. The approach has been developed to be as flexible as possible so that it is able to be updated quickly and adapted and applied to different contexts, whether a different department, different hospital or different country.

17:00-18:30

SESSION VIII

SESSION VIII A

DISEASE MODELLING AND POLICY (III)

Chair **Leonid Churilov**

S8A.1

MODELLING THE OPTIMAL ETHNIC COMPOSITION OF AN ADULT STEM CELL REGISTRY

John Blake, Ken McTaggart, Donna Killeen

Abstract

For individuals suffering from blood related diseases a stem cell transplant represents the best, and sometimes the only, possible course of treatment. While a genetically matched near-relative is preferred, in many cases a suitable relative

cannot be found, and hence there is a need for a transplant from an unrelated donor.

Canada's adult stem cell registry, OneMatch, was formed to match Canadian stem cell donors to Canadian patients. However, only 20-30% of unrelated adult stem cell transplants in Canada are sourced from Canadian donors. Smaller stem cell registries, like OneMatch, face a dilemma: Should they recruit to maximize the likelihood of a match, and possibly duplicate entries from other registries, or should they recruit to promote genetic diversity, and perhaps increase national reliance on international sources?

In this paper, we discuss optimization models to set the composition of the Canadian registry to promote ethnic diversity, while meeting patient needs. We adopt a linear programming formulation to define the composition problem and describe methods for scaling the problem to make it tractable. An instance of the exact model is solved and the solution used to tune a simulated annealing algorithm capable of solving large scale problem instances.

Results show that when maximizing the populations covered, a highly diverse ethnic composition is suggested (72.4% non-Caucasian). However, when coverage is weighted by the ethnic composition of the patient population, a less diverse registry is suggested (8.6% non-Caucasian). We conclude that in environments where national resources are constrained, but donor searches are global, there are advantages to increasing the ethnic diversity of the adult stem cell registry.

S8A.2

VALUE-BASED REIMBURSEMENT MODELING FOR OCULAR GENE THERAPY IN PATIENTS WITH CHOROIDEREMIA

Reza Mahjoub, Benoit Kudinga, Christopher McCabe, Tania Bubela

Abstract

The predicted high cost of gene and cell therapies for rare diseases present financial challenges for public and private health system payers. Here, we use a game theoretic approach to model the interactions between a manufacturer and a payer for the value-based reimbursement of a gene therapy for Choroideremia. Choroideremia is a rare X-linked, recessive disease causes progressive retinal degeneration due to mutations in CHM gene that encodes the Rab escort protein 1 (REP1). It affects around 1 in 50,000 males; no treatment options exist to prevent blindness. However, results of a recent gene therapy

clinical trial that uses an adenoassociated viral vector (AAV) encoding REP1 promise in preventing further retinal degeneration and central vision loss. This gene therapy has been granted orphan drug status from both the U.S. Food and Drug Administration and the European Medicines Agency.

Bringing gene therapies to market requires not only flexibility in regulatory approaches, but new models to mitigate budget impact for payers. We model the underlying disease progression using a continuous time Markov chain. In this model, the objective functions of the payer and the manufacturer re the net profit and the net health benefits resulting from the sales and administration of the viral vector, respectively. The manufacturer decides on the price of the vector, the dose of vector for the given area of retina to be treated in each patient, as well as the time for the visual function tests for evaluating the effectiveness of the therapy after the administration of the vector. On the other hand, the payer decides the cut-off points for markers representing the effectiveness of the therapy, including the change in treated eye visual acuity as well as the change in the point of maximal sensitivity associated with the minimal detectable light stimulus.

Also, the payer needs to decide on a rebate rate for the reimbursement of the cost of the therapy for patients in whom the effectiveness of the therapy is lower than the respective cut-off values. We investigate the optimal decisions for the payer and the manufacturer and illustrate with a numerical model parameterized using data from a Phase 1/2 clinical trial of the gene therapy for choroideremia conducted in the United Kingdom.

S8A.3

APPLICATIONS OF UTLEY-GALLIVAN'S CONSENSUS PROCESS FOR IDENTIFYING A PRIORITISED LIST OF STUDY QUESTIONS IN STROKE CARE

Leonid Churilov

Abstract

In 2008, Utley, Gallivan and colleagues described a structured consensus process for identifying a prioritized list of alternatives by a panel of experts. This method utilises the knowledge and experience of experts and relies on a robust graph theory-based voting system to produce a ranked list of alternatives according to the aggregation of preferences expressed by individual expert panel members.

In this presentation we discuss how the Utley-Gallivan process was used in a number of different projects in stroke care. We demonstrate how it was extended to multi-attribute evaluation context by prioritising barriers relating to the stroke T-three intervention: triage, treatment and transfer of stroke patients in Emergency Departments. We also discuss how the consensus process was used together with the Keeney's Value-Focused Thinking methodology to guide the selection of the most appropriate outcome measures in stroke rehabilitation by the participants of the Stroke Recovery and Rehabilitation First International Roundtable Meeting (USA, 2016).

SESSION VIII B

DATA ANALYSIS & RISK MANAGEMENT (II)

Chair **Mathias Barra**

S8B.1

PERINATAL HOSPITAL ACTIVITIES AND HEALTHCARE PATHWAY OPTIMIZATION IN THE ILE DE FRANCE REGION: HOW TO MANAGE THE FULL SET OF DATA FOR REGIONAL HEALTH AUTHORITY?

Catherine Crenn Hebert, Elodie Lebreton, Chloe Poulain, Soufiane Zemrani, Claudie Menguy

Abstract

Background: Perinatal hospital activities are submitted to authorization from the Regional Health Authority. In IDF region, 2016 is time to assess applications for renewal.

The perinatal activities are allowed within a regional 5 years plan; hospital activities have to take part of healthcare pathways and perinatal network are in charge to coordinate and optimize the circuits. Assessment means to collect and manipulate outpatient care and hospital medical as well as organizational data. How to manage all the required data?

Material and Methods: Use of routine data from Perinatal health Information System which combines hospital discharge summaries, census data and organizational data. We have sent data about 40 indicators measuring activity and medical practice to the maternities involved in the routine Information system and who had already given their data for 2015, 2014 and 2013. To compare these measures with declarative data of surveys among midwives and hospital directors or doctors, we focus on «Hauts de Seine» district to draw a

«territorial diagnosis» for the perinatal network. They will be compared with questionnaires for renewal files, including 6 chapters about administrative, equipment, activity, quality and safety, medical and paramedical staff, prenatal, delivery and neonatal care activities, postpartum organization, enquiry about relationships with the perinatal network and routine practice assessment.

Results: Among 348793 childbearing age women (15 to 49 years old), living in the district with 1600569 inhabitants, having a total fertility rate of 1.99, 24469 delivered in 2014 (13.5% of total deliveries among IDF living women). In 2014, maternities have registered 27115 deliveries (14.8% of deliveries in IDF maternities), receiving women from other districts.

In 2015, a first survey asked the 15 maternities of the district about their organization and activities. 12 have answered. 2 hospitals follow an «autarcic model». The others practice «shared prenatal follow-up» with city physicians. The ratios of deliveries per delivery room varies from 10 to 600 and ratios of deliveries per postpartum bed varies from 25 to 80, in accordance with general activity varying from 536 to 3448 deliveries in 2015. A great heterogeneity is also seen in caesarean rates varying between 12% to 48% in 2 level one maternity hospitals.

A second survey, asked 120 independent midwives working in the district, about their organization and activities. 97 have answered about distribution of prenatal consultations, ultrasounds for low-risk pregnant women, high-risk care under medical order, postpartum care for mothers and neonates.

Discussion: Health authority is facing a great number of data to achieve the renewal files analysis, comparing hospital declarative data and routine measured data. A great number of meetings are necessary to achieve agreement about the meanings of the data.

Perinatal networks should get benefit from these analysis to build the various perinatal healthcare pathways, but the out-care data are still difficult to obtain and match with hospital data.

Conclusion: We hope that a shared territorial diagnosis about coordinated perinatal healthcare pathway between ambulatory care and hospital will come to light after these intensive data management.

S8B.2

SENIOR CITIZENS' POTENTIAL DEMAND FOR EXERCISING

Jiun-Yu Yu, Pei-Yi Cheng

Abstract

Taiwan has already become an aged society, and the percentage of senior citizens in capital Taipei is the highest among all cities in Taiwan. Therefore, helping senior citizens live with better quality during the process of getting older has become a tough challenge for Taipei City Government.

In the study, we use different ways to analyze data provided by Easy Card Corporation to understand how senior citizens commute within the city. We then compare the result we got from the data with the result from observation method. By doing so, we can summarize the potential demand of exercising for elders in the city.

This study has three main achievements: The first is to understand the current condition and potential demand of exercising for senior citizens. The second is that government can use the result of this study as the base of the establishment of the 2nd generation sport center. The third is that government can use the result of this study as a guideline to adjust and reinforce the current facilities in the city.

S8B.3

CONFIRMATORY FACTOR ANALYSIS WITH SMALL SAMPLES – ARE SIMULATION STUDIES MATCHED BY ECOLOGICAL DATA?

Mathias Barra, Jonas Lindstrøm, Jurate Saltyte-Benth

Abstract

Introduction: The use of confirmatory factor analysis (CFA) for validation of instruments purporting to measure so-called latent variables has become a sub-genera of the literature on patient-reported outcomes. Often the samples used in such studies are small (n<200—300) and there is reason for concern about the merit of such studies. There is empirical evidence from simulation studies which suggest that for samples of more than 100 responders, CFA correctly confirms existing structure in a high proportion of data-sets. In the 2005 paper Four Recommendations for Getting the Most From Your [Exploratory Factor] Analysis (EFA) Costello and Osborne probed the question of how well EFA performs on ecological data. Contrary to the community's beliefs, that

study established that while results from studies on simulated data suggested that EFA was well-behaved for sample sizes down towards 100; when the same experimental test-setup was used on ecological data with a known factor-structure much larger samples were necessary to achieve acceptable performance for the EFA-methodology.

Having searched the methodological contributions to the CFA literature on the sample-size issue, we found that an ecological-data sample-size study for CFA methodology is needed: the articles we found about how sample-size affects CFA's ability to correctly confirm underlying structure were all based on simulated data sets. We therefore undertook to test CFA-methodology on ecological data.

Methods: A data set of Cornell Scale for Depression in Dementia instrument (19 items) answers from an anonymised data set with 1682 patients with dementia was obtained. This data has a known 5-factor structure, which was confirmed by CFA, and the estimated factor loadings (FLs) were defined as the gold standard. Next, for sample sizes n=75,100, ..., 975,1000, we sampled 10K n-sized samples to which a factor-structure was fitted with standard CFA-software in R (lavaan). Key model-fit parameters (TLI, CFI, GFI, RMSEA, SRMR) and FLs were stored for each sample size n. We next analysed to what extent the various fit-measures indicated satisfactory fit, and the distributions of estimated FLs.

Results: We found that a threshold was crossed for sample sizes below 300-400; so that accuracy of CFA is likely to deteriorate for higher sample sizes than commonly assumed; both for FLs and for the fit-measures. For example, for n=150, a sample size used in several CFA validation studies, the 0.1 quantiles of the distribution of differences (estimated-FL – actual FL) had range -0.15 -0.13 for a typical strong item (FL=0.87) and -0.16 -0.17 for a typical weak item (FL=0.50); about 22% of the CFA-runs had an FL < 0.40 for the weak item; often used as threshold for non-confirmation. Similar results was found w.r.t. the fit measures.

Conclusions: Studies using CFA for validation purposes which consult simulation-studies for adequate sample-size may cause rejection of (and confirmation of?) factors which are (not?) present. This is a potentially big problem, also with regard to publication bias. This work focus on false rejection of factors, and artificially low model fit measures, and more research is needed to determine how often non-loadings are falsely confirmed.

