

RAHS 2014

40th Annual Meeting
EURO Working Group on
Operational Research Applied to
Health Services



FOR BETTER PRACTICES IN HEALTH CARE
MANAGEMENT

20-25 July

Faculdade de Ciências
Universidade de Lisboa



THE EUROPEAN WORKING GROUP ON
Operational Research Applied to Health Services



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The logo for ORAHS 2014 features a stylized green circular emblem on the left. Inside the circle, there is a balance scale with a caduceus (a staff with two snakes) superimposed over it. To the right of the emblem, the text "ORAHS 2014" is written in a large, bold, green, sans-serif font.

ORAHS 2014

Welcome

Dear Colleagues,

Welcome to ORAHS 2014, the 40th annual meeting of the EURO working group on Operational Research Applied to Health Services.

The theme of this year's conference is "For Better Practices in Health Care Management". We have two plenary speakers, a discussion session with a panel of academics and practitioners, 24 parallel sessions where 105 papers will be presented as well as a poster session with 8 posters. In addition, there will be a visit to the Hospital de Santa Maria (HSM). This hospital integrates our university and is part of the Portuguese National Health Service.

Besides the scientific program, we also have an intense social program, including a boat trip on the River Tagus, a day tour visiting Nazaré and Óbidos, and a conference dinner on Thursday in Tenda do Cristo-Rei. The restaurant, located in Almada, in the sanctuary of the monument with the same name, has a unique setting, with a fabulous view over Lisbon and the river.

This is the second time the ORAHS meeting takes place in Lisbon, but this is the first time it is hosted by Faculdade de Ciências, Universidade de Lisboa. We know that some participants of ORAHS 1996 are here today, and no doubt some of them still recall the 1996 meeting. We are very pleased to have among us José Gíria, the organizer of ORAHS 1996 and we hope the 2014 meeting will also last in our memories for all the good reasons.

We would like to express our gratitude for the hard work performed by our colleagues who joined us in the Organizing Committee of ORAHS 2014. Without their contribution we would not be here today.

We wish you all a very interesting and fruitful meeting and a wonderful stay in Lisbon,

Inês Marques, Margarida Vaz Pato and Maria Eugénia Captivo.

Organizing Committee

- Maria Eugénia Captivo (Faculdade de Ciências, Universidade de Lisboa)
- Bernardo Almada-Lobo (Universidade do Porto)
- Inês Marques (Faculdade de Ciências, Universidade de Lisboa and Universidade Lusófona de Humanidades e Tecnologias)
- José Luís Borges (Universidade do Porto)
- Margarida Moz (ISEG, Universidade de Lisboa)
- Margarida Vaz Pato (ISEG, Universidade de Lisboa)
- Maria da Conceição Fonseca (Faculdade de Ciências, Universidade de Lisboa)
- Pedro Martins Moura (Faculdade de Ciências, Universidade de Lisboa)

International Programm Committee

- Angela Testi (Italy)
- Erik Demeulemeester (Belgium)
- Erwin Hans (The Netherlands)
- Greet Vanden Berghe (Belgium)
- Jan Vissers (The Netherlands)
- Margarida Vaz Pato (Portugal)
- Maria Eugénia Captivo (Portugal)
- Marion Rauner (Austria)
- Michael Carter (Canada)
- Mónica Oliveira (Portugal)
- Roberto Aringhieri (Italy)
- Sally Brailsford (United Kingdom)
- Xiaolan Xie (France)
- Yasar A. Özcan (USA)

Useful information and Guidelines

Conference Venue

The ORAHS 2014 Conference will take place at the Faculdade de Ciências, Universidade de Lisboa, Portugal. See figure 1 for a simplified version of the faculty campus, highlighting the building where the conference will take place. Figure 2 presents a bird's-eye view of the faculty campus and all its buildings.

The Conference lunches will be served every day of the week (except on Wednesday, the day of the tour) in the school canteen (Building C7), starting at 12:30. To have access to the lunches, simply present your conference badge.

All parallel sessions take place in the Building C6 of the faculty campus, in rooms 6.1.36 (ground floor, see figure 3) and rooms 6.2.53 and 6.2.56 (2nd floor, see figure 4). The Plenary talks, Panel Discussion and Business Meeting take place in room 6.1.36.

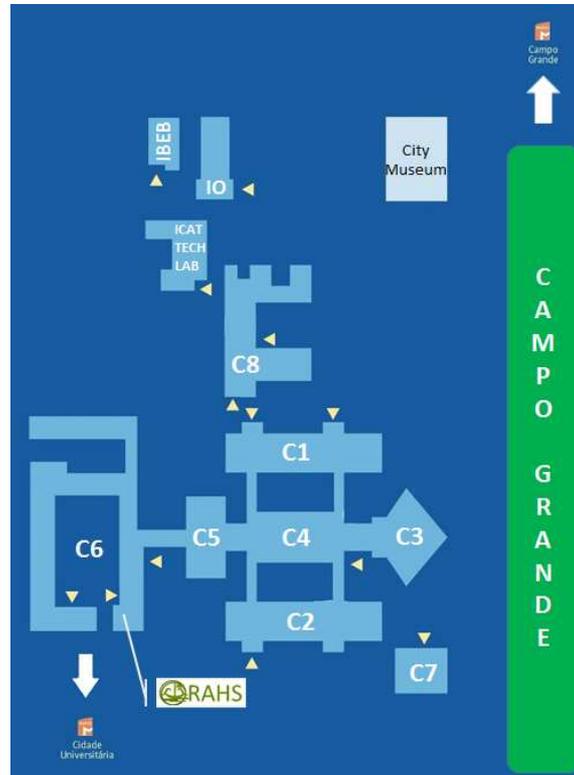


Figure 1: Campus of the Faculdade de Ciências.

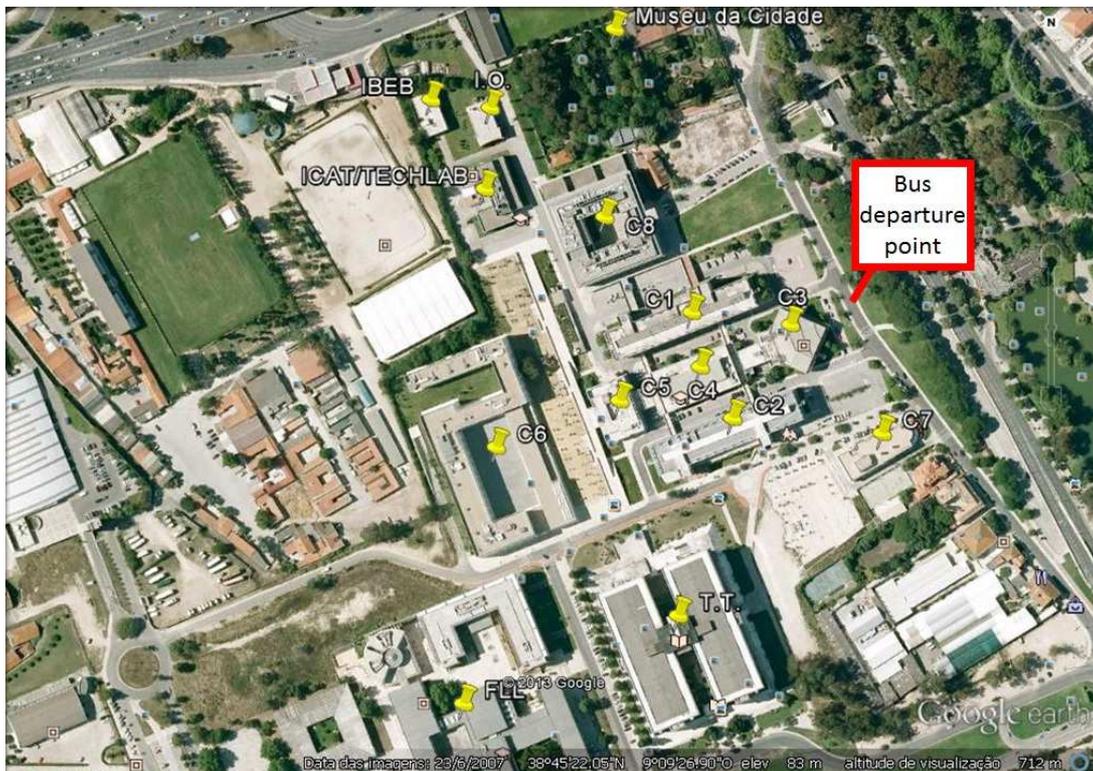


Figure 2: Campus of the Faculdade de Ciências: bird's-eye view.

Coffee breaks and the Poster display take place on the inner yard of Building C6 (see figure 3). All rooms will be signposted during the conference.

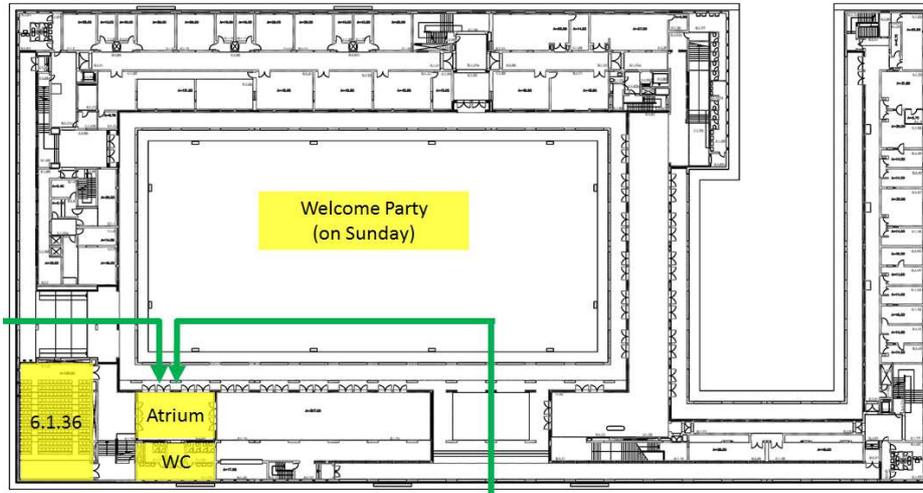


Figure 3: Building C6, ground floor.

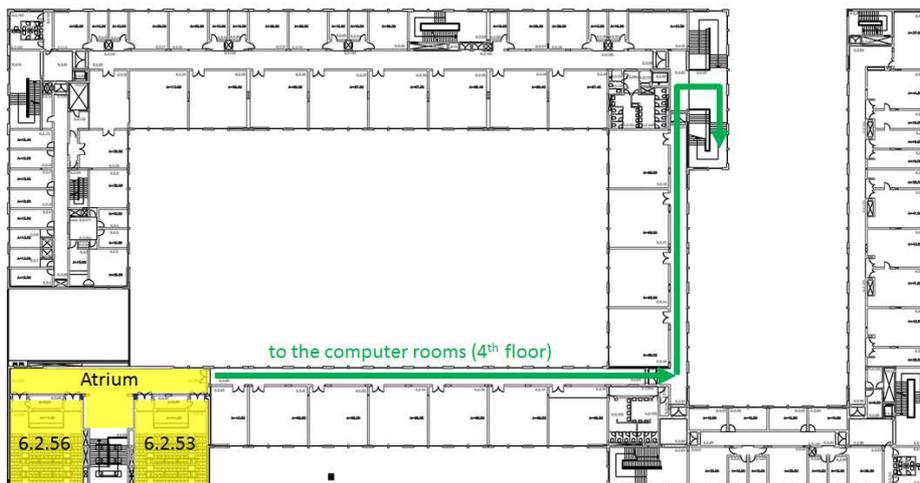


Figure 4: Building C6, 2nd floor.

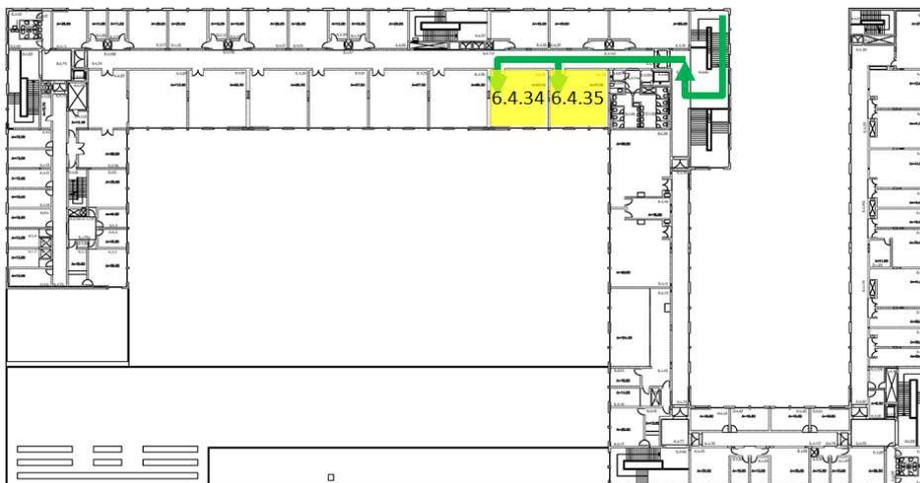


Figure 5: Building C6, 4th floor.

Getting around the campus

The Faculdade de Ciências is located in the campus of the Universidade de Lisboa in the northern part of the city of Lisboa. The area is well served by public transport, both bus and metro lines. Although there are several buses crossing the university campus, using the metro is the fastest way to reach the conference venue. Most of the hotels suggested by the Organizing Committee are nearby the Yellow Line. To the north of the faculty campus you will find the metro station *Campo Grande* where the Yellow Line and Green Line meet. To the southwest you will find the metro station *Cidade Universitária* part of the Yellow Line. See Figure 6 for the location of the metro stations.



Figure 6: Campus of the Universidade de Lisboa: Metro location.

Registration desk

The registration desk will be located in the ground floor atrium of Building C6. It will be opened on Sunday (16:00 - 20:00), Monday, Tuesday, Thursday (9:00 - 17:00) and Friday (9:00 - 12:30).

Poster Display Session

The Poster Session starts Tuesday at 15:30 on room 6.2.53 with the 2 minute slide presentation. The posters will be displayed until the end of the conference.

Hospital Visit

As part of the scientific program, there will be a visit to the Hospital de Santa Maria (HSM). This hospital integrates the Universidade de Lisboa and is a reference in the Portuguese National Health Service. The meeting point is in Building C6 - ground floor atrium at 13:40 and from there we will walk to the Hospital (see figure 7).





Figure 7: Hospital Visit: walk from the conference venue to the hospital.

Social Program

Sunday: Get Together (18:00 - 20:00). The welcome party will be on the inner yard of Building C6 (see figure 3).

Monday: Boat tour (18:00 - 20:00). The Boat Tour will take you on a journey on the river Tejo (Tagus) from the Alcântara Dock upstream to the Terreiro do Paço, an open square where once stood the Royal Palace. Then the tour continues downstream to the mouth of the river, to see the Torre de Belém (Belém tower), an important milestone in the Portuguese Discoveries. A cocktail will be served on board. Transfer from the conference venue to the docks will be provided by the organization. The meeting point is at 17:00 in front of Building C3 (see the *Bus departure point* in figure 2).

Wednesday: Tour (9:00 - 18:00). The meeting point is at 8:45 in front of Building C3 (see the *Bus departure point* in figure 2). Then the buses departure towards Nazaré, the most picturesque fishing village of Portugal. At the viewpoint of *O Sítio* we can enjoy a wonderful view over the village and observe women wearing the traditional costume of the Seven Skirts. After some free time (which you can use to go to the beach and even bathe in the Atlantic Ocean), lunch will be served at a local restaurant. After lunch we will head to Óbidos, one of the most charming villages of Portugal, surrounded by the walls of a medieval castle. Entering through the arch of the eighteenth century, covered with image decorated tiles, along narrow and winding streets, we can admire the whitewashed houses with their balconies covered with colorful flowers. We can also admire the many Gothic and Renaissance churches, especially the wonderful church of Santa Maria which recalls the importance that Óbidos had in the past. At the end of a long, leisurely day we will return to Lisbon.

Thursday: The Conference Diner (19:00 - 23:00). The Conference Diner will be served at the Tenda do Cristo Rei (Christ, the King), a panoramic view restaurant in the city of Almada, in front of Lisboa, on the other bank of the river Tejo (Tagus). The restaurant is located in the sanctuary of the monument with the same name and it offers a fabulous view over the city of Lisboa and the river. Transfers from the conference venue to the restaurant and back again will be provided by the organization. The meeting point is at 19:00 in front of Building C3 (see the *Bus departure point* in figure 2).



Figure 8: The panoramic view at the restaurant Tenda do Cristo Rei.

Internet Access

Free Wi-Fi is available to all participants - the username and password will be given at the registration desk. Also, the university campus is covered by the Eduroam network. In addition, participants may use the computer rooms 6.4.34 and 6.4.35, in the 4th floor of Building C6 (see figure 5) that will be opened from 8:00 to 20:00 during the conference. To use the computers in these rooms you also need the username and password.

Post Conference Publications

There will be a special issue of the Operations Research for Health Care (ORHC) journal dedicated to the ORAHS 2014 Conference, aiming at collecting high quality papers presented during the conference. Please submit your full papers through <http://ees.elsevier.com/orhc/>. Select the article type option for special issue from the drop down menu "Special Issue: ORAHS 2014". Deadline for special issue submissions is November 1, 2014. The targeted date for publication is August 2015.

Guidelines for session chairs

The chair should contact the speakers before the session to verify their presence. Must also guarantee that each session begins and ends on time. To allow participants to switch between sessions, in case of speakers that don't show up, the given schedule should still be maintained.

Guidelines for speakers

A total time of 20 minutes, including questions, is allocated to each presentation. All session rooms are equipped with DLP video projectors and a laptop. Please try to arrive early before your own session begins, in order to copy your presentation into the provided laptop.

The session code at the the header of each session (see the Scientific Program - Day by Day on page 13) identifies the day, the period of the day and the room. For example, session MA1 takes place on Monday - *M*, on the first period - *A*, on room 6.1.36 - 1. Session TuB2 takes place on Tuesday - *Tu*, on the second period - *B*, on room 6.2.53 - 2 and session ThC3 takes place on Thursday - *Th*, on the third period - *C*, on room 6.2.56.

Scientific Program

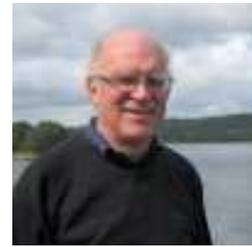
Program at a glance

	Sunday 20 th July	Monday 21 st July	Tuesday 22 nd July	Wednesday 23 rd July	Thursday 24 th July	Friday 25 th July		
9:00		Registration	Parallel Sessions	TOUR	Parallel Sessions	Parallel Sessions	9:00	
9:30		Coffee/Tea	TuA		ThA	FA	9:30	
10:00		Conference Opening					10:00	
10:30		Panel Discussion	Coffee Break			Coffee Break	Coffee Break	10:30
11:00			Plenary Talk			Plenary Talk	Business Meeting	11:00
11:30			Geoff Royston			Manuel Delgado		11:30
12:00		Lunch	Lunch			Lunch	Lunch	12:00
12:30								12:30
13:00								13:00
13:30								13:30
14:00		Parallel Sessions	Hospital Visit		Parallel Sessions		14:00	
14:30		MB			ThB		14:30	
15:00		Coffee Break	Poster Display		Coffee Break		15:00	
15:30			& Coffee Break		Parallel Sessions		15:30	
16:00		Parallel Sessions	Parallel Sessions		ThC		16:00	
16:30	Registration	MC					16:30	
17:00		Transfer to the dock	TuC				17:00	
17:30							17:30	
18:00		Boat Tour					18:00	
18:30	Registration & Get Together						18:30	
19:00					Conference Dinner		19:00	
19:30							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	

Plenary speakers

Geoff Royston, immediate past President of the Operational Research Society

Dr Geoff Royston is former Head of Strategic Analysis and Operational Research in the Department of Health for England, where for almost two decades he was the professional lead for a large group of health analysts. He is now an independent analyst and researcher and is the current President of the Operational Research Society. He is also an Associate of the Public Health Action Support Team (PHAST) and a Senior Associate of the Centre for Health Service Economics and Organisation at Nuffield College, Oxford. He has had a wide range of activities and responsibilities involving analysis and research to inform the design, implementation and evaluation of evidence-based policies and programmes in the health field. He has particular experience of modelling and understanding the behaviour of complex systems; of monitoring performance and evaluating the impact of innovations; of resource allocation methods; of analysis and communication of risk; and of horizon scanning and futures thinking. Much of his work has involved assisting others to develop strategies, policies and programmes, and developing their capacity to do this more effectively. This has included designing and running participative events up to and including Chief Executive and Board level. He has also worked on information and communication technology in the health sector, and has been an adviser to the UK communications industry regulator (OFCOM). He made the original proposal for the development of the telephone and internet service “NHS Direct” and subsequently led its national launch. Dr Royston has been a member of various university advisory groups, has been an external examiner for postgraduate courses in operational research and management science, and has served on both scientific and medical UK Research Council panels. He has published extensively in both health and management journals and is a member of the editorial board for the journal Health Care Management Science, and is its Guest Editor for a forthcoming Special Issue on Global Health. He has a variety of experience in the international health arena including being a consultant for the World Health Organisation, an adviser to the HIFA (Health Information for All) 2015 programme and a long standing member of the EURO Working Group on Operational Research Applied to Health Services. He was Chair of the UK Government Operational Research Service in 2003/4. In 2008 he was elected Companion of Honour of the Operational Research Society and in 2010 he was elected to be the Society’s President for 2012-2013.



Program

Manuel Delgado, General Manager of IASIST Portugal

Manuel Delgado was born in 1952 and is married with 2 children. Since 2010, he is the Chief Executive Officer (CEO), of IASIST Portugal Lda., a specialized and international company on health services assessment and benchmarking. He is the President of the General Assembly of the Portuguese Association of Hospital Managers and Board Member of the General Council of The Portuguese Association for the Hospital Development. He is member of the Scientific Council of Raríssimas (Patient Association for rare diseases). He is also member of the Representative Council of Escola Superior de Tecnologias em Saúde de Lisboa (ESTeSL). Since 2013 Manuel Delgado is designated by The Ministry of Health as board member of the Council for The Hospital Reform. Manuel Delgado was President and Chief Executive Officer of the Board of Curry Cabral Hospital, a central and general Hospital in Lisbon, Portugal, from 2007 to 2010. As Hospital Manager, M. Delgado has been linked to the management of other Central Hospitals in Lisbon since 1981, namely as CEO in Capuchos Hospital



(1996-2004) and Pulido Valente, EPE, Hospital (2005-2007). Simultaneously he developed a University career on hospital management matters, teaching in the National School of Public Health/Universidade Nova de Lisboa (UNL) since 1985. His principal fields of interest are Health Policies, Strategic Planning, Hospital Management and Quality affairs. Manuel Delgado holds a degree in Economics from the University of Lisbon (1974) and a graduation in Hospital Management (1981). From 1992 to 2008, Manuel Delgado was President of the Portuguese Association of Hospital Managers and from 2002 to 2006 was President of the European Association of Hospital Managers. The Portuguese Government Ministers Board appointed Manuel Delgado for the Health Reform Group in 1996 and is the co-author of the final Report edited in 1998. In 1994 integrated the Study Group designated by the Minister of Health to reform the Mental Health Sector. Manuel Delgado participated as Consultant, in different international projects, sponsored by EU and the World Bank, in Angola, Brazil and Albania. Manuel Delgado publishes, frequently, opinion articles and scientific papers on specialized magazines, national newspapers and books.

Monday

9:00 - 10:30 Registration and Coffee/Tea C6 - ground floor atrium

10:30 - 11:00 Conference Opening Room: 6.1.36

Maria Eugénia Captivo, Chair of ORAHS 2014.

José Artur Martinho Simões, Director of the Faculdade de Ciências, Universidade de Lisboa.

