

# Stochastic dynamic nursing service budgeting

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# **ORAHS'2007**

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## **The 33<sup>rd</sup> International Conference on Operational Research Applied to Health Services**

***Saint-Étienne, France  
15 – 20 July 2007***



**Organized by**

**École Nationale Supérieure des Mines de Saint-Étienne  
Centre Hospitalier Universitaire de Saint-Étienne  
Université Jean Monnet**

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**IFR143  
IFRESIS**



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# Welcome!

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## Welcome from the Conference Chairs

As conference chairs, we are delighted to welcome all conference participants and their accompanying persons to the 33<sup>rd</sup> International Conference on Operational Research Applied to Health Services (ORAHS'2007).

ORAHS is the annual meeting of the EURO Working Group on Operational Research Applied to Health Services that has at present 112 members from 22 countries, mainly in Europe but also with 17 from overseas.

ORAHS'2007, sponsored by EURO, ROADEF, GDR-RO, GDR-MACS, is **a unique international conference since over 30 years on engineering and management of health care delivery** including issues related to design and management of health care systems and clinical applications. It aims bringing together researchers, health professionals, IT solution providers and consultants in the area.

ORAHS'2007 comes back to France after 27 years since ORAHS'80 in Paris. Health system has drastically changed and health care delivery engineering has attracted a lot of interests of academics. Many French hospitals have been engaged in major re-engineering projects. The French speaking working group GISEH (Gestion et Ingénierie des Systèmes Hospitaliers) attracts over 120 members in management and engineering of healthcare systems. The region of Rhone-Alps fund since 2000 several major research programmes on health services engineering (HRP (2000-2003), HRP2 (2004-2006), HRP3 (2006-2010)). In Saint Etienne, the Ecole des Mines de Saint Etienne (ENSM.SE, a top-10 graduate engineering school in France), the University of Jean Monnet (UJM) and the University Hospital Complex CHU-SE have created a joint research institute in health and health care. It is the right time for France to play a major role in ORAHS.

ORAHS'2007 offers an impressive and intensive scientific program with six tutorial lectures, 8 invited plenary talks, and 102 technical presentations covering various aspects of health care delivery engineering. While preserving the traditions of ORAHS conferences, ORAHS'2007 introduces some innovations that, we hope, contribute to make ORAHS a truly international conference in a domain of increasing demands and to spread OR in health. Feature sessions are organized by several national/regional working groups on management and engineering of health care systems for picturing research in the world on health care engineering. A "Project Ideas" of short presentation of 5-10 mins seeks to identify challenges of health care delivery that need joint European and international research efforts. Tutorial talks of 2 hours each by 6 world renown experts are organized to give young researchers and health professionals a comprehensive view of in healthcare delivery engineering.

ORAHS'2007 is jointly organised by ENSM.SE, UJM and CHU-SE. It is our great pleasure to thank everyone that helped make ORAHS'2007 a reality. We are especially grateful to tutorial lecturers and keynote speakers David Bensley, Mike Carter, Ruth Davies, Denis Debrosse, Frank Dexter, Eva Lee, Yasar Ozcan, Rober Reichert, Arjan Shahani and Sébastien Wonyar. Our thanks also go to feature session organisers Frank Dexter, Alain Guinet, Erwin Hans, Aida Jebali, Frédérique Laforest and Christine Verdier. Special thanks go to members of the organizing team especially Françoise Bresson and Fatiha Adsi for their effort and excellent work.

Xiaolan Xie (Conference chair)  
Françoise Lorca (Organizing co-chair)  
Eric Marcon (Organizing co-chair)

# Committees

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## International Program Committee

- Xiaolan Xie (FR), Program chair
- Hari Balasubramanian (USA)
- Sally Brailsford (UK)
- Michael Carter (CA)
- Thierry J. Chaussalet (UK)
- Vanda De Angelis (IT)
- Franklin Dexter (USA)
- Steve Gallivan (UK)
- Michel Gourgand (FR)
- Alain Guinet (FR)
- Erwin Hans (NL)
- Zhibin Jiang (CN)
- Pierre Ladet (FR)
- Eva Lee (USA)
- Liming Liu (CN)
- Françoise Lorca (FR)
- Eric Marcon (FR)
- Nadine Meskens (BE)
- Stefan Nickel (D)
- Yasar A. Ozcan (USA)
- Marion Rauner (AT)
- François Sainfort (USA)
- Arjan Shahani (UK)
- Leyuan Shi (USA)
- Christian Tahon (FR)
- Joseph Tan (USA)
- Christine Verdier (FR)
- Jan Vissers (NL)
- Philippe Wieser (CH)

## Organizing Committee

- Xiaolan Xie (FR), co-chair
- Eric Marcon (FR), co-chair
- Françoise Lorca (FR), co-chair
- Didier Bernache (FR)
- Alexandre Dolgui (FR)
- Frederic Grimaud (FR)
- Johann Dréo (FR)
- Françoise Bresson (FR)
- Fatiha Adsi (FR)
- Mehdi Lamiri (FR)
- Vincent Augusto (FR)

## Sponsors

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We are most grateful for the support from the following ORAHS'2007 sponsors:



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Rhône-Alpes Région





## Practical Information

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### Meeting Location

The meeting will be held within the École Nationale Supérieure des Mines de Saint-Étienne, in the **Espace Fauriel building (1)**. We will use two lecture theatres (*amphi*) and one lecture room for presentations during the conference, as there are occasions when parallel sessions are necessary :

- **amphi 022** (entre-sol);
- **amphi 104** (level 1);
- **room 214** (level 1).

In addition, two working rooms (224 and 230) will be available for delegates.

The Espace Fauriel building is 1.5 kilometer away from the city center or from the **Châteaureux railway station (2)**. It is easily accessible by bus (stop “Centre des Congrès”) or taxi. Allow 20 to 30 minutes if you want to walk!

For delegates staying at the listed hotels (**Astoria (5)**, **Mercure (4)**, **Tenor (3)** or the **Student Residence (6)**), the Espace Fauriel is only about a 15 minutes walk. All event places are easily reached by foot (see the maps on the two next pages).

### Welcome Party and Registration

The welcome party and registration will take place on Sunday 15th July (6:00pm – 9:00pm) in the **Espace Fauriel (1)** on level 6.

### Meals

- **Lunch** for delegates will be served in the **Espace Fauriel (1)** on level 6.
- **Reception on Monday** (for delegates and accompanying people) will be given in the **Art and Industry Museum (7)**.
- **Dinner on the Wednesday** will be included in the half-day outing to Lyon (for all delegates and accompanying people).
- **Gala diner** takes place Thursday evening in the **Le Flore restaurant (8)**.

More details on the social programme can be found in the following pages.

### E-mail and Internet

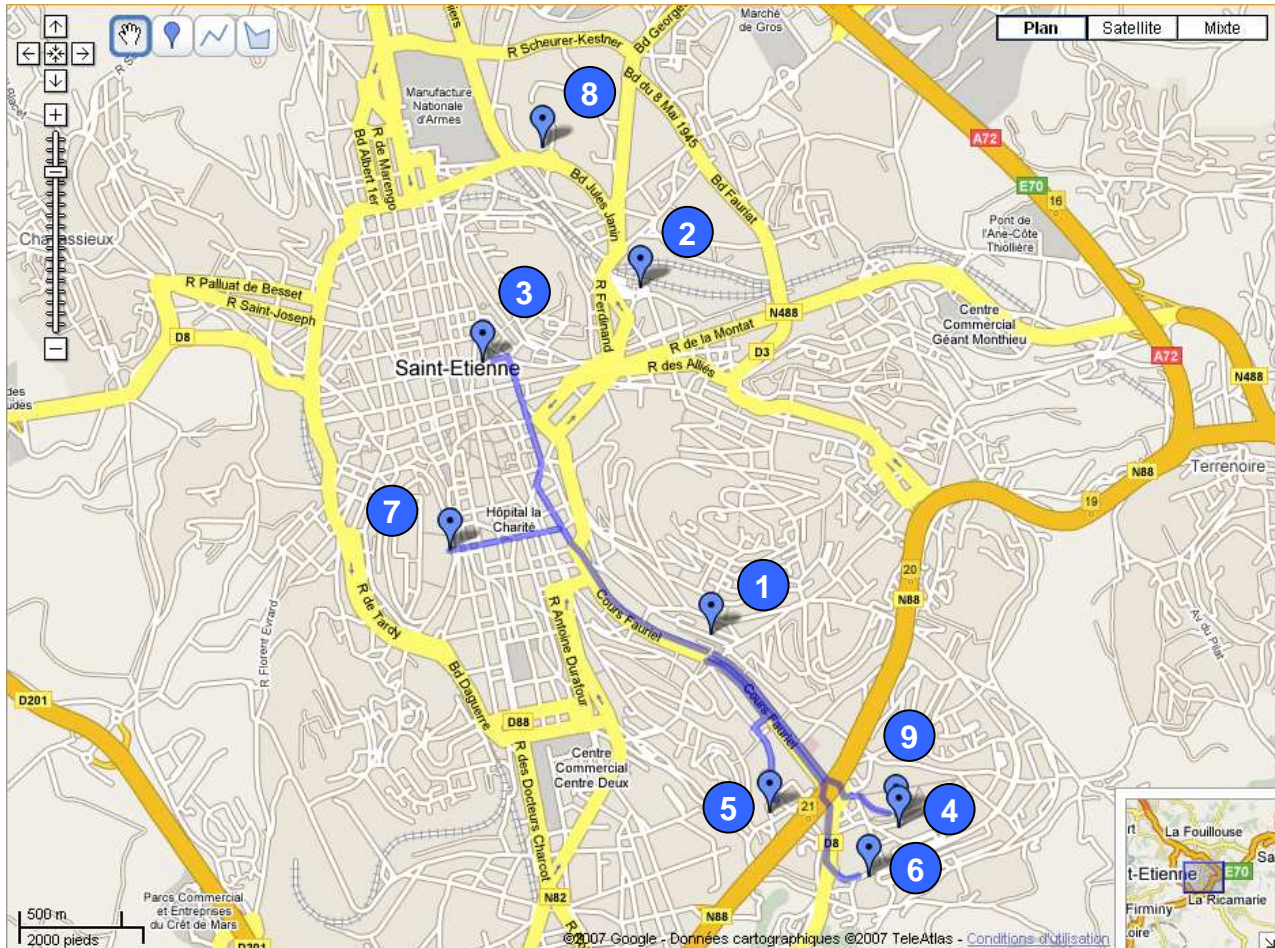
Internet access (LAN and WIFI) is available in the Espace Fauriel. Details of access will be provided at the conference.

### Emergency Contact

In case of emergency, you can reach Mehdi (06 83 91 17 71), Vincent (06 81 02 98 84) or Xiaolan (06 63 19 04 69) by phone.

## Practical Information

ORAHS'2007 will be held at the École Nationale Supérieure des Mines de Saint-Étienne. More precisely, the conference will be held in the Espace Fauriel. The following maps indicates the locations of the social events of the conference.

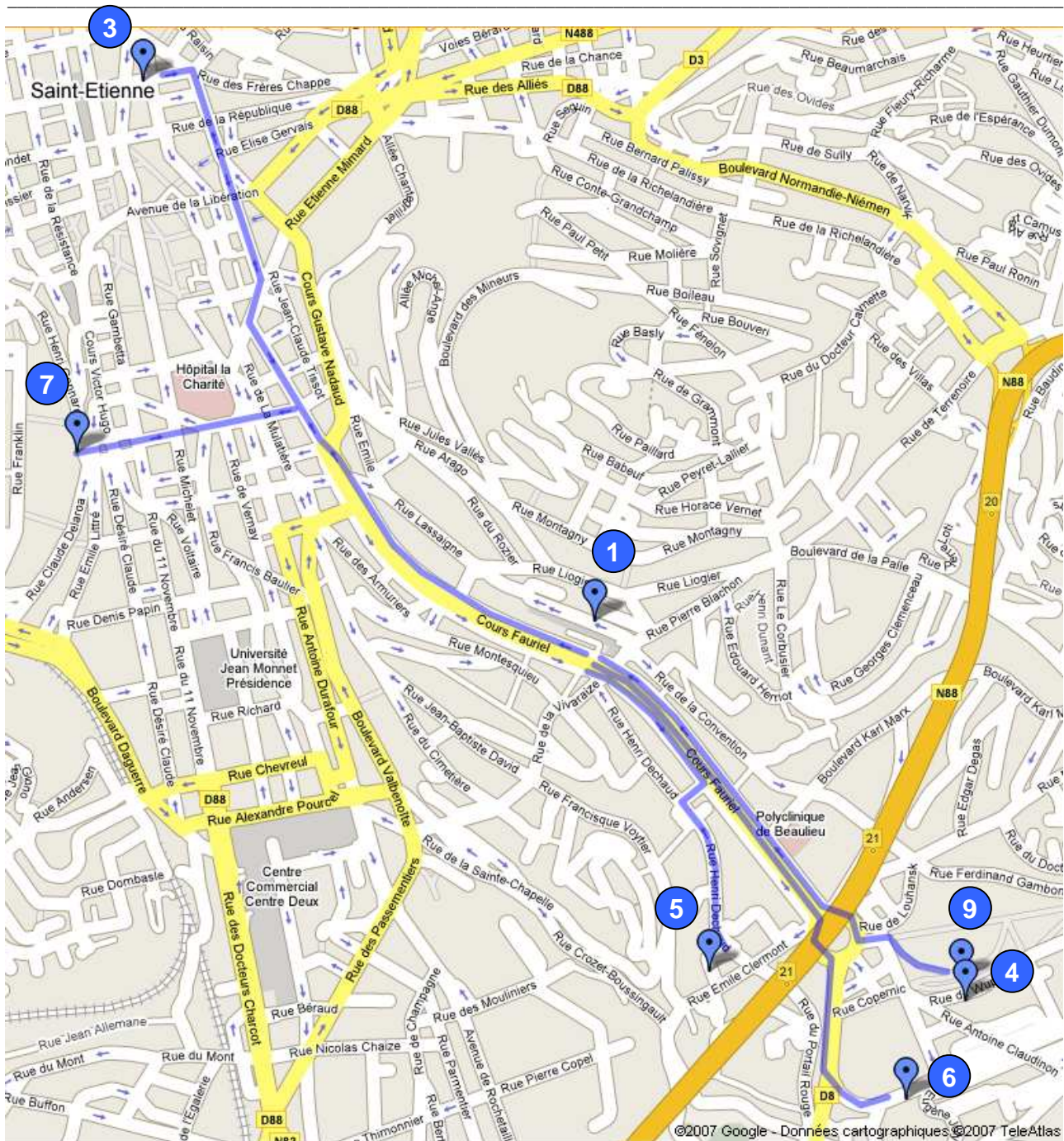


General map of Saint- Étienne.