SESSION VIII C

PERFORMANCE EVALUATION (II)

Chair **Vicent Augusto**

S8C.1

THE HOSPITALS SERVICE'S EFFICIENCY: A RELATIONAL MODEL WITH NOT DISCRETIONAL VARIABLES

Pinto Claudio

Abstract

The current pressure on hospitals costs reduction suggest a more efficient use of its resources. Inside Operation Research (OR) discipline the Data Envelopment Analysis (DEA) it has been widely applied in the hospital efficiency measurement despite its easy way to accomplish multi-outputs production. However, one of DEA drawbacks is that it not allow to see inside the internal structure of the production process. The network DEA (NDEA) models allow to do this estimating the whole production process efficiency as well as the efficiency of its parts. Here we estimate several network DEA models under different assumptions one of this is the not-controllable relational variables, attending different policy indications. Preliminary results suggest that under NDEA-CRS (Constant Return to Scale) model with not discretional relational variables, on average, the efficiency of the hospital acute care production process is higher (of little) than under all discretional variables assumption (0.48 vs 0.44).

Assuming Variable Return to Scale (VRS), on average, the scores efficiency's difference between the NDEA models is more marked (as before the efficiency scores are higher under not-controllable relational variables assumption than in the case of all discretional variables, 0.54 vs 0.47). The DEA efficiency estimates show partially different results, however in general, on average, the efficiency scores are higher than in the NDEA models To test the effectiveness of the not-controllable relational variables assumption on the measurement, different statistical tests are applied. The evidence of the tests suggests that in the case of NDEA models both under VRS (with1% significance) and CRS (with 5% significance) we can not accept the null hypothesis (equal distribution under the two specifications), concluding for the validity of the assumption. Differently as happen in the DEA models, where statistical tests suggest do not reject the null hypothesis concluding for the not relevance of this assumption in the DEA efficiency measurements.

This open an interesting space to different policy indications under DEA and NDEA models. Yet, the not-controllable variables assumption in our NDEA models allow to reflect on the trade-off between competing objectives that hospital manager encountering. For now we omit a second stage analysis of external factors influence.

S8C.2

DEVELOPMENT OF AN NHS PATIENT ACTIVITY FORECASTING TOOL IN ENGLAND

Philip Worrall, Thierry Chaussalet

Abstract

Monitor is the NHS organisation in England with main focus to assess applications by NHS bodies to become NHS foundation trusts – organisations that provide and develop healthcare within a devolved decision making framework. Since 2012 Monitor has the power to set and enforce a framework of rules for providers and commissioners. Monitor does this through regulating providers of NHS services, setting prices for NHS funded services in England, supporting the delivery of integrated services, preventing anticompetitive behaviour within the system, and supporting the continuity of services in the event of failure of a health care provider.

Here we present the development and application of a tool to help Monitor in forecasting NHS activity to be used for economic evaluation and impact assessment of pricing policies. The overall approach is based on the application of operational research modelling and econometric-based methods to understand the processes governing NHS activity in England with respect to Admitted Patient Care; Outpatient Attendances and Procedures; and Accident and Emergency. The tool incorporates break/outlier detection and semiautomation of model fitting. It is also able to with deal with exogenous variables (e.g. age group) and with currency change through data aggregation at various levels.

Ultimately the significance of the work relates to how it can help measure and gauge the effect of different pricing policies, with respect to both patients and providers, so as to support the setting of efficient tariffs that promote and consider the interests of all affected parties.

S8C.3

PERFORMANCE EVALUATION OF HEALTH INFORMATION SYSTEMS IMPLEMENTATION THROUGH DISCRETE-EVENT SIMULATION

Vincent Augusto, Claire Pilet, Lionel Perrier, Xiaolan Xie, Saber Aloui, Pierre Biron

Abstract

Objective: Development and implementation of Information and Communication Technology (ICT) are required to improve patient care. In this study we propose a cost evaluation of hospital medical consultation taking into account the level of deployment and the integration of Health Information Systems (HIS) along with a performance evaluation approach to evaluate HIS implementation scenarios considering both quantitative and qualitative performance indicators.

Methods: Data has been collected through observations and hospital surveys. A cost analysis has been conducted with data from three French hospitals. ARIS modular models have been proposed in order to apply the methodology to other hospitals. Discrete-event simulation (DES) has been used to simulate scenarios to determine the elements of the HIS providing the best improvements and the best return on investments of each component compared to the other costs of the consultation, such as the salary of the doctor or environmental costs.

Results: The study has been conducted on 179 patients from three hospitals with various level of HIS. The relative cost of the HIS is low (3 to 6 % of total cost). However, the usage rate of computers is high when the HIS is well deployed and integrated (30 to 40 % of total duration). DES shows that the implementation of numeric patient file, voice recognition report dictation, and HIS integration are the best improvements to reduce costs. Voice recognition implementation has the best return on investment among all possible HIS components. High level HIS improve the quality of the consultation, evaluated through the evaluation of the number of required examinations provided by the HIS.

Conclusions: The cost analysis coupled with a performance evaluation study allows to conclude on the impact of HIS on the consultation and it is possible to point out the best actions to take to improve the overall performance of the consultation. DES allows to consider a long horizon and to calculate the return on investment of each HIS component. Such tool can be used by HIS manger in order to take decisions on the best investments to make. In future works doctor practice should be taken into account to accurately evaluate the proper usage of high level HIS. Decision aid tools through simulation-optimization will also be investigated.

FRIDAY

9:00-11:00

SESSION IX

SESSION IX A

HOME CARE / LTC (III)

Chair **Nadia Lahrichi**

S9A.1

DRUDGERY MINIMIZATION IN HOMECARE PLANNING

Thierry Garaix, Nizar Triki, Xiaolan Xie

Abstract

Health care professional positions are at higher risk for burnout. Managers are looking for an effective way to manage stress, avoid internal staff disagreements, prevent burn out and improve patient care. The task-to- caregiver assignment and the schedule of tasks impact the working conditions.

In this study, we consider 3 drudgery criteria: (1) the burden of the task ; (2) the overtime ; (3) the ratio between travel and care times. These criteria are combined to determine the burden of an individual working day. In order to measure drudgery over a week, we consider the number and the distribution of difficult days for each caregiver.

We use a multi-step optimization approach to compute weekly planning on artificial and real instances with up to 20 caregivers per day. At the first step, the minimum number of caregivers with a difficult day is computed for every day, according to the 3 criteria described above. Then, caregivers are assigned to difficult days over the week with a drudgery balancing objective. Finally, daily planning are computed with a performance (travelling distance minimization) objective assuming a limited number of caregivers with a difficult day.

Reaching a small optimality gap is challenging in the first-step optimization problem, since this problem is strongly NP-Hard (as an extension of the Vehicle Routing Problem) and solutions only take small integer values (the number of caregivers with a difficult day). In our implementation, a constructive heuristic procedure (inspired from Clark and Write's algorithm) is completed by a column generation algorithm. This approach is slightly modified to solve the routing problem when the number of difficult days is set as a constraint and the performance is maximized.

S9A.2

SOLVING A RICH HOMECARE ROUTING AND SCHEDULING PROBLEM WITH LNS

Florian Grenouilleau, Nadia Lahrichi, Louis-Martin Rousseau

Abstract

This Homecare Routing and Scheduling Problem consists of scheduling a given number of home visits, over a week, and deciding which health resource will be used to perform each visit in which sequence. This problem can be seen as a mix between an assignment problem, with the coupling nurse-patient decision and a vehicle routing problem with time windows for the scheduling part. In our study, we try to take into account a maximum of real practical constraints. These constraints are linked to the assignment component of the problem, such as assuring the qualifications and availability of each nurse for each visit. We also consider, for the scheduling part, the time-dependent aspect of the travel times and the maximum amount of work hours per nurse over the week and over each of the work days. We propose to take into account the periodic aspects of planning multiple visits and the synchronization of multiple nurses during a single visit. To solve this problem, we use a well-known method calls Adaptive Large Neighborhood Search that permits, starting from an initial solution, to iteratively modified some parts of this solution to find a better assignment nurse- patient or to find a better schedule for the nurses' roads. To test this method, we have used real data provide by the Alayacare company, a Canadian company which have created software for the home health care management.

Because of the reduced size of the weekly assignment problem of difficult days (with our instances) any integer linear programming solver can be used to reach optimal solutions quickly.

We conduct numerical experiments under several assumptions on the type of geographical area, the presence patterns of caregivers and the weight of each difficulty criterion. Our experiments show the cost of drudgery minimization in the weekly planning process for different types of organization.

S9A.3

A MEMETIC ALGORITHM FOR HOME HEALTH CARE ROUTING PROBLEM

Mohamed Cisse, Yannick Kergosien, Christophe Lente

Abstract

Home Health Care is a growing field. It brings new challenges and problems to Operations researchers. One of them is Home Health Care Routing Problem (HHCRP).

HHCRP is a Vehicle Routing Problem with some additional constraints that stem from home care context.

HHCRP can be defined as follows: care workers leaving from single or multiple depots must provide services to patients scattered on a rural or urban area. The planner must design a schedule for each care workers while respecting all the constraints and minimizing the total cost. These constraints can be classified in three categories: timing constraints, assignment constraints, geographic constraints.

Timing constraints are related to starting time of services and the working hours (time windows, frequency of visits, etc.).

Assignment constraints are mainly related to the relationship between care workers and patients without considering a time aspect (qualification, continuity of care, preferences, etc.)

Finally, geographic constraints concern the geographic elements: locations and type of network flow.

Due to the success of memetic algorithm to solve Vehicle Routing Problem, we propose a similar approach in order to solve HHCRP. For that purpose, an extension of the split tour algorithm working on a giant tour is proposed. The algorithm is based on a label setting algorithm that has been adapted to take into account the features of HHCRP. This algorithm is used in a memetic algorithm that is a hybridization between a genetic algorithm and a local search procedure. Usual selection procedures and crossover operators are used into the genetic algorithm and distance measures are exploited to avoid to be get trapped in a restricted solution space. Finally, computational experiments have been conducted to validate our approach comparing our results to those from literature and those from exact method using CPLEX solver.

S9A.4

A NEW DECOMPOSITION APPROACH FOR SOLVING THE ASSIGNMENT AND ROUTING PROBLEMS IN HOME HEALTH CARE

Nadia Lahrichi, Ettore Lanzarone, Semih Yalçındağ

Abstract

Home Health Care (HHC) service plays a crucial role in reducing the hospitalization costs while improving the quality of life for those patients who receive treatments at their home. HHC is one of the recent service systems where human resource planning has a great importance, and the service providers have to deal with several operational issues such as the assignment problem of the operators to patients together with their routing process. In the HHC literature, these problems are mainly considered via two different approaches: either these problems are solved simultaneously or decomposed by first solving the assignment problem and then the routing problem. In this work, we develop an alternative approach where the decomposition is based on the «first route and then assign» approach. We aim to perform a comparison between this new approach and the previously developed ones (i.e., simultaneous and «first assign and then route» approaches) to analyze the efficiency and quality of the solutions with respect to the others under different HHC service settings. Since different agencies have different HHC structures and cover different areas (urban vs rural, density, etc.), such an analysis will be useful to select the best approach for the considered HHC problem. In our approach, as first step, daily giant tours are generated by solving a Periodic Vehicle Routing Problem (PVRP) to cover all the territory while minimizing the total cost. Then, all these tours are split and assigned to operators (nurses) while taking into account the continuity of care, operators' capacities and workload balancing. Finally, a post assignment process is adopted (improvement stage) in order to guarantee feasibility (if not already obtained) and to improve the solution of the splitting process. Our new «first route and then assign» approach is generic and can be adapted to any kind of HHC context (i.e., large or small territories, with or without districts, with different types of services and objectives, etc.).

SESSION IX B

HEALTH PLANNING (II)

Chair **Felipe Rodrigues**

S9B.1

A NEW CONFIGURATION OF INPATIENT BEDS IN HOSPITALS

Navid Izady, Israa Mohamed

Abstract

Every day, a considerable number of children in need for health monitoring and treatment are denied admission to different specialties of the Paediatric department at Zagazig University hospital in Egypt due to lack of inpatient beds. The bed strain is not restricted to developing countries. In the UK and US, for example, official statistics show record-high values of bed occupancy rates, often manifested by long waiting times for admission and/or patients outlying in inappropriate wards, leading to adverse health outcomes and patient dissatisfaction. Building on the theory of pooling and overflow analyses in queueing systems, we propose a new configuration of inpatient beds, which we refer to as the overflow configuration. In this configuration patients who are denied admission to their primary wards as a result of beds being fully occupied are admitted to overflow wards, each designated to serve overflows of specific specialties. This configuration provides the combined advantages of the dedicated configuration, where patients are only admitted to their primary wards, and the flexible configuration, where excess demand is absorbed in non-primary wards. Developing analytical methodologies for optimal bed allocation in the presence of over/under-dispersed demand, we compare the performances of the three configurations using real data. The analysis of the results shows that flexible configuration may actually lead to a worse performance compared to the optimal dedicated configuration, while substantial improvements are likely to arise as a result of implementing the overflow configuration.