Luís Gouveia, Coordinator of the Centro de Investigação Operacional, Faculdade de Ciências, Universidade de Lisboa.

Miguel Constantino, Vice-President of APDIO.

Francisco George, Director-General of Health.

Sally Brailsford, Coordinator of the EWG on ORAHS.

11:00 - 12:30 Panel Discussion Room: 6.1.36

For Better Practices in Health Care Management in Portugal

Prof. Adalberto Campos Fernandes, Invited Assistant Professor, ENSP UNL, Portugal.

Prof. Bernardo Almada-Lobo (chair), Associate Professor at Faculdade de Engenharia da Universidade do Porto and Director of the INESC-TEC - Centre for Industrial Engineering and Management of the Associate Laboratory.

Prof. Carlos Moreira (moderator), Comissão de Avaliação de Medicamentos (Committee for Drug and Medicines Evaluation) and INFARMED - Autoridade Nacional do Medicamento e Produtos de Saúde, IP (National Authority of Medicines and Health Products), Portugal.

Dr. Francisco George, Director-General of Health, Portugal.

Prof. João Carvalho das Neves, CEO of ACSS, IP - Administração Central do Sistema de Saúde (Central Administration of the Health System) and ISEG - Instituto Superior de Economia e Gestão (Lisboa School of Economics and Management) - Universidade de Lisboa, Portugal.

12:30 - 14:00 Lunch Canteen (C7)

14:00 - 15:30 Session 1 (page 15)

MB1 Operating Room Planning and Scheduling (1) Chair: Maria Eugénia Captivo Room: 6.1.36	MB2 Workforce planning Chair: Sally Brailsford Room: 6.2.53	MB3 Health economics Chair: Angela Testi Room: 6.2.56
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Inês Marques
Bicriteria elective surgery
scheduling using an
evolutionary algorithm

Sally Brailsford
The influence of unscheduled
admissions on critical care
nurse staffing

Mário Amorim Lopes
Assessing and planning for the
future needs of the healthcare
workforce

Monday

Ivanna Mandzyuk
A software tool to support the surgical planner

Ilgin Acar
An overview of nurse-to-patient assignment problem

Hui Zhang
Pricing and promotional decisions of a drug manufacturer with the presence of price-volume agreement

Rosita Guido
A hybrid genetic approach for solving multiobjective operating room planning and scheduling problems

Steffen Bayer
Ophthalmology workforce planning in Singapore

Michele Sonnessa
An agent-based simulation model to evaluate the impact of different co-payment scenarios on health services consumption and public budget

Mohsin Malik
A bi-objective optimization approach to healthcare aggregate capacity planning

Paolo Tubertini
Emergency room management in Lazio, Italy

Mahsa Ghandehary
An investigation on inventory model with considering on expire date of hospital pharmacy

15:30 - 16:00 Coffee Break C6 - inner yard

16:00 - 17:00 Session 2 (page 21)

MC1 OR Methodologies for Home Care (1)
Chair: Andrea Matta
Room: 6.1.36

MC2 Modeling Blood Delivery
Chair: Honora Smith
Room: 6.2.53

MC3 Modeling Infectious Diseases
Chair: Lerzan Ormeci
Room: 6.2.56

Sacramento Quintanilla
A mobile route-planning application for planning routes at the hospital at home

Honora Smith
Online allocation and routing for blood delivery in conditions of variable and insufficient supply: a case study in Thailand

Alexander Rutherford
A network-based approach to testing for infectious diseases transmitted on contact networks

Daniela Lüers
The home health care problem under consideration of working regulations

Samuel van Brummelen
Production and waiting time computation for blood donor centers

Krisztina Vasarhelyi
Developing an operational framework for the global expansion of antiretroviral treatment delivery to control the HIV epidemic

Andrea Matta
A data-driven approach for estimating the travel times of operators for the assignment problem of home health care services

Sharon Hovav
Optimization and approximation techniques in service of constructing blood sampling supply chain

Lerzan Ormeci
Modeling the effect of nurse as a transmitter on hospital acquired infections

18:00 - 20:00 Boat Tour river Tejo (Tagus)

MB1

14:00 - 15:30

Operating Room Planning and Scheduling (1)

Room: 6.1.36

chair: Maria Eugénia Captivo

1 - Bicriteria elective surgery scheduling using an evolutionary algorithm

Inês Marques, *Centro de Investigação Operacional, Faculdade de Ciências, Universidade de Lisboa, and Departamento de Estatística e Investigação Operacional, Faculdade de Ciências, Universidade de Lisboa, and Universidade Lusófona de Humanidades e Tecnologias, ECEO, ines.marques@fc.ul.pt*

Co-author(s): M. Eugénia Captivo (mecaptivo@fc.ul.pt), Centro de Investigação Operacional, Faculdade de Ciências, Universidade de Lisboa, and Departamento de Estatística e Investigação Operacional, Faculdade de Ciências, Universidade de Lisboa; Margarida Vaz Pato (mpato@iseg.utl.pt), Centro de Investigação Operacional, Faculdade de Ciências, Universidade de Lisboa, and Departamento de Matemática, Instituto Superior de Economia e Gestão, Universidade de Lisboa.

Current social and economic environment forces better practices among health care service organizations. Portuguese National Health Plan outlines the urgency of improving the efficiency of the health care systems' installed capacity, and reducing the waiting lists for surgery. Hence this work is dedicated to a case study of an elective surgery scheduling problem arising in a Lisbon public hospital. In order to increase the surgical suite's efficiency and reduce the waiting lists for surgery, two conflicting objectives are therefore considered: maximize surgical suite occupation and maximize the number of surgeries scheduled. This elective surgery scheduling problem consists of assigning an intervention date, an operating room and a starting time for elective surgeries selected from the hospital waiting list. To obtain potentially non-dominated solutions to this bicriteria problem an evolutionary algorithm is presented. The algorithm uses an indirect representation and randomly generates weights for each objective in order to decode each chromosome into a complete solution. The elitist strategy and the structure of the evolutive process are based on a biased crowded tournament selection and a parametrized uniform crossover. Tests performed using hospital real data showed a good performance of the algorithm proposed: instances with 508 to 2,306 elective surgeries are solved in less than 80 seconds. A very good representation of the Pareto front was achieved thus providing the opportunity to improve the decision-making process at the hospital. This study presents a powerful method with potential to improve the delivery of surgical activity in the hospital under study.

Keywords: operating rooms; elective case scheduling; bicriteria optimization; evolutionary algorithms.

2 - A software tool to support the surgical planner

Ivanna Mandzyuk, *Universidade de Lisboa, Instituto Superior de Economia e Gestão, ivannamandzyuk@hotmail.com*

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The Portuguese health system faces major new challenges due mainly to the growth of the health care sector and to the strong financial constraints on hospital budgets. It is well known that the surgical suite represents one of the major cost and profit units of the hospital. A difficult problem arising in the surgical suite is the scheduling of elective patients. In most Portuguese hospitals this is still a hard

Monday

and time consuming handmade task to the surgical planner. Considering these issues, a software tool was developed in order to support the surgical planner in his decisions about elective case scheduling. This tool works as an interface between the solutions obtained by some heuristic or exact procedure to optimize the elective surgery scheduling previously developed and the surgical planner. A case study entailing a Portuguese hospital is considered. The software was developed in Microsoft Excel using a VBA programming language, and offers good results in the treatment of data and a very attractive display. This tool presents an intuitive visualization of the operating rooms schedule, which can also be segmented by surgical priority or specialty and by surgeon. Moreover it allows to exchange planned surgeries and to respond correctly to unexpected occurrences (in terms of surgery planning), automatically validating the new plan according to the relevant constraints on hospital resources. Visual information and quantitative reports are easily available to the surgical planner as well as to clinicians and administrators. This tool not only facilitates the planning process but also improves the hospital internal control regarding the surgical suite. It is a user-friendly software for hospitals not requiring costs with additional software licenses and minimizing the training needs.

Keywords: operating rooms; elective case scheduling; visualization.

3 - A hybrid genetic approach for solving multiobjective operating room planning and scheduling problems

Rosita Guido, *deHealthLab, Dipartimento di Ingegneria Meccanica, Energetica e Gestionale, Università della Calabria, Italy*, rosita.guido@unical.it

Co-author(s): Domenico Conforti (domenico.conforti@unical.it), *deHealthLab, Dipartimento di Ingegneria Meccanica, Energetica e Gestionale, Università della Calabria, Italy*.

The operating room (OR) department is a critical hospital resource. Decision-making processes strongly affect an operating theatre organization, which is a high dynamic environment where, above all, safe and efficient schedules have to be ensured. Usually, hospital managers strive to satisfy conflicting objectives, such as maximization of efficiency, quality of care and minimization of OR team waiting, overtime, being aware that achieving all is quite difficult or sometimes impossible (this could explain why waiting, delays, and cancellations seem often intrinsic in OR activities). In this context, surgical planning and scheduling problem is highly complex and the majority of papers splits the OR management problem in a planning phase and a scheduling phase; each phase is thus solved separately although all decision levels strongly interact with each other. Here we present a new approach for enhancing OR efficiency and effectiveness by defining a multiobjective optimization model, which solves, at the same time, both tactical and operation decision levels. We assume a block-scheduling system and multiple ORs shared among several surgical specialties. The mathematical model is an NP-hard multiobjective binary problem. With the aim to support hospital managers in finding solutions of good quality in a reasonable running time, we designed a hybrid genetic approach, which defines good approximated Pareto frontiers. The so defined schedules are trade-offs between under utilization of operating room capacity, balanced distribution of operating room time among surgeon groups, and minimization of waiting time for surgery and overtime working hours. The proposed approach can provide decision supports for hospital managers to solve real multiobjective problems.

Keywords: operating room management; patients scheduling; multiobjective mathematical model; hybrid genetic approach.

4 - A bi-objective optimization approach to healthcare aggregate capacity planning

Mohsin Malik, *Abu Dhabi University United Arab Emirates*, mohsin.malik@adu.ac.ae

An operation room (OR) is the usual bottleneck resource in a healthcare chain where the treatment capacity has lagged behind resulting in the queuing up of patients for their turns to undergo the elective

surgeries commonly referred to as the "waiting lists". The "maximum waiting time guarantee" is an important policy tool to control the number of patients waiting time. Backed by additional resources, these guarantees have been effective in restricting patients waiting times but it also increases healthcare costs which makes the healthcare planning as a bi-objective planning problem. This study uniquely formulates and solves this bi-objective combinatorial optimization problem to simultaneously minimize the number of patients waiting for an elective procedure and the associated costs by a Non Dominated Sorting Genetic Algorithm (NSGA II) giving a range of Pareto plans that have important managerial repercussions. The obtained Pareto frontier has ramifications for managerial decision making because of the range of solutions that may help set and analyze the impact of various maximum service guarantees.

Keywords: healthcare capacity planning; operations room planning; multi-objective optimization; patient's waiting lists.

MB2

14:00 - 15:30

Workforce planning

Room: 6.2.53

chair: Sally Brailsford

1 - The influence of unscheduled admissions on critical care nurse staffing

Sally Brailsford, *University of Southampton, School of Management*, s.c.brailsford@soton.ac.uk

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The Childrens' Hospital Wisconsin uses an internally developed software tool called Maestro to assist day-to-day nurse staffing decisions for each unit. Maestro takes into account the predicted numbers and acuities of patients, as well as senior nurses' estimates of the desired staffing level. However, for the Paediatric Intensive Care Unit (PICU), Maestro's predictions are currently not very reliable. The PICU managers believe that a key factor impacting on the accuracy of Maestro is its inability to predict admissions; around 70% of PICU admissions are unscheduled. In this study we assess the accuracy of Maestro to predict admissions, discharges and staffing levels, comparing historical data from calendar year 2012 with the corresponding Maestro predictions. We also analyse all unscheduled admissions in 2012 in order to identify any predictable trends that could be factored into the Maestro algorithms to improve accuracy. The analysis showed that the recommended staffing levels produced by Maestro were on average between 27% and 33% too low, compared with the desired numbers entered by the nursing staff. Moreover, there was a significant gap between expected admissions and expected discharges. The ability of senior nurses to estimate admissions varied by floor and by shift. Seasonality analysis of the data revealed clear daily patterns of unscheduled admissions; there was no weekly seasonality, but there was a substantial difference between weekdays and weekends, and one floor had significant monthly differences in unscheduled patient arrivals. A probability distribution was developed and simulated in order to model the pattern of unscheduled admissions over the year. This was compared with the empirical data and found to be a good fit. However, before implementing this in Maestro, we recommend that a similar analysis be undertaken for scheduled admissions. The surprising discrepancy between total predicted admissions and discharges remains a subject for further investigation.

Keywords: nurse staffing; intensive care; unscheduled admissions; predictive models.

Monday

2 - An overview of nurse-to-patient assignment problem

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Nurse to patient assignment problem is a complex assignment problem that affects hospital staff on a daily basis. The total Registered Nurse (RN) population increased from 2,909,357 in 2004 to 3,063,162 in 2008, but this increase (5.3%) was comparatively low considering growth between earlier report intervals (7.9% between 2000 and 2004) (USHHS, 2013). Though the RN population is growing, it is not projected to meet demand. To combat the excessive workloads that may be encountered due to these shortages, researchers are looking to eliminate nonproductive movements and balance hospital unit activities among the nursing staff through better planning (Punnakitikashem, 2007). Nurse planning in the hospital environment typically has four stages: nurse budgeting, nurse scheduling, nurse rescheduling and nurse assignment (nurse-to-patient assignment) (Punnakitikashem, 2007). In general there is an ambiguity between Nurse Scheduling and Nurse Assignment. Nurse scheduling has been a very popular academic exercise in the 1970s and early 1980s and then has shown increase in the number of studies since then. Although literature has addressed nurse scheduling specifically for over 30 years, nurse-to-patient assignment have received little attention in the literature. In this study, we begin by briefly discussing the review and overview papers that have appeared in the literature. The main body of the study describes and evaluates solution approaches and classifies nurse-to-patients assignment. We outline the key issues that need to be addressed in future nurse to patient assignment problems while interpreting the structure and the attributes of the problem.

3 - Ophthalmology workforce planning in Singapore

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Singapore's population as that of many other industrialized countries is aging. As the population ages its eye care needs are increasing. The prevalence of cataracts, but also of other age-related conditions such as glaucoma, AMD or diabetic retinopathy is likely to increase substantially over the next decades. The effect of aging on demand will be further compounded by the increase of Singapore's population due to immigration. Based on a model of the future demographic development in the city state, this project employs system dynamics to project future demand for eye care services. The model projects workforce and training needs for ophthalmologists as well as the required numbers of nurses, optometrists, technicians and patient service assistants to meet this increasing demand. Overall a doubling of the eye care workforce is likely to be required before 2030. The model allows investigating the workforce and training demands under different policies which could impact demand and the uptake of services such as the implementation of new models of care or the introduction of screening programmes which might impact the uptake of services. The work is based on data from local epidemiological studies, data on service utilization collected by the Singapore National Eye Centre and extensive discussions with ophthalmologists and healthcare planners as well as expert estimates.

Keywords: workforce planning; ophthalmology; system dynamics.

4 - Emergency room management in Lazio, Italy

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The Department of Epidemiology of the Regional Health Service of Lazio, Italy (DEP-Lazio), a regional center for health monitoring and management, is currently involved in a project that aims at defining optimal allocation policies of patients to regional hospital network facilities. The reorganization of health centers in order to deliver services in an effective way safeguarding economic sustainability is a topic of increasing importance for Regional Health Services in Italy. In recent years several inputs have been given, through financial laws, to reorganize hospitals infrastructure in order to decrease inefficiencies. The objective of the present study is to develop an hybrid optimization model that considers both Emergency Rooms workload and service allocation, evaluating what could be the impact of a remote triage management that, anticipating the patient classification, can address population requests to the first-aid structure, thus assuring the best possible service level. Since the assignment of service requests to Emergency Rooms is of paramount importance, both from a life-threatening and an economical viewpoints, the final objective of the case study is to develop an allocation policy that maximizes quality of care and service timeliness. We have implemented and tested with real-world data of all service requests of 2012 a Mixed Integer Programming model that computes such an optimal request allocation by minimizing travel and waiting times and penalize workload unbalance among Emergency Rooms in the Lazio region. Within the development process we have studied special cases and relaxations of the complete model showing interesting mathematical properties that are, in turn, useful from a practical viewpoint. The present study is a first step in the evaluation process of centralized allocation strategies, like remote triage, that could have a remarkable impact in making the allocation process much more efficient and effective.

Keywords: emergency rooms; mixed integer programming; remote triage; allocation policy.

Monday

MB3

14:00 - 15:30

Health economics

Room: 6.2.56

chair: Angela Testi

1 - Assessing and planning for the future needs of the healthcare workforce

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Planning the healthcare workforce required to attend to the medical needs of the population can be restated in layman terms as assessing the right number of people with the right skills in the right place at the right time to provide the right services to the right people. A growing body of research literature has been produced in the last decades, with no consensus on establishing an approach. In Portugal, the commissariat responsible for the planning of the healthcare workforce (ACSS) limits its analysis to the forecast of the total number of physicians available given the intakes, migration and the drop out rates in order to ensure that the doctor to population ratio stays inline with the historical records of the EU-15 ratios. In 2009, ACSS supported a more comprehensive study by University of Coimbra that tried to match the supply of physicians with the demand for medical services by measuring the demographical evolution and the worker-to-population ratios of the EU-15. Notwithstanding the remarkable effort, these models fail to fully address the problem. Both reports ignore the evolution of the needs of the population, *i.e.*,

the morbidity and epidemiological factors that may drive the demand for medical services. Furthermore, the models are static, deterministic and unable to handle with indeterminacy or stochastic distortions, thereby lacking an important feature to assist in policy making. We propose a novel simulation model capable of mimicking both the medical training process through a system dynamic's approach, in this way characterising supply; and an agent-based module for projecting the demand for healthcare services incorporating demographic, socio-economic and epidemiological factors that influence the quantity of services required. Furthermore, the model generates a baseline along with other alternative scenarios according to the assumptions defined by the policy maker instead of those imposed by the analyst.

Keywords: health economics; healthcare workforce planning; healthcare operations research; simulation; forecast.

2 - Pricing and promotional decisions of a drug manufacturer with the presence of price-volume agreement

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When physicians prescribe they consider not only the health outcome of a drug, but also its cost. Besides these two factors, they also prescribe based on their personal judgement and preference over certain drugs. Drug manufacturers thus have invested significant amount of effort on promoting their products to physicians, including detailing, invited conferences, and sponsored research etc. These promotional efforts impact physicians' preference toward a drug, resulting higher demand. Since a third-party payer has to pay for all claims of a drug that is covered by an insurance plan, the expense for the drug may be very high and uncertain. To control the increasing drug costs and sales uncertainty, price-volume agreements have been proposed as a way to reduce the risk of higher than expected drug expenses. In the agreement, a drug manufacturer has to return to the payer a portion of sales exceeding a pre-specified volume threshold. In this paper, we investigate the promotional decision and pricing decision of a drug manufacturer in the presence of a form of price-volume agreement. We assume that physicians prescribe based on cost-effectiveness analysis, which is influenced by the drug manufacturer's promotional effort. We consider two different settings of drug pricing: (1) the drug price is regulated and thus is not a decision by the manufacturer; and (2) the drug price is the decision by the manufacturer. We obtain the optimal solution of both problems and explore the properties of the optimal solutions. We thus provide managerial insights to the manufacturer on how to make pricing and promotion decisions when confronted with a price-volume agreement.

Keywords: detailing; price-volume agreement; pharmaceutical; cost-effectiveness.

3 - An agent-based simulation model to evaluate the impact of different co-payment scenarios on health services consumption and public budget

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Co-payment is worldwide used in order to help financing health systems getting additional resources directly from the citizens. The design of the "best" set of co-payment rules is a challenging and critical issue because it should help financing more and more expensive public health care without affecting the ability to access the system especially with regards to the more frail patients. An agent-based simulation model has been developed in order to analyse the impact of different co-payment rules on the revenue amount collected by the Government as well as on the rationing effect on services consumed while taking into account the equity of treatment among different group of patients. The model herein presented extends a previous validated agent-based-model based on a large observational dataset of patient records collected by general practitioners over a one year period. Three main extensions are introduced for

better modelling the patient reaction. The first is an "overlook" response function to link the patients response and the consequent health services consumption to both the price they are asked to pay and, also, to their expected future expense which in turns determines the probability to achieve their personal ceiling cap. Secondly, we consider the patient decision of exiting from the public health system and moving to the private one, when co-payment charge reaches some critical levels. Third, citizens are completely free to move from one doctor to another, when the physician does not accord their request. This physician behaviour is usually motivated by appropriateness reasons and depends on the individual doctor propensity to prescribe. Several co-payment rules scenarios are implemented and compared by means of a set of indicators, such as consumption of drugs and diagnostics, co-payment individual expense and total revenue collected by the Government, equity among different groups of patients homogeneous with regard to pathologies (chronic, non-chronic), age and income.

Keywords: health economics; decision support systems; public expenditure; simulation.

4 - An investigation on inventory model with considering on expire date of hospital pharmacy

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As we know pharmaceuticals industry has a huge effect on the health care's costs while there is not any effective cost controlling done in this section, that can either provide the drugs for hospital patients, on time, and also decrease the cost of buying, storage and holding in this section. Considering the high service level requirement in hospitals and the changing the random demands and expires sensitive medicines and hospital drug shortage in this sector can be dangerous and costly for the patient and the system imposes and In this regard, considerable research has not been done. We focus on the inventory management on the expiry date of the drugs at a local storage unit within an individual Care Unit (CU). For the operational inventory decision we provide the reorder point and order up to level (called min and max par levels) that control the automated ordering system. These parameters are based on a near-optimal allocation policy of cycle stock and safety stock under storage space constraint. As a result we try to decrease the costs of this industry by working on inventory models based on the expiry date of the drugs and solved it by simulation, that in The drug industry has not had to do. At last we solved and invested these models using the real data of a hospital pharmacy in Isfahan and compared the results.

Keywords: health care; hospital medications; inventory model; simulation.

Monday

MC1

16:00 - 17:00

OR Methodologies for Home Care (1)

Room: 6.1.36

chair: Andrea Matta

1 - A Mobile Route-Planning Application for planning routes at the Hospital at Home

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The Hospital at home is a health care alternative, which consists of an organizational model where diagnostic and therapeutic care, similar to that provided by the hospital, can be carried out by medical professionals using resources from the hospital. This health care is for a limited period and takes place at a person's home. If patients were deprived of this service they would require hospital care and for their

stage of disease the home is the "best therapeutic place". This new service which is not considered in the traditional hospital implies some important new costs for the hospital. Doctors and nurses who make up assistance teams in home hospitalization must move daily to the different homes where patients are hospitalized. In the hospital we are working with, these routes are currently performed by taxi, and are very costly. We have developed efficient metaheuristic algorithms to minimize the cost of travel and meet the constraints defined in the service. The proposed algorithms achieve a significant reduction in both cost and staff waiting times. The algorithms are based on four pillars: solution representation, creating an initial population from what we define as clusters of households, perturbation and local search. We have also developed a mobile route-planning application, ORAS, to use in this home hospitalization service. The software is designed to show daily the most efficient route to be taken by each doctor and nurse and to update in real time the information about the routes. A graphic visualization is used to show the routes taken by each taxi or person. The core of the software is the set of algorithms we have created to solve the problem.

Keywords: hospital at home; heuristics; route optimization; software.