- (1) Espace Fauriel, conference venue and welcome party (sunday, 6:00pm – 8:00pm).  
35 rue Ponchardier 42031 Saint-Etienne
- (2) Chateaucieux Railway Station.
- (3) Tenor Hotel.
- (4) Mercure Hotel.
- (5) Astoria Hotel.
- (6) Student's Hall Residence.



## Practical Information



Map details and foot pathways.

- (7) Reception at the Art and Industry Museum (Monday, 7:00pm – 9:00pm).  
2 place Louis Comte, 42000 Saint-Etienne.
- (8) Gala dinner at the Le Flore restaurant (Thursday, 8:00pm – midnight).  
31 boulevard Jules Janin 42000 Saint-Etienne.
- (9) Bowls game tournament at the Europe Square (Tuesday, 7:00pm – 9:00pm, if shiny weather).

## Social Programme

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	Delegates	Accompanying persons
<b>SUNDAY</b>	<p style="text-align: center;">6:00pm – 9:00pm  <b>Welcome party at the Espace Fauriel (1).</b></p>	
<b>MONDAY</b>		<p>9:00am – 6:00pm  <b>Mining museum (am).</b>  <b>Guided tour of the city of Saint-Etienne (pm).</b></p>
	<p style="text-align: center;">7:30pm – 9:00pm  <b>Reception at the Art and Industry Museum (7).</b></p>	
<b>TUESDAY</b>		<p>9:00am – 6:00pm  <b>Le Puy en Velay.</b>  <b>The gorges of the Loire river.</b>  <b>Saint Victor sur Loire (medieval village).</b></p>
	<p style="text-align: center;">7:00pm – 9:00pm  <b>Game of bawls party in the Europe Square (9).</b></p>	
<b>WEDNESDAY</b>	<p style="text-align: center;">2:00pm – midnight  <b>Excursion to Lyon</b></p> <ul style="list-style-type: none"> <li>- Visit of the Vieux Lyon, a UNESCO world heritage;</li> <li>- Boat trip on the Saone River;</li> <li>- Diner at the Brasserie Georges of traditional Lyon's cuisine.</li> </ul>	
<b>THURSDAY</b>		<p>9:00am – 6:00pm  <b>The Galo-Roman city Vienne.</b>  <b>Tour in the winery area of Côte Rôtie.</b></p>
	<p style="text-align: center;">8:00pm – midnight  <b>Gala diner at the Restaurant "Le Flore" (8).</b></p>	

# Scientific Programme Overview

Monday July 16		
08h00	<b>Registration</b>	<b>Tutorial track</b>
08h45	<b>Opening ceremony</b> <b>Amphi 022</b> <b>Robert Germinet</b> , Director of ENSM.SE. <b>Didier Bernache</b> , Director of the Engineering & Health Division, ENSM.SE. <b>Jan Vissers</b> , Chairman of ORAHS. <b>Xiaolan Xie</b> , Program chair of ORAHS'2007.	<b>8h30 – 10h20</b> <b>Franklin Dexter</b> <b>Amphi 104</b> Making tactical (budget/financial) decisions based on allocations of OR block time for outpatient and inpatient surgery
09h30	<b>1A Local Health policies and Operations Research in Health care</b> <b>Amphi 022</b> - Chair: Xiaolan Xie <b>Denis Debrosse</b> , Conseiller Général des Hopitaux, Ministère de la Santé, FR <i>National health policies (SROS, Hôpital 2007-2012)</i> <b>David Bensley</b> , Operational Research Programme Manager, Dpt of Health, UK <i>OR Contributions and Challenges in Health Care</i>	<b>10h20 – 10h40</b> <b>Coffee break</b>
11h00	<b>Coffee break</b>	<b>10h40 – 12h30</b>
11h20	<b>1B Local Health policies and Operations Research in Health care</b> <b>Amphi 022</b> - Chair: Xiaolan Xie <b>Robert Reichert</b> , Chairman & CEO, CHU-Saint Etienne, France <i>Reengineering a large teaching hospital</i> <b>Sebastien Woynar</b> , Mission Nationale d'Expertise et d'Audit Hospitaliers, FR <i>Evaluation and auditing of French health care systems</i>	<b>Yasar A. Ozcan</b> <b>Amphi 104</b> Benchmarking & performance evaluation in health care: DEA approach
12h40	<b>Lunch</b>	
14h00	<b>2 Operating theatre optimization</b> <b>Amphi 022</b> - Chair: Franklin Dexter <b>Jeroen M. van Oostrum</b> - Improving OR efficiency by applying bin packing and portfolio techniques to surgical case scheduling <b>Ruth E Wachtel</b> - Reducing tardiness in the start times of surgical cases <b>Frank Dexter</b> - Coordination of appointments for anesthesia care outside of operating rooms using an enterprise-wide scheduling system <b>Natalie Smith-Guerin</b> - Proposal for the planning of the nurses in operating theatre	<b>3 Patient flow planning</b> <b>Room 214</b> - Chair: Ruth Davies <b>Jan Vissers</b> - Patient mix optimisation and resource allocation: a case study in cardiothoracic surgery planning <b>Marc Haspeslagh</b> - Patient allocation on the basis of competence: conceptual considerations and measurement difficulties <b>J.J.W. Molema</b> , Improving patient flow in a hospital <b>Stefano Villa</b> - Restructuring patient flow logistics around the level of intensity of care: Implications and practicalities
15h30	<b>4 French research initiatives</b> <b>Amphi 022</b> - Chair: Jan Vissers <b>Michel Baer</b> , SAMU92, APHP, Paris & coord. of the EU project HESCUAEP <i>HESCUAEP for an improved coordination in a pre-hospital setting</i> <b>Alain Guinet</b> , INSA-Lyon & coordinator of GISEH group <i>Engineering and management of health services</i> <b>Eric Marcon</b> , UJM & coordinator of HRP3 project <i>Engineering the emergency care delivery network</i>	<b>14h00 – 15h50</b> <b>Michael Carter</b> <b>Amphi 104</b> Simulation modeling in health care: some examples and lessons learned <b>15h50 – 16h10</b> <b>Coffee break</b> <b>16h10 – 18h00</b> <b>Arjan Shahani</b> <b>Amphi 104</b> Practical models for health care and health services
16h30	<b>Coffee break</b>	
16h50	<b>5 New paradigm</b> <b>Amphi 022</b> - Chair: Yasar A. Ozcan <b>Luciano Brandao de Souza</b> - Launching lean thinking at the University Hospitals of Morecambe Bay NHS Trust in the UK <b>Ruth Davies</b> - Leaning an emergency department <b>Frédéric ALBERT</b> - Hospital reorganization: how to help decision makers? <b>Murat M.Gunal</b> - Waiting lists, performance targets, and simulation for alternatives in reducing patient backlog	<b>6 Health informatics &amp; information systems</b> <b>Room 214</b> - Chairs: F. Laforest & C. Verdier <b>David Télisson</b> - Ambient intelligent and pervasive architecture designed within the EPI-MEDICS personal ECG monitor <b>Françoise Vendittelli</b> - The AUDIPOG sentinel network: a tool built by perinatal professionals for professionals <b>M. Lamure</b> - New information technologies and governance of health care institutions <b>N. Javaux</b> - Computerized medical file at patient's bedside
18h20		
19h30		
21h00	<b>Reception at the Art and Industry Museum</b>	



# Scientific Programme Overview

Tuesday July 17			
08h30	<b>7 Staffing and capacity planning I</b> <b>Amphi 022</b> - Chair: Sally Brailsford  <b>G. Celano</b> - Using simulation to test the staffing reconfiguration in a speech therapy ambulatory care <b>Mariel S. Lavieri</b> - Optimizing nursing human resource planning <b>Gergely Mincsovics</b> - Stochastic dynamic nursing service budgeting <b>Sally Brailsford</b> -Modelling the effects of workforce change in emergency care in the UK	<b>8 Health information systems I</b> <b>Room 214</b> - Chair: Paul Harper  <b>Red Ceglowski</b> - Text mining emergency department “reason for presentation” data <b>Paul Harper</b> - TreeFit: the development and use of a powerful decision tree data mining tool <b>Lei Zhao</b> , The impact of clinical decisions in In Vitro fertilization-embryo transfer <b>Joseph Tan</b> - Using E-Health for Physicians' Decision Making to Combat HIV/Aids in Sub-Saharan African	<b>8h30 – 10h20</b> <b>Ruth Davies</b> <b>Amphi 104</b> Fit for purpose - a taxonomy of models for disease modelling  <b>10h20 – 10h40</b> <b>Coffee break</b>  <b>10h40 – 12h30</b> <b>Eva Lee</b> <b>Amphi 104</b> Optimization in medicine and health care
10h00	<b>Coffee break</b>		
10h20	<b>9 Healthcare delivery engineering in Mediterranean</b> <b>Amphi 022</b> - Chair: Aida Jebali  <b>Sondes Hammami</b> - Supplying the operating theatre: disposables products or reused products <b>Hanen Bouchriha</b> - Toward a decision tool for home care planning <b>Houda Tlahig</b> - A mathematical model for the “make” or “buy” decision in the hospital sterilization <b>Sondes Hammami</b> - Joint replenishment for the operating room	<b>10 Modelling and simulation I</b> <b>Room 214</b> - Chair: John T. Blake  <b>Brijesh Patel</b> - Taxonomy of modelling and simulation methods in healthcare: emerging findings of the Research Into Global Healthcare Toolkit (RIGHT) <b>Dave Worthington</b> - What is a 'generic' hospital model? <b>Vincent Augusto</b> - A simulation framework for health care systems <b>John T. Blake</b> - Getting OR Tools into the Hands of Users: Development of a Blood Donor Clinic Simulation	
11h50	<b>Plenary talk</b> <b>Amphi 022</b> - Chair: David Bensley  <b>Michael Carter</b> , University of Toronto, CA <i>The Role of Operations Research in Health Care Planning and Policy Making</i>		
12h40	<b>Lunch</b>		
14h00	<b>Field visit at the CHU-Saint Etienne</b>		
17h00	- Visit of an automated biological examination platform ; - Visit of the new operating theatre ; - Visit of the logistic department.		
17h30	<b>11 Project ideas for international collaborative research</b> <b>Amphi 022</b> - Chair: Bart Veltman  Program to be announced.		
19h00			
19h30 21h00	<b>Bawls game party at the Europe Square</b>		

# Scientific Programme Overview

Wednesday July 18	
08h30	<b>12</b> Software solutions in health care <b>Amphi 022</b> - Chair : Michael Carter  <b>Bart Veltman</b> (ORTEC, NL) Providing Software Solutions for Health Care Delivery <b>Sofiane Oussedik</b> (ILOG, FR) Building Interactive Decision Aid applications, a Nurse Scheduling case study
09h20	<b>13</b> Staffing and capacity planning II <b>Amphi 022</b> - Chair: Arjan Shahani  <b>Md. Asaduzzaman</b> - Capacity Planning Issues in Neonatal Care Networks in UK: A Case Study on North Central London Perinatal Network <b>Christina Pagel</b> - The dynamic forecasting of short to medium term workload based on current case mix <b>WANG Tao</b> - A sizing tool for allocation planning of hospital bed resources <b>A.K. Shahani</b> - Detailed Models for Capacities and Organisation of Critical Care Units for Cardiac Patients
10h50	<b>14</b> Emergency care <b>Amphi 104</b> - Chair: Mario Jorge Ferreira de Oliveira  <b>Aissam Belaidi</b> - Identifying and Modelling decision problems for emergency network in France: a literature review and analysis <b>Ali Vahit Esensoy</b> - Evaluation of Ambulance Transfers Into Urgent Care Centres To Improve Ambulance Availability & Reduce Offload Delays <b>Ana Paula Iannoni</b> - Analyzing large scale emergency medical systems on highways using an approximated hypercube queuing model <b>Mario Jorge Ferreira de Oliveira</b> - The accessibility and quality of the emergency service of a public hospital in the municipality of Resende, Rio de Janeiro
10h50 11h10	Coffee break
11h10	<b>15</b> Operating rooms planning I <b>Amphi 022</b> - Chair: Erik Demeulemeester  <b>Mehdi LAMIRI</b> - Surgery Planning with Uncertain Operating Times <b>Brecht Cardoen</b> - Determining surgery schedules on the operational level through column generation <b>Angela Testi</b> - Planning surgical activities: a societal point of view <b>A. Hanset</b> - Limited-time decision making with Tabu search for an operating theatre daily scheduling problem
12h40	<b>16</b> Modelling and simulation II <b>Amphi 104</b> - Chair: Peter Williams  <b>Philip Ruttle</b> - An examination of preoperative assessment using simulation modelling <b>Mario Jorge Ferreira de Oliveira</b> - The multi-user simulation of the emergency department of Brazilian hospital: three views of the admission process <b>Virginie André</b> - Modelling and simulation of logistic flows <b>Martin Pitt</b> - Addressing the model-decision making interface – A key requirement for operational research in healthcare
12h40 14h00	Lunch
14h00	<b>Social outing: Excursion to Lyon</b>  - Visit of the Vieux Lyon (Old town), a UNESCO world heritage site - Boat trip on the Saone River - Diner at the Brasserie Georges of traditional Lyon's cuisine
24h00	...plus a lot of fun and songs for making friends!