S9B.2

DEDICATED EMERGENCY BEDS OPTIMIZE THE EMERGENCY ADMISSION FLOW

Anton J Schneider, Peter L. Besselink, AJ Fogteloo, Paul Bilars, Ton J. Rabelink

Abstract

Aim: The increasing number of acute medical admissions the last decade results in overcrowded emergency departments (ED) and a decrease in quality of care. In this paper the emergency admission process is optimized by evaluating the impact of introducing emergency beds to general hospital wards. The acute admission flow of this study consists of the following hospital departments: ED, acute medical unit (AMU) and general wards. These emergency beds are exclusively dedicated for patients transferred from the AMU. An AMU is a ward specifically staffed and equipped for acute patients. Two key performance indicators evaluated the performances of the emergency beds: length of stay at the acute medical unit and refused patients at the emergency department. A second objective was to analyze the impact of adjusting ward sizes.

Methods: To optimize the acute admission process a discrete event simulation model was developed. Two heuristics were developed for locating the optimal bed allocation. The first heuristic determines the number of emergency beds in hospital wards. The second heuristic determines the required number of emergency beds in hospital wards when multiple wards are merged into a single ward (e.g. increasing the ward size). Results: The simulation model was applied in a Dutch university hospital. Historical data of patients arriving at the AMU of this hospital were included for flow distribution and length of stay based on their treating specialty. Applying the first heuristic showed that all individual wards together require 33 dedicated emergency beds to maintain the length of stay at the acute medical unit and not refusing patients at the ED. Applying the second heuristic showed that only 24 dedicated emergency beds are required without significantly reducing performances. The simulation model is now embedded in the tactical planning process of the acute admissions of aforementioned hospital by re-evaluating the required dedicated beds every quarter.

Conclusion: Dedicating emergency beds at wards optimizes the internal emergency admission flow in terms of refused patients and LoS at the AMU's. Merging wards will result in a decrease in the number of required dedicated emergency beds without yielding performance.

S9B.3

DYNAMICS OF THE PROCESS OF CARE FROM INPATIENT AND ITS INFLUENCE ON THE HOSPITAL STAY

Paula Andrea Velásquez Restrepo, Tatiana María Ceballos Acevedo, Sebastian Jaén Posada

Abstract

Taking into account the disparity between supply and demand of health services which leads to overcrowding of services, efficiency is an important condition due to the fact that resources are limited. In hospitals, the bed is one of core resources for the provision of services. For this reason, global measures of hospital efficiency are those that relate to the use given to this resource. The average hospital length of stay of patients is used as an indicator of efficiency, because it sums up the use. Additionally, the hospital length of stay of patients is a permanent concern around the world because this generates negative effects for the system as on costs in the provision of the service, easy accessibility to services hospital for lack of beds, overcrowding in emergency departments and the risk of adverse events in patients. In this research we studied the dynamics of the process of care from inpatient and its influence on the hospital stay. Study system was the unit of hospital of the Clínica León XIII of Medellin-Colombia, and the study populations were patients with related diagnosis group (GRD) infections of the kidneys and the urinary tract of high severity.

Research includes the most common process variables in the extension of the stay and study the dynamics and interaction among them, by applying the methodology of dynamics of system in order to develop policies to guide decision making in the hospital process and allow shorten stay. Policies evaluated with dynamics system model made it possible to reduce 0.7 days approximately the average stay in a 23% with respect to the international standard. In addition, this reduction enables an 'effective' gain of approximately 60 beds in the Clínica León XIII, according to Advisory Board International.

S9B.4

LEVEL 2 BED PLANNING IN THE LONDON HEALTH SCIENCE CENTRE IN ONTARIO, CANADA: A SIMULATION MODEL BASED ON NEMS SCORES

Felipe Rodrigues, Greg Zaric, David Stanford, David Barret, Juddy Kojlak, Fran Priestap, Claudio Martin

Abstract

In highly congested hospitals, it is common for patients to overstay at ICU's due to capacity imbalance or downstream congestion. ICU overstay is a three pronged problem. Clinically it represents a misalignment between the care needed vs care provided. Operationally, it disrupts patient flow as a congested ICUs cannot admit new patients from upstream units such as Emergency departments and Operating rooms. Financially, it represents an increase of 3-5 times in the patient's daily cost.

Step-down beds, also known as Level 2 beds, have become an increasingly popular alternative to smooth patient flows between ICUs and wards. Currently the University Hospital of London Health Sciences Centre does not have a general medicine Level 2 unit. This hospital keeps its medicine patients in the ICU until their health improves enough that they can go straight to a ward bed. If wards are full, patients may stay in the ICU until discharged. When the hospital requires Level 2 care for certain patients, it frequently utilizes non-medicine Level 2 units such as the multi-organ transplant unit. Roughly 30% of the beds in this unit are occupied by non-transplant patients. Capacity imbalance and lack of the medicine level 2 unit are likely causing increased patient length of stay (LoS), higher costs and reducing the hospital's operational performance.

We developed a discrete event simulation model that estimates Level 2 bed needs for the study hospital. Every patient receives a daily measurement of her nursing workloads, following standardized methodologies such as the Nine Equivalents of Nursing Manpower Use (NEMS) index. Using data from the hospital and current nursing practices, we defined a NEMS score that represents patient readiness to step-down. Then, we extract from the data several components of the patients' total ICU LoS. First, the true ICU service time, which is the time patients spend above the NEMS threshold score. Second, the theoretical Level 2 service time, which is the time spent below the threshold, but still at the ICU. Third, the daily death and step-down probabilities. Those components feed a simulation routine to generate patient outcomes (Death, Stay or Step-down) for each patient at the ICU each day. We evaluate multiple scenarios regarding

management of the Level 2 unit, including forcing all medicine ICU patients to pass through the Level 2 unit before proceeding to the wards; and making the Level 2 unit unit an «overflow» unit for congested wards. We also investigate the optimal mix of capacity between the step down unit and hospital wards.

Acknowledgments: This research is partially funded by: The Ontario Trillium Scholarship (OTS); Universidade Federal do Parana (UFPR); Ivey International Centre for Health Innovation.

SESSION IX C

EMERGENCY MEDICAL SERVICES (II). MISCELLANY

Chair **Brigitte Werners**

S9C.1

FACILITY LOCATION AND SPATIAL DATA ANALYTICS IN PUBLIC ACCESS DEFIBRILLATION

Derya Demirtas, Timothy Chan, Roy Kwon

Abstract

Out-of-hospital cardiac arrest (OHCA) is a significant public health issue and treatment, namely, cardiopulmonary resuscitation and defibrillation, is very time-sensitive. Public access defibrillation programs, which deploy automated external defibrillators (AEDs) for bystander use in an emergency, have been shown to reduce the time to defibrillation and improve survival rates. The focus of this research is on data-driven decision making aimed at improving survival from OHCA by analyzing cardiac arrest risk and optimizing AED deployment. This work establishes a unique marriage of data analytics and facility location optimization to address both the demand (cardiac arrest) and supply (AED) sides of the AED deployment problem. In the demand side, we analyze the spatiotemporal trends of OHCAs in Toronto and show that the OHCA risk is stable at the neighborhood level over time. In other words, high risk areas tend to remain high risk, which supports focusing public health resources for cardiac arrest intervention and prevention in those areas to increase the efficiency of these scarce resources and improve the long-term impact. In the supply side, we develop a comprehensive modeling framework to support data-driven decision making in the deployment of public location AEDs, with the ultimate goal of increasing the likelihood of AED usage in a cardiac arrest emergency. As a part of this framework, we formulate three optimization

models that consider probabilistic coverage of cardiac arrests using AEDs and address specific, real-life scenarios about AED retrieval and usage. Our models generalize existing location models and incorporate differences in bystander behavior. The models are mixed integer nonlinear programs, and a contribution of this work lies in the development of mixed integer linear formulation equivalents or tight and easily computable bounds. Next, we use kernel density estimation to derive a spatial probability distribution of cardiac arrests that is used for optimization and model evaluation. Using data from Toronto, Canada, we show that optimizing AED deployment outperforms the existing approach by 40% in coverage and substantial gains can be achieved through relocating existing AEDs. Our results suggest that significant improvements in survival and cost-effectiveness are possible with optimization.

S9C.2

CONSTRUCTING OPTIMAL ROUTES FOR INTER-FACILITY TRANSFER AMBULANCES USING THE DIJKSTRA-BASED TOPOGRAPHIC-TIME DEPENDENT MODEL: A CASE STUDY OF ZOMBA DISTRICT HEALTH OFFICE

Elias Mwakilama, Javier Faulin, Levis Eneya

Abstract

Applying methods and techniques of vehicle routing problem (VRP) to health care industry and other logistics activities has been a subject of interest for long. However, health care logistics departments in Malawi are yet to adapt to such methods. While this worrisome situation may be attributed to lack of research in VRP methods and applications, on the other hand, it appears most of the proposed methods are better used for urban settings unlike in countries dominated by rural areas where topography offers much resistance to vehicle's speed.

Therefore, housed within a designed graphical user interface (GUI) using Java NetBeans IDE version 8, this thesis proposes a Dijkstra-based topographic-time dependent (TTD) mathematical model for constructing and managing of optimal routes and ambulances respectively within the existing transportation system of Zomba District Health office (ZDHO). An analysis of inter-facility transfers' (IFT) historical data for the case study and in-depth review of existing VRP solution methods were done to establish the nature of and identify proper routing algorithms for the case study's characteristics. The road

network data was prepared through computer based tracking (CBT) method and validated for quality and reliability using descriptive and t-Test methods in Excel 2010. Findings show that ZDHO operates within a range of low to middle degree level of dynamism, requiring use of advanced static heuristic algorithms to offer a VRP solution method. Compared to previously reported travel times, simulated optimal TTD travel times imply that the proposed ZDHO-VRP tool offers an opportunity for logistics staff of ZDHO to improve their ambulance and route management skills within a rural setting through offering timely and dynamic IFT ambulance services.

S9C.3

A QUEUEING MODEL WITH ADJUSTABLE SPEED OF AN INTENSIVE CARE UNIT

Eman Almehdawe, Armann Ingolfsson

Abstract

We investigate a fluid model of an intensive care unit, in which patients are discharged at an adjustable speed, which influences the proportion of patients that are readmitted after a delay. We formulate the model as a delay-differential equation. We study the transient and steady-state behavior of the system occupancy in four different regimes and we obtain conditions under which speedup reduces average occupancy.

S9C.4

IMPROVING EMERGENCY MEDICAL SERVICES IN A REAL-WORLD SETTING

Brigitte Werners, Lara Wiesche, Pia Steenweg

Abstract

A key task for health care systems is to provide high quality emergency medical services (EMS) and to ensure accessibility to these services for the public. EMS-vehicles have to be located and relocated during a day such that emergencies can be reached within a legal time frame respecting a limited budget. Empirical studies show temporal and spatial variations of emergency demand as well as variations of travel times during a day. The numbers of emergency calls within a 24 hours interval differ significantly and show peaks especial-

ly during rush hours. To determine an optimal solution for this problem, a time-dependent ambulance allocation model has been developed and successfully evaluated (Degel et al. 2015).

When improving real world systems, only small amendments of the existing situation are acceptable. In this contribution the consequences of different modifications as for instance a small increase in the number of ambulances, some changes in positioning these vehicles and the influence of additionally undertaking non- urgent transports are analyzed. For this purpose the data driven MILP- model considering time and spatial dependent degrees of coverage is used and extended to determine optimal changes with respect to different criteria and specific requirements. Using a simulation tool and large empirical data records from a German city, an extensive evaluation is performed to compare different suggestions and their respective optimal solutions with respect to degrees of coverage and additional results.