2 - The home health care problem under consideration of working regulations

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Home health care is a growing sector in the health care system. As people, receiving services from home health care providers, stay at their homes, the providers are facing complex routing and scheduling problems for planning their nurses and services for a given time horizon. To perform this planning task the home health care problem from literature combines the well-known vehicle routing problem and nurse rostering problem and extends them by domain-specific requirements. The integration of routing and rostering at the same time is crucial to obtain satisfying schedules, which meet client preferences as well as working regulations. It also allows using information from both parts for the optimization, which is lost when solving routing and rostering separately. Especially, the consideration of relevant working regulations is missing in publications concerning the home health care problem, although those are already widely used in the nurse rostering problem for stationary institutions. We extend the home health care problem with relevant aspects mostly coming from the nurse rostering problem in order to improve the satisfaction of nurses and comply with legal requirements. Therefore, working regulations, such as rotating shifts and break rules, are adapted and included into a mixed-integer formulation for the home health care problem. We present results using a commercial solver as well as a heuristic approach, which is essential to face the complexity of the integrated problem and is able to get solutions for data instances in reasonable computing time.

Keywords: home health care problem; home health care; working regulations; routing; rostering.

3 - A data-driven approach for estimating the travel times of operators for the assignment problem of home health care services

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Home Health Care service is an alternative to conventional hospitalization and consists of delivering medical, paramedical and social services to patients in their homes. This is one of the recent service systems where human resource planning has a great importance. The assignment problem in the served territory is an important issue that the service provider must address and it consists of deciding which operator will provide services to which patients. Because the routing optimization is not considered and exact travel times between patients are unavailable when the assignment problem is solved, an

estimation of the travel time necessary to reach each patient is required to solve the assignment problem. Traditionally, these travel times are considered based on only the geographical criterion with Euclidean traveling times. However, service provider should also take into account several characteristics of patients and operators while considering the travel times. Examples of such characteristics can stem from features related to patient care requirements (i.e., their care profile) or the geographical aspects of the territory. Modeling and integrating these features would not be computationally tractable since one would have to formulate each feature as a new decision variable or a new constraint and integrate it in the formulation of the model. Alternatively, such features can be captured by the available historical data that would give information regarding the choices made in previous routes accomplished by a given operator. Then, such data-driven approach would enable to estimate (future) travel times of operators based on their past behaviors. Hence, in this work we propose data-driven method to estimate travel times of health care operators in the assignment problem. Numerical results based on realistic problem instances are performed as well to show the performance of the proposed method.

Keywords: home health care; human resource planning; assignment problem; travel time estimation; data-driven approach.

MC2

16:00 - 17:00

Modeling Blood Delivery

Room: 6.2.53

chair: Honora Smith

1 - Online allocation and routing for blood delivery in conditions of variable and insufficient supply: a case study in Thailand

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Blood is a perishable product which suffers from physical deterioration; fresh blood is preferred for treatment. However, transportation costs are a major factor to be considered by administrators of Regional Blood Centres which act as blood collection and distribution centres. A trade-off must be reached between transportation costs and short-term holding costs. In this paper we propose several algorithms for online allocation and routing of blood supplies, for use in conditions of variable and insufficient blood supply, as often encountered in developing countries. A case study in Chiang Mai province in northern Thailand provides an application of the allocation and routing policies. The plan proposed for daily allocation and distribution of blood supplies consists of two components: firstly, fixed routes are determined for the supply of hospitals which are far from a Regional Blood Centre. Over the planning period of one week, each hospital on the fixed routes is visited once. A robust allocation of blood is made to hospitals on the fixed routes that can be guaranteed on a suitably high percentage of days, despite variable supplies. Secondly, a variable daily route is employed for close-by hospitals, for which more than one visit per week may be needed to fulfil targets. The variable routing takes into account the amount of blood available for each day's deliveries, which is known only on the morning of delivery. For hospitals on the variables routes, the day and amounts of deliveries cannot be guaranteed but are designed to attain targets over the six-day planning horizon. We suggest several policies that could be chosen by decision makers, with different trade-offs between transportation and holding costs.

Keywords: blood distribution; on-line algorithm; health care; developing countries.

2 - Production and waiting time computation for blood donor centers

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As blood donations are provided on a voluntary non-remunerated basis, blood donors should be handled as user-friendly as possible. Delays and waiting times within blood collection sites (donor centers) should thus be kept to acceptable levels. The capacity for collection sites in contrast is merely determined by production norms. Waiting times are not incorporated directly other than by practical experience. A more rigorous approach is required. An analytic waiting time computation is therefore investigated to compute waiting times as a function of production. First an analytic so-called product form solution is concluded. This product form leads to an exact expression for the joint queue lengths (workloads) for the exponential case, an exact expression for the marginal waiting time percentiles for the exponential case and a more formal justification for approximate computation of the total mean waiting time for the non-exponential case. In addition, a computational procedure is developed and applied for the total sojourn time distribution. The results are tested for and applied to a real-life test case of a Dutch representative donor center. These illustrate the practical usefulness and support the development of a user-friendly computer program to combine waiting time and production norms.

Keywords: queueing network; blood donor centers; product form expression.

3 - Optimization and approximation techniques in service of constructing blood sampling supply chain

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The problems of blood tests are a central challenge which takes a central place in the medical world. Construction and sensitivity design of efficient and flexible constraint-based system is critical. The challenge is that the test results must be correct and exact for all practical conditions and constraints imposed. This study deals with collecting, transporting and processing of the blood samples. In Israel there are two different approaches for this process. One is known as the centralized approach, transport the blood samples directly to the central lab. In the decentralized approach, the samples are routed to an intermediate station for the preliminary process and after that to the central lab. There is some sense in both approaches and since some of the infrastructure is already there it might be impossible to rearrange the transportation system from the beginning. We focus on integration both approaches by obtaining necessary amount of the intermediate stations, locations and operational responsibility. This work takes place in Clalit (Israel) the world's second largest health care organization which provides comprehensive healthcare services to more than 4 million customers and operates over than 1,400 community clinics, 14 hospitals, 400 pharmacies, dozens of laboratories, research institutes and subsidiaries.

Keywords: blood sampling; logistics; supply chain; facility location; approximation algorithms.

MC3

16:00 - 17:00

Modeling Infectious Diseases

Room: 6.2.56

chair: Lerzan Ormeci

1 - A network-based approach to testing for infectious diseases transmitted on contact networks

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Social network structure plays an important role in the transmission of infectious diseases through direct contact. Examples include sexually transmitted and blood-borne infections such as HIV, syphilis, gonorrhoea, human papillomavirus, hepatitis B, and hepatitis C. An important determinant of infectious disease spread on a network is the degree distribution, which is approximately power law for many social networks such as sexual and injection drug user networks. High degree nodes play an important role in driving disease spread on networks. This presents a significant challenge for public health agencies, because such nodes represent individuals engaged in high-risk behaviours, such as street-based sex work or injection drug use. These individuals are often marginalised, having limited access to the healthcare system and are difficult to reach by traditional screening programmes. Contact tracing for those who test positive is an alternative to screening; however, it is considerably more expensive and may only diagnose high degree infected individuals after they have been infectious for a considerable length of time. We investigate a modified form of screening in which individuals are asked to encourage their contacts to seek testing. This testing approach is based on the property of social networks that on average "your friends have more friends than you do". As a result, a screening programme based on this principle will preferentially screen high degree nodes. We study the impact of this testing programme on a network simulation of an HIV epidemic implemented with the NepidemiX software package developed by our group. The result is an approximate 50% reduction in incidence compared to a traditional screening programme with the same cost. This has a substantial longterm impact on the epidemic and could result in significant cost-savings to the healthcare system.

Keywords: HIV testing; public health; epidemiology; network modelling; simulation.

2 - Developing an operational framework for the global expansion of antiretroviral treatment delivery to control the hiv epidemic

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The United Nation's Millennium Development Goal 6A is to reverse the Human Immunodeficiency Virus (HIV) epidemic by 2015. Currently, 35 million people are living with HIV worldwide and 2 million new infections occur annually. Modern antiretroviral therapy stops viral replication but cannot eliminate the virus, requiring life-long treatment adherence to maintain health and prevent HIV transmission. Therefore, sustained delivery of treatment and related health services is essential for controlling the HIV epidemic. Only 35% of those eligible based on current guidelines are receiving treatment. A massive operation is underway to expand antiretroviral coverage globally through implementing Treatment as

Monday

Prevention programs. The Joint United Nations Programme on HIV/AIDS is coordinating the global treatment scale-up and developing new targets for 2030. The World Health Organization publishes HIV treatment guidelines, which promote operations research to improve treatment access, focusing on target recommendations, identifying barriers to health-service delivery through qualitative assessment and data collection, and program monitoring and evaluation. Consideration of analytical tools that could inform interventions and policy on optimal use of scarce resources is often lacking. In the prevailing atmosphere of fiscal restraint, analytical operations research methods merit more than their current peripheral role in the global expansion of HIV treatment delivery. For example, system dynamics modeling and optimization of resource allocation along the HIV care continuum could provide critical information for country-level planning. Facility location, vehicle routing, staffing, task allocation, scheduling and related methods could inform operations to increase efficiency on the ground. Barriers and potential avenues to facilitate the wider application of resource allocation models and other operations research methods have been previously discussed in the literature. We propose an extended operational framework for the global implementation of Treatment as Prevention to invite feedback and engagement from the operations research community.

Keywords: HIV; policy development; treatment delivery; public health; epidemiology.

3 - Modeling the effect of nurse as a transmitter on hospital acquired infections

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We explore how the hospital acquired infection dynamics evolve in an intensive care unit (ICU), using a data set, which includes the bed assigned to the patient as well as the patients' age, sex, admission and discharge dates, length of stay (LOS), Apache II score, and colonization/infection test results during the course of patient's stay over 9 months. The ICU management believes that the following measures can affect the infection dynamics: (1) neighborhood effect, (2) colonization pressure, (3) occupancy rate. We calculate these measures from the data to carry on a logistic regression, which showed that only LOS and neighborhood effect significantly influence the infection of a patient. In the context of ICUs, this coincides with the role of the nurse as an agent. Accordingly, we develop a corresponding Markov chain model to represent the interactions between a nurse and patients. We consider the effects of nurse-to-patient ratio, the hand washing behavior of the nurse, the contact rate between the patients and nurse, as well as the probability of contamination during the contact if one of them is infected/colonized, while the other one is not. These quantities are not easy to estimate, so that a numerical study is carried on for different values of each of these parameters. We will present the preliminary results of this study.

Keywords: hospital acquired infections; intensive care unit; effect of nurse; regression analysis; markov chain modelling.

Tuesday

9:00 - 11:00 Session 3 (page 29)		
<p>TuA1 Modelling in Healthcare Chair: Paul Harper Room: 6.1.36</p> <p>Paul Harper Embedding healthcare modelling in the health service: Making an impact in South Wales!</p> <p>Teresa Cipriano Rodrigues The MACBETH approach to health value measurement: Building a population health index</p> <p>Joe Viana A comparison of two approaches to hybrid simulation in a healthcare context from an operational researcher's perspective</p> <p>Olav Goetz Simulation based analysis of operational processes of a general hospital</p> <p>Angel Ruiz Modeling the logistics response to a bioterrorist Anthrax attack</p>	<p>TuA2 Cancer Treatment Planning Chair: Thierry Garaix Room: 6.2.53</p> <p>António Cruz A tabu search approach to IMRT beam angle optimization</p> <p>Arantzazu Arrospe Evaluation of health benefits and harms of the breast cancer screening program in the basque country (1996-2011)</p> <p>Ingeborg Bikker Reducing access times for radiation treatments by aligning the doctor's schemes</p> <p>Leslie Anne Campbell Average risk colorectal cancer screening: understanding the consequences of introducing competing demands for limited colonoscopy resources</p> <p>Salim Rostami Appointment scheduling for ambulatory chemotherapy</p>	<p>TuA3 Patient scheduling Chair: Erik Demeulemeester Room: 6.2.56</p> <p>Michael Samudra The effect of three different scheduling strategies on patient related performance measures</p> <p>Amina Awedni Outpatient scheduling problem: the case of infectious diseases service in Hédi Chaker Hospital of Sfax</p> <p>Daniel Gartner Flexible hospital-wide scheduling of elective patients</p> <p>Aleida Braaksma Online appointment scheduling with different urgencies and appointment lengths</p> <p>Jennifer Morgan Using text mining and simulation for health system understanding: modelling hospital outpatient follow-up demand</p>
11:00 - 11:30 Coffee Break		C6 - inner yard
11:30 - 12:30 Plenary Talk (page 37)		6.1.36
Chair: Margarida Vaz Pato		
<p>Geoff Royston Exploring New Worlds for Applying Operational Research in Health Services</p>		
12:30 - 13:40 Lunch		Canteen (C7)
14:00 - 15:30 Hospital Visit		Hospital de Santa Maria

Tuesday

15:30 - 16:30	Poster Session (page 37)	6.1.36
	Poster Display	C6 - inner yard
	Chair: Marion Rauner	

Alcides Algarra Grande

Predicting no-shows in a Brazilian hospital to improve patient scheduling performance

Andres Osorio

A stochastic optimisation model for technology selection and donors assignment in the blood supply chain

Daniel Gartner

Emergency department-wide capacity dimensioning

Francisco Sabbadini

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Sara Ribeiro

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Sarah Kok

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Walaa Ismael

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Tracey England

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Izabela Komenda

Compliance with national guidelines for stroke in radiology

Erwin Hans

Minimising variation in bed demand by improving the operating room scheduling

Paula Velásquez Restrepo

Systemic analysis of the flow of hospital patient and determination of the capacity of beds in a high complexity hospital

Mahsa Keshtkaran

Validation of complex decision-support model for investigation and improvement in health services: the case of stroke thrombolysis

Manuel Dios

A decision support system for solving the stochastic operating theater tactical problem

Jivan Deglise-Hawkinson

An outpatient planning optimization model for integrated care and access management

Fredrik Dahl

Ranking stroke-related instruments for a rehabilitation context through an analytical hierarchical process

Ana Tavares

Optimal master surgical planning: A block scheduling approach to the operating theatre

Penny Holborn

Reducing cancellations for day of surgery admissions

Patrick Soriano

Master surgical schedule planning integrating waiting list management for targeted surgeries

Tuesday

TuA1

9:00 - 11:00

Modelling in Healthcare

Room: 6.1.36

chair: Paul Harper

1 - Embedding healthcare modelling in the health service: Making an impact in South Wales!

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An exciting recent initiative is the creation of a Healthcare Modelling Unit funded by the Aneurin Bevan University Health Board (ABUHB) and Cardiff University. The unit consists of four research associates who are the first of a new generation of modellers to be embedded within the NHS Wales. Joint working agreements allow the team to operate from office space at both the School of Mathematics and the Aneurin Bevan Continuous Improvement (ABCi) team at the Health Board. ABCi exists to help and support clinical teams to improve the safety, quality and efficiency of care they deliver with a strong focus on patient experience. The unique opportunity to be embedded within this team brings numerous benefits to the modellers: not only are they directly linked with improvement coaches, financial planners, senior managers and clinicians; but they are regarded by NHS staff as "colleagues", giving them access to a wide range of opportunities to pioneer novel modelling techniques within the NHS. The team also works closely alongside the Information Department. The ability to speedily provide the necessary data has been key in allowing the modellers to progress their analyses and deliver results at pace. The team receives enquiries from any and all parts of the organisation: clinical and support services; primary, community and/or hospital based. To date, several different modelling techniques have been used to approach the problems such as forecasting, demand and capacity planning, simulation, optimisation, and scheduling across a wide range of hospital services. In this joint talk (by Paul Harper at Cardiff University and John Frankish, ABCi Improvement Lead), we will overview the unit, provide some examples of the projects and resulting impact, and discuss lessons learnt from our experience so far.

Keywords: NHS; impact; modelling unit.

2 - The MACBETH approach to health value measurement: Building a population health index

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Monitoring the health status of a population not only helps detecting emerging patterns of illness and disease, but also provides valuable information to drive health related policies and the planning of health services. Formal assessment tools, such as health indices, have been developed, taking into consideration multiple indicators of the health of a population. The on-going study aims at avoiding critical problems in aggregating performances, from the viewpoint of multicriteria value measurement. The study is carried out within the scope of the GeoHealthS research project, aiming to build a value-based health index of the Portuguese population at the local administrative level (in each municipality of the Portuguese mainland) and applied in a twenty year period. The MACBETH approach was used to construct a multicriteria additive value-health model, in which the criteria are indicators that were grouped in "health

Tuesday

determinants” and “outcomes” areas of concern. Building the model with MACBETH involved the use of participatory methods, namely a Delphi process with a group of experts and decision conferencing with a strategic group. Besides the values of the index, the MACBETH model has been shown to generate a wide set of outputs within a “tableau-de-bord” structure which will integrate a Geographic Information System and which will be the starting point for policy makers and planners analysing variations in population health and geographical health inequalities in the Portuguese territory.

Keywords: health index; MACBETH; multicriteria decision aid; performance evaluation.

3 - A comparison of two approaches to hybrid simulation in a healthcare context from an operational researcher’s perspective

Joe Viana, *University of Southampton, Southampton Business School*, j.viana@soton.ac.uk

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Hybrid simulation, the combination of simulation paradigms to address a problem is becoming more popular as the problems we are presented with become more complex. This is evidenced by an increase in the number of hybrid papers published in specific domains and the number of hybrid simulation frameworks being produced across domains. This paper focuses on two hybrid simulation models from a healthcare context through the lens of an operational researcher. Two models are developed, contrasted and compared. The first model was produced from a solely operational research point of view with the engagement of external stakeholders, consisting of a discrete event simulation model of a sexual health clinic in England combined with a system dynamics model of the spread of the sexually transmitted infection Chlamydia. The second model was produced as part of a large multidisciplinary project consisting of: demography, social statistics and complexity science a branch of computer science in addition to external stakeholders, to model the whole system effects of the eye condition age related macular degeneration. This model combines a discrete event simulation model of a hospital outpatient eye unit, an agent based model of the population with the eye condition who attend the eye unit and within each agent two embedded system dynamics models of sight representing each agent’s eyes. The two models are critiqued and reflections on the models are presented to add to the debate about the viability of hybrid modelling and suggest future steps to the development of the approach.

Keywords: discrete event simulation; system dynamics; agent based modelling; hybrid simulation; composite modelling.

4 - Simulation based analysis of operational processes of a general hospital

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The health care sector in general and hospitals in special have faced many challenges over the last years. Economic analyses of processes and the utilization of resources are increasingly important for hospitals. Operations research offers a variety of tools that may support the presentation, evaluation and design of processes in general and surgery processes in particular. Especially, Discrete Event Simulation (DES) represents a promising method to support critical analyses in hospitals. Based on empirical data, gathered by observation, interviews, process analysis and a time study, the present study examines operation processes of a general hospital. Therefore we constructed a stochastic Discrete Event Simulation model of the operation theatre to represent the current operational processes. After verifying and validating the basic model using animation, tracing and debugging, interviews and testing against historical data we analyzed parameter changes within several scenarios. Resource utilization, further key process indicators as well as costs were taken into account. The results of the study show that Discrete Event Simulation is an appropriate method for representing the basic operational processes of a general hospital. In addition,

by simulating several scenarios it is possible to investigate effects of process changes. The utilization of resources as well as important process indicators can be influenced in these scenarios. The current level of operations could also be performed in a reduced number of operating rooms, which would lead to free and alternative usable capacity. Thus, the mean average utilization of all operating rooms could be increased essentially - between 10% and 35% depending on the scenario. Obviously, Discrete Event Simulation is an excellent tool to analyze important issues in hospitals and provides essential support for decision processes and decision makers.

Keywords: process management; operations process management; modelling; simulation; discrete event simulation.

5 - Modeling the logistics response to a bioterrorist Anthrax attack

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As a bioterrorist anthrax attack has serious consequences, an emergency response plan which can reduce the number of casualties should be studied. However, the papers studying this area are still few. This paper proposes a model which links the disease progression, the related medical intervention actions and the logistics deployment altogether to help crisis managers to extract crucial insights on emergency logistics management from a strategic level standpoint. Preliminary numerical results assess the potential contribution of our model to support the decision making process facing a real anthrax attack.

Keywords: Anthrax attack; bioterrorism; logistics response; mathematical modelling.

Tuesday

TuA2

9:00 - 11:00

Cancer Treatment Planning

Room: 6.2.53

chair: Thierry Garaix

1 - A tabu search approach to IMRT beam angle optimization

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The number of cancer patients continues to grow worldwide, and around 50% of them will be treated with some kind of radiation therapy in some stage of the disease. Radiotherapy aims at delivering high doses of radiation to volumes to treat, but at the same time it aims at sparing as much as possible healthy tissues. The development of new treatment machines allowed the improvement of treatment quality, but it also increased the complexity of treatment planning. One of the most important types of radiotherapy is Intensity Modulated Radiation Therapy (IMRT). In IMRT, the linear accelerator that delivers the radiation has a multileaf collimator that allows the delivery of complex radiation intensity profiles. One of the most important steps in IMRT treatment planning is deciding which angles should be used for radiation delivery. This problem is known as Beam Angle Optimization (BAO) and is characterized by

being highly non-convex and having many local minima. In clinical practice the treatment planning is most of the times done by a lengthy trial and error procedure. Different sets of angles are considered (usually 3 to 9 angles), until a treatment plan complying with the medical prescription is achieved. The use of OR models and algorithms can contribute to the automation of this decision making process. In this work, we propose the use of Tabu Search to tackle BAO problem. The Tabu List considered will guarantee that the algorithm will not waste time with previously visited solutions, which is a very important feature since the evaluation of each of the visited solutions is computationally very demanding. Two solutions that have at most k different angles are considered neighbors. Computational results are presented, considering ten clinical cases of already treated head-and-neck tumor patients at the Portuguese Institute of Oncology of Coimbra.

Keywords: radiotherapy; IMRT; beam angle optimization; tabu search.

2 - Evaluation of health benefits and harms of the breast cancer screening program in the basque country (1996-2011)

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In the Basque Country (Spain), mammographies have been done in biennial basis to women in their fifties and sixties since 1996. The main objective of this project was the evaluation of the impact of the Screening program in terms of health benefit and harms in the Basque women population since 1996. A discrete event simulation model was built to represent the natural history of breast cancer in women invited to the breast cancer screening program in the Basque Country during the period 1996-2011. The disease progress was described in three main states (healthy, preclinical and clinical). We assumed that all women would be diagnosed at the beginning of the clinical stage unless they had been diagnosed previously through the screening program. Data collected during the 15 years of the screening program allowed the model's calibration and validation. Age-specific incidence and breast cancer mortality rates were calculated for the screening and non-screening scenarios. The number of false positive results and overdiagnosed cancers were calculated to assess screening harms. Since the program started working, 5,267 cancers were detected by screening among 341,880 women who attended the screening which represents the 83% of the invited ones. Among 13,477 women submitted to the reference hospital for additional tests 39.1% were diagnosed breast cancer. One out of five screen-detected cancers was overdiagnosed. Focusing on year 2011, breast cancer incidence in the screened population increased more than a 20% for women aged 50-69 and decreased for those aged 70 in comparison with the non-screened scenario. Overall breast cancer mortality rates, on the other hand, decreased a 16.3% by year 2011. Fifteen years after the screening program started our results support an important decrease in breast cancer mortality with reasonable harms.

Keywords: breast cancer; screening; discrete event simulation.