# Scientific Programme Overview

Thursday July 19		
09h00	<b>17 Operating rooms planning II</b> <b>Amphi 022</b> - Chair: Eric Marcon  <b>Hongying Fei</b> - Exploring the analogs and differences between the industrial logistic system and the patient support system in the operating theatre <b>R. Velasquez</b> - Solving the multi-criteria next-day elective surgery scheduling problem <b>Riitta A. Marjamaa</b> - Different workflow models and resource allocation for operating room <b>Jeroen Belien</b> - Design and implementation of heuristic procedures for multi-objective master surgery scheduling	<b>18 Location and transportation planning</b> <b>Amphi 104</b> - Chair: Stefan Nickel  <b>Honora K. Smith</b> - Location modelling for community healthcare facilities <b>Giuliana Carello</b> - Ambulance location through optimization and simulation: the case of Milano urban area <b>Olivier Peton</b> , Designing a decision support system for the transportation of disabled persons <b>Stefan Nickel</b> - Planning Patient Transports in Hospitals <b>Geerhard de Vries</b> - Optimization of the transport of blood products
10h40	<b>Coffee break</b>	
11h00	<b>19 Optimization of core hospital resources in the Netherlands</b> <b>Amphi 022</b> - Chair: E.W. Hans  <b>Jan A.M. Hontelez</b> - Simulation of appointment-based systems in hospitals <b>P. Joustra</b> - Applying simulation to reduce access times for radiotherapy treatment <b>E. Bredenhoff</b> , Focused Factories in Hospital Care? Using OR/OM to study feasibility and impact <b>E.W. Hans</b> - Integrated planning of operating rooms and wards in an ambulatory clinic	<b>20 Performance assessment</b> <b>Amphi 104</b> - Chair: Martin Pitt  <b>Thierry Chausalet</b> - Modelling Readmission: A multilevel transition model approach for new performance indicators <b>Yasar A. Ozcan</b> - The use of data envelopment analysis (DEA) for evaluation of Brazilian teaching hospitals <b>Guangfu Tai</b> , A Modelling Technique for Evaluating Operational Performance of Capacity Balance in a Multi-Level Healthcare System <b>Sophie RODIER</b> - Obstetrical theatre suite modelling and simulation
12h30	<b>Lunch</b>	
13h40	<b>21 Disease modelling and clinic pathway</b> <b>Amphi 022</b> - Chair: ZhiBin JIANG  <b>Crina Tabita Nicolescu</b> - Diabetes network modelling: A System dynamics approach <b>Ursula-Anna Schmidt</b> - Process improvement in hospitals – Clinical Pathways and appointment planning <b>Jiang ZhiBin</b> , The Framework of Clinical Pathway Adaptive Workflow Management System <b>Véronique Deslandres</b> - A decision support system for clinical pathways analysis <b>Martin Utley</b> - Better out than in? The use of a simple mathematical model to assess the evidence concerning resection of lung metastases from colorectal tumours	<b>22 Health information systems II</b> <b>Amphi 104</b> - Chair: Joseph Tan  <b>Joseph Tan</b> - Evaluating User Acceptance and User Satisfaction of Healthcare IT using Formal Models <b>Ali Larab</b> - Home health care system for dependent people: application to Alzheimer disease <b>Marek Lubicz</b> - Modelling and Information Technologies for Funding Hospital Care System at Lower Silesia in Poland: Current Issues, Classifications, Priorities, Allocation <b>Nathalie CISLO</b> - Fall detection for elderly people: State of the Art and Open Issues <b>Ikram ELAZAMI</b> - Approach based on Patterns for the Mediation between Hospital Information Systems
15h40	<b>Coffee break</b>	
16h00	<b>23 Organisational issues</b> <b>Amphi 022</b> - Chair: Marion Rauner  <b>Lucas Delesie</b> - Checks and balances <b>Penelope Mullen</b> - A little knowledge is... a good thing <b>Marion S. Rauner</b> - Using Operations Research Techniques for Internet-based Hospital Games <b>I.J. Baars</b> , Planning and control in outpatient mental health care <b>D. Bensley and L. Sinclair</b> - The 48 hour access target for Genitourinary Medicine Clinics: A Generic Discrete Event Simulation Model <b>N. Ravichandran</b> - Operations Research and Health Care: An Opportunity Assessment in the Indian Context	<b>24 Work Organisation I</b> <b>Amphi 104</b> - Chair: Hari Balasubramanian  <b>Hari Balasubramanian</b> - A metaheuristic simulation-optimization approach to improving primary care access <b>Korina Katsaliaki</b> - Reconfiguring the Operations of a Pediatric Intensive Care Unit (PICU) <b>Alexandre Mazier</b> - Scheduling preparation of doses for a chemotherapy service <b>Farida Bouhamou</b> - Generating master surgical schedule using integer programming <b>Steve Burnell</b> - Improving access to psychological therapies <b>M.H. Yarmohamadian</b> - Assessing Probable Risks in Hospital Medical Record Department via FMEA Model
18h20		
20h00 24h00	<b>Gala diner at the Restaurant "Le Flore"</b>	



# Scientific Programme Overview

Friday July 20		
08h40	<b>25 Stochastic models</b> <b>Amphi 022</b> - Chair: Martin Utley  <b>S. Ketabi</b> - A Study on the Discharge Process at Kashani Hospital, Isfahan, Iran via Computer Simulation <b>Luiz Guilherme Nadal Nunes</b> - Markov decision process applied to the control of admissions in elective hospitals <b>Stefan Creemers</b> - The Impact of service epochs on waiting times in a healthcare environment <b>Khanh Ngo Cong</b> - Use of stochastic models in health care: a survey	<b>26 Work Organisation II</b> <b>Amphi 104</b> - Chair: Michel Gourgand  <b>Sima Ajami</b> - Queue on discharge process in Beheshti hospital in Iran <b>Roberto Aringhieri</b> - Efficient Team Planning at Emergency Medical Service of Milano <b>Selma Arbaoui</b> - Home Healthcare Process: Challenges and Open Issues <b>E.G.E. Leers</b> - Optimizing decisions on work organization in intellectual disability care
10h10	<b>Coffee break</b>	
10h30	<b>27 Hospital supply chains</b> <b>Amphi 022</b> - Chair: Alain Guinet  <b>Salma Chahed</b> - What about operations research opportunities in the home care domain? <b>Julien Fondreville</b> - Centralized and decentralized replenishment policies considering inventory and transportation in a two-echelon pharmaceutical downstream supply chain <b>Anissa MAKHLOUF</b> , Application of bayesian network model to a healthcare process : sterilization process of medical devices <b>Ali MEHRABI</b> - The effect of leadtime information sharing on safety stock in a downstream pharmaceutical supply chain	<b>28 Patient safety and quality of care</b> <b>Amphi 104</b> - Chair: Thierry Chausalet  <b>Evrin Didem Gunes</b> - Quality Competition for Screening and Treatment Services <b>Jacques J.</b> - Patient Safety Evaluation in Belgian Hospitals starting from the AHRQ Patient Safety Indicators (PSI) <b>Juha-Matti Lehtonen</b> - Speed and quality in Coronary Artery Bypass Graft (CABG) surgery: is there a connection? <b>POURREAU Aurélie</b> - Analysis and management of adverse events related to central venous catheter in intensive care units
12h00	<b>Closing session</b> <b>Amphi 022</b> - Chair: Jan Vissers  Concluding remarks and post-conference publications of ORAHS'2007. Introduction of ORAHS'2008. Applications for organization of ORAHS'2009. Other ORAHS group affaires.	
13h00 14h30	<b>Lunch</b>	

# Publications

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## Special Issues

There will be one special volume and two special issues:

### **Annals of Operations Research**

Guest-editors: Xiaolan Xie, Steve Gallivan, Alain Guinet, Marion Rauner  
instructions for authors on <http://www.springerlink.com/content/101740/>. Submit your papers to Xiaolan Xie ([xie@emse.fr](mailto:xie@emse.fr)).

### **Health Care Management Science**

Guest-editors: Eric Marcon, Frank Dexter, Xiaolan Xie  
on-line submission only on <http://www.springerlink.com/content/101767/>. Quote "Special Issue: ORAHS'2007 – France" on the cover page of your paper.

### **International Journal of Healthcare Information Systems & Informatics**

Guest-editor: Christine Verdier  
Instructions for authors: <http://www.igi-pub.com/journals/details.asp?id=4835>. Submit your papers to: Christine Verdier ([Christine.Verdier@imag.fr](mailto:Christine.Verdier@imag.fr)).

This will be based on (but not limited to) the papers presented at ORAHS'2007. You are invited to submit a paper by end November 2007. Authors should submit their paper electronically, in either Word (.doc file) or a pdf file (single files only), following above instructions. Detailed CFPs will be distributed during ORAHS'2007. Anticipated publication date: Autumn 2008 or beginning 2009.

## ORAHS Proceedings

Presenters at ORAHS'2007 are invited to submit papers for the conference proceedings. Papers should be submitted by end September 2005. Please e-mail your paper (Word .doc document only please) to Xiaolan Xie at: [xie@emse.fr](mailto:xie@emse.fr)

Manuscripts must be typed on one side of the A4 paper using single line spacing throughout, with page margins set at 2.5cm. Use Times New Roman font size 10. Please keep your paper to within 8 pages. For the format of the paper title, authors, abstract, keywords, figures, tables and referencing, please follow the format of the Journal of the OR Society: [www.palgrave-journals.com/jors/instructions.html](http://www.palgrave-journals.com/jors/instructions.html)

# Plenary Sessions

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## **1A** Monday, 9:30am – 11:00am

### ***Local Health policies and Operations Research in Health Care I***

Chair : Xiaolan Xie

#### **National Health Policies**

*Denis Debrosse,*

*Conseiller Général des Hôpitaux, Ministères de la Santé, France.*

#### **OR Contributions and Challenges in Health Care**

*David Bensley,*

*Operational Research Programme Manager, Department of Health, UK.*

In the UK there has been a sustained period of unprecedented growth in planned spending on health. Against a background of changes in size and complexity of the NHS there have been major improvements in access to treatment, in mortality from major diseases such as heart disease and stroke and in increased life expectancy overall.

OR has made a really significant contribution to these improvements.

Applications covering policy formulation, implementation and evaluation will be described and illustrated with successful practical case studies such as improved incentives directed towards implementation of behaviour change programmes, implications of introducing screening programmes including for Abdominal Aortic Aneurysms, improved access to treatment for both emergency and elective hospital care and evaluation of the impact of major organisational change programmes.

There remain significant challenges for both health care and OR in the future. There is a trend towards greater personal responsibility for health, an increased focus on early preventative interventions, more customised services for meeting demands and a movement away from hospital care to that provided in the community. OR needs to rise to meet these challenges for improving the health of the population and for how health care is commissioned and provided.

Some of the obstacles in meeting these challenges will be described and in particular the need for OR studies to be successfully implemented in practice.

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## **1B** Monday, 11:20am – 12:40am

### ***Local Health policies and Operations Research in Health Care II***

Chair : Xiaolan Xie

#### **Evaluation and Auditing of French Health Care Systems**

*Sebastien Woynar,*

*Mission Nationale d'Expertise et d'Audit Hospitaliers (MEAH), France.*

#### **Reengineering a Large Teaching Hospital**

*Robert Reichert,*

*Chairman & CEO, CHU-Saint-Etienne, France.*

# Plenary Sessions

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**4** Monday, 3:30pm – 4:30pm

## ***French Research Initiatives***

Chair : Jan Vissers

### **HESCULAEP for an improved coordination in a pre-hospital setting**

*Michel Baer,*

*SAMU92, APHP, Paris & coordinator of the EU project HESCULAEP.*

### **Engineering and management of health services**

*Alain Guinet,*

*INSA-Lyon & coordinator of GISEH group.*

### **Engineering the emergency care delivery network**

*Eric Marcon,*

*UJM & coordinator of HRP3 project.*

The French emergency care network is a complex supply chain of care that should both ensure quality and safety of care, and guaranty to the patient a maximum efficiency in the emergency care process. HRP3 (Hôpital en Réseau : Prévoir, Partager et Piloter) is a research project supported by the Rhône-Alpes research cluster GOSPI (Gestion et Organisation des Systèmes de Production et de l'Innovation) from 2006 to 2008. The purpose of HRP3 is to study the emergency care supply chain with the aim to: (1) optimize the emergency care for all patients. (2) ensure ease of access to appropriate services at the appropriate time. (3) improve the co-ordination between the stakeholders of the emergency care supply chain. (4) optimize the efficiency of the different services: pre-hospitalization, emergency service, ...

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**Plenary Presentation** Tuesday, 11:50am – 12:40am

Chair : David Bensley

### **The Role of Operations Research in Health Care Planning and Policy Making**

*Pr. Michael Carter,*

*University of Toronto, Canada.*

Operations research has enjoyed some moderate success in a number of operational level problems, typically looking at a specific department of one institution. However, if we really want to make a difference in health care, we need to address large scale policy questions that affect all institutions in a city, a region or a country. This is easier said than done. In this talk, I give a brief overview of the types of problems that have been considered in practice. I also will describe a few recent examples of applications of operations research in Canadian health care policy issues. For example, we worked on models to help the Ontario Ministry of Health and Long Term Care forecast the number of surgeries that needed to be done to reduce the waitlist to target levels for several priority areas.