POSTER PRESENTATIONS

POSTER PRESENTATIONS

POSTER CONTEST

PC1

DECISION SUPPORT FOR EMERGENCY MEDICAL SERVICES: LINKING AMBULANCE ALLOCATION AND SHIFT SCHEDULING

Lara Wiesche

Abstract

Emergency medical services (EMS) have to be assured on a continuous basis, 24 hours a day, seven days a week. Since ambulance providers are responsible for scarce emergency resources and response times are important for life-saving medical care, it is crucial that ambulances are located in a way that good coverage is provided. In this purpose, a data-based approach is proposed providing emergency medical service decision makers to efficiently deploy their resources. By increasing data accuracy, timely adjustments can be made to emergency resources. Nevertheless, in state-of-the-art literature, the location of ambulances is optimized, while staff requirements are neglected making such approaches not practicable for real-world applications. We develop a linear integer optimization model to ensure comprehensive decision support linking ambulance allocation and shift scheduling of crews. By using a real-world case study, we show that ambulance planning that neglects staff requirements is not practicable, since staff cannot be used as flexibly as ambulances. Considering shift patterns, there will be a slack of extra ambulances scheduled in addition to the required number. To use these ambulances in the best possible manner, different objective functions are proposed. The influence of these objective functions and the resulting positioning of emergency resources on real-world outcome measures are analyzed via a detailed discrete event simulation study. We show the advantages of the suggested comprehensive approach, which results in a higher response time threshold. Applying our model, it is possible to make use of the available data and determine practicable, optimal location of ambulances according to given shift patterns.

PC2

T-CARER: TEMPORAL-COMORBIDITY ADJUSTED RISK OF EMERGENCY READMISSION, USING HOSPITAL INPATIENT DATA

Mohsen Mesgarpour, Thierry Chassalet, Salma Chahed

Abstract

The objective of this study was to develop a new adjusted casemix model, to improve the accuracy of comorbidity scoring for emergency readmission. In order to achieve this, the model incorporates temporal dimensions and medical procedure groups as well as diagnoses groups using inpatient data from Hospital Episode Statistics database. It has been shown that ignoring the durations and performed procedures, like prior score models such as Charlson and Elixhauser, noticeably degrade the risk model's calibration. The development of Temporal-Comorbidity Adjusted Risk of Emergency Readmission (T-CARER) model using routinely collected hospital inpatient data can help in monitoring temporal comorbidities of patients and potentially reduce the cost of inappropriate hospital and A&E admissions. The majority of prior scoring methodologies are focused on addressing comorbidity scoring for admission and mortality using odds ratio or very basic casemix models. And, their performances are constrained due to exclusion of major correlated factors like medical procedures and length-of-stay, ignoring temporal dimensions, omitting secondary diagnoses and medical procedures, using small sample sizes and applying unrepresentative weights. The main outcome of this research is the development of an adjusted casemix risk model for emergency readmission, which includes temporal correlations, diagnoses groups and medical procedure groups.

PC3

IMPROVING THE ROUTE TO DIAGNOSIS OF BREAST CONDITIONS

Christina Saville, Honora Smith, Katarzyna Bijak, Navid Izady

Abstract

In order to diagnose breast cancer cases quickly, it is recommended that General Practitioners (GPs, family doctors) send patients with suspicious symptoms to a specialist clinic as a matter of urgency. We are tackling three objectives to improve the route to diagnosis, in collaboration with the Whittington breast diagnostic clinic. This project models the pathway from when a patient visits their GP until diagnosis. Firstly we are developing a discrete choice model to provide

insights into what factors affect choice of clinic. In particular we are testing the assumption that GPs choose in their patients' best interests. There are few existing hospital discrete choice models using revealed preferences for state-funded healthcare systems. Secondly we are investigating whether information provided by GPs is complete and accurate enough to triage patients. Classification models to predict relative urgency and diagnostic test requirements could help improve the efficiency of the clinic, while accounting for different patients' needs. Thirdly, we model the processes in the specialist clinic itself. Patients visiting the clinic face multiple on-the-day waits between a series of diagnostic tests and consultations. We present a discrete event simulation model to test the effects of various changes on waiting times and clinic efficiency.

PC4

IMPROVING SURGICAL OUTCOMES THROUGH OPTIMAL VOLUMES ALLOCATION

Elisabetta Listorti, Arianna Alfieri, Andrea Matta

Abstract

Uneven distributions of health outcomes within countries, reported by national health services, hinder equity among citizens and recall governments' commitment. In particular, unequal quality levels have been highlighted among healthcare facilities performing different volumes of activity, i.e., worse outcomes are observed in hospitals performing less procedures. Throughout the health literature, this relation has been defined as the volume-outcome association.

In our research, we study an innovative use of the volume-outcome association, i.e., how it can be used to help decision makers in allocating surgery interventions among healthcare structures, a relevant planning problem. We have analysed different objective functions that can be used to drive the allocation process towards better health conditions for patients. Interestingly, each objective function supports a specific health policy priority, even though increasing the risk of neglecting some others.

We tested our model on three case studies taking into account real life factors. Specifically, we considered: 1- geographical distribution of hospitals, with a minimum number of facilities required by province; 2- specialization thresholds, e.g., a minimum number of interventions imposed per hospital; 3- hospital performance, allowing different outcomes for equal volumes, depending on hospital physicians' excellence. The results, which have been compared

with real data from the Italian National Outcome Evaluation Program (PNE), shed some lights on the possibility to define a unique optimal volume of activity, around which an intense debate is involving the research community. We highlight the importance of considering the relevant factors of the real case, which drive to different optimal solutions for different contexts.

All in all, our research confirm the paramount importance of considering the volume-outcome association within the strategic planning of healthcare provision, in order to guarantee better population health, both in terms of quality and fairness.

PC5

SOCIAL NETWORKS AND THE OBESITY EPIDEMIC

Mark Tuson

Abstract

The rise of Obesity across the global population continues to be a source of concern for the medical population. More recently the spread of behaviours and values through social networks has been linked to healthcare issues, in particular obesity. This project sets out to understand the impact of such networks on the spread of obesity and in doing so to answer a number of questions: Which sub-populations have the most impact on the spread through the network? What intervention strategies might be effective in addressing this? How does the impact vary between sub-populations? Which sub-populations have the most impact on cost?

After the initial mathematical modelling it is intended to build a mixed model simulation representing three levels:

- The onset of the individual behaviours that result in obesity within the individual.
- The impact of the social networks within which the individual is situated on those behaviours.
- The broader environmental factors that impact on the individual and network.

A separate challenge is the development of a large scale network (100,000+), that mimics the features of social networks; multiplexity, homophily, evolution and diffusion. An alternative maybe to use existing data sets and scale up. The simulation will then be used to test a range of scenarios and strategies in order to address the questions initially posed.

PC6

DYNAMIC APPOINTMENT SCHEDULING WITH PATIENT TIME PREFERENCES AND DIFFERENT SERVICE TIME LENGTHS

Anne Zander, Uta Mohring

Abstract

Advance admission scheduling in the field of health care is an important and complex problem. Often, exact models of realistic size cannot be solved due to the curse of dimensionality and heuristics have to be used. We consider the appointment schedule of a physician's day where the day is composed of a fixed number of time intervals. We assume patient types defined by different time preferences and service time lengths (in number of time intervals). Patient requests for the day are handled directly during a booking horizon. We present a mixed integer linear programming model to quickly determine a set of appointments to offer to the requesting patient. The patient chooses one of the offered appointments or leaves. This procedure mimics the process of booking an appointment via internet. The objective is to schedule the requesting patient while also taking the expected future demand of every patient type into account. We want to maximize utilization assuring a predefined fairness level with respect to the distribution of assigned appointments over the patient types. We perform a simulation in order to test the mixed integer linear program and to compare it to its offline version and to two simpler online heuristics. The offline version knows the number of requesting patients instead of only the expected values at the beginning of the booking horizon. The online heuristics consider the service time lengths and preferences of the requesting patients but not the expected future demand. For the simulation we implement a Poisson arrival process for every patient type. The patient's choice is modeled with a logit decision model. We present two scenarios and show that using the mixed integer linear program to schedule patients is beneficial due to the explicit consideration of time preferences and service time lengths.

PC7

MACHINE LEARNING, CLUSTERING, DISCRETE OPTIMIZATION, HEURISTICS, HOSPITAL INFORMATION SYSTEMS

Daniel Gartner, Yiye Zhang, Rema Padman

Abstract

Order sets are a critical component in hospital information systems and the reduction of physical workload associated with order set optimization has been

the scope of recent research. In this study, we formulate a mathematical programming model and embed it into an exact and a heuristic solution procedure with the objective to minimize cognitive workload associated with order set prescription. We show dominance properties of the problem when cognitive workload reduction is pursued. Our case study using data from a major U.S. hospital confirm the theoretical results and the hospital's solution is compared with the exact and heuristic ones on a variety of metrics and detail level. Our cognitive workload analysis reveals that our exact approach reduces the hospital's current cognitive workload for patients from 21% to 23%. We finally developed a decision support system which allows practitioners to analyze order sets based on different methods, objectives and performance metrics.

PC8

EFFICACY OF THE PROCESS MANAGEMENT CONCEPT IN DESIGNING A SUSTAINABLE HEALTHCARE DELIVERY MANAGEMENT SYSTEM: CASE STUDY OF ACCESS TO URGENT AND EMERGENCY CARE IN LONDON, UK

Ganye Kwah, Honora Smith, Jonathan Klein, Yuan Hung

Abstract

In recent years, calls for massive redesign of the British healthcare delivery system (NHS) have become louder. One main contended area, the Accident and Emergency Department (A&E), designed to treat patients suffering from acute health problems and accidents, has in recent years faced intense scrutiny due to overwhelming demand. According to the Foundation Trust Network (2013) at least 25% of these patients could and should have been treated by other parts of the NHS. As a result they posit that the NHS care delivery system is broken and needs a whole system approach in tackling the problem longer term. This will involve fundamental re-design of the whole pathway. As such we identified operational and process inconsistencies and designed this study in that line.

We started by evaluating the efficacy of a number of process management techniques in designing a sustainable healthcare management system. We find these methods are indeed efficacious, by a wide range of criteria, but find lack of evidence of implementation. Our focus then turns to access to urgent and emergency care in the NHS in England. We first look for evidence of process management in the system but find a lack of definition and ownership, and resulting confusion to a high degree for patients. Descriptive statistics highlight the growth

of non-admitted patients accessing A&E departments. Our case study centres on A&E departments in London: we investigate factors influencing numbers of non-admitted patients by providers of A&E services, considering the catchment area of each A&E department. Significant factors include numbers of GPs in the catchment, particularly small GP practices. The final part of our study concerns modelling, both simulation and geographical, of different scenarios for urgent and emergency care access, in one borough of London.

PC9

UNDERSTANDING VANCOUVER'S HIV CONTINUUM OF CARE: A WHOLE-SYSTEMS REPRESENTATION FOR MODELLING AND OPTIMISATION

Benny Wai, Alexander Rutherford, Rolando Barrios, JF Williams, Krisztina Vasarhelyi

Abstract

Human immunodeciency virus (HIV) infection is a well-known global health issue. Recently, the United Nations Joint Programme on HIV/AIDS (UNAIDS) set new health service delivery targets, known as 90-90-90, that aim to reduce the epidemic to a low-level endemic disease by 2030. HIV treatment delivery is the central focus of this strategy. There is no cure or a widely effective vaccine for HIV. However, highly active antiretroviral therapy (HAART) treats the symptoms of HIV infection, extends life expectancy, and prevents the transmission of infection.

Our team of mathematical modellers, joined forces with health care experts at Vancouver Coastal Health to develop a whole-system approach to managing the HIV continuum of care in Vancouver, British Columbia, Canada. We aim for a better understanding of the large complex system of HIV health service delivery on a qualitative and quantitative levels. Our long-term objective is to use operations research for finding the optimal allocation of HIV health care resources to best reduce infectivity, morbidity, and mortality. Our first step, which we described here, was to develop a qualitative model of the HIV care continuum in Vancouver.

For the qualitative model, we created two robust visual representations that help health care experts and mathematical modellers understand the continuum of care better. These unied modelling language (UML) diagrams acted as an effective first step in the entire research process. They were used to facilitate discussions at expert panel meetings and allowed for easy conversion of the qualitative model to system dynamic equations.

POSTER GENERAL

PG1

HOW DO WE MEET TOMORROW'S NEEDS FOR HEALTH CARE?

Tone Breines Simonsen, Joe Viana, Fredrik A. Dahl

Abstract

There is a strong need for innovation in health care. Rising costs, an ageing population and increasing public expectations are making the current healthcare system unsustainable.