3 - Reducing access times for radiation treatments by aligning the doctor's schemes

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Radiotherapy is the most common treatment for cancer patients worldwide. Delays in treatment are associated with psychological distress and decreased cancer control. To this end, standards for the access times for radiation treatment are set, which are currently not met in many oncological centers. The treatment process consists of several consecutive steps with time constraints in between, a.o. a first consultation, a CT-scan, scan contouring, treatment planning and radiation sessions. A bottleneck analysis showed that even if the capacity of each separate step in the treatment process is enough to avoid congestion, inadequate capacity allocation can cause large delays; for example if the capacity allocation of different steps is not aligned, or the time division of single resources over different activities is unsuitable. The objective of this study is to increase compliance to access time standards without extending resource capacities, by developing a methodology for optimizing resource capacity allocation in the entire treatment process. In Radiotherapy, time division of resources over different activities particularly applies to doctors, carrying out consultations and contouring. Time slots for these activities are set for each doctor in a cyclic weekly scheme. To improve the capacity allocation in the treatment process, an Integer Linear Programming (ILP) model was developed to design optimal weekly doctor's schemes, such that the expected access times of all patient groups in the treatment process are minimized. Further, a discrete event simulation model was developed to evaluate the consequences of several doctor's schemes in a stochastic environment. Results show that by the introduction of a scheme created by the ILP model, the percentage of patients treated within the required access time increased from 50% to 70%. The corresponding doctor's schemes will be implemented in the Academic Medical Center in Amsterdam.

Keywords: radiotherapy; capacity allocation; linear programming; simulation.

4 - Average risk colorectal cancer screening: understanding the consequences of introducing competing demands for limited colonoscopy resources

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Population-level average risk screening is becoming an important strategy for the control of colorectal cancer. When implementing a population-level colorectal cancer screening program, it is essential to consider how to manage both the short- and long-term consequences of the screening yield and the shifting effects of disease prevalence and population demographics. Of particular concern is the competition for limited colonoscopy resources among average-risk screening program participants, symptomatic or high-risk patients, and the ongoing surveillance requirements for all groups. Failure to understand the effects of operational decisions such as screening test selection, positivity threshold, and follow-up test modality may cause unintended harm, hinder the program's effectiveness, and make inefficient use of limited health care resources. Two-step screening attempts to mitigate the burden on colonoscopy services by requiring a positive stool test before colonoscopic follow-up, however there are many tests available with different abilities to detect true positive and negative cases. A discrete event simulation model was constructed to compare the effects of various colorectal cancer screening decisions on demand for colonoscopy services, crude colorectal cancer incidence, and cumulative colorectal cancer mortality. Unlike previous screening evaluations, the study model considers the effects of competition for constrained colonoscopy services between patient groups on patient and health system outcomes. The study results indicated an increase of 33% to 54% of total colonoscopy services depending on the test selected and the uptake rate. Increased demand for screening follow-up and surveillance colonoscopy services was not offset by modest reductions in disease prevalence and subsequent diagnostic service demand. Failure to provide adequate colonoscopy

services reduced the effectiveness of screening. Screening strategies such as repetition of weak positive stool tests or selection of a stool test with a variable positivity threshold may take advantage of potential benefits of screening without overwhelming colonoscopy services.

Keywords: colorectal cancer screening; colonoscopy resources; simulation modelling.

5 - Appointment scheduling for ambulatory chemotherapy

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We consider the appointment scheduling problem for the outpatients of the chemotherapy facilities. Each appointment session is consisted of two phases. In the first phase, a fixed referee oncologist visits the patient to assess his(her) health condition and ability of receiving further chemotherapy drugs. In the second phase, if the patient's health condition is recognized above satisfactory thresholds, he(she) will receive the next injection. Otherwise the injection will be postponed to the next appointment. The duration of consultation session is the same for all patients and the duration of the injections are known for all patients based on their treatment protocol. Between these two phases there is a fixed known delay time for the preparation of the drugs. Postponement probabilities can be updated after each consultation. We aim to use these probabilities in order to build robust schedules. Each patient receives the fixed time of his(her) next appointment after the last appointment. Furthermore, we assume that (1) the beds are identical, (2) no-show and late arrival probabilities for the consultation sessions are zero, and (3) adequate number of nurses are always available to prepare the patients for receiving injections. The objectives are to minimize both the makespan of the facility and the total waiting time of the patients between their consultation and injection sessions. We propose a linear model to solve this problem exactly by taking into account all possible scenarios of postponements. The solution is a sequence of the patients which will determine their consultation and injection starting times at each realized scenario. In the computational results we provide interesting properties and patterns of the optimal sequences which are obtained based on the solutions of the proposed model. Finally, we also provide a discussion over interesting properties of special cases of this problem.

Keywords: appointment scheduling; chemotherapy; no-show; stochastic programming.

TuA3

9:00 - 11:00

Patient scheduling

Room: 6.2.56

chair: Erik Demeulemeester

1 - The effect of three different scheduling strategies on patient related performance measures

Michael Samudra, *KU Leuven*, samudra@kuleuven.be

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In most hospitals there are patients who receive surgery later than required. Hospitals could solve this problem by simply increasing their capacities, but typically this is not an option. Serving patients late is a problem because their health condition can quickly worsen, exposing them to an increased health risk. This needs to be avoided, primarily from a humanitarian standpoint, but there is also a hidden cost perspective as a patient in a worsened health state is likely to require larger amounts of resources.

In order to improve the current situation, the lateness of patients has to be quantified. Moreover, also the reasons for patients being scheduled late need to be understood. This understanding can be acquired by modeling the patient scheduling process. We were using a factorial analysis, on the one hand, to statistically quantify the effect and, on the other hand, to determine the codependence of three different scheduling mechanisms. Firstly, we tested whether it is beneficial to allow different groups of patients to be served the next day, that is, the day after they see a doctor for the first time. Secondly, we tested whether it is beneficial to allow some group of patients to be served on a FCFS basis. Thirdly and lastly, we investigated the effects of pushing low urgency patients more into the future in order to serve high urgency patients quicker. We will show extensive computational results to demonstrate the impact that combinations of the different scheduling mechanisms have on various patient related performance measures.

Keywords: patient scheduling; due time; factorial analysis.

2 - Outpatient scheduling problem: the case of infectious diseases service in Hédi Chaker Hospital of Sfax

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This paper tackles the problem daily encountered in all hospitals causing a congestion situation and a delay in patient appointments; this problem is known in the literature by outpatient scheduling problem. In Tunisia, the public health system suffers from several problems due to the incoherence between the available resources and the intensive needs for treatments. That is why; we have selected the outpatient care service in which there is a limited number of servers (doctors) compared with the huge flow of patients suffering from an acute pathology. The case study of this paper is the outpatient service of infectious diseases of the CHU Hédi Chaker of Sfax in which there are several problems concerning the instauration of a well studied appointment system. We have proposed at first a computer program which is able to manage all the appointment scheduling system in the infectious diseases service. Secondly, we have developed a mathematical model taking into account all hard and soft constraints in order to minimize due date of patient.

Keywords: outpatient; appointment scheduling; modeling; waiting time.

3 - Flexible hospital-wide scheduling of elective patients

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This research builds up on the hospital-wide patient scheduling problem as modelled in Gartner und Kolisch (2014). There, for elective inpatients it is decided on the time of admission, the length-of-stay and the schedule detailing on what day the patients have access to scarce medical resources such as beds, operating rooms and diagnostic devices. The objective is to maximize hospital's contribution margin. We extend this model in the following three ways. First, we include a decision if a patient is admitted or not. Second, we undertake a decision on the assignment of a patient to one out of several resources as it is possible for multi-morbid patients. Third, we take into account overtime of human resources such as residents and nurses. We propose a mathematical programming formulation and in a computational study we report on different performance measures using real-world instances from a collaborating hospital.

Keywords: patient scheduling; clinical pathways; mathematical programming.

4 - Online appointment scheduling with different urgencies and appointment lengths

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In various service industries, and in healthcare in particular, customers' appointment requests arrive randomly over time and have to be assigned to a future day and time slot instantaneously. We study such a problem, in which different customer types have different access time norms and different appointment lengths. The objective is to maximize the number of customers served within their access time norm, while utilizing resources efficiently. Both in current practice and in the literature, this objective is often jeopardized by not accounting for future appointment requests when scheduling the current appointment. Applying such a policy entails the risk of scheduling the current appointment in a way that disables efficient scheduling of future appointment requests. We provide an efficient procedure for this online appointment scheduling problem by applying dynamic programming techniques. In particular, we develop an Approximate Dynamic Programming (ADP) approach for solving the problem. We illustrate the performance of our method by applying it to appointment scheduling for a short stay nursing ward in the Academic Medical Center (AMC) in Amsterdam, the Netherlands.

Keywords: appointment scheduling; dynamic programming.

5 - Using text mining and simulation for health system understanding: modelling hospital outpatient follow-up demand

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Understanding and anticipating demand is essential for safe and cost effective healthcare service delivery. The objective of this work is to help one of the UKs largest healthcare providers to understand the demand on their outpatient clinics to ensure that follow-up appointments are provided in the time-scale required for safe and effective care. Studies of this kind frequently rely only on data collated from electronic patient management systems and/or manually collected. This work presents an alternative approach, necessitated by a combination of incomplete data and the volume of patients involved, making any attempt to manually address the problem cost and time prohibitive. Outpatient demand consists of newly referred patients, patients requiring treatment or diagnosis in an outpatient setting and patients identified by a clinician as requiring a follow-up appointment. A proportion of this demand can be anticipated as the clinician's decision to discharge a patient or request follow-up is frequently conveyed to the patient and their GP using clinical letters. This work utilises information contained within these letters to identify discharged patients or those requiring a follow-up appointment and the time-scale stipulated by the clinician in which it needs to be provided. By analysing the free-text letters it is possible to systematically extract discharge or follow-up information to automatically update a patient record providing live demand insight. This information forms the pipeline of demand on outpatient departments which can be used to populate simulation models of the system to explore the impact of this demand and provide clinic managers with information on their expected clinic performance. This paper highlights the challenges and potential utility of text based data, approaches used to obtain the demand information required and possible models for system exploration.

Keywords: text-mining; demand modelling.

TuPlenary

chair: Margarida Vaz Pato

11:30 - 12:30

Room: 6.1.36

Exploring New Worlds for Applying Operational Research in Health Services

Geoff Royston, *immediate past president of the Operational Research Society.*

In recent publications and presentations I have proposed areas in which operational research could usefully develop to fulfil its mission as system improvement science, in particular by pushing the boundaries in areas such as decision analytics, behavioural modelling and system design. This presentation will consider ways to apply that thinking specifically in the health field, with illustrations from areas such as developing more personalised care, dealing with health risks and designing applications in eHealth. Exploring and developing these areas should help ensure that operational research will thrive in the new worlds of health care.

Poster Session

chair: Marion Rauner

15:30 - 16:30

Room: 6.1.36 and C6 - inner yard

1 - Predicting no-shows in a Brazilian hospital to improve patient scheduling performance

Alcides Algarra Grande, *PUC-RIO*, alcides.algarra@labnexo.com

Co-author(s): Silvio Hamacher (hamacher@puc-rio.br), PUC-RIO.

The clinic appointment no-show problem has been widely studied in literature and is assumed to be one major drawback to build up efficient appointment schedules. Previous studies have reported several factors affecting no-show phenomenon, such as lead time to the appointment day, and socio-demographic ones. To mitigate the influence of relatively large non-attendance rates, practitioners often adopt overbooking strategies. However, due to the hospital uncertainty of determining whether a patient will miss or not a specific programmed visit, the performance of the appointment system in terms of patient waiting time and resource utilization becomes highly variable in overbooked environments. Some recent approaches propose to estimate the individual probability of attendance failure by building predictive models using historical records, in order to use that information to better construct scheduling policies. This study has focused in modelling and describing the nature of no-shows so as to predict individual patient no-show probability considering factors such as gender, age, paying source, lead time to appointment day or prior history of no-shows, and by taking into account seasonality effects associated to non-attendance occurrence. More than 15.000 of individual historical scheduled appointments were examined from the database of a hospital from Rio de Janeiro, containing both if the patient showed up to the scheduled visit and the initially considered factors of potential influence to appointment attendance. The article's goal is to provide improved understanding of patient no-show behavior in addition to suggest practical guidelines to enhance the performance of the appointment system by integrating the no-show predictive model.

Keywords: no-shows; appointments; predictive modelling; patient scheduling.

Tuesday

2 - A stochastic optimisation model for technology selection and donors assignment in the blood supply chain

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Several collection and processing alternatives are available in the blood supply chain. Fractionation alternatives and aphaeresis technologies differ in cost and efficiency. Blood managers are often faced to choose the technology to be used in the collection and production of blood products. This decision becomes complex since multiple aspects should be taken into account in the decision making process. Technology selection should consider aspects such as demand structure, compatibilities, donor's availability, blood type proportions, costs, and process efficiencies. On the other hand, the use of a demand forecast is not always enough to make a strategic decision like this; a robust decision must consider changes in parameters and possible variations in the demand. To support the technology decision, an Integer Linear Programming model has been developed. This model considers the demand parameter as stochastic and includes multiple constraints such as capacity, proportionality, and demand fulfilment. Since the deterministic model can be solved by mathematical programming techniques in a short time, Sample Average Approximation was used as stochastic solution approach. This methodology is a combination of Monte Carlo simulation and optimisation. The methodology generates multiple samples of the stochastic parameter and solves a deterministic model for each scenario. Indicators of convergence of solutions are estimated to support the decision making process. Open Solver 2.1 interface and Coin-OR Branch and Cut solver were used to solve this problem in combination with Visual Basic for Applications for controlling samples generation and execute the optimisation models according to the methodology of the algorithm.

Keywords: blood supply chain; blood fractionation; aphaeresis; stochastic optimisation; donors assignment.

3 - Emergency department-wide capacity dimensioning

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This paper addresses the problem of dimensioning the capacity of resources throughout the entire emergency department (ED). Arriving patient demand that is classified by a triage system such as Manchester Triage must be covered by all ED resources including rooms, staff and diagnostic devices. The goal is to determine a cost-optimal capacity level for equipment and staff. Since demand is fluctuating over the week, overtime can occur for staff resources which, however, can be compensated or paid out. We model the problem as a mixed-integer program which creates a staff schedule while hospital equipment such as diagnostic rooms and reanimation rooms have to be available every day. In our computational study we employ data from a collaborating hospital and demonstrate that our model can solve real life problem instances within an acceptable solution time. In addition, using a simulation model, we test the solution quality of the mathematical model by evaluating patient waiting times.

Keywords: mathematical programming; emergency department; waiting times; simulation; triage.

4 - Modeling the accessibility of patients with chronic disease in a public outpatient clinic using service design and discrete event simulation

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Health services access to care and the continuity of the therapeutic process are critical factors for success in the treatment of patients with chronic health problems, which if not care at the right time and with the appropriate frequency cause activity limitations, loss of quality of life of patients and generate acute frames which require special care and greater complexity. The health system of the municipality of Resende, RJ, caters to an increasing number of such patients. Despite the efforts of the municipal government to offer services in this area, particularly that relating to appointments with specialists, has been less than the demand. The structural mismatch between supply and demand generates a series of distortions as the difficulty of scheduling appointments, resulting in difficulty of access to health care. In this context, the management of specialized health service, assumes a strategic character to ensure access and continuity in treatment, being fundamental sizing of resources and processes, resulting in a model that effectively enable care to patients. We report on the use of the service design and simulation modeling in order to improve the patient' access in a public outpatient clinic. Discrete event simulation provided valuable input for new design process and showed the gaps in the system of service. Initial results was positive, however, the health administrators needs to change political rules in order to delivery good quality care to the patients.

Keywords: DES; service design; accessibility; outpatient clinic.

5 - Improving length of stay in emergency departments: A real-life case study

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Emergency department (ED) crowding is a major problem in healthcare institutions all over the world. A key issue affecting this problem, is inpatient boarding or inpatient access block. If inpatient units are heavily loaded, emergency patients that should be admitted may be blocked in the emergency department. These blocked patients occupy valuable emergency department space, time and resources and thus aggravate crowding. This poster presents the results of a detailed simulation study carried out at the ED of a large regional hospital in Turnhout (Belgium), where hospital management considers introducing buffer beds, located outside the emergency department, for patients that are waiting to be admitted. Although it is known that the inpatient units are a major factor influencing emergency department overcrowding, they are rarely considered in analyses of emergency departments. The most important contribution of this case study is that it indirectly takes the impact of the inpatient units into account, by analyzing the times that patients currently remain "blocked" in the ED department, and studying the mitigating impact of buffer beds on this blocking effect. It thus allows hospital management to determine how many beds are necessary to avoid blocking in the emergency department. Furthermore, we analyze to which extent the combined effect of staff schedule changes and number of buffer beds can influence the length-of-stay of patients in the ED. The simulation model is built upon highly detailed data regarding patient mix, patient routings, and patient processing requirements with respect to different ED resources (doctors, nurses, boxes/beds).

Keywords: emergency department; simulation; blocking, staffing.

6 - What are the effects of climate change on the distribution of malaria in Africa?

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Since the discovery of climate change, the scientific community has been alerting for its potential effects upon mankind, especially on health. The increased emission of greenhouse gases due to human activity has led to unprecedented changes in temperatures. Variability in climate can affect the biology, transmission and distribution of vector-borne diseases. Africa is home to several life-threatening vector-borne diseases, including malaria. It is, also, one of the continent's, which less contributes to the increase of greenhouse gases and thus is condemned to suffer more intensively the effects of climate change. The aim of this work is to analyse the possible effects of climate change on the distribution of malaria, including alterations on the biology and transmission of the *Anopheles* mosquito, in the African Continent. The results demonstrate that the malarial vector is extremely sensitive to climate variability, in particular temperature, however, the recent changes in the distribution of malaria can, also, be explained by non-climatic factors, including urbanisation, land-use, drug resistance, among other.

Keywords: climate change; distribution; vector-borne diseases; malaria; Africa.

7 - NepidemiX - a tool for simulating disease and intervention processes on networks

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The importance of contact processes in epidemiological modelling is becoming increasingly evident. For instance, network structure can be a key feature to incorporate when modelling operational recommendations for sexually transmitted diseases. Initial work on contact processes has focused on the effect of network properties on disease progression, assuming classic SIS or SIR models. However, posing operational questions related to testing, treatment, and care increases process complexity. Consequently, the basic results may not hold. The majority of such models must be analysed by demanding numeric simulations. In order to facilitate simulation and testing of stochastic processes on complex networks we have developed NepidemiX, a Python framework based around the popular NetworkX library. NepidemiX simplifies modelling considerably by automating common simulation steps: building a network according to user specifications, and carrying out given processes on this structure over a specified number of iterations. During the simulation data such as disease prevalence and state transitions can be saved for later analysis or visualisation. State transitions for a large class of processes can be expressed as formulae for the probability of a state change of a node, given the states of its neighbours. The true strength of NepidemiX is that these are scripted directly and without general programming, allowing for quick and easy specification of fairly complex systems. If needed, more advanced state transition models may be specified at a lower level in the Python programming language. The result is an approach not only useful when modelling diseases but also when studying the impact of network-aware interventions and policies. This poster gives an overview of NepidemiX, how to configure processes, and examples from our current research, including a project to determine if HIV testing interventions taking advantage of social network structure can improve epidemic outcomes without increasing the testing budget.

Keywords: simulation; software; network modelling; epidemiology; public health.

8 - Rationalisation of insurers' underwriting decisions for individual health risks.

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The wealth of a nation lies within the health of its people. In order for citizens of any country to lead healthier lives, access to a basic standard of healthcare is necessary. However, for many countries, especially those in the developing world, healthcare is often characterized by inadequate financing and barriers to care. Developing countries rarely have the financial means and institutional capacity to provide state-based health insurance. A large amount of health costs is, thus, directly borne by patients. So-called "out-of-pocket-payments" account for one third of total health expenditure in two thirds of all low-income countries. The Egyptian healthcare system can be described as multifaceted and disjointed. In other words, Egypt has a pluralistic and fragmented health system with multiple sources of financing, financing agents, and providers. The critical question is hence how to improve the access to health care and financial protection of the poor in developing countries. Whereas formal statutory health insurance schemes have largely failed to reach the poor, private for profit and not-for profit schemes are emerging in different regions of the world offering a potential improvement in risk sharing for a larger part of the population. Consequently, health insurance or private health insurance can play a positive role in improving access and equity in developing countries. However, health insurance industry faces some obstacles. These obstacles could limit the effectiveness of the private health insurance. Previous literatures reveal that most of these problems have been discussed in developed countries. However, they continue to be investigated in the developing world. This research aims to study the rationalization of the decisions of insurance companies for underwriting risk health insurance, to control adverse selection and assemble a group of insureds whose loss potential is homogeneous. The research aims to introduce statistical modelling by using SAS program.

Keywords: healthcare; health insurance; risk management; developing countries; Egypt.

Tuesday

TuC1

16:30 - 18:00

Patient Flow

Room: 6.1.36

chair: Penny Holborn

1 - Modelling patient flow in a busy fracture and orthopaedic unit

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The Fracture and Orthopaedic Unit at the Royal Gwent Hospital in Newport, Wales, is a busy outpatient clinic seeing both patients that been referred from Accident and Emergency, and elective patients from several orthopaedic specialties (hands, knees, hips). The unit runs in excess of 80 fracture clinics and 207 elective clinics in a four week rota utilising 24 consultants, special wounds nurses and physiotherapists. A typical fracture clinic has 50 patients attending whilst an elective clinic up to 40. The Fracture and Orthopaedic Unit is run from three clinic suites: Clinic 1, Clinic 2 and Clinic 3. The unit also has its own plaster room and X-ray facilities. The aim of the project was to consider how patients flow through the clinic space and identify any possible bottlenecks and constraints in the current system. Currently, there are five cubicle areas used for patient consultations in each clinic suite. The areas are quite small

and typically contain a couch for the patient and two chairs, one for the consultant and one for a visitor that accompanies the patient. The manager of the Orthopaedic Directorate wanted to investigate what would happen if the five cubicle areas were replaced by four larger areas. In particular, she wanted to see if changing the configuration of the rooms would affect the flow of patients through the unit. To investigate the effect that the room reconfiguration might have, we developed a simulation model to represent how patients flow through a particular clinic, say a fracture clinic with a special wounds clinic running alongside, and then looked at different scenarios with regard to the room configuration. We were interested in both the patient variation and the different ways that different consultants work when treating patients in their clinics. The simulation model and initial results will be discussed.

Keywords: simulation; patient flow; reconfiguration; orthopaedic; outpatients.

2 - Systemic analysis of the flow of hospital patient and determination of the capacity of beds in a high complexity hospital

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Patient flow is at the core of healthcare, where hospital planners, managers and medical staff have the challenge of providing quality service. If patient outflow is constrained, the level of occupancy rises, as also does the risk of adverse events and infections. Further, the number of attended patients decreases, along with profits. This research introduces a System Dynamics-related methodology for modelling patient flow in terms of the causal influences among the hospital wards, thereby assessing the hospital's dynamic capacity. The analysis identifies hospital wards' dynamics by finding analytic expressions able to elicit the required number of beds and length of stay that each ward needs in order to guarantee the required throughput. Using the data provided by Clinic León XIII, the research results allowed the hospital's managerial staff to reach a better understanding of the system and define new strategies for intervention resulting in an increased patient-discharge rate.

The purpose of the methodology was to provide a simple framework for assessing hospital capacity and analysing patient flows and ward interaction. The discussions among the team considered that, even though the analysis might be referred to as simplistic, given its aggregated level, still it is informative, descriptive and suggests ways intervention practical help hospital administrators do a real analysis of their ability and make strategic decisions. It goes beyond the concept-mapping role that SD has traditionally performed, by aggregating rigour with a quantitative basis to support decisions increasing capacity by going beyond static and deterministic analyses. This methodology presents novel tools for understanding and quantifying the broad interaction among hospital wards.

Keywords: patient flow; hospital bed capacity; length of stay; patient discharge; system dynamics.