## Plenary Sessions

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**11** Tuesday, 5:30pm – 7:00pm

### ***Project Ideas for International Collaborative Research***

Chair : Bart Veltman

**12** Wednesday, 8:30am – 9:20am

### ***Software Solutions in Health Care***

Chair : Michael Carter

### **Providing Software Solutions for Health Care Delivery**

*Bart Veltman,*

*Managing Partner, ORTEC, The Netherlands.*

The pressure on an efficient and effective delivery of health care has been growing significantly last decennium. The dynamics and complexity of these delivery processes, the inherent uncertainty of care programs for individuals, and the volume of patient contacts with health care organisations offer a rich source of challenging operations management related research themes. Along with the growing pressure on the health care delivery system, one can observe a growing attention of operations research practitioners to this domain, both from research institutes (the academic world) as well as from (advanced planning) software suppliers.

The topic of this talk is addressed to the question *when* and *how* to deliver software solutions for health care services. The '*when*' refers to the market potential offered by health care organisations and especially how we, as software suppliers, perceive their willingness to invest in software solutions. The '*how*' refers to the difference between software products, where upfront investments are made by the software supplier, versus tailor made software solutions, where the investments are taken by the user.

The presentation is about examples of solutions and products for health care delivery and how they support processes in domains such as nurse rostering, home care services, patient treatment planning, capacity management at nurseries, and blood sample collection. It also addresses the challenges we see for the coming 1-2 years for product development in the domain of health care delivery. We have the impression that these challenges differ from the research topics that are addressed in research projects and proposals, and thus may offer new challenges for research in addition to the very valuable existing research themes.

### **Building Interactive Decision Aid applications, a Nurse Scheduling case study**

*Sofiane Oussedik,*

*ILOG, Gentilly, France.*

One of the major challenges facing the healthcare sector today is to maintain high standards of service, but with scarce resources. Determining the best use of resources to meet service expectations requires the use of complex mathematical models that can be analyzed using optimization and computational techniques.

Problems solved using optimization techniques in healthcare include, but are not limited to, treatment planning, health-care delivery, operations management, and workforce scheduling. The presentation will start with a short overview of healthcare optimization problems and applications, including a presentation of the application development methodology. Then, the workforce scheduling example will be considered in more depth, and illustrated with a nurse scheduling application.

Workforce scheduling involves a large number of rules (often conflicting) related to various aspects of labor regulations, human resource management and personal preferences including the maximum number of consecutive working hours and number of day and night shifts a person can work, requirements linked to seniority levels, restrictions on the number of consecutive day and night shifts assigned, vacation periods, time off requests, and fair distribution of responsibilities among the staff. A MIP model for this type of problem including both hard and soft constraints for a certain planning horizon will be presented.

Then, an efficient application development methodology using ILOG OPL Development Studio and ILOG Optimization Decision Manager for work shift assignment of hospital nursing personnel will be presented. The objective of the developments is to build a flexible decision support application that is able to generate alternative schedules and test several scenarios with regard to data changes, objective function changes and rules changes.

# Tutorials

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## **T1** Monday, 8:30am – 10:20am

### **Making tactical (budget/financial) decisions based on allocations of OR block time for outpatient and inpatient surgery**

*Pr. Franklin Dexter,  
University of Iowa, USA.*

Perioperative tactical decisions include hiring more staff to extend hours and expand operating room (OR) capacity, purchasing capital equipment, building more ORs, supporting growth of a surgical group, changing the employment relationship of anesthesia nurses, and/or building a free-standing facility. Increasing block time to a surgical group as it hires an additional surgeon is an example of a tactical decision. OR information systems and hospital accounting databases can be combined for purposes of such tactical decision-making. Hospitals can use these methods to assist in achieving a sufficient operational margin to have capital for making improvements (e.g., new information technologies) and for providing uncompensated community benefits (e.g., teaching and indigent care). The analogy in other areas of operations research would be revenue management.

In the talk, I will review: a) managerial accounting; b) types of revenue to include; c) incorporation of constraints such as limited operating room, hospital ward, and/or intensive care unit resources; and d) uncertainty in estimated contribution margin per operating room hour. Invariably analyses can be performed in Excel using the complementary version of Solver.

## **T2** Monday, 10:40am – 12:30am

### **Benchmarking & performance evaluation in health care: DEA approach**

*Pr. Yasar A. Ozcan,  
Virginia Commonwealth University, Richmond, USA.*

Management in all industries is moving toward more objective performance evaluation and decision making, the health care industry, however, has lagged behind many other industries in this respect. A typical response to poor performance from health care organizations tends to be cutting costs, most administrators realize that the only way to keep their institutions financially viable is to improve the performance. Hence, benchmarking became the new buzz word. Unfortunately, the benchmarks established using old analytical schemes based on various multiple ratios created more dilemmas than solutions. Performance evaluation based on optimization techniques with their normative structure not only creates benchmarks, but also provides information for those organizations that are lacking in their performance as a prescribed way to improve it. This is what is needed in the health care industry today.

This tutorial places emphasis on the application of contemporary performance, efficiency evaluation methods, using Data Envelopment Analysis (DEA), to create optimization-based benchmarks including but not limited to: hospitals, physician group practices, health maintenance organizations, nursing homes, home health and other health care delivery organizations. Hence, this tutorial would be beneficial for graduate students, operations research professionals who are new to health care and/or performance analysis; and practicing health care administrators. The tutorial will provide examples of basic envelopment models, as well as other advanced methods where managerial and policy issues can be imposed. Additionally, efficiency and quality dimensions of health care performance will be emphasized.

# Tutorials

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## **T3** Monday, 2:00pm – 3:50pm

### **Simulation modeling in health care: some examples and lessons learned**

*Pr. Michael Carter,  
University of Toronto, Canada.*

This talk will consist of two parts. In the first half, I will present several examples of using simulation models in health care. Most of the examples use discrete event simulation (DES) plus one example of system dynamics (SD). The session will conclude with a group discussion comparing the merits of DES with SD.

In the second half, I will present some of lessons that I have learned about trying to use simulation in health care.

## **T4** Monday, 4:10pm – 6:00pm

### **Practical Models for Health Care and Health Services**

*Pr. Arjan Shahani,  
University of Southampton, UK.*

Health Care is concerned with prevention, early detection, and treatment of particular diseases. A wide range of Health Services are needed in the community for the delivery of Health Care. Health Care and Health Services involve complexity, variability, uncertainty, and use of scarce resources and these features must be reflected in models if the aim in developing the models is practical usefulness.

Practical models are powerful tools for obtaining quantitative information for making good decisions in Health care and Health Services. The development of such models typically requires:

- Joint work by Health Professionals and Operational Researchers.
- Appropriate data.
- Statistical analysis of the data including classifications.
- Sufficiently complex models. The mathematically simple Markov processes are, typically, not suitable for the necessary modelling work. Semi-Markov processes are often very helpful. Simulation is usually needed for solving the complex models.
- Careful selection of scenarios to be evaluated by the models.
- Ease of use of the models. This requires careful design of computer screens for inputs and outputs.

The development and use of practical models, at the level of individuals, will be discussed. Health Care models will be illustrated by work on breast cancer, colorectal cancer, diabetes, and HIV/AIDS and trachoma. Health Services models will be illustrated by work on the capacities and organisation of Intensive and High Dependency Care within a hospital, capacities in a hospital as a whole, and regional capacities.

Computer programs for some of the data analysis and modelling work will be demonstrated.

# Tutorials

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## **T5** Tuesday, 8:30am – 10:20am

### **Fit for purpose – a taxonomy of models for disease modelling**

*Pr. Ruth Davies,*

*University of Warwick, Coventry, UK.*

Models of disease processes are used to evaluate choices of treatments, to assess new drugs and prevention measures and/or to determine future resource requirements based on treatment policy decisions. Many papers describe good modelling practice, but few describe how to choose from the many types of models available. This presentation is based on the paper from Brennan *et al.* that develops a new taxonomy of model structures. The presentation compares two models of end stage renal failure, two models of childhood "flu" infection and looks at a simulation of helicobacter pylori infection. The examples show that aggregate models of large populations may produce similar results to patient-level models but on other occasions it is possible for different models to lead decision makers to arrive at very different conclusions. A well known example where this is the case is in models of a potential terrorist outbreak of smallpox to determine the best vaccination strategy. The presentation identifies some of the issues to be considered in deciding on a model for a particular problem.

## **T6** Tuesday, 10:40am – 12:30am

### **Optimization in Medicine and Health Care**

*Pr. Eva Lee,*

*Georgia Institute of Technology, Atlanta, USA.*

Optimization has long been a cornerstone for advancement of various industrial, government, and military applications. In particular, computational and modeling technologies play an increasingly important role in modern medicine, life sciences and healthcare. Many problems arising in these domains can be formulated into mathematical models and can be analyzed using sophisticated optimization, and computational techniques. In this talk, we will review some healthcare, medical and biological applications in which optimization methodologies have/can be applied. Applications include medical treatment design, disease modeling and prediction, bioinformatics and genomic analysis, healthcare systems modeling, quality improvement, operations efficiency, information management, and logistics.



## 2 Monday, 2:00pm – 3:30pm

### Operating Theatre Optimization

Chair : Franklin Dexter

#### Improving OR efficiency by applying bin packing and portfolio techniques to surgical case scheduling

*Jeroen M. van Oostrum, Gerhard Wullink.*

Erasmus University Medical Center, Rotterdam, The Netherlands.

**Background:** Erasmus MC's operating room department has adopted an efficient business model and subsequently investigated how efficiency could be further improved. Based on the current business model the study investigates the efficiency improvement of lowering organizational barriers and applying advanced mathematical techniques.

**Methods:** We applied advanced mathematical algorithms in combination with scenarios that model relaxation of various organizational barriers using prospectively collected data. The setting is the main inpatient OR department of a university hospital, which sets its surgical case schedules two weeks in advance using a block planning method. Main outcome measures are the number of freed OR blocks and OR utilization.

**Results:** Lowering organizational barriers and applying mathematical algorithms can yield a 4.5 percent point increase in OR utilization (95% confidence interval 4.0% - 5.0%). This is obtained by reducing the total required OR time.

**Conclusions:** Efficient OR departments can further improve their efficiency. The paper shows that a radical cultural change that comprises the use of mathematical algorithms and lowering organizational barriers improves OR utilization.

#### Reducing tardiness in the start times of surgical cases

*Ruth E Wachtel and Franklin Dexter.*

Department of Anesthesia, University of Iowa, USA.

**Introduction:** Operating rooms (ORs) that run behind schedule are a source of frustration and dissatisfaction for both health care providers and patients. Dexter, Marcon and Epstein<sup>1</sup> recently used discrete event simulation to show how to monitor the tardiness of surgical cases. We applied their findings to study the extent to which tardiness in case start times could be reduced by simple management interventions, such as changing the way the OR schedule is calculated.

**Methods:** Data were all surgical cases performed at one hospital on scheduled workdays in 2005-2006. Tardiness for elective cases was calculated as the positive difference between the actual start time of a case and its scheduled start time. If the difference was negative, meaning the case started early, tardiness was zero. Case duration bias was calculated as the difference between the actual number of hours needed to perform a series of cases and the total number of hours scheduled for those

cases. If the expected duration of a case was less than its actual duration, then the bias was positive.

After correcting the OR schedule for case duration bias and tardiness in first cases of the day, scheduled start times were revised for each case. New values for tardiness were then determined based on these revised start times.

To reduce the effects of autocorrelation (i.e., if one case was tardy, then other cases performed the same day were more likely to be tardy), data were divided into twenty-five 4-week periods, as described previously. Total tardiness per day was calculated independently for each period. Values for the 4-week periods were averaged to determine a mean and standard error.

**Results:** For the main suite of 24 ORs, average tardiness for all 4-week periods was 58 min  $\pm$  1.6 min (SE) per OR per day. Bias in case duration predictions ranged from 7 min  $\pm$  4 min per 8 hr of OR time for cardio thoracic surgery to 1 hr 7 min  $\pm$  4 min per 8 hr of OR time for otolaryngology. Tardiness of the first cases of the day averaged 4 min. For the 6-OR ambulatory suite, average tardiness was 1 hr 35 min  $\pm$  2.7 min per OR per day. Despite a shorter workday, the overall tardiness was greater. Tardiness of the first cases of the day averaged 3 min.

The previous simulations showed an effect of tardiness in first cases of the day. Total tardiness could be reduced by 29% (95% CI 28%-30%) in the main surgical suite and 23% (22%-24%) in the ambulatory suite by adjusting predicted start times for case duration bias and for tardiness in first cases of the day, as well as by estimating predicted start times to the nearest minute instead of rounding them to the nearest 15 min.

The previous simulation work did not include add-on cases. We expanded the scope of investigation by studying the impact of urgent cases added on the day of surgery. They contributed only 4 min per OR per day to tardiness in the main suite. Cases were moved to different ORs to compensate when rooms ran late. If cases that were moved at least 4 hr after the start of the workday had not been moved, tardiness would have been increased by 9% (6%-12%) in the main suite and 17% (14%-20%) in the ambulatory suite.

**Conclusions:** Moving cases to different ORs late in the day helped prevent tardiness. Additional interventions, such as correcting scheduled start times for case duration bias and tardiness in first cases of the day, could reduce tardiness throughout the day by another 20%-30%.

#### Coordination of appointments for anesthesia care outside of operating rooms using an enterprise-wide scheduling system

*Franklin Dexter and Ruth E. Wachtel.*

Department of Anesthesia, University of Iowa, USA.

We describe implementation by an anesthesia department of changes to the hospital's enterprise-wide scheduling system. These changes permit clerks and nurses from other departments to schedule anesthetics outside of operating rooms (non-OR) for radiology or other procedures. An example is MRI of the brain and spine in a 1.5 yr old.

Observational studies chronicled implementation over a 2 year period as non-OR time was allocated by specialty

and non-anesthesia clerks and nurses scheduled anesthesia teams. Experimental studies investigated how simulated tabular and graphical displays affected the scheduling of milestones, such as fasting times and patient arrival times. The former is often referred to as the period of "NPO".