Recent Norwegian white papers regarding Coordination reform (coordination between healthcare levels), quality of care and patient safety all address the need for innovative solutions, with particular focus upon the integration of people and technology.

The Centre for Connected Care (C3) aims to accelerate adoption and diffusion of patient-centric innovations that change patient pathways and delivery systems, empower the patients and increase growth in the healthcare industry. C3 holds a status of a centre for Research-based Innovation (SFI) supported by The Research Council of Norway for a period of 8 years from 2015. The OR group at Akershus University Hospital is a C3 partner.

The OR group is using modelling and simulation methods to support existing and potential C3 projects by providing tools to allow stakeholders within each project to assess in a safe «virtual environment» the anticipated and unanticipated implications of various «what-if» scenarios. The projects may be at different levels, in established projects only minor changes may be achievable. Other projects may be at an early stage, by actively utilising modelling techniques to gain a clearly understanding of the system they are working within, they may be able to avoid potential stumbling blocks or barriers. Possible future C3 projects may also arise through the supportive role simulation plays.

By utilising discrete event simulation, agent based modelling, system dynamics, hybrid modelling, and statistical approaches, including: regression modelling, phase type modelling, multilevel modelling, the OR group will evaluate suggested innovations in terms of costs effectiveness, patient and societal benefits.

It is anticipated that multiple C3 related modelling studies will be presented at future ORAHS events.

PG2

OPTIMIZATION OF APPOINTMENT SCHEDULING

Matthias Deceuninck, Stijn De Vuyst, Dieter Fiems

Abstract

We consider the problem of determining appointment schedules in settings where patients can request different types of consultations in advance. The main challenge is to schedule the appointments to time slots so that cost-effective service is ensured while patients experience short waiting times.

In our study, we investigate a local search-based procedure to optimize schedules under fairly general conditions. Our method is based on the exact evaluation algorithm of De Vuyst et al. (2014), which obtains accurate performance predictions at a low computational cost by using the transient solution of a modified Lindley recursion and a discrete-time setting. In contrast to many other studies in the literature, this model requires no special assumptions regarding the consultation time distributions, no-show probabilities or other model parameters. The fact that each patient may have a distinct consultation time distributions and no-show probability allows us to take prior knowledge into account when estimating the consultation time. Moreover, the method is fast in comparison to simulation and the explicit expressions of the Lindley recursion allow us to exploit some structural properties of the problem.

The performance of the heuristic is tested against a wide and diverse test-bed. We compare the results with both traditional appointment rules and the optimal solution. The analysis reveals that our method is able to find very good results within a few seconds (average optimality gap is 0.003%). In another experiment, we also investigated the impact of incorporating doctor's lateness into the model. Most studies assume punctual doctors, but Klassen and Yoogalingam (2013) reported that this is not always the case. Our results indicate that modeling lateness should only be considered when there are few other sources of variability. That is, when the no-show rates and service time variability are relatively low.

PG3

MULTICRITERIA MODEL FOR MAINTENANCE BENCHMARKING IN HOSPITALS

María Carmen Carnero

Abstract

Traditionally, maintenance is considered to be a source of costs to organizations, and so there is a serious lack of models and techniques to improve its ef-

ficiency, especially in Health Care Organizations. In consequence, maintenance offers considerable potential for improvement in organizations. A continuous improvement tool such as benchmarking could be of help to a Health Care Organization in improving their maintenance function based on a search for and adaptation to industry best practice, leading to excellence in maintenance. This research presents a multicriteria model which facilitates benchmarking in maintenance. The model uses a Fuzzy Analytic Hierarchy Process (FAHP) to obtain the weightings for the decision criteria and subcriteria. These weighting are converted into utility functions which, subsequently, allow the end utility of a Health Care Organization to be calculated using a Multi-Measure Utility Function. From these data on the state of maintenance in the Spanish building sector, discrete probability distributions were calculated for the criteria; this allows the uncertainty in the results to be calculated by a Monte Carlo simulation. The multicriteria model thus derived allows competitive and generic benchmarking to be applied, by comparing the results for the hospital with those of the building and other industrial sectors. Unlike with conventional benchmarking, where mean values for an industrial sector are compared with those obtained for an organization, this model uses all the information for the sector through discrete probability distributions, producing a method that is better suited to industrial averages. The model has been applied to the maintenance department of a public hospital in the region of Castilla-La Mancha (Spain).

PG4

MULTICRITERIA DECISION-MAKING APPROACH FOR MAINTENANCE POLICY SELECTION

María Carmen Carnero, Andrés Gómez

Abstract

Health Care Organizations have equipment and facilities which are technologically highly complex, and in continuous renewal, together with conventional machines and facilities. Furthermore, the Technical Services of Health Care Organizations have targets related to availability, safety and quality which are much higher than other organization, as a great deal of medical apparatus interacts directly with patients, and so has a direct effect on people's lives. Therefore, the maintenance policy applied will condition the availability and efficiency of the clinical equipment, the safety of the patient and of the care staff using the equipment, and the operating quality of the devices and

facilities. This research presents an innovative multicriteria decision-making approach designed by integrating Measuring Attractiveness by a Categorical Based Evaluation Technique (MACBETH) and Markov Chains to choose the best combination of maintenance policies to be applied to different typologies of medicinal gas and vacuum subsystems in a Health Care Organization. The model uses a group of decision makers made up of various heads of department of a Health Care Organization. The results show that, independently of the type of criticity, corrective maintenance plus quarterly preventive maintenance is the best strategy to apply. It should be noted that the model gives the best combination of maintenance policies with regard to actual practice in maintenance departments, to achieve the availability, quality, cost and safety targets set by the organization. This research may serve as an example to other hospitals to develop their own decision groups and to choose, depending on their specific circumstances, the most suitable combination of maintenance policies to be applied, based on objective mathematical tools.

PG5

A PREVENTIVE PROGRAM FOR UNIVERSITY INSTRUCTORS BASED ON ACOUSTIC FEATURES AUTOMATICALLY EXTRACTED FROM VOICE RECORDINGS

María Jesús Rufo Bazaga, Jacinto Martín Jiménez, Carlos Javier Pérez Sánchez, Yolanda Campos Roca, Antonio J. Moreno Gómez

Abstract

Vocal fold nodules are recognized as an occupational disease for people whose professions require the continued use of voice. Teachers, actors, call center operators... are some examples of vulnerable groups. This recognition demands the detection of associated risks in a preventive program.

The feasibility of using acoustic features extracted from voice recordings has been previously analyzed to assess the risk of vocal fold nodules in university instructors. Specifically, a database composed of 90 instructors was collected. A protocol, which consisted of a physical examination, a survey and voice recordings, was applied to all these instructors within the Health Prevention Program of the University of Extremadura between March and July 2014. Based on 19 patients suffering from nodules and 53 healthy individuals from the MEEI database (Massachusetts Eye and Ear Infirmary), probability of having vocal fold nodules was calculated to the instructors, classifying them as healthy or suffering from nodules.

The aim of this work is to provide a methodology to classify the previous instructors into one of three risk groups: low, medium and high. The identification of medium-risk patients will lead them to a speech therapy program, whereas those allocated to the high-risk group will be candidates for a more advanced treatment that could include surgery.

A Bayesian decision analysis is proposed for this objective. Firstly, the posterior probabilities of being healthy are calculated for each individual based on a probit regression model. Next, a multicriteria additive utility function is considered. Those criteria are the cost of the corresponding treatment and the utility of recovery. This information is provided by doctors. It is also possible to consider an additional criterion corresponding to the patient's aversion to surgery. Finally, a classification approach for each patient based on the maximization of the expected utility is obtained.

PG6

SUSTAINABLE DECISION MAKING IN HOME CARE MOBILITY ON A STRATEGIC AND OPERATIONAL LEVEL

Jana Voegl, Patrick Hirsch

Abstract

Demographic changes and chronical diseases such as obesity or dementia lead to an increase in the number of care dependent people, while changes in family structure decrease the care potential within families. Consequently, a future rise in demand for extramural care services can be expected, therefore leading to more mobility of home care (HC) staff. Planning approaches for HC are mainly maximizing economic efficiency. Although decisions made (in)directly impact ecological and social sustainability, these factors are hardly taken into account.

In this ongoing research we aim to integrate the ecological and social aspects in decision making.

Therefore, we present different mobility concepts, i.e. the single or combined use of cars, bikes, private buses, walking and public transport as well as their related logistical problem-definitions.

The basis of this work is a list of 138 sustainability criteria, which we identified using content analysis of qualitative interviews conducted with 15 members of HC organizations in Austria. Moreover, we made an extensive review of scientific and grey literature.

We condense and divide these criteria into sustainability criteria for strategic and operational decisions.

The strategic criteria are used to identify aspects which need consideration when choosing mobility concepts.

On the basis of the operational sustainability criteria, we further propose aspects as well as measurements thereof, which may be used in objective functions and aspiration criteria for the sustainable routing and scheduling of HC services with different mobility concepts.

Thus, this work is intended to create a toolkit for HC organisations to help them to decide what mobility concepts are suitable for them. Moreover, it supports further research in the field of sustainable HC routing and scheduling by providing ideas of what may be integrated into forthcoming research.

PG7

LACK OF DATA?... USING OPEN DATA AND OPEN SOURCE TOOLS TO PRODUCE AN ONLINE VISUALISATION PLATFORM: THE CANCER WAITING TIMES STANDARDS OF THE NHS IN ENGLAND EXAMPLE

Richard Guerrero-Ludueña, Bradley Keogh

Abstract

We may be 'swimming' in oceans of health and social care data, but the lack of data for Operational Research projects remains one of the biggest challenges for the ORAHS community.

The aim is to present a framework for the use of open data and open source tools to develop a set of online visualisations. NHS England national cancer waiting times (CWT) standards are been used as example.

Since 2010, the NHS in England has been expected to comply with maximum CWT standards, monitoring the length of time that a patient with cancer or suspected cancer waits from referral by the General Practitioner to diagnosis and subsequent treatment. The CWT standards are considered to be an indicator of the quality of cancer diagnosis, treatment and care NHS organisations deliver.

CWT are monitored centrally using information standard to all cancer services providers funded by NHS. The information is sent to a collection service and NHS are given a monthly extract of anonymised data which is used to produce official reports online as open data.

The data presented was collected from NHS England open data. Python was used for the data collection, transformation and analysis. To disseminate the information, an online platform, based on Data-Driven Documents (D3), D3plus and HTML5, was developed.

The benefits of open data and open source in health are diverse and range from improved experience of care, improved efficiency of healthcare systems, to economic growth in the private sector.

The methodology presented can be used to extract information from open data sources, summarise big data sets, generate data input for ORAHS projects, and to communicate results in order to inform and guide decision making.

Combining open data sources and open source applications we are able to develop reproducible research, facilitating the replication and test of our work.

PG8

REDUCING THROUGHPUT TIMES IN RADIOTHERAPY BY AN EFFICIENT ALLOCATION OF RADIATION THERAPY TECHNOLOGISTS

Bruno Vieira, Wim van Harten, Erwin Hans, Jeroen van de Kamer, Corine van Vliet-Vroegindeweij

Abstract

Radiotherapy (RT) is a therapy modality for cancer treatment where patients receive a high radiation dose, localized to the tumor, while minimizing the exposure of surrounding normal tissue. The logistics of this type of treatment is complex because (1) many steps occur between first arrival of the patient at the hospital and the start of treatment and (2) fluctuations in the inflow of new patients and their care content occur. In RT, delays in the start of treatment increase the risk of tumor progression, and may lead to psychological distress that might decrease the quality of life of patients. Therefore, efficiently managing resources becomes increasingly important and challenging. This PhD project, which is part of a five year research and implementation project (2015-2019), is divided in four research subprojects. These are aimed to develop models based on operations research to study how patients, personnel, and equipment can be efficiently coordinated to ensure patient-centeredness care while minimizing the throughput times of patients.

In the ongoing research work, we propose a two-stage methodology for efficient allocation of radiation therapy technologists (RTTs), who have different skills and time availability, to multiple operations. We propose a decompo-

sition approach in which we break down the planning and control into hierarchical levels, and develop models for each level. On a tactical (mid-term) level, we analyze what part of demand is known, and define a set of ad-hoc rules to allocate a pre-defined pool of 'fixed' RTTs. For the operational (short term) level, a second model (ILP) schedules a pool of 'flexible' RTTs on a daily basis to cover fluctuations in demand. Expected results are to achieve significant reductions in the throughput times of patients while balancing the workload in the main operations of the RT chain. Preliminary results are expected to be presented at the conference.