3 - An outpatient planning optimization model for integrated care and access management

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To better service patients, support providers, and obtain greater operational efficiency, our work develops operations models of direct impact to capacity planning and outpatient appointment scheduling. We are concerned about provider utilization, and our approach also seeks to limit the length of waiting time until an open appointment slot/time can be provided, allowing patient classes to be defined with a

heterogeneous amount of waiting time (in days) for patients of each class. We present a data driven healthcare operations management methodology that has grown out of a practice-based collaboration with Mayo Clinic Rochester (MCR). MCR currently uses a decentralized approach to reserve appointment capacity for different types of patients seeking appointments. For destination patients, an initial visit usually generates a series of other visits in both the initial department and in other medical departments. This often results in longer than desired access delays for the root appointment of some patients and in blocking/delays for later downstream visits across other medical departments. Our capacity planning model, called OptiCare (Outpatient Planning Tool for Integrated Care), seeks to meet visit targets on the time delay from the appointment request to the appointment occurrence by patient type while managing the patient mix (which is steered by goals such as increasing the volume of new patient visits). Our approach uses mixed integer programs to optimize a booking plan that is also sensitive to utilization and incorporates stochastic models of future return visits and the downstream appointments generated to follow up on the initial visit.

Keywords: patient flow; mixed integer programming; capacity planning; access management.

4 - Reducing cancellations for day of surgery admissions

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The aim of this project is to better understand the current state of Day of Surgery Admissions (DOSA) at the Royal Gwent Hospital, Newport and to look to identify ways to reduce the large number of cancellations of surgeries. DOSA describes the process whereby patients are admitted to hospital and have surgery on the same day. It is also believed that these patients should then stay in hospital for around 24 hours following their surgery, before being discharged home. Initial investigations including data analysis, patient shadowing and process mapping identified that a significant number of cancellations were being recorded due to no bed being available on the DOSA ward for the patient following surgery. The main factor affecting this was the use of the DOSA ward beds by emergency patients and the inconsistent scheduling of surgeries to the availability of beds. In this talk we will overview the work that has been achieved thus far including how discrete event simulation has been used to identify the correct number of beds on the DOSA ward to ring fence from emergency patients to decrease cancellations. Work has also been carried out on identifying improvements to the scheduling of patients surgeries. The outcomes from this work have the potential to greatly improve patient safety and quality along with a significant cost saving in lost theatre time.

Keywords: admissions; cancellations; simulation; scheduling.

Tuesday

TuC2

16:30 - 18:00

Disease Modeling and Policy (1)

Room: 6.2.53

chair: Fredrik Dahl

1 - Compliance with national guidelines for stroke in radiology**Izabela Komenda**, *Cardiff University*, komendai@cardiff.ac.uk

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Stroke is a medical emergency, and if patient outcomes are to be improved there should be no time delays in accessing treatment. As management and prognosis of stroke are determined by aetiology, it is vital to delineate the causality of an event as soon as it is practicable. This project focuses on the application of Operational Research methodology to investigate how the Royal Gwent Hospital can comply with revised CT scanning guidelines for stroke. Such guidelines, released by the Royal College of Physicians in December 2012, recommend a 50% reduction in maximum time from hospital admission to delivery and report of a CT head scan to just 12 hours. Statistical analyses were conducted upon historical hospital data to investigate trends in CT scan request demand. The results of this investigation were used to populate a discrete event simulation model describing patient flow through the CT scanning process in SIMUL8 software. Following successful validation and verification, the model was applied to explore a number of operational modifications to the CT scanning system through a series of scenario analyses. Each of the scenarios focused upon policies in direct relation to stroke, and were proposed during observations of key processes and through discussion with radiology staff. The results of this investigation presented evidence of a number of strategies to support operational improvements in relation to revised stroke guidelines. A range of areas for further investigation were also proposed.

Keywords: simulation, stroke; computerised tomography; radiology.

2 - Validation of complex decision-support model for investigation and improvement in health services: the case of stroke thrombolysis**Mahsa Keshtkaran**, *School of Mathematical and Geospatial Sciences, RMIT University & Florey Institute of Neuroscience and Mental Health, University of Melbourne, Australia*, mahsa.keshtkaran.mk@gmail.com

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Health services domain presents a rich and diverse context for decision modelling activities including those aimed at decision automation, routine decision-support, investigation and improvement and providing insights, as per the well-known Pidd's modelling taxonomy. For a decision-support model, the process of model validation provides enough evidence that within its domain of applicability the model possesses a satisfactory range of accuracy consistent with the intended application of the model. Models for investigation and improvement provide a particularly challenging task as far as validation is concerned due to their complex nature that often relies on a wide variety of data sources and empirical estimates

for important parameters originating from the clinical literature that are used as model inputs, as well as on multiple conceptual and computational modelling techniques. In this study, following an extensive literature review into the use of validation techniques for health care models in operations research literature, both published calls for systematic approaches for validation of complex operations research decision-support models, and a clear lack of relevant applications of validation techniques in many published health care models are identified. Subsequently, the model for evaluation of long-term benefits of faster access to thrombolysis therapy in acute ischaemic stroke is used as a case to demonstrate how multiple aspects of data validity, conceptual model validity, computerized verification, and operational model validity can be systematically addressed when developing a complex decision-support model for investigation and improvement in health services research.

Keywords: validation; decision-support model; health services.

3 - Ranking stroke-related instruments for a rehabilitation context through an analytical hierarchical process

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NOR-SPOT is a comprehensive data collection initiative at the Stroke Unit of Akershus University Hospital. The present project was a spin-off from this, and focused on neurological rehabilitation clinic. The issue was prioritising among different instruments that may be used for evaluating the health status of stroke patients. This is a complex domain with different sub-goals, many of which are conflicting, and therefore Analytical Hierarchical Process (AHP) was chosen as the theoretical framework, implemented as a workshop with 28 employees from the clinic. WHO's ICF model defines three levels of function, denoted bodily function/structure, activities of daily living and participation. We treated these as sub-goals, with the modification that we split bodily function/structure into a somatic and psychological sub-goal. The instruments were grouped under the four sub-goals, and evaluated according to six generic criteria: sensitivity (ability to measure changes of the desired magnitude), burden on the patient (work required by measurement procedure), feasibility (compatibility with clinical routines), usefulness for health personnel (diagnostics, treatment), usefulness for patient (motivation, adjustment of expectations) and spread (how common the instrument is worldwide). The relative importance of these dimensions was determined on a scale from 1 to 10 through group discussions, where a high level of consensus was reached. Each instrument was thereafter given a percentage score for each dimension, again through group discussions, and a total score was computed. Scores were used to rank instruments grouped under the same sub-goal. A total of 13 Instruments were successfully evaluated, and the participants reported a high over-all satisfaction with the workshop.

Keywords: analytical hierarchical process; stroke; rehabilitation.

TuC3

16:30 - 18:00

Operating Room Planning and Scheduling (2)

Room: 6.2.56

chair: Erwin Hans

1 - Minimising variation in bed demand by improving the operating room scheduling**Erwin Hans**, *University of Twente, CHOIR research centre*, e.w.hans@utwente.nl

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We consider the problem of optimizing the operating room schedule so that the variation in the subsequent demand for beds in wards is levelled. We propose a MILP model that determines, given a Master Surgery Schedule (block schedule) and expected demand, a schedule of surgical case types. The case types are determined by clustering surgeries into case types based on their stochastic ward LOS durations and deterministic surgery durations. The MILP objective function minimises two weighted goals: minimizing the peaks in OR utilisation and minimising the peaks in bed demand. We also study a quadratic variant of the model. Both models are used in conjunction with a FCFS admission policy/assignment of surgeries to case types in the case type schedule. For the studied Dutch hospital we show a potential of up to 15% reduction in bed requirement.

Keywords: operating rooms; surgery; scheduling; tactical planning.**2 - A decision support system for solving the stochastic operating theater tactical problem****Manuel Dios**, *Industrial Management, School of Engineering, University of Seville, Spain*, mdios@us.es

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In this paper we propose a stochastic decision model for solving a tactical operating theater planning problem, which deals with assigning patients to planning periods and allocating human resources -*i.e.* surgeons and nurses- among the different facilities of the operating theater -*i.e.* consultation, operating room and post anesthesia care unit- and the different surgical specialties. Patients served by a surgical specialty are characterized by the following stochastic parameters: arrival frequency (number of patients per planning period), procedures duration (consultation, intervention, and recovery) and care pathway (sequence of visited facilities from arrival to discharge). Each specialty has a set of waiting lists corresponding to transitions between any two consecutive facilities, *e.g.* consultation - operating room, or operating room - wards. Several objective functions are evaluated, *e.g.* to level the allocation of resources between consecutive planning periods in each facility (avoiding the appearance of peaks of workload) or to level the number of patients on each waiting list for every surgical specialty. Finally, we present a prototype decision support system that integrates the stochastic decision model with an implementation of the sample average approximation procedure. The decision support system is programmed in C# and uses Gurobi for solving the MILP. Several scenarios have been analyzed for evaluating how uncertainty affects the operating theater management.

Keywords: operating theater planning; stochastic approach; decision support system.

3 - Optimal master surgical planning: A block scheduling approach to the operating theatre

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The operating theatres are considered core elements in the efficient management of hospitals due to its influence on the trading of costs and incomes and, specially, to the importance of its social dimension in patients health cares'. Moreover, the Portuguese National Health System is facing deep changes due to a whole reorganization of services, involving great managing challenges to hospitals, within a constraining budget. To handle this constraining problem, we proposed a former contribution for the strategic planning of the operating rooms in the Centro Hospitalar Universitário Coimbra, EPE. An aggregate time approach was implemented to help decision making on the annual planning of hospital surgeries (e.g. inpatients/outpatients). The achieved results stimulated the extended of the proposal to enhance a Master Surgical Planning (e.g. weekly with daily allocations). The achievement of a master surgical plan that accounts for capacities, medical criteria and services indicators can be particularly useful to decide on the conflicts emerging from the equipment and other resource sharing at the operational level. Following these motivations, this contribution proposes an optimal Master Surgical Plan based on a Block Scheduling approach. The proposed integer programming model defines the optimal allocation of resources involved in the operating theatre (e.g. the assignment of medical specialties, equipment and human resources to each operating room, at each Time Block) in order to fulfil the contract program of the Hospital while maximizing the services indicators through the reduction of the patients list. The impact of the surgical Time Block duration is illustrated through a scenarios approach where different intra and inter resource sharing policies, surgeons availabilities and preferences are explicitly accounted. The impact of some seasonal behaviors related with the resources' availability (e.g. holidays) on the achieved master plan is also analyzed.

Keywords: master surgical scheduling; operating room; optimization.

4 - Master surgical schedule planning integrating waiting list management for targeted surgeries

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The Master Surgical Scheduling Problem is a key problem in the management of operating rooms (OR) in hospitals. This problem, which arises at the tactical decision level, consists in determining the assignment of specific ORs and time blocks to the different specialties of a surgery department. Given the recent policy of the Ministry of Health and Social Services (MSSS) of the Province of Québec to monitor and enforce maximal waiting times for several targeted surgeries, it has now become essential to be able to identify and take into account the impacts of these assignment decisions on resource utilisation and on the demand for surgeries in order to efficiently manage surgery resources. In collaboration with several hospitals in the Province of Québec, we have modeled the new Master Surgical Scheduling Problem they are faced with. This problem involves the following characteristics/constraints: available equipment resources each day, available personnel resources each day (e.g. nurses, anaesthesiologists...) the MSSS objectives and rules relating to the maximum waiting times for targeted surgeries, post-op bed utilisation, historical data on typical procedures performed in each surgical specialty, etc. This problem must also account for the cyclical nature of the planning process since the Master Surgical Scheduling Problem is generally solved for a two to four week horizon and will then be repeated over a period of

several months. In this paper we propose two different mathematical formulations of the problem, both based on integer linear programming, and analyse their behaviour when solved with a state of the art commercial ILP package. We then propose a matheuristic algorithm to efficiently solve the problem. Computational results on a set of pseudo-real instances will be presented.

Keywords: operating room; planning; master surgical schedule; sequencing; integer programming; matheuristic.

Thursday

9:00 - 11:00 Session 5 (page 52)		
ThA1 Patients Flow in Emergency Departments Chair: Xiaolan Xie Room: 6.1.36	ThA2 Performance Evaluation Chair: David Stanford Room: 6.2.53	ThA3 Healthcare Planning (1) Chair: Thierry Chausalet Room: 6.2.56
Iago Mansur Study of the impact of patient arrival in a public hospital emergency unit	Marion Rauner Benchmarking rescue departments of the Austrian Red Cross using data envelopment analysis and fractional regression models	Francisco Sabbadini Using the theory of constraints and discrete event simulation in hospitals: 03 case studies
Guy Wachtel An alternative approach for improving patients' scheduling in the emergency department	Ana Nascimento Assessing the effectiveness of noncommunicable diseases control and prevention using data envelopment analysis: An international comparison	Teresa Cardoso A stochastic planning model for long-term care: Moving towards an equitable and health centered multi-service network of care
Cigdem Gurgur Improving patient flow through capacity planning and scheduling	David Stanford An optimization model to minimize expected excess waiting time in systems adhering to key performance indicators	Soheil Davari Gamma-robust preventive health care network design
Paolo Landa Capacity planning and bed management for improving the flow of patients through emergency and acute inpatient departments	Penelope Mullen That doesn't apply to you - it's a standard letter!: OR and commonsense in Health Care Management	Mario Oliveira Simulation of the capacity of intensive care units in the state of Rio de Janeiro
Tomi Malmström Reducing hospital admissions - effects of emergency department observation unit	Roxani Karagiannis Analysing scale efficiency estimates using a system-of-equations two-stage DEA approach: The case of public hospitals in Greece	Hannah Mitchell Using the hidden Markov model to capture quality of care in healthcare systems
Martin Prodel Hospitalization admission control of emergency patients using Markov decision process	Tone Simonsen Increasing response rate for patient surveys	Thierry Chausalet Forecasting NHS patient activity in England
11:00 - 11:30 Coffee Break		C6 - inner yard

Thursday

11:30 - 12:30 Plenary Talk (page 61) 6.1.36
 Chair: Inês Marques

Manuel Delgado
 The Hospital Performance: The use of a benchmarking tool

12:30 - 14:00 Lunch Canteen (C7)

14:00 - 15:30 Session 6 (page 61)

ThB1 Ambulance Location	ThB2 OR Methodologies for Home Care (2)	ThB3 Healthcare Planning (2)
Chair: Patrick Soriano Room: 6.1.36	Chair: Margarida Moz Room: 6.2.53	Chair: Fermin Mallor Room: 6.2.56

Valérie Bélanger The relocation and pre-assignment problem in real-time management of ambulance fleets	Mohamed Cisse A generic model for home health care routing problem	Fermin Mallor Control problems in health care considering general length of stay distributions: Application to intensive care units
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Melanie Reuter Demand for emergency rescues in Germany and its impact on ambulance planning	Issam Nouaouri The home health care routing and scheduling with patients' preferences	Julie Vile The MetSim tool for short-term forecasts of hospital admissions and bed occupancy incorporating meteorological information
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Lara Wiesche Simulation based evaluation of ambulance location models	Patrick Hirsch Tabu Search strategies for daily scheduling of home health care services that use time-dependent public transport networks	Mathias Barra Modelling bed constraint effects through cox regression with time varying covariates
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José A. Oliveira A genetic algorithm to solve the non-emergency patient transport problem in Portugal	Ettore Lanzarone Different perspectives and goals in home care planning
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15:30 - 16:00 Coffee Break C6 - inner yard

16:00 - 17:00 Session 7 (page 68)

ThC1 Disease Modeling and Policy (2)	ThC2 Regional Health Service	ThC3 Risk Management
Chair: Margaret Brandeau Room: 6.1.36	Chair: Jan Vissers Room: 6.2.53	Chair: Mónica Oliveira Room: 6.2.56

Miguel Constantino Robust kidney exchange optimization	Jan Vissers Modelling and evaluation of regional healthcare delivery systems: Approach and methodology	Diana Lopes A MACBETH-Choquet model to evaluate interdependent health impacts
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Thursday

Margaret Brandeau

Modeling and calibration for exposure to time-varying, modifiable risk factors: the example of smoking behavior in India

Sylvia Elkhuizen

Modelling and evaluation of diabetes care in regional health service provider networks: A comparative analysis of six european practices

Mónica Oliveira

Building a value risk-matrix for the evaluation and mitigation of health and safety risks

Angelico Fetta

Investigating Adolescent friendships and smoking behaviours with social network analysis and agent based simulation

Cheryl Voake-Jones

Modelling the value of community-based secondary care services

Cristinca Fulga

Risk-reward optimization with linear tolerance to risk with applications to the health management sector

19:00 - 23:00 Conference Dinner

Tenda do Cristo Rei

Thursday

ThA1

9:00 - 11:00

Patients Flow in Emergency Departments

Room: 6.1.36

chair: Xiaolan Xie

1 - Study of the impact of patient arrival in a public hospital emergency unit.**Iago Mansur**, *University of Rio de Janeiro State*, iagoma@gmail.com

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The availability of simulation tools, the growing computing power and advances in simulation methodologies have made it one of the techniques used and accepted in task analysis and systems development. The aim of this project is to apply computer simulation to evaluate the patient in a public hospital emergency service. The methodology consists in planning the study, the definition of the system, namely, the conceptual model, and from this, the computational model to apply to experiments using outputs as parameters for discussion and suggestions for improvements. As this is a service complex structure, with a wide variety of processes and flows of people, it becomes strategic to meet the demand of the study hospital, so this is the expected outcome of the balancing service capacity in order to streamline patient care by reducing the waiting time, reducing the pressure on the medical staff and improving the quality of patient service.

Keywords: simulation; emergency service; hospital.**2 - An alternative approach for improving patients' scheduling in the emergency department****Guy Wachtel**, *Bar-Ilan University, Ramat Gan, Israel*, guy.wachtel@outlook.co.il

Co-author(s): Amir Elalouf (amir.elalouf@biu.ac.il), Bar-Ilan University, Ramat Gan, Israel.

Hospital crowding and the impact on patients admitted through the emergency department (ED) have received increasing attention in recent years. Stories such "Emergency Room Gridlock: On the Verge of Crisis" have become almost commonplace in newspapers all over the world. This paper proposes an alternative approach where we assume that the ED's management determines a maximal (fixed or dynamic) value for patients' length of stay (LOS), and that patients who cannot be evaluated in the ED in a timely fashion are redirected for treatment in other hospital departments; this value is known to the patient and should decrease his/her uncertainty. The latter approach (referred to as the "floating patient" method) is practiced, for example, in Israel. Finding the optimal or approximate schedule is done by executing a pseudo-polynomial algorithm or an ϵ -approximation algorithm respectively. In the first problem introduced in the paper, patient attributes are assumed to be known. We then extend this problem to incorporate uncertainty; specifically, we assume that the physician carries out initial examinations to obtain information on patient attributes 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 evaluations of the examined patients. The proposed algorithms are demonstrated using a simulation with real-life data. The proposed algorithms were tested using a simulation with real-life data. It was found that by selecting the appropriate scheduling of the patients' examinations, the ED's profit increased, the patients' LOS was shortened thereby raising the quality of patient-care and patient satisfaction.

Keywords: emergency department; approximation algorithm; patients scheduling; optimal stopping.

3 - Improving patient flow through capacity planning and scheduling

Cigdem Gurgur, *Purdue University*, gurgurc@ipfw.edu

A patient flow simulation model is developed for an Emergency Department (ED) with the incorporation of patient classification, blocking effects, and time dependent arrival patterns to study the tradeoffs in patient satisfaction and system efficiency. The operations factoring the interaction with Diagnostic Imaging, Diagnostic Lab and Surgery Center are studied to answer questions of daily scheduling and medium to long range planning, including staffing and capacity management decisions. Primary measures such as time until treatment, as well as secondary measures such as time until first seen are considered. System design is investigated under various HealthCare Accreditation requirements.

Keywords: health-care modeling; simulation; emergency department; outpatients; inpatients.

4 - Capacity planning and bed management for improving the flow of patients through emergency and acute inpatient departments

Paolo Landa, *Department of Economics and Business studies, University of Genova, Agenzia Regionale Sanitaria Liguria*, paolo.landa@unige.it

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In larger hospitals from 30% to 65% of the flow of patients through acute inpatients beds come from Emergency Departments (EDs). The capacity to move patients with a decision to recover out of the emergency department is linked to the ability of the hospital to admit them, *i.e.* to the availability of ward inpatient beds. Due to the growing concern in reducing the number of inpatient ward beds and the overcrowding of emergency department, it is crucial to improve the capacity planning and control activities which manage the patient flows from EDs to hospital wards. Bed Management has a key role in this context. This study starts by a collaboration with the Local Health Government (LHG) of the Liguria region aimed at study the impact and potential of capacity bed planning in a large city health district network made up of seven acute hospital and seven emergency department. A large amount of data has been collected over a one year period and a preliminary observational analysis was conducted to get the main information and data related to the flow of emergency and elective patient through the hospital network. A discrete event simulation model has been then developed and validated in order to represent the real system and illustrate the context and impact of organizational changes. A scenarios analysis is going on with the collaboration of the LHG in order to analyze the effects of several organizational and capacity planning strategies on the performance of the system. Preliminary results are presented to show the ability of the model to be used as a decision support tool for optimizing the use of the available resources and improving the organizational patient flow through the EDs and hospital wards network.

Keywords: discrete event simulation; emergency department; capacity planning; bed manager; patient flow management.

5 - Reducing hospital admissions - effects of emergency department observation unit

Tomi Malmström, *Department of Industrial Engineering and Management, Aalto University*, tomi.malmstrom@aalto.fi

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Objective: Emergency department has critical role in managing hospital patient flows. Major part of patients admitted to the hospital wards come through emergency department. In an observation unit adjacent to emergency department patients can be treated for longer period (1-3 days) than in emergency

department. These patients can be often discharged to home after the period of emergency department observation unit. Emergency department observation unit have been implemented in numerous emergency departments and studies present several positive effects. However, hospital-wide effects to patient flow are not fully understood. The aim of the study is observe the effects of emergency department observation unit to whole hospital patient flow and other operational measures. Methods: The study setting was Finnish university hospital with 60 000 emergency department patient visits in a year. An intervention of establishing emergency department observation unit was done and its effects to the patient flow was monitored. We analyzed both emergency admissions and total inpatient days. A breakdown to specialty and diagnosis groups was also done to understand the effects of emergency department observation unit in different patient segments. Results: The results of before and after intervention patient flow are presented. The amount of hospital bed days in total decreased after establishing emergency department observation unit. There were also improvements in other operational measures. Conclusions: The literature and the study show number of positive effects of implementing emergency department observation unit. Segmenting emergency patients based on expected inpatient days is encouraged.

Keywords: emergency department; observation unit; patient flow; intervention; statistical analysis.

6 - Hospitalization admission control of emergency patients using Markov decision process

Martin Prodel, *Ecole nationale supérieure des Mines de Saint-Etienne*, martin.prodel@emse.fr

Co-author(s): {Vincent Augusto (augusto@emse.fr), Xiaolan Xie (xie@emse.fr)}, *Ecole nationale supérieure des Mines de Saint-Etienne*.

We address the hospitalization admission of patients from an emergency department to be admitted or transferred. When an emergent patient arrives, a physician may decide to hospitalize him/her in a specific department. Patient admission depends on the availability of beds, the length of stay (LOS) and the reward of hospitalization which are both patient-class specific. The problem consists in determining admission policies in order to maximize the overall gain. We focus on the case of two patient classes and use Markov Decision Process model to characterize the optimal admission policy under assumptions of Poisson arrival and exponentially distributed LOS. The state of the system is defined by a two-dimensional integer vector giving the number of on-going patients of each class. For each state the control policy decides whether to admit the next arrival of each class of patient. The problem consists in maximizing the total discounted reward over an infinite time horizon. The optimal control policy is determined by solving the optimality equations by value iteration. Graphic representation is used to investigate the properties of the optimal policy. The state space is represented by the set of integer points on 2-D plane. The control policy is a function on 2-D plane taking values 0 to 3 or equivalently 00 to 11 indicating whether the next class-1 or -2 patient is admitted. The following numerical facts are observed: (i) patients of class-1 with the highest ratio of reward over LOS are always accepted and (ii) the admission policy of class-2 patients can be approximated by two thresholds L and $L1$ that forbid admission of class-2 patients if the total number of patients is beyond L or the number of class-1 patients is beyond $L1$. The deviation of the two-threshold policy from the optimal one is within 1%.