Scheduling of anesthetics by non-anesthesia clerks and nurses increased progressively from 0% to 77%. The number of anesthetics performed in allocated time increased progressively from 0% to 75%. Consistency of patient instructions was improved. The quality of resulting schedules was good. Implementation was not associated with worsening of multiple operational measures of performance, such as cancellation rates, turnover times, or complaints.

However, schedulers struggled to understand how fasting and arrival times of patients should be determined, despite using a web site with statistically generated values in tabular formats. Recommended times were simply be read from a table, without interpretation and thus the ability to modify recommendations appropriately when exceptions arose. Experimental studies with nursing students revealed they did not know how to apply their knowledge that anesthetics can start earlier than scheduled. A graphical format that required schedulers to make decisions about fasting and arrival times resulted in significantly ( $P < 0.001$ ) more anesthesia team and patient waiting per case. In contrast, participants made good decisions with both tabular and graphical displays when scheduling appointments that preceded the anesthetic, such as a pre-anesthesia evaluation.

In conclusion, enterprise-wide scheduling, in combination with allocation of anesthesia time to individual specialties, can coordinate anesthetics with other appointments on the same date. The system is more convenient for schedulers outside the anesthesia department. It can also improve consistency and accuracy of patient instructions customized to the probability of an anesthetic starting early. The results likely apply to different but similar medical situations, such as efforts for patients to arrive just-in-time for non-OR anesthesia, surgery, or regional block placement (e.g., at facilities with limited physical space).

## **Proposal for the planning of the nurses in operating theatre**

*Natalie Smith-Guerin, Nathalie Cislo and Selma Arbaoui.*

Laboratoire Vision et Robotique, Bourges, France.

This paper presents the study of the use of the Little's algorithm for the planning of the male nurses in an operating theatre.

Our prime objective was to study the effectiveness of an algorithm developed for the industrial engineering on an application to the healthcare systems.

For our study, we started from a case detailed by L Trilling about planning of the anaesthetists nurses in an operating theatre. In this article, the constraints and criteria are entirely exposed; the authors propose to establish the planning of the nurses by linear programming optimizing a criterion of painfulness of the time section.

From these painfulnesses of "tasks", we defined the painfulnesses of change of time section, written in a matrix. We then applied the Little's algorithm in order to

obtain an "optimal" sequence or a whole of optimal solutions within the meaning of less painfulnesses.

The result obtained is a sequence with a fixed first part (only one optimal sequence) and a second part for which several sequences are possible for the same painfulness. A comparison is made between the mathematics (programming linear) and industrial (De Little) approaches.

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## **3 Monday, 2:00pm – 3:30pm**

### **Patient Flow Planning**

Chair : Jan Vissers

#### **Patient mix optimisation and resource allocation: a case study in cardiothoracic surgery planning**

*Ivo Adan, Jos Bekkers, Nico Dellaert, Jan Vissers, and Xiaoting Yu.*

Eindhoven University of Technology, Erasmus University Medical Centre Rotterdam.

Cardiothoracic surgery planning involves different resources such as operating theatre time, beds, IC beds and nursing staff. In practice the planning in the Thorax Centre focuses on optimal use of operating theatre time, though the performance of the Thorax Centre as a whole is often more limited by the capacity of the IC. For operating theatres a master surgical schedule is used to allocate operating theatre resources at tactical level for a longer period. Operational schedules at weekly level are derived from this master schedule. Within cardiothoracic surgery different categories of patients can be distinguished on behalf of their requirement of resources. The mix of patients is, therefore, an important decision variable for the Thorax Centre to manage the use of these resources. In the paper we will consider the planning problem to generate a master operation schedule that realises a given target of patient throughput and optimises an object function for the utilisation of resources. This problem can be mathematically approached by mixed integer programming. We will discuss the mathematical model developed for this planning problem, the implementation in a decision support model for tactical surgery planning, the results obtained and the way the model can help to broaden the focus of planning of cardiothoracic patients.

#### **Patient allocation on the basis of competence: conceptual considerations and measurement difficulties.**

*Marc Haspeslagh, Luc Delesie and Paul Igodt.*

Centre for Health Services and Nursing Research, Katholieke Universiteit Leuven.

Patient allocation is common practice in psychiatric nursing. The allocation is managed on the basis of the number of patients already allocated and experience of the head nurse with her nurses. As a consequence patient outcome is not always optimal. This study investigates the possibilities of the use of the concept of

competence to underpin the patient allocation with a view to better patient outcome.

The concept of competence is clear in its first two sub-concepts knowledge and skill. The debate on the third sub-concept is still on. We adhere to aptitude since it is a basic pillar which moreover also underpins knowledge and skill. Every psychiatric nurse has a diploma and certificates so knowledge and skill are officially present. For operationalising aptitude we can only rely on literature on competence and then translate the principles to operationalising aptitude.

Some conceptual considerations arise. The degree of competence measures either an organization, a team, an individual or one individual's specific attribute. The job context, the terminological system and the socio-cultural frame of reference play an important role. Competence evolves over time. Most evidence on competence compares groups of people the so-called nomothetic or population approach. But the therapeutic relation between a patient and a nurse in psychiatric care is an individual matter which requires the individual or so-called idiographic approach to research competence and aptitude specifically. Aptitude is clearly a non-physical qualitative attribute, hence assessment can only rely on opinions. These are most personal matter.

As a consequence some measurement difficulties are to be tackled: whose opinions about the aptitude of the nurses do we question? Do we use self and peer opinion? How do we aggregate opinions in a proper way? What aspects and components of aptitude are essential and understood by the nurses? How long may a questionnaire be to capture earnest opinions in a reliable way? How many response categories do we use for each item?

The presentation will deal with these considerations and difficulties and illustrate some possible ways to deal with them.

## Improving patient flow in a hospital

*JJW Molema, S. Groothuis, and GG van Merode.*

Care and Public Health Research Institute, Maastricht University.

**Background:** Hospitals are healthcare production systems that can be considered as networks, with beds as one of the main type of servers. Between servers, patient flows exist. Patient flows are often characterized by discontinuity. Discontinuity causes variability in both the service system and system performance and can impact quality of care. Managing flow to restrict discontinuity is therefore important. Queuing theory offers guidelines to restrict discontinuity in flow. Following queuing theory, we expected that the aggregation level of beds affects patient flow directly, with opportunities for substantial performance improvement. We hypothesized that removing bed labels could increase the level of supply aggregation in a network, which could improve overall patient flow.

**Method:** To test the hypothesis, we studied a case of a Dutch hospital. Hospital management wanted to aggregate acute care beds to an Acute Care Department (ACD) and reorganize the whole network of flows and beds in the hospital. We simulated several scenarios for ACD organization. Our objectives were twofold: i) gain insight into opportunities for improving acute patient flow

continuity by introducing ACD; ii) provide hospital management with insight into the effects of decisions about the organization of ACD. The simulations were performed via an experimental design, with a model developed in Mathematica®. ANOVA analyses were performed to test the effects of each organization scenario.

**Results:** The study shows that increasing the level of supply aggregation restricts the network and, as a result, also the number of flows. The simulation results make clear that this restriction in flows can decrease discontinuity in patient flow, dependent on the organization of ACD. For example, discontinuity in flow was increased by inflexible ACD organization in the form of discharge slots. These slots increased the chance of patients not being discharged home or to another department although they were medically ready. Also, in terms of efficiency, they increased the chance of a patient occupying a 'wrong bed', i.e. a bed with care qualifications which a patient no longer needs. Not having discharge slots resulted in less discontinuity in patients flowing out of the department and less wasted bed capacity.

**Discussion and conclusion:** The study proved that discontinuity in flows can be improved through manipulating the network organization and the aggregation level of capacity within the network. The simulations made clear that in the case studied decisions regarding network organization affect performance within the network. Also, these decisions can have a multiplier effect. For example, the effect of introducing discharge slots on discontinuity, i.e. decreased discontinuity in patient flows out of ACD, could be multiplied to result in unavailable capacity at ACD which can result in unused follow-up capacity, such as operating rooms. For example, a new acute surgery can only be performed if an ACD bed is available for admitting the patient after the operation.

We conclude by stating that patient flows in hospitals can be improved by considering hospitals as networks and studying the level of server aggregation within the network. We studied one of the main servers in hospitals, namely beds. Also, servers and server aggregates can be studied this way. What the right level of server aggregation in a network is depends, among other things, on the organization of the aggregate. Simulation can help to gain insight into this organization as well as into changes in the network's and aggregate's behavior due to decisions regarding aggregate organization. Which network organization(s) is acceptable or optimal depends on the objectives of the decision makers within or outside the system.

## Restructuring patient flow logistics around the level of intensity of care: Implications and practicalities

*Stefano Villa, Marta Barbieri and Federico Lega.*

CERGAS (Centre for Research on Healthcare Management) Bocconi University, Milano, Italy.

**Background:** Recently, hospitals worldwide have made different attempts to re-organize patient flow logistics in an effort to develop a patient-centered model, more efficient and integrated. These redesign efforts are intended to eliminate inefficiencies created by the departmentalization of hospital services, and to focus

hospital operations around patients rather than around departments or disciplines.

In fact, through patient flow reengineering, hospitals aim to:

- Obtain better use of nursing skills and time;
- Implement a patient-focused system of care;
- Find a better match between demand and capacity;
- Reduce delays and waiting times;
- Reduce the length of hospital stays;
- Increase volumes and productivity;
- Improve the appropriateness of clinical settings;
- Reduce workload, stress and therefore the probability of errors;
- Concentrate resources on the most complex and needy patients.

**Goals of the paper:** The present paper studies current trends in hospital patient flow logistics within the Italian national health service. Specifically it tries to assess three different issues:

(i) What are the drivers behind the re-design of patient flows within hospitals?

(ii) What are the results hospitals aim to pursue with the re-structuring of patient flow logistics?

(iii) What is the impact on organizational structure and operative systems?

**Research Methodology:** Following an extensive literature review on the themes of patient flows, logistics, and hospital re-structuring, the authors focus their analysis on three best practices that represent, in the current Italian scenario, pilot cases that have drawn significant attention within the healthcare arena.

For each of the selected cases the authors:

- collected a set of standard information. This step was aimed at depicting the three different cases with respect to a set of standard information such as the number of beds, number and type of clinical specialties, level of production, case-mix, and so on.
- administered semi-structured interviews to the main stakeholders involved in the restructuring process: top management, professionals and nurses. The administration of the questionnaire was intended to assess the impact of the restructuring process on the organizational structure and operative systems.
- collected a series of quantitative data regularly available on the organization data-set. This set of data allowed the authors to carry out a first assessment of the impact of changes on different dimensions such as productivity, case-mix, patient satisfaction, waiting time and so on.

**Main findings:** It is frequently stated that modern hospitals should be organized around the concept of the intensity of care required by patients. The hospitals analyzed in the present study reveal that there are different possible drivers that can lead to innovative re-design of patient-flows in a hospital: Length of Stay, Nursing Assistance (need of cure), Urgency, Technological requirements, Inpatient vs. Outpatient.

Some of these criteria have little to do with the level of intensity of care required by patients, others (like, for example, the expected length of stay) can be considered as a proxy of it.

The three cases analyzed have completely re-designed their patient flow logistics according to these criteria obtaining good results in terms of:

- Reduction in length of stay;
- Increase in clinical complexity of cases treated (expressed in terms DRG case-mix);
- Increase in productivity;

- Appropriateness of setting of care with consequent possibility to concentrate resources (scarce by definition) on the most needy patients;

- Better utilization of human resources (particularly nurses);

- Increase in patient satisfaction.

In all the three cases analyzed, changes in patient flow management have been accompanied by a series of interventions on several other organizational dimensions that have successfully sustained the process of change, particularly:

- Organizational structure (e.g. the redesign of hospital activities has determined the necessity to create new roles, new skills and competencies);

- Processes and procedures have been changed to be aligned with the new logistical structure (for example OR agendas and nursing shifts have been changed);

- The hospital reporting system is changed in order to comprehend new objectives and the presence of new settings;

- Organizational culture: in all the three cases analyzed the new logistical model implied a pooling of resources and facilities that required the resolution of a series of cultural resistance especially on the side of professionals.

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## 5 Monday, 4:50pm – 6:20pm

### New Paradigm

Chair : Yasar A. Ozcan

#### Launching lean thinking at the University Hospitals of Morecambe Bay NHS Trust in the UK

*Luciano Brandao de Souza and Michael Pidd.*

Department of Management Science, Lancaster University Management School, UK.

In many countries there is an increasing concern about the explosion of healthcare costs, without an equivalent improvement in healthcare delivery being observed. As a consequence, finding solutions for this problem is a current debate. In this scenario, one approach that has recently gained considerable acceptance is lean thinking. Lean thinking has brought remarkable results in manufacturing but its applicability and usefulness in healthcare are still under discussion.

This paper presents the results of a successful implementation of lean thinking techniques in three hospital departments related to the flow of patient records at the University Hospitals of Morecambe Bay NHS Trust in the UK. This application was established in April 2007 as a trial event to assess the usefulness of lean in healthcare in order to launch the implementation of lean thinking across the whole Trust. The paper also provides a discussion about the advantages and disadvantages of the proposed methodology. It is suggested that Lean Thinking can provide a good scope for improvement in healthcare but its implementation relies on a structural cultural change among healthcare practitioners.

#### Leaning an emergency department

*Ruth Davies*

Warwick Business School, University of Warwick, UK.

Lean Thinking started with Toyota in the 1950s and has been developed by Womack and Jones. It seeks to provide what the customer wants, quickly, efficiently, and with little waste. The obvious application in health lies in creating better care pathways by minimizing or eliminating (within a framework of clinical excellence) delay, repeated encounters, error and inappropriate procedures (see Young et al. 2004). There are some success stories and those from St Luke's hospital, Iowa are typical.

In one story, furniture was moved so that nurses did not have to walk so far and thus could operate more efficiently. In another, the lean consultants looked at the stores in every cupboard in the Emergency Department and were able to return \$3000 of supplies.