PG9

A MILP MODEL FOR OPERATING ROOM SCHEDULING CONSIDERING PACU BEDS: A DECISION SUPPORT TOOL PROTOTYPE

Manuel Dios, Jose M. Framinan

Abstract

The operating room scheduling is a key decision in modern hospitals in order to achieve their objectives regarding number of patients intervened, patients' waiting times, etc. Due to the economic crisis, budgets are nowadays especially tight, what makes this task even more important, as operating rooms represents one of the most expensive facilities in every hospital.

Usually, most operations research models focus on the operating room as, typically, this is the critical resource, but it is also important to achieve a good coordination with the rest of resources, such as beds, nurses, and so on, involved in the surgical process. This coordination prevents from the appearance of bottlenecks that increase waiting times between the different activities in the surgical process, e.g. if a good scheduling is achieved but no PACU beds are available, the operating room would remain blocked until a bed is released. In this work, we consider the scheduling of operating rooms together with the assignment of PACU beds, as this resource shows the biggest capacity problems in the hospital under study.

In practice, operating room scheduling has been done manually and even most cases where software is used, it is limited to spreadsheets. To help decision makers with this task and to overcome the limitations of this approach, such as it is a high time-consuming task or the information processing capacity is limited, in this work, we present the prototype of a decision support tool that embeds a MILP model. This contribution considers surgeons, operating rooms

and PACU beds. Our prototype also serves as a tool for analyzing the scheduling (capacity balance, average surgery duration...), that can help hospital managers to control the performance of operating rooms in the different SUs.

PG10

MATHEMATICAL MODELLING TO CONTROL THE HIV EPIDEMIC IN PANAMA

Jamie Nordio, Alexander Rutherford, Krisztina Vasarhelyi, Lorna Jenkins, Aurelio Nuñez

Abstract

Panama has the largest HIV epidemic in Latin America, with approximately 0.8% prevalence in 2013. The Panama Canal attracts mobile populations, including military forces and sex workers from other Latin American countries. Key affected populations within Panama are men who have sex with men, trans individuals and female sex workers. HIV prevalence for these groups in 2013 was 16.8%, 37.6% and 1.6%, respectively. Sexual partners of key populations are also at significant risk for infection. Panama adopted the Treatment as Prevention public health strategy in 2015, which entails an expanded program of testing and treatment with antiretroviral therapy to prevent new HIV infections. To inform the effective implementation of Treatment as Prevention, we developed compartmental models, consisting of systems of differential equations that describe the time evolution of the HIV epidemic in these key populations. The models for female sex workers and trans individuals are both two-population models, featuring the key population and their sexual partners. The model for men who have sex with men is a single-population model. The models are calibrated and validated using data provided by the Panamanian Ministry of Health. We determine treatment rates and the associated program costs required to reduce new HIV infections by 50%, 70% and 90% within 15 years in each key population. For female sex workers and trans individuals, we find that focusing treatment expansion on the key population is the cost optimal approach to reducing HIV incidence in both the key population and their sexual partner population. We also find that through treatment expansion alone, HIV incidence can be reduced by 50% and 70% in all key populations. However, a 90% reduction in incidence through treatment expansion alone is only possible for men who have sex with men. Our findings are currently informing Panama's national HIV policy.

LIST OF AUTHORS

			Sesion
Abbasgholizadeh Rahimi, Samira	amira.abbasgholizadeh-rahimi.1@ulaval.ca	Department of Mechanical Engineering, Université Laval, Quebec (Canada)	**S3C.2**
Abbasi, Babak	babak.abbasi@rmit.edu.au	RMIT University (Australia)	S1C.1
Aghezzaf, El-Houssaine	elhoussaine.aghezzaf@ugent.be	Ghent University (Belgium)	S1A.1
Ait-Kadi, Daoud	Daoud.Aitkadi@gmc.ulaval.ca	Université Laval (Canada)	S3C.2
Alfieri, Arianna	arianna.alfieri@polito.it	Politecnico di Torino (Turin, Italy)	PC4
Almada-Lobo, Bernardo	almada.lobo@fe.up.pt	FEUP, INESC-TEC (Portugal)	S3A.3
Almehdawe, Eman	eman.almehdawe@uregina.ca	University of Regina (Canada)	**S9C.3**
Aloui, Saber	saloui@ch-sens.fr		S8C.3
Amorim Lopes, Mário	mario.lopes@fe.up.pt	FEUP, INESC-TEC (Portugal)	**S3A.3**
Aringhieri, Roberto	roberto.aringhieri@unito.it	University of Turin (Italy)	S7B.3/**S2C.3**
Arrospide, Arantzazu	arantzazu.arrospideelgarresta@osakidetza.net	OSI Alto Deba (Spain)	**S4A.2/**S5C.2
Augestad, Liv Ariane	i.a.augestad@medisin.uio.no	University of Oslo, Norway (Norway)	**S6C2**
Augusto, Vincent	augusto@emse.fr	MINES Saint-Etienne (France)	S8C.3
Azcarate, Cristina	cazcarate@unavarra.es	Public University of Navarre (Spain)	S7B.2
Ballestin, Francisco	francisco.ballestin@uv.es	Universidad de Valencia (Spain)	**S6B.2**
Bana e Costa, C.A.	carlosbana@tecnico.ulisboa.pt	Universidade de Lisboa (Portugal)	S6C.1
Bana e Costa, J.C.	joao@banaconsulting.com	Bana Consulting (Portugal)	S6C.1
Barbosa-Póvoa, Ana	apovoa@tecnico.ulisboa.pt	Universidade de Lisboa (Portugal)	S4B.1
Barra, Mathias	mathias.barra@ahus.no	Akershus University Hospital (Norway)	S6C.2/S7C.4/ **S8B.3**
Barret, David	dbarrett@ivey.uwo.ca	Ivey Business School, Ivey International Centre for Health Innovation	S9B.4
Barrios, Rolando	Rolando.Barrios@vch.ca	Vancouver Coastal Health, BC Center of Excellence in HIV / AIDS (Canada)	PC9
Batista, Ana	abatista@uc.cl	Pontificia Universidad Católica de Chile (Chile)	
Bélanger, Valérie	valerie.belanger@cirrelt.ca	HEC Montréal (Canada)	**S3C.4**
Beraldi, Patrizia	patrizia.beraldi@unical.it	University of Calabria (Italy)	S5A.2

* Boldface in the code session is associated to the speaker.

			Sesion
Besselink, Peter L.	plbesselink@icloud.com	Leiden University Medical Center (Netherlands)	S9B.2
Bijak, Katarzyna	K.Bijak@soton.ac.uk	University of Southampton (United Kingdom)	PC3
Bilars, Paul	p.bilars@lumc.nl	Leiden University Medical Center (Netherlands)	S9B.2
Biron, Pierre	pierre.biron@lyon.unicancer.fr		S8C.3
Blake, John	john.blake@dal.ca	Dalhousie University (Canada)	S2C.1/**S8A.1**
Borgman, Nardo	n.j.borgman@utwente.nl	University of Twente (Netherlands)	**S7C.1**
Boyle, Laura	lboyle12@qub.ac.uk	Queen's University Belfast (United Kingdom)	**S7B.4**
Brailsford, Sally	scb@soton.ac.uk	University of Southampton (United Kingdom)	**S2A.3**/SS_A/ S3B.4/S4A.1
Brandeau, Margaret	brandeau@stanford.edu	Stanford University (United States)	S6A.2
Brayne, Carol	carol.brayne@ medschl.cam.ac.uk	University of Cambridge (United Kingdom)	S1C.3
Breines-Simonsen, Tone	Tone.Breines.Simonsen@ahus.no	Akershus University Hospital (Norway)	S7C.4/PG1
Brennan, Alan	A.brennan@sheffield.ac.uk	University of Sheffield (United Kingdom)	S1C.3
Bruneel, Herwig	hb@telin.ugent.be	Ghent University (Belgium)	S1A.1
Bruni, Maria Elena	mariaelena.bruni@unical.it	University of Calabria (Italy)	**S5A.2**
Bubela, Tania	tbubela@ualberta.ca	University of Alberta (Canada)	
Campbell, Leslie Anne	leslie.anne.campbell@dal.ca	Dalhousie University (Canada)	**S2C.1**
Campos Roca, Yolanda	ycampos@unex.es	Universidad de Extremadura (Spain)	PG5
Cappanera, Paola	paola.cappanera@unifi.it	University of Florence (Italy)	S4B.2
Captivo, Maria Eugénia	mecaptivo@fc.ul.pt	Universidade de Lisboa (Portugal)	S1A.3/S6B.1
Cardoso Grilo, Teresa	teresacardoso@ tecnico.ulisboa.pt	CEG-IST (Portugal)	S1B.3/**S4B.1**
Carello, Giuliana	giuliana.carello@polimi.it	Politecnico di Milano (Italy)	**S2B.3**
Carnero, María Carmen	carmen.carnero@uclm.es	University of Castilla-La Mancha (Spain)	PG3/PG4
Carter, Michael	Mike.Carter@utoronto.ca	University of Toronto (Canada)	SS_A/**S3A.4**

			Sesion
Ceballos Acevedo, Tatiana María	taticeba@gmail.com	IPS Universitaria – Clínica Leon XIII (Colombia)	S9B.3
Chahed, Salma	chaheds@westminster.ac.uk	University of Westminster (United Kingdom)	S1B.3/S4C.2/ PC2
Chan, Timothy	tcychan@mie.utoronto.ca	University of Toronto (Canada)	S9C.1
Chaussalet, Thierry	chausst@westminster.ac.uk	University of Westminster (United Kingdom)	S1B.2/**S4C.2**/ S8C.2/PC2
Cheng, Pei-Yi	pycheng555@gmail.com	National Taiwan University (Taiwan)	S8B.2
Churilov, Leonid	leonid.churilov@florey.edu.au	Florey Institute of Neuroscience and Mental Health (Australia)	S1C.1/S1C.2/ **S8A.3**
Cildoz, Marta	marta.cildoz@unavarra.es	Public University of Navarre (Spain)	**S7B.2**
Cisse, Mohamed	mohamed.cisse@univ-tours.fr	University of Tours (France)	**S9A.3**
Claudio, Pinto	clpinto@unisa.it	University of Salerno (Italy)	**S8C.1**
Comas, Mercè	MComas@imas.imim.es	Hospital del Mar – IMIM REDISSEC (Spain)	S4A.2
Crenn-Hebert, Catherine	catherine.crenn-hebert@aphp.fr	CHU L Mourier/Perinat-ARS-IDF (France)	**S8B.1**
Dahl, Fredrik	Fredrik.A.Dahl@ahus.no	Akershus University Hospital (Norway)	S1B.1/**S4C.3**/ S7C.4/PG1
De Haas, Masja		Sanquin Blood Supply	S3B.3
De Kort, Wim	w.dekort@sanquin.nl	Sanquin Blood Supply (Netherlands)	S3A.1/S3B.3
De Manuel, Esteban	edemanuel@kronikgune.org	Kronikgune (Spain)	S5C.2
De Miguel-Bilbao, Silvia	sdemiguel@isciii.es	Carlos III Health Institute (Spain)	**SS_B1**
De Oliveira, Mario	mario_jo@pep.ufrj.br	Universidad Federal de Río de Janeiro (Brazil)	S5A.1
De Vuyst, Stijn	Stijn.DeVuyst@ugent.be	Ghent University (Belgium)	S1A.1/PG2
De Wit, Puck		Sanquin Blood Supply	S3B.3
Deceuninck, Matthias	matthias_deceuninck@ hotmail.com	University of Ghent (Belgium)	PG2
Demeulemeester, Erik	Erik.Demeulemeester@ kuleuven.be	KU Leuven (Belgium)	S1A2/S2A.1
Demirtas, Derya	d.demirtas@utwente.nl	University of Twente (Netherlands)	**S9C.1**