Keywords: hospital admission; control policy; patient flow; Markov decision process; value iteration.

ThA2

9:00 - 11:00

Performance Evaluation

Room: 6.2.53

chair: David Stanford

1 - Benchmarking rescue departments of the Austrian Red Cross using data envelopment analysis and fractional regression models**Marion Rauner**, *University of Vienna, Austria*, marion.rauner@univie.ac.at

Co-author(s): Margit Sommersguter-Reichmann (margit.sommersguter@uni-graz.at), Department of Finance, Karl-Franzens University of Graz, Austria.

We performed a radial input-oriented variable returns-to-scale (VRS) Data Envelopment Analysis (DEA) for benchmarking 52 rescue departments of a single province for the Austrian Red Cross. Three inputs (working hours of employed personnel, of non-employed personnel, and number of vehicles) and two output variables (duration-weighted number of two different service transportation categories) were selected. First, we assessed the service production process of the Red Cross to obtain insight into the level of performance and performance differences among the rescue departments. We found that average technical efficiency of the rescue departments amounted to almost 88%. The theoretically derived potentials of input reductions and output increases for inefficient rescue department are, among others, restricted by several settings which were analyzed in a second step. Here, several socio-economic, environmental, and institutional settings were investigated using a second stage regression analysis based on fractional regression models (logit, probit, loglog, and cloglog specifications) to find out whether and to what extent they impacted the performance of the rescue departments. We found a negative relationship between wintery weather conditions, measured as the number of ice days, and performance, while we identified a positive impact of the number of people aged 64+ and the number of hospital beds in the catchment area on Red Cross performance. Due to the differing settings, the implementation of the DEA-based recommendations might be challenging for some Red Cross departments.

Keywords: Austrian Red Cross; district rescue departments; data envelopment analysis; fractional regression models.

2 - Assessing the effectiveness of noncommunicable diseases control and prevention using data envelopment analysis: an international comparison**Ana Nascimento**, *Centro Hospitalar do Algarve*, anasoares_nascimento@hotmail.com

Co-author(s): {Carla Amado (camado@ualg.pt), Sérgio Santos (ssantos@ualg.pt)}, Faculty of Economics, University of Algarve and CEFAGE-UE.

Noncommunicable diseases (NCDs), with special relevance cardiovascular diseases, cancer, diabetes and respiratory diseases, are leading causes of death worldwide. For policymakers across countries, the prevention and control of these diseases is fundamental to ensure an effective management of healthcare systems. The main purpose of this dissertation is to explore the potential of using Data Envelopment Analysis (DEA) to assess the effectiveness of healthcare systems in preventing and controlling NCDs. To this purpose, data from 27 OECD counties has been used. Our results point out a remarkable variation in NCDs prevention and control across countries, suggesting that the identification of best practices in this context may contribute to the development of more effective strategies to prevent and control NCDs among the population. These results also demonstrate the potential strategic role of DEA for an effective planning of the available resources.

Keywords: NCDs; DEA; healthcare system; effectiveness.

Thursday

3 - An optimization model to minimize expected excess waiting time in systems adhering to key performance indicators

David Stanford, *Department of Statistical and Actuarial Sciences, Western University, London, Ontario, Canada*, stanford@stats.uwo.ca

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Key Performance Indicators (KPIs) are a measure of service system performance comprising a target delay and compliance probability (the chance a customer starts service by the target). While our motivating KPIs arise in the field of health care, other applications arise in call centre settings, telecommunication messaging systems, and elsewhere. The primary flaw of a pure KPI approach is that no consideration is given for the consequences of customers whose waiting time exceeds the target. We present an optimization model for the such systems which seeks to minimize the weighted average of expected excess waiting time for the various classes. We test the model extensively in an Accumulating Priority Queue (APQ) setting. The Accumulating Priority Queue selects patients for treatment according to a linear priority accumulation function at a rate that depends upon the acuity class. Some results are anticipated: most notably, that the optimal priority accumulation rates are in inverse proportion to the delay targets when the value of the excess waiting time is deemed to be the same for all patient classes. In terms of its mathematical properties, we find that the expected excess objective function is not typically convex. We establish one convexity result, show how our expected excess can be obtained readily from our numerical procedures, and present our insights gained from extensive numerical testing.

Keywords: optimization; waiting time; key performance indicators; expected excess; accumulating priority queue.

4 - That doesn't apply to you - it's a standard letter!: OR and commonsense in Health Care Management.

Penelope Mullen, penelope.mullen@btinternet.com

Members of the general public - users, patients etc - can be faced with apparent illogicalities, errors and contractions when interacting with organisations. Instructions can seem vague, contradictory, irrelevant or even non-existent. Inappropriate "standard" letters can cause confusion. Signposting is unclear or stops completely mid-route. The "computer" does not offer relevant input options and/or produces apparently unchallengeable illogical results. Staff can find they have (or claim to have) no power to resolve problems. Even when staff acknowledge there is a problem, the response is often "that is how it works" or "that is what the computer says". Thus users face an apparent lack of commonsense. Whilst such apparent illogicalities can be found in many types of organisations both public and private, in the UK at least, they appear to be prevalent in health services. Does it matter? Aren't such issues unimportant? But frustrating experiences for patients could indicate inefficiencies in the system. Dealing with the consequences of "illogicalities" can lead to further inefficiencies. Further, such illogicalities could undermine the benefits of potentially excellent OR applications in health care. So should such apparently trivial issues be the concern of OR in the pursuit of "Better Practices in Health Care Management"? In addressing that question, this paper examines possible reasons for such "illogicalities", including modern-day Taylorism, inadequately designed computer systems, defensiveness/hostility in the face of complaints and even in response to suggestions, and a general failure to view the world from the point of view of the user/patient. It explores potential impacts on the organisation and then advances some possible solutions including valuing spontaneous user/patient "feedback", developing approaches to help view the world from the user's point of view and designing systems adapted accordingly.

Keywords: patient experience; efficiency; organisation; OR.

5 - Analysing scale efficiency estimates using a system-of-equations two-stage DEA approach: The case of public hospitals in Greece

Roxani Karagiannis, *Centre for Planning and Economic Research, Athens, Greece,*
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The paper adopts a two-stage approach to analyze scale efficiency estimates for a panel of Greek public hospitals. The first stage employs a DEA approach in which scale efficiency scores could be determined from data on observed inputs, like as the number of beds, the number of physicians or the number of other hospital personnel and outputs, like as the number of inpatient days or the number of outpatient visits. The second stage applies a system-of-equation model to explain the impact of environmental variables, like as socio-economic factors and hospital-environmental characteristics, on scale efficiency. The scale efficiency measure is usually not obtained directly, but is calculated indirectly by noting that, if one calculated the distance from the observed data point to the CRS technology then it can be used to calculate the scale efficiency score residually as the ratio of technical efficiency scores under CRS and VRS. The main advantage of using a system of equations in the two-stage approach is that we analyze simultaneously and in a theoretically consistent way the impact of factors affecting technical efficiency and thus scale efficiency, instead of considering separately their impact on either technical or scale efficiency. The degree of scale efficiency estimated on average to be around 95% was higher than the degree of technical efficiency indicating that a greater portion of overall inefficiency was due to producing below the production frontier rather than operating at an inefficient scale. The two stage analysis indicated that factors like as the size of hospitals and the percentage of population up to 65 years old seem to have a negative effect on scale efficiency and the average length of stay a positive one. However, the specialization of hospitals and the ratio of physicians per patient seem to have an effect only on technical efficiency.

Keywords: scale efficiency; two-stage data envelopment analysis; hospitals; Greece.

6 - Increasing response rate for patient surveys

Tone Breines Simonsen, *HØKH Ahus University Hospital, tone.breines.simonsen@ahus.no*
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In general, modelling is simple, finding data is hard. This is particularly true for health care modelling that includes delayed patient related outcomes, because such data will not be available through a hospital's electronic patient record system. Data of this kind must often be collected through questionnaire surveys, distributed electronically or by conventional mail. In either case, the crucial indicator of success is the response rate. If this is low, the responses will be useless as endpoint in a simulation model. In this presentation we give a summary of what is known from the scientific literature about the effect that different measures may have on response rates in general, ranging from the choice of ink colour in letters, to outright monetary rewards. We also present the design of a randomized controlled trial that we are currently running, where the intervention is pre-contacting stroke patients by phone, before they receive a postal questionnaire.

Keywords: response rate; questionnaires; patient survey.

ThA3

9:00 - 11:00

Healthcare Planning (1)

Room: 6.2.56

chair: Thierry Chausalet

1 - Using the theory of constraints and discrete event simulation in hospitals: 03 case studies

Francisco Sabbadini, *UERJ - Universidade do Estado do Rio de Janeiro*,
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The Theory of Constraints find extensive documentation in industrial manufacturing. However, few papers in healthcare or considering the integrated use of both are related in literature. This paper describes the combined use of the Theory of Constraints (TOC) as formulated by Eliyahu M. Goldratt and discrete event simulation (DES) to identify and manage bottlenecks in care processes in 03 hospitals, namely: in a cancer treatment center of the National Institute of cancer (INCA), in a hospital unit at the municipal emergency hospital Sérgio Henrique Gregori and in an outpatient clinic at the Posse municipal hospital. All organizations studied are located in the state of Rio de Janeiro, Brazil. For the studies preparation the method of continuous improvement as proposed by the Theory of Constraints, also called the "five steps focusing process" was used. This approach is intuitive and made easy the identification of bottlenecks in the systems studied. The methodology considered two phases: in the first stage, constraints are identified using the five steps focusing process. After bottleneck identification, a simulation study to suggest improvement of alternatives was carried out. The results obtained were among others the reduction of cancer diagnosis length, waiting time in hospital emergency rooms and the improvement of outpatient beds.

Keywords: theory of constraints; discrete event simulation; capacity management; hospital; health care.

2 - A stochastic planning model for long-term care: Moving towards an equitable and health centered multi-service network of care

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Many countries across Europe are currently facing an increasing demand for Long-Term Care (LTC). As a result, many governments are increasingly concerned about LTC investment and planning. This is especially true for countries based on a National Health Service, in which governments have responsibilities in both LTC financing and planning. An adequate planning of a LTC network should consider its multi-service nature, the uncertainty in the demand and delivery of care, the pursuit of multiple health policy objectives, as well as the variety of strategic health policy options that can impact on LTC. By considering these features all together, a multi-objective stochastic mathematical programming approach is proposed for supporting the planning of a multi-service LTC network (including a wide range of institutional, home-based and ambulatory services). This approach is based on a model with two objectives - the minimization of expected costs and the maximization of expected health outcomes - while guaranteeing

minimum satisficing levels of equity (in terms of equity of access, equity of utilization, socioeconomic equity and geographical equity), being the latter taken as model constraints. Taking these objectives and concerns as a basis, the proposed model supports decisions on: when and where to locate services and with which capacity; how to distribute this capacity across services and patient groups; and which changes to the network of care are needed over time, including increasing and reducing capacity, and the opening and closure of services. These planning decisions also take into account the uncertainty surrounding LTC demand and should be defined for a variety of inter-related health policy scenarios/options that can be adopted by governments. The model was applied to analyze the reorganization of the LTC network currently operating in the Great Lisbon region in Portugal for the 2014-2016 period.

Keywords: long-term care planning; equity; uncertainty; policy options; health outcomes.

3 - Gamma-robust preventive health care network design

Soheil Davari, *Sabancı University*, soheil@sabanciuniv.edu

Co-author(s): Kemal Kilic (kkilic@sabanciuniv.edu), Sabancı University.

The problem of locating preventive health care centers plays a vital role in the success of any public health care network. However, the change in population density throughout the time calls for relocating facilities. Therefore, this study puts forward the location-relocation problem of preventive health care facilities on a network. We will assume that future demands are uncertain in advance; however, scenarios for demand realizations are available. There is a potential to relocate facilities which calls for investing money to open/close facilities. Facilities are heterogeneous and offer different service levels to clients. Moreover, we assume that proximity of clients to health care centers, congestion levels at facilities, and their reputation are three main factors affecting the attractiveness of facilities. The goal is to maximize the participation level of clients and to have a certain level of equity among nodes. We propose a mixed-integer programming model for such a problem which maximizes the expected participation level of people while making sure that the relative regret for each possible scenario is less than a threshold (Γ). In order to solve this problem, we will propose an efficient heuristic and will analyze the current preventive health care network in Istanbul.

Keywords: preventive health care; facility location; robustness; incremental service; Turkey.

4 - Simulation of the capacity of intensive care units in the state of Rio de Janeiro

Mario Jorge Ferreira de Oliveira, *Universidade Federal do Rio de Janeiro*, mario.jo@pep.ufrj.br

Co-author(s): Raphael Soares de Moraes (raphasm@gmail.com), Instituto Brasileiro de Geografia e Estatística.

The accessibility to health services is a critical problem in Brazil and much effort has been made to understand the nature of the problems and to produce an Integrated Operational Research model to treat this complex issue. The demand for emergency services has shown a significant increase in recent years and an adequate supply for the most services does not always follow what should be ideal. The access to the Intensive Care Units (ICU) adds to the gravity of the problem, because this service is indispensable for seriously ill patients that require immediate availability of beds. The Brazilian Unified Health System (UHS) is responsible for providing services free of charge to the entire population. The UHS allows users the query to a huge database with records on several health facilities including hospital admission data for specific hospitals by geographical regions. It is possible to search good quality information for desired periods of time and to present the results in a consolidated basis. These data allowed the construction of several discrete event simulation models to study and evaluate the capacity and the provision of ICU beds, not just in one hospital, but in a large region. This aspect makes a big difference with regards to previous studies because what we see in the health services simulation field is a large number of papers focused on simulation in either specific hospitals or certain sectors. There are few applications in groups of hospitals or large sets of regions, due mainly to the difficulty of accessing data. In this article, a

number of simulation models are presented, with data from hospitalizations that occurred in a period of three years, in the whole State of Rio de Janeiro. The focus is on the capacity and demand, reducing the waiting times and the number of refusals.

Keywords: simulation; intensive care; capacity planning.

5 - Using the hidden Markov model to capture quality of care in healthcare systems

Hannah Mitchell, *Centre for Statistical Science & Operational Research, Queen's University Belfast, United Kingdom*, hmitchell03@qub.ac.uk

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Healthcare providers are coming under increasing pressure to deliver the highest quality of care to their patients. In recent years there has been an increase in demands on healthcare resources across Europe but the quality of care delivered is expected to remain or reach a high quality. Quality of care is a multifaceted concept and not seen to be amenable to a single performance measure. Due to this its measurement and incorporation into scientific study is difficult. One possible way of incorporating quality of care into a statistical model is by using the Hidden Markov model. This is a doubly embedded stochastic model with an under-lying stochastic process that is not observable but can only be observed through another set of stochastic processes that produce the sequence. Modelling patient flow in healthcare systems is considered vital in understanding the system's activity. The Coxian phase-type distribution which is a special type of Markov model that can represent patient's length of stay as a series of transient states which terminate in the one absorbing state is used to achieve this. It is thought that by looking at patient's length of stay in hospital the quality of care could in some way be teased out. This paper intends to combine the Coxian phase-type distribution with the Hidden Markov model, which will hopefully capture the quality of care delivered by healthcare providers. This in turn would help with planning and effectively managing a hospital so that the highest possible care could be delivered. Future work will be to incorporate patient covariates into the Coxian Phase-type distribution and hospital covariates into the Hidden Markov model.

Keywords: hidden Markov model; coxian phase-type distribution; quality of care.

6 - Forecasting NHS patient activity in England

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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. Under the 2012 Act Monitor now exercises a range of powers granted by Parliament which include: setting and enforcing a framework of rules for providers and commissioners, making sure providers are well led so that they can provide high quality care; making sure essential NHS services are protected if a provider gets into difficulty and lastly, that the NHS payment system rewards quality and efficiency. Monitor achieves 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 first phase of research and development of models to help Monitor in forecasting NHS activity to be used for economic evaluation and impact assessment of pricing policies. In this phase we review the literature around patient activity forecasting and develop a semi-automatic time series procedure to develop activity forecasts for groupings of clinically

similar treatments which use common levels of healthcare resources. 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. 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.

ThPlenary

chair: Inês Marques

11:30 - 12:30

Room: 6.1.36

The Hospital Performance: The use of a benchmarking tool

Manuel Delgado, *General Manager of IASIST Portugal*, mdelgado@iasist.com

The clinical performance is the core business on the health care management. On the critical issues for the success - more value for patients and efficiency on the resources utilization - the clinical performance has an essential and decisive role. So, assessing the clinical performance, looking for the organization of care provision, the quality of care on the different procedures and the final or the intermediary results, is a central task to evaluate the health services performance. We will show an evaluation frame based on a benchmarking among similar hospitals. It is important to assure basic rules of comparison, regarding hospitals characteristics, namely the resources and the technology available, but also about the patients (complexity and severity of diseases, diagnosis and therapeutic procedures, etc.). We will present the methodology and the indicators used on IAMETRICS (the IASIST benchmarking tool applied on Portuguese hospitals). Some results and conclusions will be shared with the audience.

Keywords: clinical performance; benchmarking; quality assessment; efficiency.

ThB1

Ambulance Location

chair: Patrick Soriano

14:00 - 15:30

Room: 6.1.36

1 - The relocation and pre-assignment problem in real-time management of ambulance fleets

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Emergency medical services (EMS) generally evolve in highly random and dynamic contexts. Indeed, the arrival of emergency calls is uncertain and varies throughout the day, forcing decision makers to adapt their decisions in response to observed changes. Two types of decisions are thus generally considered in real-time: dispatching and relocation. Dispatching decisions consider the selection of which ambulance to send to an emergency call. Relocation decisions consist in relocating available ambulances throughout the day in response to changes in the system state. Up to now, dispatching and relocation decisions have generally been considered independently. Sending the nearest ambulance to serve an emergency call is a widely accepted dispatching strategy in practice. However, it does not consider the impact of the unavailability of the dispatched ambulances on the capacity of the system to adequately respond to future

demands. On the other hand, dispatching decisions are rarely accounted for when relocation decisions are considered. In fact, relocation and dispatching decisions are closely related when analyzing the ability of an EMS to adequately serve future demands. Considering them simultaneously could help to maintain an adequate service to the population with less relocation efforts. Hence, this study focuses on modeling and solving the dynamic relocation and pre-assignment problem (DRAP) arising in the real-time management of ambulance fleets. The DRAP seeks to determine the location of each available ambulance as well as an ordered list of available ambulances that can be dispatched to each demand zone while maximizing the preparedness of the system as well as minimizing relocation "costs". To solve this problem, metaheuristics are proposed and validated through a set of experiments using data representative of a real application context.

Keywords: ambulances; relocation; pre-assignment; metaheuristic.

2 - Demand for emergency rescues in Germany and its impact on ambulance planning

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Ambulance planning at the strategic and the tactical level minimizes the cost for installing ambulances and bases assuring at least one predefined coverage level. Corresponding formulations and solution approaches usually assume the demand for emergency rescues to be known or at least to be predictable in advance. Therefore, the demand used in the approaches can be deterministic or stochastic. Stochastic demand can be modeled as either scenarios or expressed by probability distributions. When applying the solution approaches for ambulance planning in practice, it is necessary to determine or predict the demand for emergency rescues for the region under consideration. Especially in Germany, the demand for emergency rescues is not well studied or analyzed. Often, only last year's data exist and no further information is used for planning the locations and number of ambulances and bases for the upcoming period (one year or several years). In Germany, the federal states have the sovereignty over the Emergency Medical Service system including independent laws and regulations. This includes also the coverage constraints that define a maximum allowed travel time to the patients. In this talk, we first analyze historic demand data of an EMS region in the south-west of Germany. We try to determine probability distributions for the demand in that specific EMS region and express the same demand as a set of scenarios. We then solve a stochastic programming formulation for the ambulance planning problem and compare the solutions for both the probability distributions and the set of scenarios. Using further instances, we study the impact of the demand and its modeling on the solution. As an outlook, we present ideas how to handle large sets of scenarios (more than 1000) that can already arise for small instances with only 10 demand nodes as we will show.

Keywords: EMS; ambulance planning; data analysis; stochastic programming.

3 - Simulation based evaluation of ambulance location models

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Rescue services are an important part of public health care, offered by the state to the general public. A crucial aspect of rescue service is the first aid of patients provided by local emergency medical services. Resources for emergency medical services, e.g., ambulances, have to be positioned such that emergencies can be reached within a given time frame. Well-known models in literature consider different variants of demand coverage as a proxy for emergency quality, which is usually defined as the ratio of calls served within the legal respond time. The main challenge faced by covering models is to provide an

adequate service level with respect to unavailable ambulances. Different kinds of model formulations are published to support ambulance planning such as single coverage, double coverage and empirical required coverage models and streams with busy fractions and reliability level models. All models make various assumptions and need different detailed data input. We evaluate typical objective functions and the resulting optimal positioning of ambulances and their influence on real world outcome measures. The performance of optimization models are compared and tested for different urban structures to evaluate the solution especially regarding emergency service quality and practicability. To evaluate the solutions and ensure comparability of the results, a detailed simulation study is conducted.

Keywords: ambulance location; coverage models; simulation.

4 - A genetic algorithm to solve the non-emergency patient transport problem in Portugal

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We present a study on the Non-emergency patient transport problem in Portugal that benefit support from National Health Service. Portugal established recently new legislation in order to reduce costs, attending to the recommendations from the recent financial rescue program. We find several gaps in the laws that affect the performance of the optimization process. We want to discuss some issues with the purpose to promote changes in the law that allow to achieve better results in terms of efficiency and effectiveness to reduce operational costs. The patient transport problem is a classical optimization problem largely studied in Operations Research community. Toth and Vigo (1997) studied the Handicapped persons Transportation Problem in Bologna as a generalization of the well-known Pickup and Delivery Problem with Time Windows that is a variant of the Vehicle Routing Problem. Since then, their work was cited 193 times, and several works were presented in the literature demonstrating the importance of the problem. We modelled the Portuguese case as a variant of the Team Orienteering Problem as also known as VRPs with profits. Indeed we modelled this problem to maximize the savings relatively to the single person transport. Our approach is different from the previous ones once we must include the particular constraints imposed by the law. We developed a Genetic Algorithm to provide good solutions and it can be implemented in a Decision Support System.

Keywords: non-emergency transport; team orienteering problem; genetic algorithm; heuristics; optimization.

Thursday

ThB2

14:00 - 15:30

OR Methodologies for Home Care (2)

Room: 6.2.53

chair: Margarida Moz

1 - A generic model for home health care routing problem

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These last years, we observed an increasing number of academic publications dealing with Operational Research in Home Health Care context. Many Operational Research problems exists in this field. We can mention Districting Problem, Resource Dimensioning, Home Health Care Routing Problem, etc. In this paper, we focus on Home Health Care Routing Problem (HCRP). HCRP consists in designing routes

followed by a team of home care workers to care a group of patients living in a given geographical area. For this scheduling stage, the decision maker has to take into account many constraints : time windows, qualification requirements, breaks, temporal dependencies, etc. Models based on studies of specific home care structure have already been proposed in the literature. Depending on papers, constraints took into account are different and models suffer from a lack of genericity. We stated a literature review on studies dealing with HCRP and propose a classification of papers with respect to constraints, criteria, solution methods and planning horizon. As preliminary study and based on this literature review, we introduce a mixed integer linear formulation as generic as possible for the HCRP. In order to solve this problem, we use CPLEX solver to obtain optimal solutions with respect to usual criteria found in the literature: total routing cost, balance workload, quality of care, etc. Since CPLEX solver can only solve small instances of the problem in a reasonable amount of time, we also propose a heuristic to solve real size instances. Finally, computational results are given to evaluate the efficiency of that heuristic, and some research perspectives are outlined.