Some Hospital Trusts in the UK are introducing lean in patient pathways based both on specialties and also on common facilities such as day surgery and Treatment Centres. One hospital in the Midlands started this process with "See and Treat" for minors in the Emergency Department. The principles are that there is a dedicated area for See and Treat with clinicians: doctors or nurse practitioners who are always available. There is no triage and the patients go straight from reception to the See and Treat area where receive they assessment and treatment and only leave that area for an external service, such as X-Ray.

In a simulation project for this Trust, some of our observations were as follows. Initially, the practice nurses were compliant but the doctors were not and the nurses resented the fact that the doctors had not changed and appeared to work relatively slowly. Some nurses adapted the system to make it more efficient from their point of view but contrary to the basic principles of Lean. The system was about to be reorganized again to address some of these problems and to make more use of less well-qualified nurses for treatment, such as bandaging. Attempts to assess the system through simulation were largely thwarted by the data collection which, while useful for monitoring the time spent in the department overall was incorrect in recording the more detailed activities.

It is clear that there are problems in both introducing and assessing change in patient pathways within healthcare and need to be addressed if there are to be radical and properly evaluated success stories.

## **Hospital reorganization: how to help decision makers?**

*Frédéric Albert, Lorraine Trilling and Eric Marcon.*

University of Saint-Etienne, France.

**Issue:** A reengineering project raises a certain number of issues, particularly regarding the design of the new facilities. Along this reorganization process, decisions that are taken have a great impact during the next 10 to 30 years. After the end of the reengineering project, the choices still have to be questioned according to the environment changes, in order to maintain an efficient organization. Our purpose is to provide a global decision support methodology supported by a computer tool able

to help decision makers figure out how to size the resources, organize the activity, and design the processes.

**Methods:** Using the principle of the enterprise modelling, the simulation, and the optimization techniques, we developed a platform based on 3 models: (1) an activity flow model driving the user to the definition of the activity demand, (2) a process model helping for the design and the assessment of various configurations, thanks to simulation, and (3) an organization model which involve tools for resources dimensioning. Through a set of user interfaces, this platform which supports our approach guides the user in the reengineering process, it helps him for considering decisions relative to the three levels of the strategy hierarchy: (a) design, configuration and sizing of the most critical resources (bottleneck, expensive resources, like operating rooms in the case of a surgical suite) according to a global activity to perform, (b) sizing of other non critical resources (like the number of beds in the recovery room), (c) definition of the staff required to perform the activity according to the work organization (skills, responsibilities, activity scheduling).

The platform developed is specific to surgical suite reengineering. In a first step the specification of the surgical suite organization (names of the specialties, number of rooms, number of PACU, etc.) is specified. The second stage describes the processes related to the patient care, and also the logistical processes. In a third stage the activity data are defined. The activity data is characterized by the number of cases performed per period and the statistical duration law of each type of surgery. These activity data are extrapolated in order to figure out the evolution of the activity for the next 10 years. In the next step, the surgeon (or surgeons' group) block time assignment is defined. After these stages, we check if for each of surgeon the surgeon's block time assignment comply with the surgeon's surgical activity. After this checking step the simulation model can be generated. The next step is to run an infinite capacity simulation to obtain the global performance of surgical suite. This simulation gives also as result, the workload curve that traduces, for each time slot of the day, the number of human resources required for each skill category. This workload is used to find the more efficient shift design, and implement the calendar of human resources into the simulation model. It allows assessing the performance with limited human resources. After this, human resources organization can be adjusted in order to improve performances.

**Results:** The approach and the platform supporting it have been developed within the scope of the HRP<sup>2</sup> project involving several French hospitals and academic researchers. This approach has shown its effectiveness through its implementation to a hospital apart from the consortium but involved in the reengineering of its multi-disciplinary surgical suite, The Hospital of Annecy.

This project has been driven on 3 months and has provided three main results:

Definition of the number of operating rooms, the opening hours and the master surgical schedule (MSS): the original MSS used highlights a high variability of the occupational rate among the operating rooms (from 30% to 98%). Our decision-support platform led to reduce the number ORs required and to re-dispatch the chirurgial activities in among the Ors in order to balance the workload (from 50% to 82%).

Determination of the secondary resources workload and their opening period: for example, concerning the Post Anaesthesia Care Unit (PACU), the use of the platform showed that 9 beds were sufficient instead of the 23 beds initially planned. However, the final configuration will include 11 beds in order to face a predictable activity increase.

Determining staff requirement for specific transversal personnel: the use of the platform has provided workload curves traducing staff requirement for each time slot of the day and for each skill categories in the new structure.

**Discussion:** The feedback of the Hospital of Annecy was full of teaching for our project, highlighting the strengths and weaknesses of the platform felt by the users. The interactive software has been rapidly appropriated by the hospital decision makers since they had the possibility to assess by themselves the performance of the actual facility as well as the performance of the future one (through the adjustment of several parameters), and to compare both according to the same criteria.

The managers have appreciated the user interface approach and were satisfied by the relevancy of the results given by the tool, particularly regarding the two first stages of the approach. The managers interest for the two first stages was due to the rapid progression of the modelling process, thanks to a pre-parameterized generic model of a surgical suite. The director adapts a generic model by changing parameters (i.e., statistics on surgical activity, surgery durations, master surgical scheduling, process specificities), then the simulation can be run and plot the occupation charge of each critical resources (operating rooms) and other material resources (i.e., PACU beds, induction area, stretchers, etc.).

The third stage dealing with human resources provided workload curve for each skills category (stretcher-bearer, Housekeeper, nursing auxiliary, nurse) and for each area of the surgical suite. This part of the reengineering process was more long and tiresome for managers, because there was a great diversity of possible organizations and each organization required precise description of personnel's activities. For avoiding that, we must develop and improve automatic approaches of optimization linked to simulation model which will provide efficient solutions without consuming an important part of the of manager working time.

## **Waiting lists, performance targets, and simulation for alternatives in reducing patient backlog**

*Murat M.Gunal, Mike Pidd.*

Lancaster University Management School, UK.

Reducing the waiting times for elective care has been a major aim of UK health policy in recent years. Hence, waiting times have been a significant part of the National Health Service (NHS) performance measurement regime. Previous targets have been tightened and, by the end of 2008, the aim is that no patient should wait more than 18 weeks from GP referral to inpatient admission. This is an ambitious target for many hospitals in England, because of the backlog in their elective surgery waiting lists and, possibly, because of current working practices.

In this paper, we examine alternative options for reducing the backlog in hospitals' waiting lists. We describe a simulation model for evaluating these options which

includes increasing capacity such as beds and clinics, increasing throughput by efficiency such as shorter length of stay and shorter clinic slots, diverting patients elsewhere such as to private providers, and finally demand management such as reducing unnecessary waiting before out-patient clinics.

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## **6 Monday, 4:50pm – 6:20pm**

### **Health Informatics & Information Systems**

Chairs : Frédérique Laforest and Christine Verdier

#### **Ambient intelligent and pervasive architecture designed within the EPI-MEDICS personal ECG monitor**

*Hussein Atoui and David Télisson.*

University of Lyon, France.

In recent years, there has been a growing interest in developing personalized and non-hospital based care systems to improve the management of cardiac care. Event recorders and transtelephonic ECG recorders have thus been increasingly used to improve decision making in the pre-hospital phase. However, the high cost of deploying such systems has hindered their use on a large scale use.

The EPI-MEDICS project has designed an intelligent, portable Personal ECG Monitor (PEM) with advanced embedded decision making system. The PEM is capable to record a simplified 4 electrode, 3-lead ECG, to derive from it a standard 12-Lead ECG, to detect arrhythmias and ischemia or acute infarction using Artificial Neural Networks (ANN), to generate different levels of alarms and forward the alarm messages together with the recorded ECGs and the patient's Electronic Health Record (EHR) to the relevant health care providers by means of a standard Bluetooth-enabled, GSM/GPRS-compatible mobile phone.

We present two updated ambient intelligence models embedded in the PEM device at the prototype stage in terms of fully implemented services and scenarios: the neural-network based ischemia detection module and the alarm management module. The ischemia detection was expanded to a more personnalized decision making taking into account the patient ECG, clinical data and medical history. The alarm management module was adapted to the additional decision parameters by using fuzzy-logic.

We also present two telemedical solutions that we have designed and in which the PEM is integrated. The first architecture is created for general practionners to allow the collection of medical data and their transmission to cardiologists. The second one is intended for old people's home care. In both cases, we present the remote physician tele-assistance service embedded in these architectures.

#### **The AUDIPOG Sentinel Network: a tool built by perinatal professionals for professionals**

# Technical Presentations

*Françoise Vendittelli, Catherine Crenn-Hébert, Olivier Claris, Bernard Maria, Michel Collet and Bernard Jacquetin.*

AUDIPOG sentinel network, Lyon, France; the Clermont-Ferrand Maternity University Hospital.

AUDIPOG (computerized pediatric, obstetric and gynecologic records users association) is a nonprofit organization. Its work is performed by 5 employees and numerous physicians, all unpaid volunteers. This association was created in 1980, at the request of the ministry of health. AUDIPOG's first objective was to develop a national consensus about the contents of perinatal files, in preparation for the computerization of maternity unit data. Since 1980, the catalogue of files available at our printer includes 16 paper files to meet the needs of perinatal professionals. Approximately 300 maternity units in France, not counting the numerous «clones» or copies, use these files. Revision of these files was completed at the beginning of 2007. At the same time, AUDIPOG, working through national multidisciplinary groups, produces specifications intended for the producers of specialized computer software. A common structure for paper and computer files promotes coordination of care and facilitates clinical audits for the evaluation of professional practices, evaluation that is now mandatory for physicians in France.

In 1994, AUDIPOG first created a data bank from volunteer maternity units that provide at least 1 month of their perinatal results (delivery files) each year. This is now known as the AUDIPOG sentinel network. It makes possible the regular production of annual national data, directly accessible to members on the association's web site (<http://audipog.inserm.fr>). Numerous publications are based on these annual data.

Since 1996, AUDIPOG has also worked to facilitate self-evaluation of professional practices, as some of its publications attest. This involves in particular benchmarking with diverse tools. Accordingly, the professional members of AUDIPOG can interrogate the data bank 24 h a day for answers to questions they may ask themselves in their own practice (for example, what is the national rate of induction for nulliparas?) and then compare it with their own rates. A tool available on the site also makes it possible to compare one's own global cesarean rate with the expected cesarean rate, given the population characteristics and risk factors of the women delivering at that maternity ward. It is also possible to have (for the maternity units that provide a full year of data) a table with selected indicators, including for women at low risk (this 4-page "score card" is also accessible on the internet). A global table, including fewer indicators, will be sent free-of-charge in 2007 to the maternity units furnishing a year's worth of data.

More recently, in order to aid the evaluation of professional practices for colleagues who do not participate in the sentinel network, we have developed simpler tools for such evaluations in various topics. The first topic available is episiotomy, which was the object of French guidelines issued at the end of 2005 (cf. [www.cngof.asso.fr](http://www.cngof.asso.fr)). Members of our association have free access on our web site to the tab "evaluation of professional practices" and to tools that can be easily printed (we will charge only for automated online data treatment). The "episiotomy" topic includes 4 tools,

including 3 very short targeted clinical audits to facilitate compliance and a benchmarking tool with comparison of data of that maternity ward to those in the AUDIPOG data bank (or to national data), including as a function of parity. The next topic (now underway) will be monitoring of low-risk pregnancies.

The reorganization of AUDIPOG over the last two years has led to a partnership with the National College of French Gynecologists and Obstetricians (CNGOF) and with the National College of Midwives (CNSF). AUDIPOG has been accredited as an organization authorized to evaluate professional practices by the French agency charged with, among other things, promoting this procedure: the High Health Authority (HAS) (cf. [www.has-health.fr](http://www.has-health.fr)). The topic of its next national seminar will be the evaluation of professional practice and will take place during CNGOF's annual meeting, on 12 December 2007.

## **New information technologies and governance of health care institutions**

*J.P. Auray, G. Duru, M. Lamure and C. Blein.*

LIRIS – University Lyon 1, France.

In most European countries, health care expenditures are growing up, inducing policies for constraining health care costs. According to countries, hospital expenses have a heavy weight in the overall health care expenditure. So, governments are amazing to develop policies to contain these expenses. This implies to consider all means enabling a reducing of the costs. For hospital, a consequence is to go from a "hand made" health care delivery process to an "industrial" one. Thus, the question of a new governance of hospital (private or public) by means of new information technologies arises. This is the case for France, with the "Patient File Record" which is at the center of the last reform of the French Health System. Clearly, whatever the country, an adequate information and decision system is a key point for a better governance of health care delivery organisms.

So, in this presentation, we give:

- The main features of the European current systems. In particular, we'll present the structures of health costs in each country and we'll see how these different countries developed patient classifications from the US DRGs.
- Some key points for building efficient medico-economic systems. The last reform of the French hospitals financing (T2A or Pricing by Activity) will serve as an example. We'll also examine the main new research works connected with information technologies for improving efficiency of health care delivery processes.
- We'll also analyze the consequences of introducing new technologies upon diagnosis and therapeutic process as well as upon financing of hospital and remuneration of practitioners.

## **Computerized Medical File at patient's bedside**

*N. Javaux, C. Lejeune, E. Lenaerts, D. Menager, M. Raze, I. Simon, P. Louis and P. Kolh.*

University Hospital of Liège, Belgium.

**Context (Motivation):** The University Hospital of Liège (CHU) in Belgium, a 955-bed hospital located on multiple sites, has launched the COS plan (Organizational and

Strategic Contract) in May 2003, in order to deliver health care with the highest university quality, readily accessible to all, and to maintain the long-term financial stability of the Institution, by combining various approaches, such as clinical activities performance, patient care, financial and organisational aspects (procedures effectiveness, staffs skills and motivation). The COS plan adopts an administration method based on 22 institutional projects, emerging from multidisciplinary Working Groups analysis, built-up of field doers, belonging to all CHU activity sectors.