			Sesion
Di Caprio, Debora	dicaper@mathstat.yorku.ca	York University (Canada)	S3B.2
Dell'Anna, Davide		University of Turin (Italy)	S2C.3
Dios, Manuel	mdios@us.es	University of Seville (Spain)	PG9
Duma, Davide	davide.duma@unito.it	University of Turin (Italy)	S2C.3/**S7B.3**
Dural-Selcuk, Gozdem	g.dural.selcuk@bath.ac.uk	University of Bath (United Kingdom)	**S7A.1**
Elalouf, Amir	Amir.Elalouf@biu.ac.il	Bar-Ilan University (Israel)	S2C.2/S7B.1
Eneya, Levis	leneya@cc.ac.mw	University of Malawi (Malawi)	S9C.2
Falcone, Francisco	francisco.falcone@unavarra.es	Universidad Publica de Navarra (Spain)	**SS_B3**
Faulin, Javier	javfau@gmail.com	Public University of Navarra (Spain)	S9C.2
Fiems, Dieter	dieter.fiems@ugent.be	Ghent University (Belgium)	PG2
Fikar, Christian	christian.fikar@boku.ac.at	University of Natural Resources and Life Sciences (Austria)	S4B.3
Fogteloo, AJ	a.j.fogteloo@lumc.nl	Leiden Unversity Medical Center (Netherlands)	S9B.2
Framinan, Jose M.	framinan@us.es	Universidad de Sevilla (Spain)	PG9
Fullaondo, Ane	afullaondo@kronikgune.org	Kronikgune (Spain)	S5C.2
Galli, Laura	laura.galli@unipi.it	University of Pisa (Italy)	S4B.2
Garaix, Thierry	garaix@emse.fr	Mines St-Etienne (France)	**S9A.1**
Gartner, Daniel	gartnerd@cardiff.ac.uk	Cardiff University (United Kingdom)	**S4C.1**/PC7
Geng, Na	gengna@sjtu.edu.cn	Shanghai Jiao Tong University (China)	S3A.2
Gómez, Andrés		University of Castilla-La Mancha (Spain)	PG4
Grenouilleau, Florian	florian.grenouilleau@cirrelt.net	CIRRELT – Polytechnique Montréal (Canada)	S9A.2
Guerrero-Luduena, Richard	R.E.GuerreroLuduena@soton.ac.uk	University of Southampton (United Kingdom)	S4A.1/PG7
Gutjahr, Walter	walter.gutjahr@univie.ac.at	University of Vienna (Austria)	S5A.3
Hans, Erwin	e.w.hans@utwente.nl	University of Twente (Netherlands)	SS_A/S3C.3/ S7C.1/PG8
Hayes, Matt	matt.hayes@nhs.net	NHS England (United Kingdom)	S4A.1

			Sesion
Hearne, John	john.hearne@rmit.edu.au	RMIT University (Australia)	S1C.1/S1C.2
Hirsch, Patrick	patrick.hirsch@boku.ac.at	University of Natural Resources and Life Sciences, Vienna (Austria)	**S4B.3**/PG6
Hosteins, Pierre	pierre.hosteins@unito.it	Università degli Studi di Torino (Italy)	S7B.3
Huang, Zhimin	huang@adelphi.edu	Adelphi University (United States)	**S5B.1**/S5B.3
Hung, Yuan		University of Southampton (United Kingdom)	PC8
Hynninen, Yrjänä	yrjana.hynninen@aalto.fi	Aalto University (Finland)	**S5C.1**
Ibarra, Amaia	ibarra.amaia@gmail.com	Hospital of Navarre (Spain)	S7B.2
Igartua, Juan Ignacio	jigartua@mondragon.edu	Mondragon Unibertsitatea (Spain)	S5C.2
Ingolfsson, Armann		University of Alberta (Canada)	S9C.3
Izady, Navid	navid.izady@city.ac.uk	Cass Business School (United Kingdom)	**S9B.1**/PC3
Jaén Posada, Sebastian	jjaen@udea.edu.co	Universidad de Antioquia, Departamento de Ingeniería Industrial, Grupo de Investigación INCAS (Colombia)	S9B.3
Jamshidi, Afshin	afshin.jamshidi.1@ulaval.ca	Department of Mechanical Engineering, Université Laval, Quebec, Canada	S3C.2
Janssen, Mart	m.p.janssen@umcutrecht.nl	Sanquin Blood Supply (Netherlands)	S3B.3
Jenkins, Lorna		University of South Florida (Panama)	PG10
Johns, Hayden	htjohns@gmail.com	RMIT University/Florey Neuroscience (Australia)	**S1C.2**
Karjalainen, Sakari	sakari.karjalainen@cancer.fi	Cancer Society of Finland (Finland)	S5C.3
Keogh, Bradley	brad.keogh@soton.ac.uk	University of Southampton (United Kingdom)	PG7
Kephart, George	george.kephart@dal.ca	Dalhousie University (Canada)	S2C.1
Kergosien, Yannick	yannick.kergosien@univ-tours.fr	University of Tours (France)	S9A.3
Keshtkaran, Mahsa	mahsa.keshtkaran@unimelb.edu.au	RMIT University (Australia)	**S1C.1**
Khodaparasti, Sarah	khodaparasti.sara@yahoo.com	University of Calabria (Italy)	S5A.2
Killeen, Donna	donna.killeen@blood.ca	Canadian Blood Services (Canada)	S8A.1

			Sesion
Klein, Jonathan		University of Southampton (United Kingdom)	PC8
Kojlak, Juddy	Judy.Kojlak@lhsc.on.ca	London Health Sciences Centre (Canada)	S9B.4
Koopman, Rianne		Sanquin Blood Supply	S3B.3
Kudinga, Benoit	kudinga@ualberta.ca	University of Alberta (Canada)	S8A.2
Kwah Driscole, Ganye	granscole@gmail.com	University of Southampton (United Kingdom)	PC8
Kwon, Roy	rkwon@mie.utoronto.ca	University of Toronto (Canada)	S9C.1
Lafortune, Louise	ll394@medschl.cam.ac.uk	University of Cambridge (United Kingdom)	S1C.3
Laganà, Demetrio	demetrio.lagana@unical.it	University of Calabria (Italy)	S5A.2
Lahrichi, Nadia	nadia.lahrichi@polymtl.ca	Polytechnique Montreal (Canada)	S9A.2/**S9A.4**
Lamorgese, Leonardo	leonardo.lamorgese@sintef.no	SINTEF (Norway)	S3C.1
Landa, Paolo	p.landa@exeter.ac.uk	University of Exeter (United Kingdom)	S7C.3
Lanzarone, Ettore	ettore.lanzarone@cnr.it	CNR – IMATI (Italy)	S2B.3/S9A.4
Laricini, Daniele	daniele.laricini@mail.polimi.it	Politecnico di Milano (Italy)	S2B.3
Larrañaga, Igor	Igor.LarranagaUribetxebarria@osakidetza.net	Osakidetza (Spain)	S5C.2
Lavieri, Mariel	lavieri@umich.edu	University of Michigan (United States)	SS_A/**S4A.3**
Lebreton, Elodie	elodie.lebreton@aphp.fr	PERINAT-ARS-IDF (France)	S8B.1
Lee, Elliot	elliotdl@umich.edu	University of Michigan (United States)	S4A.3
Leeftink, Gréanne	a.g.leeftink@utwente.nl	University of Twente (Netherlands)	**S3C.3**
Lente, Christophe	christophe.lente@univ-tours.fr	University of Tours (France)	S9A.3
León, Teresa	teresa.leon@uv.es	Universitat de València (Spain)	S3B.1
Leskelä, Riikka	riikka.leskela@nhg.fi	Nordic Healthcare Group Inc (Finland)	S5C.3
Li, Susan	li@adelphi.edu	Adelphi University (United States)	S5B.1/**S5B.3**
Liern, Vicente	vicente.liern@uv.es	Universitat de València (Spain)	S3B.1
Lindstrøm, Jonas	Jonas.Christoffer.Lindstrom@ahus.no	Akershus University Hospital (Norway)	S8B.3

			Sesion
Listorti, Elisabetta	elisabetta.listorti@gmail.com	Politecnico di Torino (Italy)	PC4
Lovas, David	david.lovas@iwk.nshealth.ca	IWK Health Centre (Canada)	S2C.1
Luken, Jessie		Sanquin Blood Supply	S3B.3
Mackay, Mark	mark.mackay@flinders.edu.au	Flinders University (Australia)	S7B.4
Mahjoub, Reza	reza.mahjoub@ualberta.ca	University of Alberta (Canada)	**S8A.2**
Mäklin, Suvi	suvi.maklin@cancer.fi	Cancer Society of Finland (Finland)	S5C.3
Mallor, Fermin	mallor@unavarra.es	Public University of Navarre (Spain)	S7B.2
Mannino, Carlo	carlo.mannino@sintef.no	SINTEF ICT (Norway)	S3C.1
Mar, Javier	javier.marmedina@osakidetza.net	OSI Alto Deba, Osakidetza, BioDonostia, REDISSEC (Spain)	S4A.2/S5C.2
Marques, Inês	ines.marques@fc.ul.pt	ULHT – CMAFCIO (Portugal)	S1A.3/S6B.1
Marshall, Adele	a.h.marshall@qub.ac.uk	Queen's University Belfast (United Kingdom)	S7B.4
Martin, Claudio		London Health Sciences Centre (Canada)	S9B.4
Martín Jiménez, Jacinto	jrmartin@unex.es	Universidad de Extremadura (Spain)	PG5
Marynissen, Joren	joren.marynissen@kuleuven.be	KU Leuven (Belgium)	**S2A.1**
Mateus, Catarina	catarina-mateus@hotmail.com	Universidade de Lisboa / Faculdade de Ciências (Portugal)	S6B.1
Matta, Andrea	matta@sjtu.edu.cn	Shanghai Jiao Tong University (Shanghai, China)	S3A.2/ PC4
McCabe, Christopher	mccabe1@ualberta.ca	University of Alberta (Canada)	S8A.2
McTaggart, Ken	ken.mctaggart@blood.ca	Canadian Blood Services (Canada)	S8A.1
Mecklin, Jukka-Pekka	jukka-pekka.mecklin@ksshp.fi	Keski-Suomi Hospital District (Finland)	S5C.3
Menguy, Claudie	claudie.menguy@chi-andre-gregoire.fr	Medical Information Dept, PERINAT-ARS-IDF (France)	S8B.1
Meretoja, Atte	atte.meretoja@unimelb.edu.au	Helsinki University Hospital (Finland)	S1C.1
Merino, Marisa	marialuisa.merinohernandez@osakidetza.eus	Osakidetza (Spain)	S5C.2
Mesgarpour, Mohsen	mohsen.mesgarpour@gmail.com	University of Westminster (United Kingdom)	S1B.2/PC2
Mohamed, Israa	im8g13@soton.ac.uk	Zagazig University (Egypt)	S9B.1

			Sesion
Mohring, Uta	uta.mohring@student.kit.edu	Karlsruhe Institute of Technology (Germany)	PC6
Monteiro, Ana	martacmonteiro92@gmail.com	Instituto Superior Técnico (Portugal)	**S1B.3**
Moreno Gómez, Antonio J.	morenog@unex.es	Universidad de Extremadura (Spain)	PG5
Mosley, Ian	ian.mosley@gmail.com	Latrobe University (Australia)	S1C2
Mullen, Penelope	penelope.mullen@btinternet.com	Independent (United Kingdom)	**S7A.3**
Musmanno, Roberto	roberto.musmanno@unical.it	University of Calabria (Italy)	S5A.2
Mwakilama, Elias	mwakilamae@gmail.com	University of Malawi-Chancellor College (Malawi)	S9C.2
Nie, Yajie	yn205@soton.ac.uk	University of Southampton (United Kingdom)	**S2B.2**
Niessner, Helmut	helmut.niessner@univie.ac.at	University of Vienna (Austria)	S5A.3
Nordio, Jamie	jnordio@sfu.ca	IRMACS (Canada) PG10	
Nuñez, Aurelio		Ministry of Health, National STI/ HIV/AIDS Program(Panama)	PG10
Oliveira, Mónica	monica.oliveira@tecnico.ulisboa.pt	Universidade de Lisboa (Portugal)	S4B.1/ S6C.1
Osorio, Andres	afo1e13@soton.ac.uk	University of Southampton (United Kingdom)	**S3B.4**
Padman, Rema	rpadman@cmu.edu	Carnegie Mellon University, The H. John Heinz III College (United States)	S4C.1/PC7
Painchaud, Maxime	maxime.painchaud.1@ulaval.ca	Université Laval (Canada)	S3C.4
Peclard, Vincent		University of Southampton (United Kingdom)	S2A.3
Penny, Katherine	k.e.penny@soton.ac.uk	University of Southampton (United Kingdom)	**S2B.1**
Pérez, Ángeles	angeles.perez@uv.es	Universidad de Valencia (Spain)	S6B.2
Pérez Sánchez, Carlos Javier	carper@unex.es	Universidad de Extremadura (Spain)	PG5
Pérez-Gladish, Blanca	bperez@uniovi.es	Universidad de Oviedo (Spain)	S3B.1
Perrier, Lionel	lionel.perrier@lyon.unicancer.fr	Centre Léon Bérard (France)	S8C.3
Phua, Hwee Pin	PHUA_Hwee_Pin@moh.gov.sg	Ministry of Health (Singapore)	S7C.2
Pilet, Claire	claire.pilet@emse.fr	MINES Saint-Etienne (France)	S8C.3
Poulain, Chloe	chloe.poulain-ext@aphp.fr	PERINAT-ARS-IDF (France)	S8B.1