Keywords: home health care; vehicle routing; mathematical modeling.

2 - The home health care routing and scheduling with patients' preferences

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The demand for home healthcare (HHC) services is growing as population ages and the number of people living with chronic illnesses increases. In France, 100, 000 frail people needed HHC services and 4 millions days has been devoted in 2010. Therefore, the HHC services are facing an important manpower deployment and staff organization problems while satisfying patients and reducing costs. Our works focus on scheduling and assigning caregivers to patients' homes. The objective is to come up with a decision-making approaches in order to find the most efficient organization in terms of resources. It consists in reducing costs mainly related to staffs and transportation, and maximizing satisfaction level of patients. The problem is a generalization of the vehicle routing problem with time windows (Rasmussen and al., 2012). Actually, the one major challenge HHC services are facing is to visit all patients while respecting resources constraints and patients' preferences. An analysis of the literature review on the HHC shows that optimization of caregivers scheduling are widely treated (Redjem and al., 2011) (Trautsamwieser and Hirsch, 2011). However, few works consider the preferences of patients according to the time windows of visits and the caregivers, in this case, we talk about patient-caregiver loyalty (patients prefer to be visited every time by the same caregiver, ideally) (Sorsa and Ruokokoski, 2013). In this paper, we consider an extended version of the existing HHC taking into account resources' constraints and patients' preferences. We propose a mixed integer linear programming formulation with a multi-criteria approach. The objective is (1) to reduce costs related to caregivers' traveling and their waiting time between two consecutive visits, and (2) to maximize the patient-caregivers loyalty. Caregivers are assigned to patients according to their skills. Moreover, the model assumes the balance of the workload among the caregivers. These elements, represented together, are the main novel contribution of our work. The proposed models are performed by the Cplex solver and tested on generated test instances inspired by realistic setting. Computational experiments show that the proposed models are flexible and useful for HHC manager.

Keywords: scheduling; vehicle routing; patients' preferences; mixed integer programming; multi-criteria analysis.

3 - Tabu Search strategies for daily scheduling of home health care services that use time-dependent public transport networks

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Demographic and social changes in industrial countries will lead to more care dependent people and to a reduced potential in family care in the future. Home Health Care (HHC) providers visit their clients on a regular basis and offer services ranging from doing the housework to qualified nursing. The daily HHC scheduling problem can be summarized as follows: Nurses with different qualification levels have to visit certain clients at least once per day. The number of nurses and clients is fixed and each visit has to be performed. There are assignment constraints (e.g. the required qualification level for a visit) and hard time windows at the clients. The nurses have a maximum working time per day and their workday can be separated into two shifts. A mandatory break needs to be scheduled if the consecutive working time of a nurse exceeds a certain threshold. The objective is to minimize the total travel- and waiting times of the nurses. Additionally, factors influencing the satisfaction of the clients or the nurses are either considered as penalty factor in the objective function (e.g. if nurses have to work two shifts per day) or as aspiration level in the constraints (e.g. the total overtime). We were provided with real-world data from the Austrian Red Cross (ARC), which is one of the biggest HHC providers in Austria. Most of the HHC nurses in Vienna use a combination of public transport modes (bus, tram, train, and metro) and walking. Hence, we first developed an efficient exact solution approach to compute time-dependent travel times out of the timetables from the public transport service providers on a minute-basis. These travel time matrices are used then as input for three Tabu Search solution methods, whose solutions are compared to each other and the actual planning of the ARC.

Keywords: home health care; multimodal routing; time-dependent travel times; tabu search; routing with public transport.

4 - Different perspectives and goals in home care planning

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Home care services are a crucial issue in many western countries, mainly due to population ageing. They reduce hospitalization costs and, at the same time, improve patients' quality of life, as patients continue to live in a familiar place during the treatment. In this paper, we focus on the nurse-to-patient assignment problem under continuity of care. The problem asks to assign patients to nurses over a planning horizon. Different agents are involved in planning a home care service, each one having a different perspective and being interested in different outcomes: patients, nurses and provider. From the patients' perspective, quality of service has to be pursued, which is mainly related to continuity of care. In fact, if a patient receives care from the same nurse, he/she develops a familiar relationship with the assigned nurse and potential loss of information during the treatment is avoided. From the nurses' point of view, burnout is to be avoided by assigning workloads to nurses as fairly as possible. Finally, the provider wants to minimize the overall system cost. These three goals may be conflicting. We analyse three different objective functions, representing the different perspectives, and their relationship, and we test them on a set of real-life instances.

Keywords: home care; nurse-to-patient assignment.

ThB3

14:00 - 15:30

Healthcare Planning (2)

Room: 6.2.56

chair: Fermin Mallor

1 - Control problems in health care considering general length of stay distributions: application to intensive care units

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Periodic ICU bed shortages deal to a triage process: physicians must balance the no rejection of incoming patients with the early discharge of current patients who are closer to recovery. ICU bed occupancy control can be addressed as a queuing control problem, which solution provides service time rates dependent on the system state. In previous research, the queuing control problem is modeled by assuming markovian hypothesis as a mathematical programming problem. Poisson processes, in general, are a good probabilistic model to describe the outpatient's arrivals to healthcare systems. Nevertheless, several studies report distributions different from exponential as adequate to model the patients' LoS. In this work we study this type of control problems assuming general LoS distributions. The analytical approach to solve the control problems is no longer valid and then, a simulation based optimization methodology is used. The implementation of this methodology requires the simulation of queuing systems with varying service rates. In the Markovian case, the procedure is straightforward due to the lack of memory of exponential distributions. When the system enters a new state, which operates with a new service rate, the remaining LoS of each patient is updated by sampling a new value from an exponentially-distributed random variable with the new rate. This service rate update is interpreted as a change in the time scale of the survival time probability distribution and included in the expression of the hazard function. Then, a simulation model driven by the patient LoS hazard function allows us to simulate general LoS distributions depending on the system state. We study the influence of markovianity in the queuing control policies. In particular, extensive simulation experiments are conducted using the Weibull family, where the shape parameter is used as an indicator of deviation from markovianity. Results for other LoS distributions are also presented.

Keywords: queuing control; length of stay; simulation based optimization; bed occupancy.

2 - The MetSim tool for short-term forecasts of hospital admissions and bed occupancy incorporating meteorological information

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Improved short-term predictions of hospital admissions and bed occupancy offer the potential to plan resource needs more accurately and effectively. The MetSim project explores the relationship between weather and health, building novel Bayesian models that are more sensitive to fluctuations in weather. Short-term forecasts of the numbers of admissions, categorised by age, sex and medical condition, are produced. In turn, coupled with predictions on length of stay and information on current occupancy, MetSim uses hazard ratios embedded within a simulation framework to provide forecasts of short-term bed needs. At a previous ORAHS conference we described the underpinning methodology. In this talk

we will overview the functionality and discuss how the web-based tool has since been piloted in several UK hospitals. In particular, MetSim has recently been introduced at the Royal Gwent Hospital, Wales, where staff engaged in capacity planning are consulting the forecasts on a daily basis to pro-actively plan for anticipated peaks and troughs in demand. A user-friendly interface has been added to the tool for this pilot and analysts are closely monitoring the accuracy of the daily forecasts being sent to the hospital, in addition to conducting surveys to capture the benefits of using the tool. As well as quantifying the accuracy of the forecasts for unplanned admissions and bed occupancy, this involves quantifying the impact in terms of improved resource managements and the potential impact on patient safety and quality.

Keywords: bayesian inference; admissions; length of stay; hazard ratios; simulation.

3 - Modelling bed constraint effects through cox regression with time varying covariates

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We consider modelling and simulation of patient flow through a hospital department with limited bed capacity. A standard approach is to model the in-flux of patients as a Poisson-process with time-varying arrival intensities. Typically the length of stay of patients is modelled according to some family of distributions, e.g. log-normal or exponential, whose parameters are estimated from patient registry data. This gives a simulation model that represents the throughput of patients, the average number of patients and the average patient hospitalization time correctly. However, a real hospital department will have a limited number of beds that constrains the number of patients, which is violated by a model of this kind: When arrival events and length of stay are drawn independently, there will be no strict upper limit to the number patients simultaneously present at the ward. A pragmatic solution to this would be to discharge one patient the moment that the bed constraint is overstepped, but this would compromise the shape and the expected value of the length of stay distribution. We propose a different solution, which is to model patient discharge by Cox regression, which is related to Poisson modelling, in that they represent hazard rates for events. The Cox model gives the discharge hazard as a product of a purely time-dependent factor and patient-dependent factors. It allows patient characteristics that change with time, so-called time varying covariates, which we utilize by defining the total number of currently unused beds as a patient covariate. When we estimate the model from data, it captures the effect that crowdedness has on the immediate probability of patient discharge. We have applied this model to several hospital wards, and found that the effect of crowdedness on discharge hazard varies greatly among them.

Keywords: simulation; bed constraints; Cox regression; length of stay.

Thursday

ThC1

16:00 - 17:00

Disease Modeling and Policy (2)

Room: 6.1.36

chair: Margaret Brandeau

1 - Robust kidney exchange optimization

Miguel Constantino, *Centro de Investigação Operacional, Faculdade de Ciências, Universidade de Lisboa, and Departamento de Estatística e Investigação Operacional, Faculdade de Ciências, Universidade de Lisboa*, mfconstantino@fc.ul.pt

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Transplantation is the most successful way to treat kidney failure disease, but finding a suitable organ can be difficult, because of their scarcity and blood or tissue incompatibility. Some patients have someone willing to donate him/her a kidney but, because they are not physiologically compatible, the transplantation cannot be performed. Those patient/donor pairs can join a Kidney Exchange Program. In such a program, a set of pairs is periodically chosen in such a way that each selected patient can receive a kidney from a compatible donor from another pair in the set. The pairs are then notified and crossmatch tests are performed to ensure the success of the transplants. Sometimes a partaker withdraws or a test fails, preventing the intended transplants from being performed. In those cases, a new set of pairs may be selected. The new set should be as close as possible to the initial set in order to minimize the material and emotional costs of the alteration. In this talk, we present a robust optimization approach that intend to maximize the number of pairs selected in both sets, in a worst case scenario

Keywords: kidney transplantation; kidney exchange program; robust optimization.

2 - Modeling and calibration for exposure to time-varying, modifiable risk factors: the example of smoking behavior in India

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Background: Risk factors increase chronic disease incidence and severity. To examine future trends and develop policies addressing chronic diseases, it is important to capture the relationship between risk factor exposure and disease development. This is challenging given the limited longitudinal data that is typically available. Methods: We develop model structures that encode relevant features of risk factors (e.g., time-varying, modifiable) and that can be embedded in chronic disease models. We show how calibration can be used with available cross-sectional data to capture time-varying exposures for the risk factor models. We illustrate feasibility with the policy-relevant example of smoking in India. We calibrate the model to prevalence of male smoking in 12 Indian regions. Nelder-Mead searches (250,000 starting locations) identify distributions of starting, quitting, and re-starting rates that minimize the difference between modeled and observed age-specific prevalence. We compare modeled life expectancies to estimates in the absence of time-varying risk exposures and consider gains from hypothetical smoking cessation programs delivered for 1-30 years. Results: Calibration achieves concordance between modeled and observed outcomes: probabilities of starting to smoke rise and fall with age, while quitting and re-starting probabilities fall with age. Accounting for time-varying smoking exposures is important, as not doing so produces smaller estimates of life expectancy losses. Estimated impacts of smoking cessation

programs delivered for different periods depend on the fact that people who have been induced to abstain from smoking longer are less likely to re-start. Conclusion: Our approach is feasible for numerous chronic disease risk factors. Incorporating exposure-change rates can improve modeled estimates of chronic disease outcomes and long-term, risk factor intervention effects. Such accuracy is important not only for forecasting chronic disease burden but also for evaluating the potential effects of risk factor mitigation policies (e.g., programs to prevent smoking initiation in youth or smoking cessation programs).

Keywords: chronic disease models; calibration; smoking; India.

3 - Investigating Adolescent friendships and smoking behaviours with social network analysis and agent based simulation

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Social networks are increasingly being investigated in the context of individual behaviours. Research suggests that friendship connections have the ability to influence individual actions, change personal opinions and subsequently impact upon personal wellbeing. This work investigates the role of social networks in the influence of adolescent smoking uptake, utilising Social Network Analysis, Agent Based Simulation and Link Prediction methods. This research analyses data acquired from a peer-led intervention study conducted in the South Wales and West of England region. The participating students of "A Stop Smoking in Schools Trial" contributed information related to their smoking behaviours and social connections. Analysis of the social network data suggests certain network structures may have an impact upon smoking uptake, identifying the importance of central individuals in a network. To gain an understanding of the formation of the adolescent social structures present in the data, Link Prediction methods are employed. Link Prediction algorithms use information from a particular instance of a network structure, and aim to predict its evolution over time. Five Link Prediction methods are implemented in the framework of an Agent Based Simulation, Adamic/Adar, Katz, Stochastic Actor Models, PageRank and PageRank-Max; the PageRank-Max method being a newly devised method, developed specifically for this research. The final part of this work attempts to improve upon the Link Predictions made, by placing particular emphasis upon specific individual attributes. A new PageRank-Max based method is developed, altering the calculation process of the algorithm and allowing for the adjustment of behaviours in search of optimal friendship structures. Simulations relating to the uptake of smoking are also produced, investigating the impact of central individuals in spreading a message through a social network.

Keywords: agent based simulation; link prediction; social network analysis; smoking.

Thursday

ThC2

16:00 - 17:00

Regional Health Service

Room: 6.2.53

chair: Jan Vissers

1 - Modelling and evaluation of regional healthcare delivery systems: approach and methodology

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Health service operations management has developed considerably as a scientific discipline over the last decade, but the relationships between operations and outcomes are largely unexplored. Conversely,

health sciences and outcome research have sought little connection with operations management. In this paper we propose a modelling framework which enables to explore systematically the relationship between operations and outcomes. The model refers to networks of health services providers (as opposed to the departmental or organizational perspective of service delivery) as suitable for many of today's most prevalent diseases. The basis of the framework is formed by a general model from which disease specific models can be derived. For specific cases, instances of regional networks can be created which include the health service users. In addition to the modelling framework we propose analysis methods to analyze how the operational models can explain outcomes. The models and analysis methods are applied to analyze networks for four types of diseases (diabetes, stroke, hip osteoarthritis, dementia) in six European countries (FI, GE, GR, NL, SP, UK), as part of the project Managed Outcomes which was funded by the European Union. The presentation will first introduce the Managed Outcomes project by providing some background information. Then we present the modeling framework for describing, analyzing and comparing regional health service delivery systems. Next we present the analysis methods used to analyze the relationships between operations and outcomes.

Keywords: regional health service delivery; operational model; methodology, outcomes.

2 - Modelling and evaluation of diabetes care in regional health service provider networks: a comparative analysis of six european practices

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Type 2 Diabetes (T2D) is one of the most prevalent diseases with a high burden on patient, families and society. Though diabetes can be treated, it is a chronic disease that progresses over a long period of time with a steady deterioration of the health state and increased comorbidities and complications. Treatment of the chronic condition diabetes requires long term, continuous and personalized care, and involves different professionals mostly from primary care (prevention, diagnosis, monitoring) but also from secondary care (complications). We assume therefore that diabetes care providers operate within health service provisioning networks. These networks can be formed by means of explicitly defined relationships, and/or more implicitly as collections of providers jointly visited by (a population of) diabetes patients. Given the huge burden of disease diabetes entails, and the importance of primary care networks for the treatment of diabetes our research addresses the relationship between the operations of health service provider networks for diabetes care and the outcomes obtained. The work is based on the EU FP7 project Managed Outcomes, and the corresponding framework and research methodology (Mahdavi et al, 2014). The framework and methodology enable a comparative analysis between regions and diseases. We apply the framework in this paper to diabetes care and derived a diabetes specific model from the generic model developed. The diabetes model was used to describe, analyze and compare the operations and outcomes in six case instances in six European countries. The presentation will first introduce the Managed Outcomes project, its methodology and the case study settings. Then we elaborate on the Diabetes Model and present the results from the analyses of the relationships between operations and outcomes in diabetes care.

Keywords: diabetes care; regional provider networks; operational model; outcomes; comparative analysis.

3 - Modelling the value of community-based secondary care services

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Large numbers of patients regularly travel long distances to attend outpatient appointments at a secondary care facility, usually a hospital. In many cases, these appointments are non-invasive and do not require immovable specialist machinery. By transferring these appointments to a primary care setting - a local doctors' surgery for example - a number of benefits may be realised. These include a reduced demand on the hospital and a reduction in travel time and costs for patients. Cost savings to the healthcare provider are also realised by fewer no-shows. This project was funded by The Health Foundation as part of its annual Shine programme. The local focus was on ear, nose and throat (ENT) and Audiology services at the University Hospital of Wales in Cardiff, United Kingdom. Patients were selected for transference to a self-contained medical centre based upon clinical nodes and geographical location. Significant gains were realised in terms of reduced travel distances and costs, reduced carbon footprint of travel and reduced costs to the provider. This pilot study formed the basis of the development of two software tools. The first was developed as a mapping software and interfaces GoogleMaps to calculate the travel distance and time between demand (patient) and service (clinic) location, which are displayed on a fully functioning map. The second was developed to carry out a utility based approach to the evaluation of service configurations. By taking into account travel distance, cost to patients, carbon footprint and cost to the provider, various utility functions are used to evaluate overall value of a configuration, measured in ReVS, a relative value score. This allows for better informed decision making which does not depend on bottom-line costs alone. Non-quantitative gains in patient experience were additionally evaluated via patient interviews and a focus group and yielded valuable insights for the clinical team.

Keywords: service redesign; value; location; ENT/Audiology.

ThC3

16:00 - 17:00

Risk Management

Room: 6.2.56

chair: Mónica Oliveira

1 - A MACBETH-Choquet model to evaluate interdependent health impacts

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This study proposes the combine used of the MACBETH (Measuring Attractiveness by a Categorical Based Evaluation Technique) method and the Choquet integral to model interdependencies in the evaluation of health and safety risks in working places. It is described the construction of a MACBETH-Choquet model to assist the Occupational Health and Safety unit of the Regional Health Administration of Lisbon and Tagus Valley, Portugal, to address interdependencies identified between the three dimensions of "health losses", "absenteeism" and "work capability". Other studies in the performance measurement literature have used MACBETH to determine the parameters of the Choquet integral model, from $m+1$ sets of pairwise qualitative judgments of difference in attractiveness, one for each one of the m concerns

separately and another one for pairs of interdependent concerns. However, all the MACBETH judgments assessed are judgments of global attractiveness, and therefore we propose an alternative procedure based on a value measurement scale generated by using one single MACBETH global matrix that models judgments of global attractiveness, which is the basis for then determining the CI parameters (Shapley and interaction parameters). This study further explains the questioning protocol to apply the proposed procedure, as well as an intuitive interpretation of the CI parameters.

Keywords: risk management; MACBETH; Choquet integral; interdependencies; health and safety.

2 - Building a value risk-matrix for the evaluation and mitigation of health and safety risks

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Risk matrices (RMs) are used to evaluate individual sources of risk in terms of their probability and impact on multiple dimensions, being recommended by several organizations. For instance, the Patient Safety Agency in the United Kingdom has been using them to prioritise financial, operation and clinical risks, the Government of Western Australia to prioritise risks that threaten the health system, business units and team and/or patients, and following official guidelines, many organizations use them for evaluating health and safety risks. However, risk matrices violate some theoretical principles that compromise their feasibility and use. This study explains how multiple criteria decision analysis has been used to improve the design and the deployment of RMs to evaluate health and safety risks at the Occupational Health and Safety Unit (OHSU) of the Regional Health Administration of Lisbon and Tagus Valley. Under the framework of developing 'Value risk-matrices' with the MACBETH (Measuring Attractiveness by a Categorical Based Evaluation Technique) approach, the first step was the structuring of the risk impacts, involving the construction of descriptors of impact that link risk events with health impacts and with absenteeism in the working place. In a second step, MACBETH was used to generate a cumulative value measurement scale, by using one single MACBETH global matrix that converts impact into value based upon subjective assessments on difference in attractiveness between risk impacts, and which allows for modelling interdependencies between impact dimensions using the Choquet integral. In a third step, a subjective probability scale was built with MACBETH, by converting qualitative judgments on likelihood into a numerical probability scale. Based on the cumulative value scale, the subjective probabilities scale and on the identification of risk categories, a value risk-matrix was designed. This framework constitutes the basis for the OHSU evaluating health and safety risks and identifying risk mitigation actions.

Keywords: health and safety; risk matrices; value risk matrices; risk evaluation; MACBETH.

3 - Risk-reward optimization with linear tolerance to risk with applications to the health management sector

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In this paper we address two issues considered as weaknesses of the Mean-Variance portfolio selection model: the first one is due to the fact that the variance penalizes equally the favorable and the unfavorable outcomes and is ineffective for measuring the risk of low-probability events, and second is the implicit assumption of neutrality at risk of the individual investor. We propose a portfolio selection model in the Mean-Risk framework incorporating the individual preferences in the objective related to the portfolio return, and in the risk related objective we use the Conditional Value at Risk which provides an adequate picture of risks reflected in extreme tails. We evaluate the differences and the

similarities between the efficient frontier of the proposed model and the classical Mean-Variance. We use two performance measures Rachev ratio and Sharpe ratio to compare the efficient portfolios. We apply the results obtained to the health management sector.

Keywords: quantile-based risk measures; mean-risk portfolio optimization; utility functions; performance measures.

Friday

9:00 - 11:00 Session 5 (page 75)		
<p>FA1 Operating Room Planning and Scheduling (3) Chair: Roberto Aringhieri Room: 6.1.36</p> <p>Andrea Matta Planning of hospital surgery volume activities under short term patients' outcomes</p> <p>Wim Vancroonenburg A two-phase heuristic approach to multi-day surgical case scheduling considering generalized resource constraints and desiderata</p> <p>Roberto Aringhieri A hybrid model for the analysis of a surgical pathway</p> <p>Giuliana Carello A rolling horizon approach for planning surgery cases under uncertain surgery duration: deterministic versus robust solutions</p> <p>Elizabeth Rowse Set partitioning methods for robust scheduling: an application to operating theatres</p> <p>Fabrcio Sperandio A rolling horizon approach for the surgery scheduling problem with block synchronization: MIP versus biased random-key genetic algorithm</p>	<p>FA2 Healthcare Planning (3) Chair: Vincent Knight Room: 6.2.53</p> <p>Tatiana Ceballos A model of system dynamics for the study the problem the hospital length of stay, the evaluation of solution alternative and the efficiency of the bed resource</p> <p>Leanne Smith Modelling phototherapy for dermatology services in Wales</p> <p>Ines Verena Arnolds Clinical pathway mining for downstream and upstream planning of hospital-wide patient flow</p> <p>Vincent Knight Measuring the price of anarchy in critical care unit interactions</p> <p>Ali Taghizadeh Herat A thematic analysis of leader attitudes toward re-conceptualizing the excellence model in hospitals</p>	<p>FA3 Disease Modeling and Policy (3) Chair: Christos Vasilakis Room: 6.2.56</p> <p>Christos Vasilakis Evaluating an innovative approach to the diagnostic processes for glaucoma: the role for operational research in a mixed methods study</p> <p>Myriam Soto The impact of possible early interventions in Alzheimer's disease</p> <p>Bernardete Pinheiro Determinants of healthcare utilization in hypertensive patients: a longitudinal analysis</p> <p>Sebastião Loureiro Technology and inequity in health: geographical distribution of glucometers in the control of diabetes</p> <p>David Anderson Making the case for case management: identifying high-risk diabetes patients</p> <p>Mohamad Javad Ashja Assessment of users satisfaction rate of Isfahan University of Medical</p>
11:00 - 11:30 Coffee Break		C6 - inner yard
11:30 - 12:30 Business Meeting		6.1.36
12:30 - 14:00 Lunch		Canteen (C7)

FA1

9:00 - 11:00

Operating Room Planning and Scheduling (3)

Room: 6.1.36

chair: Roberto Aringhieri

1 - Planning of hospital surgery volume activities under short term patients' outcomes**Andrea Matta**, *Shanghai Jiao Tong University*, matta@sjtu.edu.cn

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Cost reduction policies are forcing Public Health Authorities to revise the health care delivery at regional level. The reorganization of the hospitals in regions is subject of big debates about the profitability of aggregating or not specialized centers. Among these, surgeries play a relevant role in hospitals either for their related cost or for their impact on the patients' outcome, and they are the subject of the interest in this work. Specifically, this paper focus on how to re-organize operating rooms to achieve the best performance at the minimum overall cost. This problem is, in reality, very general and contains several aspects that need to be adequately treated according to the hierarchical level at which we are operating, to the performance measures used and to the considered specific costs. This study stems from the analysis of the curves mortality-number of interventions that show how the surgery volume activities impact on the short term patients' outcomes, specifically the 30-day mortality rate of patients. According to these curves, the mortality rate decreases as the number of interventions increases, thus suggesting that operating rooms of small hospitals should be aggregated into larger hospitals. However, the aggregation implies both short term costs, due to the reorganization and to the structural costs for the patients that might have to move for surgery. Moreover, the aversion to move could also have a negative impact on the mortality rate because the not moving patients do not receive the care and their related risk increases. We provide a description of the problem as well as some preliminary mathematical formulations developed from different views (Regional Health Authority, hospital and patient) and with different objective functions (cost, service coverage, 30-day mortality rate).