The computerised medical file, one of the COS plan fundamentals projects, is the software system aimed to optimise the multiple sites management and the patient health care information transmission. This project is composed of the 7 following steps : the implementation of a results server (biological results, medical imaging, nuclear medicine and anatomic pathology), of the patient computerized file, accessible to all in real time, bypassing classical paper documentation drawbacks, and eventually the computerisation of many fields such as appointments management, real time and forward-looking bed management, medication prescriptions management, complementary exams (biology, RX) prescription management and nursing care management. In addition, the access to digital imaging is conditioned to an institutional RIS-PACS, which is implemented in parallel.

**Problem addressed: the need of a mobile computing resource.** It promptly became obvious that one of the fundamental key of success for information technology implementation in our university hospital was its mobility in care units, enabling data insertion in medical patient file, prescription jobs, blood sampling management, medicine administration management and nurse file filling, wherever and whenever needed.

**Wireless infrastructure and wireless resources implementation methodology:** Simultaneously to the working groups previously mentioned, another working group named « Computerised patients file access at patient's bedside » was constituted with IT department members. The workgroup methodology was broken up in five stages:

1. Technological alternatives' analysis: The workgroup first analysed the technical alternatives enabling the work on computers in care units. Five solutions were considered and compared: mobile laptops WITH wireless connection, mobile laptops WITHOUT wireless connection (partial download of the patient file from a network connection outside the room), mobile laptops WITHOUT wireless connection (network connection INSIDE the room), fixed computers in the aisle of the care units (one computer for three rooms), one fixed computer in each room. This comparative study was based on the comparison between benefits and drawbacks of each alternative, as well as the comparison of their cost. This analysis enabled the workgroup to conclude that the first alternative was obviously better than the others. The benefits were the risk reduction of incomplete information availability because of a permanent connection to the database, an increased tool using comfort, superior functionalities and user moves reduction. Moreover, this solution enables access to the digital imaging.

2. Wireless Site Survey order in care units: Before implementation, a Wireless Site Survey was needed in order to analyse the buildings' walls resistance to the

electromagnetic waves. The Site Survey results had to define the precise locations of the access points, as well as their recommended channel to minimize shadow and hindrance zones.

3. Comparative study on mobile hardware: Simultaneously, a comparative study on mobile hardware was carried on, considering « Tablet PC », PDA and mobile computers (laptops) fixed on trolleys. This comparative study analysed all technological, applicative and ergonomic facets of each solution. The selected solution was the mobile computer (laptop) on trolley. Nevertheless, PDA were selected as a solution for specific functions, such as blood sampling management performed at patient's bedside.

4. Trolley pattern study: A trolley pattern study was consequently launched. Two workgroups were involved: one including members of the medical staff requiring mobile solutions for data introduction in computerised patient file, and another with members of the nursing staff, requiring these solutions for the input of their care reports and specific tasks, such as management of blood sampling and medicine administration.

The choice of the physicians pointed out two trolley patterns. The first one equipped with file storage compartments and the second without these compartments, more ergonomic and more suited for teaching purposes. Those patterns were tested in four care units, which chose predominantly the second pattern. The emergency department pitched on laptops without trolleys, because of rather narrow examination box sizes.

The nursing staff was interested in another pattern, enabling file storage and made of inoxidable metal because of hygiene requirements. This pattern will be tested in later stages of the project, when proceeding to the implementation of computerised nurse-related care management, in 2008 and onwards.

5. Defining parameters of the computerised patient file software: Parameters in the computerised patient file software had to be defined, in order to enable the physicians to encode data related to their daily unit tour. The deployment team had to carry on and implement this definition, by analysing each specialty demand and after workgroup ratification. The deployment team was then in charge of the training and the support of the practitioners using this new work tool.

**Results:** In June 2007, and since the beginning of the deployment in January 2006, 89 Laptops, 64 ergonomic trolleys and 20 trolleys with storage departments were installed in the care units. To date, 40 care units of the 46 units composing the entire multiple site University Hospital are outfitted with this mobile solution, that is to say 86 %. We aim to achieve this deployment by the end of September 2007. It should be emphasised that this deployment affects all the practitioners: specialists, residents and medical students working in the care units.

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## 7 Tuesday, 8:30am – 10:00am

### Staffing and Capacity Planning I

Chair : Sally Brailsford

Using simulation to test the staffing reconfiguration in a speech therapy ambulatory care



# Technical Presentations

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*G. Celano, I. Messineo and S. Fichera.*

University of Catania, Italy.

This paper describes a case study developed to evaluate the performance of a speech therapy ambulatory care after a staffing reconfiguration. In the south of Italy the need of speech therapists and structures delivering the related services dramatically increased in the last fifteen years, due to a wider consciousness of both physicians and patients about pathologies involving voice disorders. This resulted in a progressive lack of human resources to be employed within the ambulatories delivering the speech therapy care. Generally, a speech therapy ambulatory care belonging to a public hospital serves different classes of outpatients, (both children and adults) usually requiring a cycle of therapies, accordingly to standardized protocols. In spite of the high demand, in the past the scarce knowledge about the beneficial effects of speech therapy brought the health care managers to underestimate its economic value, both at the National and Regional levels: the consequence is a relatively small therapy billing for the served outpatients, (sometimes partially/totally refunded by the National Health Care Service), to be paid to the structure delivering the service. The consequence is that the hospital managers have a strong reluctance in recruiting speech therapists due to the fact that the revenue deriving from the service delivery does not cover the budget accounted to pay the salary to the involved personnel.

A discrete event simulation model has been developed following a methodology of process analysis and improvement inspired to the principles of Six Sigma philosophy. The simulation of the service was motivated by the need of the Head of the Division which controls the speech therapy ambulatory care to get knowledge about: i) the time needed to reduce the time length of the present waiting lists after the hiring of the new full time employee; ii) the side effects related to the enlargement of the service portfolio thanks to the hiring of the new resource; iii) the economic loss deriving from the introduction of the new specialist within the organization. The development of the simulation model was grounded on a preliminary analysis of the historical data which allowed the environmental setting to be defined. Then, the model was developed within the DES commercial software Rockwell Arena®. Finally, the output of the simulation study has been discussed with the Division Chief to identify both the weak and strong points of the new service configuration.

## **Optimizing nursing human resource planning**

*Mariel S. Lavieri and Martin L. Puterman.*

Sauder School of Business, UBC, Canada.

This talk describes the development of a planning tool to determine the optimal number of nurses to train, promote and recruit over a finite horizon to achieve nursing staff level targets. The model is based on the age dynamics of the nursing workforce. The tool has been developed to model the Registered Nurses workforce in British Columbia, Canada. Its simplicity to use makes it ideal for scenario and "What-If" analyses.

## **Stochastic dynamic nursing service budgeting**

*Gergely Mincsovics, Nico Dellaert.*

Eindhoven University of Technology, The Netherlands.

We address the nursing service budgeting problem from the department manager's point of view. The model allocates the budget dynamically to three types of nursing care capacities: permanent nurses, temporary nurses and overtime. The quarterly tactical decisions are the aggregate weekly shift pattern of permanent nurses and the policy for hiring temporary nurses and using overtime. The decisions are optimized with respect to nursing care shortage and a soft-constraint on the annual budget. For the aggregate weekly shift pattern, permanent nurses require a notification lead-time of one quarter to prepare the personal rosters. Our model offers a solution to the nursing service budgeting problem that extends the existing literature by using a Markovian demand model, resolving the anticipation of the operational decisions, and applying general budget and shortage penalty functions.

## **Modelling the effects of workforce change in emergency care in the UK**

*Sally Brailsford.*

University of Southampton, UK.

Major changes are taking place in the UK in what National Health Service staff do and how they work together. These changes have affected emergency and out-of-hours care. A study involving four UK universities is currently under way to investigate how workforce change is impacting on the experience, satisfaction and perceived outcome of care for patients. This talk describes progress on the project to date, and in particular, the contribution of System Dynamics (SD) modelling to the study.

In eight organisational case studies with varied out-of-hours staffing, maps of all possible patient pathways through out-of-hours care have been developed. These have been used as the basis for qualitative SD models showing how local organisational structures, staffing arrangements and practices influence patient flows. NHS activity data will be used in two of the models to simulate the ways in which patients flow through the system, where the main bottlenecks are in relation to the available skill mix, and to predict what would happen if changes were made to the way in which staff were organised. Hopefully, the research will show which changes in skill mix were associated with better experiences and reported outcomes for patients, and are least likely to have unexpected negative consequences for the wider health care system.

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## **8 Tuesday, 8:30am – 10:00am**

### **Health Information Systems I**

Chair : Paul Harper

## **Text mining emergency department “reason for presentation” data**

*Red Ceglowski and Leonid Churilov.*

Monash University, Melbourne, Australia.

The “reason for presentation” is often the first thing that is recorded about a patient’s condition at hospital emergency departments (EDs). Reason for presentation is commonly a text field in the emergency department information system (EDIS). It might include a working diagnosis or other information such as a reason for referral by a general practitioner. The reason for presentation may be amended as the patient’s treatment progresses, but, more often, a single new field of information is entered that contains diagnoses encoded as a reduced set of the International Classification of Diseases. The encoding of diagnoses facilitates statistical analyses of patient data, but it also results in the loss of some information because a decision needs to be made about which diagnosis to record for patients who might have more than one presenting problem. One way in which this shortcoming of diagnosis encoding may be addressed is through analysis of the reason for presentation text.

This paper presents analyses of reason for presentation text for all patient visits to a metropolitan ED over one year. It highlights problems in dealing with text-based data and strategies that were developed to deal with these. An ED ontology is described and used as the basis of a text mining analysis of the data that incorporates hierarchical agglomeration clustering. Text mining permits reason for presentation text to be coupled with the individual procedures involved in patient treatment and with groups of procedures that constitute “core ED treatments”.

These investigations indicate a strong link between reason for presentation and subsequent treatment (as should be expected). Consequently, the “reason for presentation” is a useful leading indicator of procedures that will be required in the near future and of waiting patients’ expected pathways through the ED. This information might supplement existing fields on the (electronic) “white boards” that most EDs use to assist with prioritisation of patient treatment.

It is a conclusion of this paper that the move by hospital administrators to cease text-based recording of ED data may be short sighted and could result in substantial loss of insight about ED operations. Efforts should rather be focused on retention of the richness of reason for presentation information to support future applications of the predictive link between reason for presentation and patient treatment.

## **TreeFit: the development and use of a powerful decision tree data mining tool**

*Evandro Leite and Paul Harper.*

University of Southampton, UK.

In this paper we present TreeFit, a powerful and user-friendly decision tree software that we have developed in collaboration with the NHS Information Centre (IC). The IC is using TreeFit to assist in the revision of Healthcare Resource Groups (HRGs). HRGs are standard groupings

of clinically similar treatments, which use common levels of healthcare resource. They may be considered as “units of currency” within the health service, allowing for costings across services, and will support the UK Department of Health’s policy of *Payment by Results*.

Decision trees are data mining tools which are used to represent rules underlying data. Decision trees are hierarchical, sequential classification structures that recursively partition the set of observations (data). The interest of our research was to create a tool that resulted in more valuable decision trees by enhancing existing theory. In particular, we are considering issues relating to scalability, hybrid trees and the development of “fuzzy trees”. We will present the latest version of TreeFit which includes the following functionality:

1. The ability to handle large data sets.
  2. The capacity to cope with data that contains several distinct values of categorical data.
  3. Provision of validation of the tree model.
  4. Possibility to move data across terminal nodes.
  5. Description of the nodes path.
  6. Visualisation of the data present in a training model.
  7. Support to missing values in the data.
  8. Allowing the user to interact with the model, choosing the split variable, split values, grow and prune subtrees.
- We will demonstrate the use and benefit of TreeFit on a HRG dataset from the NHS IC.

## **The impact of clinical decisions in In Vitro Fertilization-Embryo transfer**

*Miao He, Lei Zhao and Yue Zhang.*

Tsinghua University, China.

Since July 25, 1978, *in vitro fertilization-embryo transfer* (IVF-ET) has been helping sterile couples to have their own children. As a prevailing clinical practice, controlled ovarian hyperstimulation (COH) stimulates the ovary of a woman with medicines to induce multiple oocytes in order to greatly increase the pregnancy rate.

This research focuses on the hyperstimulation process, where the task is to inhibit the endogenous secretion of gonadotropins with gonadotropin releasing hormone analogues (GnRH a) or antagonists (GnRH A), and instead to supplement the women with exogenous gonadotropins to stimulate multiple follicles’ growing into oocytes of desired quantities and sizes. While increasing the gonadotropin dosage enhances the development of follicles, overstimulating the human body with gonadotropins may also increase the risk of *ovarian hyperstimulation syndrome* (OHSS). OHSS jeopardizes the women’s health and severe OHSS may even end in death. According to the literature, the rate of severe OHSS is 0.7%-1.7%.

Supported by clinical experience and data, in this research, we explore the hyperstimulation process and studies the impact of human characteristics, such as age, body mass index (BMI), and clinical decisions, such as gonadotropin type and dosage, on the follicle and ovary development process. Using approximate dynamic programming models, we try to capture the dynamic nature of the hyperstimulation process and the variability of individual human responses to exogenous gonadotropins. Our goal is to provide doctors with decision supporting tools to balance between the well-development of follicles (and ovary) and OHSS risks.

## Using E-Health for Physicians' Decision Making to Combat HIV/Aids in Sub-Saharan African

*Sanjay P. Sood, Oneurine Ngwa, Billy Ruhweza, Victor Mbarika and Joseph Tan.*

University of Mauritius.