			Sesion
Powell, Caroline	Caroline.Powell@soton.ac.uk	Centre for Implementation Science (CIS)	S4A.1
Priestap, Fran	Fran.Priestap@lhsc.on.ca	London Health Sciences Centre (Canada)	S9B.4
Quintanilla, Sacramento	maria.quintanilla@uv.es	Universidad de Valencia (Spain)	S6B.2
Rabelink, Ton J.	t.j.rabelink@lumc.nl	Leiden University Medical Center (Netherlands)	S9B.2
Radford, Robert	robert.radford@nhs.net	NHS England (United Kingdom)	S4A.1
Victoria, Ramos	vramos@isciii.es	Carlos III Health Institute (Spain)	SS_B1
Rand-Hendriksen, Kim	kim.rand-hendriksen@medisin.uio.no	Akershus University Hospital (Norway)	**S1B.1**/S4C.3/ S6C.2/S7C.4
Rauner, Marion	marion.rauner@univie.ac.at	University of Vienna (Austria)	S5A.3
Ravichandran, Narasimhan	nravi@iima.ac.in	I I M Ahmedabad (India)	S2A.2
Resta, Marina	resta@economia.unige.it	University of Genova (Italy)	S7C.3
Reuter-Oppermann, Melanie	melanie.reuter@kit.edu	Karlsruhe Institut of Technology (Germany)	**S7A.2**
Rickard, Sally	sallyrickard1@nhs.net	NHS England (United Kingdom)	S4A.1
Riise, Atle	atle.riise@sintef.no	SINTEF ICT (Norway)	S3C.1
Rodrigues, Felipe	frodrigues.phd@ivey.ca	Ivey Business School at Western University (Canada)	**S9B.4**
Rousseau, Louis-Martin	louis-martin.rousseau@polymtl.ca	CIRRELT – Polytechnique Montreal (Canada)	S9A.2
Rué, Montserrat	montse.rue@cmb.udl.cat	University of Lleida, REDISSEC (Spain)	S4A.2
Rufo Bazaga, María Jesús	mrufo@unex.es	University of Extremadura (Spain)	PG5
Ruiz, Angel	angel.ruiz@fsa.ulaval.ca	Université Laval (Canada)	S3C.2/S3C.4
Rutherford, Alexander	sandyr@irmacs.sfu.ca	Simon Fraser University (Canada)	**S6A.1**/PC9/ PG10
Salo, Ahti	ahti.salo@aalto.fi	Aalto University (Finland)	S5C.1
Saltyte-Benth, Jurate	Benth.Jurate.Saltyte@ahus.no	Akershus University Hospital (Norway)	S8B.3
Santana, P.		University of Coimbra (Portugal)	S6C.1
Santos, Maria	mjhsantos@netcabo.pt	Universidade de Lisboa (Portugal)	S1B.3
Santos Almeida, Álvaro	almeida@fep.up.pt	FEP, CEF-UP (Portugal)	S3A.3

			Sesion
Santos Arteaga, Francisco Javier	fsantosarteaga@unibz.it	Free University of Bolzano (Italy)	**S3B.2**
Sarriugarte, Garbiñe	garbine.sarriugarteirigoien@osakidetza.net	Subdirección de Salud Pública, Gobierno Vasco (Spain)	S4A.2
Saville, Christina	ces1g11@soton.ac.uk	University of Southampton (United Kingdom)	PC3
Schneider, Anton J	a.j.schneider@lumc.nl	Leiden Unversity Medical Center, University of Twente (Netherlands)	**S9B.2**
Schonewille, Henk		Sanquin Blood Supply	S3B.3
Scutellà, Maria Grazia	scut@di.unipi.it	University of Pisa (Italy)	S4B.2
Serrano, Luis	lserrano@unavarra.es	Universidad Pública de Navarra (Spain)	**SS_B4**
Servilio, Mara	mservilio@gmail.com	CNR-IASI (Italy)	**S2B3**
Shateri, Mahsa	mahsa.shateri@gmail.com		S3A.4
Simonsen, Tone Breines	tosi@ahus.no	Akershus University Hospital (Norway)	S7C.4
Smith, Honora	honora.smith@soton.ac.uk	University of Southampton (United Kingdom)	S3B.4/**S7A.4**/ PC3/PC8
Soares Vieira, Bruno	b.vieira@nki.nl	The Netherlands Cancer Institute (Netherlands)	PG8
Solanas, Agusti	agusti.solanas@urv.cat	Dept. Computer Engineering and Maths. Rovira i Virgili University (Spain)	**SS_B2**
Sonnessa, Michele	michele.sonnessa@edu.unige.it	University of Genova (Italy)	**S7C.3**
Soto-Gordoa, Myriam	myriam.sotoruizdegordoa@osakidetza.eus	OSI Alto Deba (Spain)	**S4A.2/S5C.2**
Stanford, David	stanford@stats.uwo.ca	Western University (Canada)	S9B.4
Steenweg, Pia	pia.steenweg@rub.de	Ruhr University Bochum (Germany)	S9C.4
Steinhäuser, Jost		Universitätsklinikum Schleswig-Holstein (Germany)	S7A.2
Tan, Kelvin Bryan	Kelvin_Bryan_TAN@moh.gov.sg	Ministry of Health (Singapore)	S7C.2
Tànfani, Elena	etanfani@economia.unige.it	University of Genova (Italy)	S7C.3
Tavana, Madjid	tavana@lasalle.edu	La Salle University (United States)	S3B.2
Teow, Kiok Liang	kiok_liang_teow@nhg.com.sg	National Healthcare Group (Singapore)	**S7C.2**

			Sesion
Testi, Angela	testi@economia.unige.it	University of Genova (Italy)	SS_A/S7C.3
Thokala, Praveen	p.thokala@sheffield.ac.uk	University of Sheffield (United Kingdom)	**S1C.3**
Torkki, Paulus	paulus.torkki@aalto.fi	Aalto University (Finland)	**S5C.3**
Toscano, Lupe	lu.ne.pi.toscano@gmail.com	Universidad Nacional de Ingeniería (Peru)	**S5A.1**
Triki, Nizar	triki@emse.fr	Mines Saint-Etienne – LIMOS (France)	S9A.1
Tuson, Mark	tusonm@cardiff.ac.uk	Cardiff University (United Kingdom)	PC5
Van Brummelen, Sem	s.p.j.vanbrummelen@utwente.nl	University of Twente (Netherlands)	**S3A.1**
Van de Kamer, Jeroen	j.vd.kamer@nki.nl	Netherlands Cancer Institute – Antoni van Leeuwenhoek Hospital (The Netherlands)	PG8
Van den Hurk, Katja		Sanquin Blood Supply	S3B.3
Van der Bom, Anske		Sanquin Blood Supply	S3B.3
Van der Schoot, Ellen		Sanquin Blood Supply (Netherlands)	S3B.3
Van Dijk, Nico		University of Twente (Netherlands)	S3A.1
Van Dongen, Anne		Sanquin Blood Supply	S3B.3
Van Harten, Wim	w.v.harten@nki.nl	Netherlands Cancer Institute – Antoni van Leeuwenhoek Hospital (Netherlands)	PG8
Van Kraaij, Marian		Sanquin Blood Supply	S3B.3
Van Ravesteyn, Nicolien T.	n.vanravesteyn@erasmusmc.nl	Erasmus University Medical Center Rotterdam (Netherlands)	S4A.2
Van Riet, Carla	carla.vanriet@kuleuven.be	KU Leuven (Belgium)	**S1A.2**
Van Sambeeck, Joost	j.vansambeeck@sanquin.nl	Sanquin Blood Supply (Netherlands)	**S3B.3**
Van Vliet-Vroegindeweij, Corine	c.v.vliet@nki.nl	Netherlands Cancer Institute – Antoni van Leeuwenhoek Hospital (Netherlands)	PG8
Vandenberghe, Mathieu	mathieu.vandenberghe@ugent.be	Ghent University (Belgium)	**S1A.1**
Vasarhelyi, Krisztina	krisztina_vasarhelyi@sfu.ca	IRMACS (Canada)	PC9/PG10

			Sesion
Vasilakis, Christos	c.vasilakis@bath.ac.uk	University of Bath (United Kingdom)	S7A.1
Velásquez Restrepo, Paula	paulavelasquezr@gmail.com	IPS Universitaria Clínica Leon XIII – Universidad de Antioquia, Departamento de Ingeniería Industrial, Grupo de Investigación INCAS (Colombia)	**S9B.3**
Veldhuisen, Barbera		Sanquin Blood Supply	**S3B.3**
Vera, Jorge	jvera@ing.puc.cl	Pontificia Universidad Católica de Chile (Chile)	
Vermeulen, Peter		University of Southampton (United Kingdom)	S2A.3
Viana, Joe	Joe.Viana@ahus.no	Akershus University Hospital (Norway)	S1B.1/S4C.3/ **S7C.4**/PG1
Vieira, Ana	ana.lopes.vieira@ tecnico.ulisboa.pt	Instituto Superior Técnico – Universidade de Lisboa (Portugal)	**S6C.1**
Vilkkumaa, Eeva	eeva.vilkkumaa@aalto.fi	Aalto University (Finland)	S5C.1
Vliegen, Ingrid	i.m.h.vliegen@utwente.nl	University of Twente (Netherlands)	S3C.3/S7C.1
Voegl, Jana	jana.voegl@boku.ac.at	University of Natural Resources and Life Sciences (Vienna)	PG6
Volk, Michael	MVolk@llu.edu	Loma Linda University (United States)	S4A.3
Wachtel, Guy	Guy.Wachtel@biu.ac.il	Bar-Ilan University (Israel)	**S2C.2**/S7B.1
Wai, Benny	bcwai@sfu.ca	Simon Fraser University (Canada)	PC9
Werners, Brigitte	or@rub.de	Ruhr University Bochum (Germany)	**S9C.4**
Wiesche, Lara	lara.wiesche@rub.de	Ruhr University Bochum (Germany)	S9C.4/PC1
Williams, JF	jfw@math.sfu.ca	Simon Fraser University (Canada)	S6A.1/PC9
Worrall, Philip	philip.worrall@gmail.com	University of Westminster (United Kingdom)	S4C.2/**S8C.2**
Xie, Xiaolan	xie@emse.fr	Mines Saint-Etienne – LIMOS (France)	S8C.3/S9A.1
Yalçındağ, Semih	semih.yalcindag@yeditepe.edu.tr	Yeditepe University (Turkey)	S9A.4
Yu, Jiun-Yu	jyyu@ntu.edu.tw	National Taiwan University (Taiwan)	**S8B.2**
Zander, Anne	anne.zander@kit.edu	Karlsruhe Institute of Technology (Germany)	**S5B.2**/PC6

			Sesion
Zaric, Greg	gzaric@ivey.uwo.ca	Ivey Business School at Western University (Canada)	S9B.4
Zemrani, Soufiane	soufiane.zemrani-ext@aphp.fr	PERINAT-ARS-IDF (France)	S8B.1
Zhang, Yiye	yiyez@andrew.cmu.edu	Carnegie Mellon University (United States)	PC7
Zhou, Chunmeng	solidmona@sjtu.edu.cn	Shanghai Jiao Tong University (China)	**S3A.2**