Keywords: hospital; surgery; short term patient outcome; mathematical programming.**2 - A two-phase heuristic approach to multi-day surgical case scheduling considering generalized resource constraints and desiderata****Wim Vancroonenburg**, *KU Leuven, CODeS*, wim.vancroonenburg@kuleuven.be

Co-author(s): {Pieter Smet (pieter.smet@cs.kuleuven.be), Greet Vanden Berghe (greet.vandenbergh@cs.kuleuven.be)}, KU Leuven, CODeS.

In this study, we present a rich multi-day surgical case scheduling problem considering generalized resource constraints and desiderata from the surgical staff. The aim is to schedule as many surgical cases in as few operating theatres as possible, within regular operating theatre opening hours and under limited resource availability. In addition, secondary objectives such as makespan and other measures of resource efficiency are optimized. Surgical cases may specify both required and optional dependencies on different resource types during different phases of the surgical procedure. To be eligible to be scheduled at a certain time, sufficient resources for required resource types must be present during the surgical phase they are required for. Optional resource type requirements are preferably met, but do not prohibit a surgical case to be planned. Furthermore, surgical staff may denote collaboration preferences that should be satisfied as much as possible. To this end, we developed a heuristic algorithm employing a list decoding procedure for generating feasible schedules. The procedure makes extensive use of interval tree data structures, to

allow for fast schedule generation, with infinite precision. This list decoding procedure is used within a local search algorithm to find good quality schedules in limited time. In a second phase, optional resources are assigned in a greedy fashion. The problem description and the algorithm is the result of a collaboration with a software company developing a software solution for operating theatre planning and scheduling. The algorithm is currently being implemented for a pilot hospital.

Keywords: surgical case scheduling; operating theatre scheduling; serial schedule generation; metaheuristic.

3 - A hybrid model for the analysis of a surgical pathway

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In this paper we focus our attention on the analysis of a surgical pathway from a patient-centred point of view. The main concern of this work is the introduction of some optimization modules in the management of the most critical resources in a surgical pathway, that is the stay beds and the operating rooms, and to evaluate their impact with respect to a set of patient- and facility- centred indicators. Our approach is an integrated simulation and optimization model. Simulation is used in order to generate a real situation with respect to the inherent stochasticity of the problem while optimization is used to take the best decisions in different points of the surgical pathway. Accordingly to the literature, we consider the operative decisions concerning the advance scheduling and allocation scheduling of patients. Furthermore we consider the real time management of the operating room planning. The advance scheduling consists in assigning a specific surgery and OR time block to each patient over the planning horizon. Given this advanced schedule, the allocation scheduling then determines the precise sequence of surgical procedures and the allocation of resources for each OR time block and day combination. The real time management of the operating room planning consists in a sort of centralized surveillance system whose main task is to verify the plan execution and, in the case of delays, to take a decision regarding the patient cancellation or the overtime assignment. The general aim is to reduce the waiting list according to a prioritized admission system, to operate patients within a given time limit depending on their level of urgency, to improve the utilization of the above critical resources and to minimize the number of cancellations. The results show an evident improvement of the patient-centred indicators without deteriorating the facility-centred ones.

Keywords: surgical pathway; operating room management; bed management; simulation, optimization.

4 - A rolling horizon approach for planning surgery cases under uncertain surgery duration: deterministic versus robust solutions

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In this work, we deal with an Operating Room (OR) Advance Scheduling Problem under a block scheduling strategy. Given a set of patients waiting for surgery and a set of OR blocks, the problem asks to determine the subset of patients to be scheduled and their assignment to the available OR blocks in a given planning horizon. The objective function aims at minimizing the total penalty associated with waiting time, urgency and tardiness of patients. In a real case setting, a provisional planning is decided several weeks ahead. However, such provisional planning cannot take into account new patient arrivals and emergent cases which should be scheduled within a short period. Besides, when the provisional solutions are applied, unpredictable extensions of surgeries may prevent to operate all the scheduled patients. The patients cancelled must be rescheduled in the following days, and the overall solution must be

updated. Therefore, we propose a rolling horizon approach combining offline and online decisions. At the beginning of each week a given time window is planned, and the resulting first week schedule is applied. Afterwards, the planned solution, new patient arrivals and patients cancelled to-be-rescheduled are taken into account in the online phase. Besides, we evaluate the benefit of taking into account uncertainty in surgery duration in the offline phase so as to reduce the number of cancelled patients. The approach has been tested on a set of real life based instances and the deterministic and the robust solutions have been compared.

Keywords: operating room planning; robust optimization; uncertain surgery duration; block scheduling; re-optimization.

5 - Set partitioning methods for robust scheduling: an application to operating theatres

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This talk presents recent work on operating theatre scheduling at the tactical level that integrates surgical specialty preferences for theatre sessions with the practical limitations imposed by bed availability. An important reason for the high number of cancelled operations is the unavailability of beds on hospital wards for post-operative recovery. By modelling the impact of the operating theatre timetable, the Master Surgery Schedule (MSS), on the demand for beds and vice versa, an MSS can be produced that results in a reduced number of cancelled operations whilst also levelling the demand for beds throughout the week. To address the stochastic nature of the factors affecting operating theatre scheduling, a robust optimisation approach has been used with a set partitioning technique. The set partitioning formulation has been adapted to assign specialties to operating theatres, and a novel extension to the model is used to incorporate constraints on the demand for beds. Initial results are presented to highlight the potential of this model.

Keywords: scheduling; set partitioning; optimisation; simulation; healthcare.

6 - A rolling horizon approach for the surgery scheduling problem with block synchronization: MIP versus biased random-key genetic algorithm

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This work addresses the operational surgery scheduling problem appearing at large hospitals. As long waiting surgery lists are a reality, priority and waiting time rules are imposed by the Portuguese legislation. Surgery schedules are subject to the maximum waiting time limits established for each priority level. Moreover, surgeons are allowed to perform surgeries in different ORs in the same day and working shift, which helps to improve OR occupancy rates. The aim is to maximize a weighted objective function combining the number of scheduled surgeries and average OR occupancy rates. This scheduling problem with block synchronization is formulated as a mixed-integer programming (MIP) model. The MIP is solved by a state-of-the-art commercial LP Solver. This problem is NP-hard, and therefore high computational time might be needed to find provably optimal solutions for real-world instances. As an alternative, heuristic solution approaches generate good-quality solutions within a reduced amount of time, but are not able to prove its optimality, though. An approach based on the Biased Random-Key Genetic Algorithm (BRKGA) is introduced here. The performance of the exact solver is evaluated against the BRKGA on a set of instances built from real data of a large Portuguese hospital. Results

show that the heuristic approach is able to generate near-optimal solutions in a small fraction of time for small instances, and good-quality solutions for the bigger instances.

This work is financed by the ERDF - European Regional Development Fund through the COMPETE Programme (operational programme for competitiveness) and by National Funds through the FCT - Fundação para a Ciência e a Tecnologia (Portuguese Foundation for Science and Technology) within project FCOMP-01-0124-FEDER-037281.

Keywords: surgery scheduling; rolling horizon; genetic algorithm.

FA2

9:00 - 11:00

Healthcare Planning (3)

Room: 6.2.53

chair: Vincent Knight

1 - A model of system dynamics for the study the problem the hospital length of stay, the evaluation of solution alternative and the efficiency of the bed resource

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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 of the bed and the agility of the services provided in hospitals. 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. This research, addressed the need for the health system to reduce hospital length of stay, starting with the identification of modifiable factors that prolong hospital length of stay, the methodologies that have been used and the selection of the most appropriate methodology to study the problem. In addition, a methodology is proposed to identify the population which prolongs hospital length of stay based on diagnosis related groups, since, the hospital length of stay is not only related to problems in the efficiency of clinical management, if not also the characteristics of the patients. The result of the investigation, is a dynamic hypothesis explaining the systemic and causal relationships of the variables that affect the problem of hospital length of stay. There is also, a model of system dynamics that allows to study the problem and seek alternative solutions.

Keywords: hospital length of stay; system dynamics; hospital bed efficiency.

2 - Modelling phototherapy for dermatology services in Wales

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Cardiff University School of Mathematics and Aneurin Bevan Academic Dermatology have recently collaborated on a series of research projects, investigating and challenging the current infrastructure of

dermatology services for the treatment of psoriasis in Wales. Phototherapy is considered to be one of the most effective and preferable forms of treatment for psoriasis; however, a number of factors impair patient access to phototherapy, including capacity limitations, waiting lists, large travel distances to clinics and inconvenience in treatment times, treatment lengths and transport. Most patients living in rural Wales are deemed to have no access to phototherapy, and across Wales, the dropout rate of treatment is high. These factors result in a large number of patients being unnecessarily prescribed alternative, easily accessible, yet expensive and risky therapies. Location analysis and simulation techniques were utilised in order to determine bottlenecks in the system, patient flow alternatives and optimal configurations of the service. The studies verified that since phototherapy is underutilised, strategic placement of phototherapy clinics at existing healthcare facilities would go some way to improving access, but that introducing home phototherapy kits could dramatically develop the service, capturing all prospective phototherapy patients. A developed tool produces details of the locations of new phototherapy clinics (in addition to existing centres) that would improve access for the population. By estimating the number of additional patients undergoing phototherapy (instead of alternatives) with this configuration, substantial savings to the health service can also be seen. Some members of the population however, would still be located far from the phototherapy centres, or might find it difficult to attend a clinic; therefore, by optimising the balance of both hospital-based and home phototherapy care using the tool, dermatology services could be greatly enhanced, resulting in improvement of patient care, access and waiting times, with considerable monetary savings.

Keywords: location-allocation; coverage; dermatology services; service access.

3 - Clinical pathway mining for downstream and upstream planning of hospital-wide patient flow

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The evaluation of downstream and upstream planning in the delivery of healthcare services has been the scope of recent research. This study examines the value of information of clinical pathways (CPs) for downstream and upstream planning. CPs represent standardized care processes for the treatment of patients. On a strategic level, i.e. at the point when it is decided to assign specialties to locations within hospitals, CPs should be known in advance to minimize distances traveled by patients. In contrast, on an operational level, CPs are employed to decide which patient should allocate which resource on which day in order to reduce length of stay. The challenge of this research is to dovetail the prediction of uncertain clinical pathways with downstream and upstream planning in the delivery of healthcare services. We approach this problem in two stages. In a first stage, we adapt a machine learning approach based on automata theory to learn significant CPs from data. We compare the performance of the machine learning approach with the one of a baseline approach. In a second stage, we develop two mathematical models. The first model is a layout planning model that minimizes distances traveled by patients given their CPs while the second model is a patient scheduling problem that minimizes lengths of stay given CPs. We plug in the CPs from the first stage into the mathematical models and evaluate them based on data from a collaborating hospital.

Keywords: clinical pathways; hospital layout planning; patient scheduling; machine learning; mathematical programming.

4 - Measuring the price of anarchy in critical care unit interactions

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Hospital throughput is often studied and optimised in isolation, ignoring the interactions between hospitals. In this paper Critical Care Unit interaction is placed within a game theoretic framework. The methodology involves the use of a normal form game underpinned by a two dimensional continuous Markov chain. A theoretical result is given that ensures the existence of a Nash equilibrium. The effect of target policies is investigated justifying the use of these to align the interests of individual hospitals and social welfare. In particular, we identify the lowest value of a utilisation target that aligns these.

Keywords: game theory; queueing theory; CCU.

5 - A thematic analysis of leader attitudes toward re-conceptualizing the excellence model in hospitals

Ali Taghizadeh Herat, taghizadeh.herat@gmail.com

Co-author(s): Rassoul Noorossana; Shadab Safaee.

Excellence Models are widely used in different sectors such as health care. Iran Ministry of Health and Medical Education (MHME) began to implement Organizational Excellence Model (OEM) in hospitals since 2007. Recently, it has been the subject of interest to re-conceptualize this model in health care sector. To reach this goal, an important step is to survey the leaders in different hospitals about implementing OEM which would be specified for hospitals. This paper aims to provide and analysis the results of this survey. The related survey consists of six open questions. The questionnaire is designed according to the experts' opinions. After submitting the questionnaires to Iranian hospital leaders which have experiences in implementing OEM in their hospitals, 173 questionnaires were filled. The answers are analyzed using thematic analysis method. After thematic analysis, six main themes are extracted. Survey results indicate that increasing commitment and participation among people is the most important achievement of the hospitals in using OEM. Also participation of people in all organizational levels in the process of using OEM is the most considered way to integrate the staffs in all organizational levels.

FA3

9:00 - 11:00

Disease Modeling and Policy (3)

Room: 6.2.56

chair: Christos Vasilakis

1 - Evaluating an innovative approach to the diagnostic processes for glaucoma: the role for operational research in a mixed methods study

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Understanding the organisational and operational context in which proposed changes to the delivery of services in health care organisations take place is critical for improving the likelihood of their implementation. The aim of this feasibility study was to design an evaluation framework for assessing

the acceptability, implementation, cost and cost-effectiveness of an innovative service configuration for "streamlining" outpatient glaucoma clinics within a specialist hospital in England. The study followed a mixed methods design combining qualitative research, operational research and cost-effectiveness analysis. It involved investigating how outpatient glaucoma clinics are currently provided and collecting information about the aims, intended outcomes and main process changes involved in the development of the new service. The use of interviews and observational data afforded a fine-grained analysis of the organisational context for innovation, enabling the likely effects of implementing change to be described from the perspective of a range of clinical and managerial staff. Operational research was used to build an understanding of the problem the innovative service configuration was intended to address from the perspective of patient flows. In particular, we developed an analytical model to help understand the impact of follow-up intervals on weekly demand for clinic appointments over time. This is a particularly challenging aspect of the organisation of glaucoma outpatient clinics as the majority of patients require life-long monitoring of their conditions. Two models were developed: a) the base model which considers new referral rate, follow-up appointment patterns, and discharge rates to calculate long-term steady-state weekly demand rates for an outpatient clinic, and b) a second model which loosely depicts the new service configuration by adding a second clinic that is used to refer a proportion of follow-up appointments from the main clinic. For both models, we observed how the weekly steady-state demand is influenced by changes in the decision variables.

Keywords: mixed methods research; patient flow models; ophthalmology; outpatient services; evaluation.

2 - The impact of possible early interventions in Alzheimer's disease

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Objective: The possibility to detect Alzheimer's disease in pre-symptomatic stages opens a crucial avenue to prevention strategies aimed at delaying or preventing the onset of dementia. The prevention of Alzheimer's disease may arise on two fronts: 1) use of specific etiopathogenic therapy in people with pre-symptomatic AD or 2) interventions aimed at controlling associated risk factors. The purpose of this project was to study the impact of different interventions targeted to prevent dementia at medium-long term. **Methods** A discrete event simulation model in Arena was built to represent the natural history of Alzheimer's disease. The model starts with the general population distributed according to the risk factors or metabolic risks associated to Alzheimer's disease (obesity, hypertension, hypercholesterolemia, physical activity and education). The capacity of the model to reproduce the epidemiology of Alzheimer's disease was evaluated by validating the preclinical stage (Nelson & Braak J Neuropathol Exp Neurol 2009) and the dementia stage (Lobo & Launer Neurology 2000). Data were projected until 2050 according to demographic changes. Subsequently the impact of various interventions were studied: 1) we analyzed what might have happened if obesity and hypertension prevalence had been 30% lower and 2) the effect of two hypothetical interventions which would lengthen the prodromal phase by 25% and 40% was analyzed. **Results:** The prevalence in 2010 represents 5.3% of the elderly population (over 70 years old) and it will duplicate by 2030 if action is not taken. Controlling obesity could reduce the prevalence by 4.8% and controlling hypertension by 4.0%. Treatments aimed at the prodromal stage could get the load to be 15.3%- 19.2% lower. **Conclusions:** The interventions targeted for Alzheimer's disease entail a significant reduction in its burden. The discrete event simulation model allowed estimating the impact in the medium and long term.

Keywords: Alzheimer's disease; prevention; risk factors; discrete event simulation.

3 - Determinants of healthcare utilization in hypertensive patients: a longitudinal analysis

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DIMATCH-HTA (FCT PTDC/SAU-ESA/103511/2008) is a cohort study conducted to identify determinants of blood pressure control among Portuguese-speaking African immigrants and Portuguese natives. The aim of this analysis was to characterize the determinants of health care utilization among hypertensive patients followed at Primary Health Care level. The sample comprises 1243 unbalanced observations from 513 patients. Data were collected through questionnaires administered face-to-face at baseline, 6 and 12 months, and by telephone at 3 and 9 months after enrolment. Number of visits to the general practitioner related to hypertension, in the three months prior to each interview, was the variable used to capture health care utilization. Covariates were chosen based on Grossman's health capital model of demand for health (1972) and Andersen conceptual model (1968). Amongst socioeconomic covariates, gender, age, ethnicity, education, monthly equivalent income, living alone and domestic work were considered. Health status was captured by the presence of diabetes, time since hypertension diagnosis and number of medicines. Self-perception of hypertension and possession of private health insurance were also included. A GLMM model for count data, with a random effect on intercept was estimated. Model adequacy was checked via residual analysis and comparison of observed and predicted values. The analysis was performed in R (version 3.0.2) using lme4 package. Results of estimated model indicated that total number of medicines ($\beta=0.05$, $p\text{-value}=0.03$) and diabetes ($\beta=0.40$, $p\text{-value}=0.01$) have significant positive impact on health care consumption. Patients whose occupation is domestic work have higher healthcare utilization ($\beta=0.73$, $p\text{-value}=0.02$). On the other hand, those who self-assess their hypertension as controlled ($\beta=-0.37$, $p\text{-value}=0.02$) and patients with higher income (in log scale, $\beta=-0.26$, $p\text{-value}=0.01$) have less visits to general practitioner related to hypertension. Based on the analysis, it seems that variables related to health status, but also socioeconomic determinants, impact healthcare utilization in hypertension.

Keywords: hypertension; health care utilization; longitudinal count model.

4 - Technology and inequity in health: geographical distribution of glucometers in the control of diabetes

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Technological innovation plays an important role in the dynamics of economic growth and promoting the welfare of the population. However studies on the access and provision, of biotechnology and image technologies are often biased on social, economic geographic characteristics. This study assesses the pattern of access to a device for insulin administration (glucometers), by patients with Diabetes mellitus in the public healthcare system in Salvador, state of Bahia, from 1998 to 2012. To achieve the proposed objective a combination of strategies for the collection and analysis of data, applying spatial statistics and an econometric model of discrete choice were used. The research addresses to the following questions: What are the factors that affect access of insulin dependent patients to necessary inputs for diabetes control? Is it possible to bring evidence of inequities, based on social economic and geographical variables, in the access to the technologies for effective diabetes control? Data were collect from 6,249 patients, all in use of insulin, residing in Salvador City in the State of Bahia that receives medical treatment

from the public health system - SUS. Only 1,941 (31,1 %) had access to the glucometer. Data were collected from a registry of patients with diabetes, and Exploratory Spatial Data Analysis (ESDA) was performed through the Global Spatial Autocorrelation Index showing a positive autocorrelation to both the diabetic patients (0,1945) and glucometers (0.1349) distributed in two clusters in different locations, one close to the provider institution. An econometric analysis using a logit and probit model performed on the data shows significant random variation in the distribution of glucometers. Random factors, largely determined the probability of access to obtaining the glucometer. Individual characteristics did not increase the likelihood of obtaining the glucometer, but rather the severity of the diabetes and the date enrolled in the program.

Keywords: technology; inequity; public health; diabetes.

5 - Making the case for case management: identifying high-risk diabetes patients

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Case management programs for chronic care have long struggled to be cost saving interventions. The effectiveness of these programs is strongly dependent on the patient cohort selected for management. Case management is only effective in lowering costs when it prevents a healthy, low cost patient, from becoming a sick, high cost patient. In this work, we build predictive models to identify these patients. Specifically, we seek to identify members with current health care costs below the mean (\$5850 per year, in our data set) that will become high cost patients (defined as the costliest 10% of patients). Using association rules mined from the data, and regression models, we predict future healthcare cost of diabetic patients who have below average costs. The average cost for patients predicted to be in the top 10% of costs is \$8070, compared to \$4106 for the lower 90%. The patients predicted to be in the costliest 1% averaged \$12,400 in costs. The model has an area under the ROC curve of 0.64, predicting which patients will move into the top 10% of costs. Our predictive models also give us insight into which types of patients are likely to become high cost patients in the future. We show that claims indicating heart issues and claims related to poor management of care lead to larger increases in the future, whereas one-time expenses and preventative care tend to lead to lower future costs. Through the use of association rules, we also show that combinations of diseases can lead to further increases in cost than their individual components.

Keywords: chronic care; predictive analytics; case management.

6 - Assessment of users satisfaction rate of Isfahan University of Medical

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Introduction: Hospital libraries as the receiving center of newest result and findings of medical sciences and publishing up to date scientific information to their referral play a determinative role. These libraries role cannot be ignored in education, investigation and presenting up to date information to their referrals. The purpose of this research was determined to assessing user's satisfaction rate of Isfahan University of Medical Sciences 'Libraries. Methods: The present research showed %50 on the overage was satisfied with the collection of libraries understudied. And %31/1 their satisfaction was low and %19/2 were quite satisfied also about the referral satisfaction of computer services, indicated that %56/5 a little and %28 on the average were satisfied. But about satisfaction of human force %36/9 and 13/4 on the average have expressed the satisfaction, also, %42/5 of referral were highly satisfied of physical

spaces and buildings of libraries and %18/8 on the average and in relation to trust wards of libraries, 33/5 had law satisfaction and %42/5 on the average satisfaction. Conclusions: Results showed that a considerable percentage of referrals to under expressed their satisfaction of the collection of the libraries, computer services, building, physical space and trust ward, on the overage rate and the percentage of dissatisfaction cases has been more than perfect satisfaction cases.

Keywords: Isfahan University of Medical Sciences; hospital libraries; satisfaction; users.

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