There is a dismal need for an insistent combat against pandemics and epidemics like HIV/AIDS, Malaria and tuberculosis in Sub-Saharan Africa. These wide spread diseases are some of the key factors responsible for the gap that is widening between the haves and have-nots. These intransigent healthcare issues call for extra efforts and techniques to tackle them. Synergistic efforts by technology experts in engineering, IT and healthcare, have made up for limited resources by developing e-Health based solutions. E-Health is a means of healthcare information and service delivery where patients are treated of their diseases from distant locations, by the use of Information Technologies, with the internet the most prominent one. E-Health improves the standards of health care, the delivery of medical information and the training of e-Health personnel's, to help developed under-privileged areas. Some countries like Mozambique, Uganda India etc are beginning to experience the impact of e-Health in its population, as e-Health have begun addressing challenges posted by the HIV/AIDS pandemic and other epidemics like malaria and tuberculosis. Lately, e-Health has found its way in the main streams of health care information and service delivery, which include concepts like tele-medicine, tele-education and computer-based clinical simulation, a situation where health care professionals learn by doing what they do in practice.

Despite the fact that clinical trials are a popular approach in evaluating medical therapy, modern medicine is producing more effective diagnostics and medications but pandemics like HIV/AIDS, malaria are still treading widely into the societies of struggling countries where education and healthcare infrastructures are limited. Today, over one sixth of the world's population is infected with HIV/AIDS, malaria, tuberculosis and Hepatitis and unfortunately, majority of these cases are found in the developing world. As a result, physicians in this developing world are looking up at computer simulations, those that will catalyze treatment design, speed up clinical trials, and eventually contribute towards efficient training of healthcare personnel. Computer based therapy simulators broaden the treatment design options available to a physician, they also provide additional tools to assist swift understanding and evaluation of those options, by reducing the treatment design process to an intuitive manipulation of data (Sherhouse, Mosher et al., 1987).

In this paper, we present key elements of a healthcare internet based technology called TheraSim Inc. It facilitates flow of training and information needed for the scaling up delivery of treatment to those suffering from pandemic diseases in resource-limited settings.

TheraSim platform includes the following modules:

- TheraSim Online : Simulation and didactic clinical training and assessment
- TheraSim ERM : Electronic Medical Records
- TheraSim TM : Telemedicine

Therasim application is an aid to insure success of global efforts to treat patients with HIV and other pandemic diseases. It measures and monitors the capabilities of clinicians and the impact of training and support systems on skill levels and ultimately clinical outcomes. It also provides a global dashboard for clinical training readiness where, by March 2005, TheraSim online had trained over 2000 healthcare personnel in over 160 countries. Although TheraSim is not focusing exclusively on HIV/AIDS as applied for HIV treatment but the complexity of treating HIV and the kind of global effort that all countries are putting together to confront HIV/AIDS makes it an ideal example to be taken up while detailing TheraSim.

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## 9 Tuesday, 10:20am – 11:50am

### Health Care Delivery Engineering in Mediterranean

Chair : Aida Jebali

#### Supplying the operating theatre: disposables products or reused products

*Sondes Hammami, Imène Elhachfi Essoussi, Pierre Ladet and Angel Ruiz.*

Ecole Nationale d'Ingénieurs de Tunis, Tunisie.

Traditionally, the operating theatre is integrated in a chain characterized by the re-use of a certain number of instruments. Indeed, a great majority of the surgical material is recovered, decontaminated then sterilized to be reinstated in the supplying chain. Thus, we can undoubtedly affirm that the operating theatre is pioneer in the modern art of the re-use and recycling. In fact, the disposable instruments are extremely expensive. Nevertheless, the management of the reversed component of such a chain presents difficulties and stakes. The rehabilitation operations in the chain are also extremely expensive. Additionally, the infections and contaminations number of the patients taking place to the block increases. The quality (and relevance) of the operations of decontamination and sterilization being given is in question. Therefore, to improve the care quality and minimizing the total supplying cost is it optimal to use only disposable materials? Or only reused materials? Or both reused and disposable materials?

#### Toward a decision tool for home care planning

*Hanan Bouchriha, Aida Jebali and Emna Benzarti.*

Ecole Nationale d'Ingénieurs de Tunis, Tunisie.

Problem statement: The health care systems are increasingly moving towards integrating the residence of the patient within the logistic chain of care. Indeed, some countries have adopted home care organization in order to reduce costs, to ensure efficient use of hospital facilities and to reduce patient length of stay. Moreover, this new form of providing care becomes more interesting mainly when the population comprises a more elderly people.

According to (Chahed and *al.*, 2004), home care services can be classified into three types of organizations: the home hospitalization, the home health care nurses and specialized home health care treatments. Our case study belongs to the last type since it deals with a specific kind of home health care through the supply of medical equipment, by a service provider, for respiratory assistance.

There are few and recent works dealing with home care planning and organization. Some studies are interested in the development of tools for the assignment and sequencing of nurse visits to patients (Begur *et al.*, 1997 ; Eveborn *et al.*, 2006). Other works are interested in the co-operation between the various actors in these new forms of organizations from an information system point of view (Bricon-Souf *et al.*, 2005).

In this work, we are interested in the case of a service provider which supplies medical oxygen, equipments and other auxiliary services to many patients at home, suffering mainly from respiratory pathologies. The services that are offered can be either rentals or sales of equipments for respiratory assistance (respirator, concentrator of oxygen, etc).

The company has two technicians whose principal tasks are summarized as follows:

- Visits for preventive maintenance of the equipment at the patient home.
- Visits to collect the patient's files for health insurance coverage.
- Visits to recuperate equipment rented once their rental period expires.
- Visits for corrective maintenance in the case of equipment breakdowns.
- Visits for new equipment installation (new patients).

The last two types of visits represent urgent tasks which must be accomplished during the business day or at the latest, within twenty four hours.

The goal of this work is to propose a tool for planning the visits of the two technicians (CMT). These visits include both programmed and urgent ones. Through better planning of technician visits, it is possible to reduce travelling costs while improving quality of service provided to the patient.

Proposed approach: The problem thus considered is decomposed into two levels:

- Weekly planning of the visits: The weekly program of the visits is established by considering those patients who has reached their release date with respect to one of the following event: (1) pick-up of medical insurance file, (2) preventive maintenance and (3) equipment recuperation. Thus, by tacking into account the patient assigned to each CMT, the localization of patients, a mixed linear program is established to determine the day of the visit of each patient and the order of the visits. The objective is to minimize travel cost and the penalty for medical files delays imposed by health insurance offices.
- DailyPlanning of the visits: for each day of the week, a mathematical program is established in order to insert programmed visits generated by the weekly planning and not yet accomplished, as well as urgent tasks (new installation, urgent corrective maintenance). This program will also refine the order of the visited patients programmed within this day.

In this paper, we propose a mathematical formulation of the two planning levels (weekly and daily) as well as heuristics developed to construct the two plans. The

whole approach will be illustrated through a real case study.

## **A mathematical model for the “make” or “buy” decision in the hospital sterilization**

*Houda Tlahig, Aida Jebali, Hanen Bouchriha and Pierre Ladet.*

Ecole Nationale d'Ingénieurs de Tunis, Tunisie.

Hospitals are today under increasing pressure to keep costs down. Moreover it is widely recognized that cost reduction in secondary processes allows improving the primary processes of patient cares. Consequently, attention for optimizing these processes has increased. In particular, there is much attention to outsourcing some activities from the hospital by entrusting them to a sub-contractor. An activity where this question arises today is the sterilization.

A literature review that we made in a previous paper [Tlahig *et al.*, 2007] shows the absence of studies focusing on the question of the configuration of the sterilization sector from an engineering point of view. In fact, this problem has been studied until now only by pharmacists, through qualitative descriptions of its practices [Bardet, 2003], [Levrat, 2003] and through economic evaluations of the Central Sterilization Service (CSS) costs [Carbonnel *et al.*, 2005]

To the best of our knowledge, there are no later works focusing in finding the best choice between the “make” or “buy” alternatives in the hospital sterilization field. In fact this sector can be made in house (make), outsourced (buy) or provided within cooperation between a hospitals network (make with) [Girraputo, 1990]. In the case of outsourcing, sterilization can be ensured by an industrial company or by one other hospital located in the same region.

In this paper, we are dealing only with the choice decision between the two first alternatives.

We are suggesting a two stepped approach for the “make” or “buy” decision of the hospital sterilization sector.

In the first step, we are aiming to identify the sterilization process activities that should be kept in-house and the ones that could be outsourced. Thus the sterilization process is explored and analyzed.

The second step consists in finding the optimum choice between the “make” or “buy” alternatives that minimizes the sterilization process costs. Then it consists of performing the model on a real case study and running sensitivity analyses related to the variation of (1) the “delivery cost”, (2) the “sterilized items required quantities” and (3) the “sterilization capacity” criterion.

We are considering in the outsourcing choice an approach taking into account all the activities of the sterilization process. This is a long term decision level. (...)

A mathematical model is developed in order to determine which activity to maintain in-house and which one to outsource and from which provider; The objective is to minimize the total cost of the sterilization process which comprises the production costs, the delivery costs and the storage costs of the sterile components. The production costs consist of fixed (human resources, equipments...) and variable costs (operating and purchasing costs, energy and water consumption ...)

The considered constraints are essentially related to (1) the respect of the available sterilization capacity, (2) the respect of the delivery capacities of the external provider, (3) the satisfaction of the demand, (4) the flow conservation, (5) the inventory constraints and (6) the working constraint (for example the product quantities to be sterilized for the considered hospital cannot be shared into a product quantity treated in-house and the rest within external provider).

This problem is modelled as a mixed linear program.

The suggested approach was tested on a pseudo-real example inspired from a real case of French hospital. Sensitivity analyses related to the considered criterion are being performed and results will be shown in the full paper.

## Joint Replenishment for the Operating Room

*Sondes Hammami, Pierre Ladet, Angel Ruiz and Atidel B. Hadj-Alouane.*

Laboratoire d'Automatique de Grenoble, ENSIEG-INPG, St-Martin d'Heres, France.

In the majority of hospitals, two aspects mark the replenishment of the operating room. First, nurses are in charge of the logistic activities: reception, handling, arrangement, etc. Second, there exist high inventory levels of stored materials. These have an impact on both the quality and the cost of the nursing activities. In this paper, we are interested in supplying the operating room while addressing the following two objectives: (1) release the nurses from the logistic activities and (2), minimize the inventory levels. Inspired from methods developed for industrial settings, we propose two different approaches for supplying the operating, that take account the hospital's specific structure and constraints. These approaches are tested and evaluated in "Charles Nicolle" Tunisian hospital.

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**10 Tuesday, 10:20am – 11:50am**

## Modelling and Simulation I

Chair : John T. Blake

### Taxonomy of modelling and simulation methods in healthcare: emerging findings of the Research Into Global Healthcare Toolkit (RIGHT)

*Brijesh Patel.*

University of Southampton, UK.

The RIGHT project is an ambitious exploration in investigating and constructing a toolkit aiding the healthcare management. This paper presents emerging findings of the RIGHT Project. The paper reviews various modelling and simulation methods based on a systematic literature survey. Analysis and discussion of the taxonomy provide basis for the findings and its implications for the healthcare management. Life cycle of systematic review survey and strategies are analysed in establishing taxonomy of modelling and simulation models in healthcare. The paper outlines how taxonomy

is related to improved collaboration of academia and healthcare industry, and value for healthcare management.

### What is a 'generic' hospital model ?

*Adrian Fletcher, Dave Worthington.*

Department of Health, Leeds, UK.

This working paper addresses the question posed in the title via a survey of 20 or so experienced healthcare modellers and a literature review of over 100 books and articles. Four levels of 'genericity' are proposed: generic principle model, generic framework, setting-specific generic model and setting-specific model. The third and fourth of these are then chosen as the focus for a further in-depth examination to extract lessons relevant to the problem of building a 'whole-hospital' model for emergency patients. Many examples of models of individual hospital departments are found and a much smaller number of multi-department models. Many of these do not report validation or implementation processes. Nevertheless potentially valuable lessons can be learned.

### A simulation framework for health care systems

*Vincent Augusto, Xiaolan Xie and Frédéric Grimaud.*

École Nationale Supérieure des Mines de Saint-Étienne, France.

Over the last decade, traditional business process modelling approaches have been used to model and understand complex health care systems. However, the health care field presents several particularities such as diversity of human resources, system management and specific phenomena as communication, behaviours and interactions between actors which cannot be captured by traditional modelling tools. Whereas some researchers are looking forward to create a generic health care model, emergent studies about modelling framework for health care systems become legion. The goal is to develop a methodology which is able to capture particularities of health care system. We introduce the medPRO (medical Process-Resource-Organization) modelling tool in this paper, a new framework designed for analysis and simulation of healthcare systems. We focus here on the arguments for the creation of a new modelling framework.

The architecture of the medPRO framework has been designed from the analysis of two health care departments: the pharmacy department and the operating theatre. We were able to build a comprehensive framework for these departments, allowing us to model different organisations observed in several hospitals. To do that, we (i) listed and formalized the needs of system actors and (ii) proposed personalized views for each category of the working staff. We focused on communication, simplicity and rapidity. Furthermore, models have to be simulated in order to get results quickly.

This framework consists of a list of generic resources and activities description, and a handbook describing the base system. The UML (Unified Modelling Language) has been chosen to model these systems. Several points

of view have been selected: process (activity diagrams), resource (state charts) and organisation (class diagrams). The process view represents the patient flow in a specific medical department: only activities related to the patient are modelled. The resource view represents the behaviour of each resource (human or material), including tasks that does not appear in the process view. Finally, the organization view represents a global view of the system: number, specialities and scope of resources, relations between them, etc. A synchronisation system is used to link these views, which constitute the physical sub-system.

From this point, we developed a formalized framework and a simulation algorithm, namely a complete architecture. Although our modelling and simulation tool is still under construction, we were able to model the operating theatre process with our framework on one hand, and with traditional modelling tools on the other hand. This way, we were able to evaluate the accuracy of medPRO.

A control system will also be developed in order to manage (i) disturbances during the simulation process, (ii) the settings of the simulation model, (iii) the decision process. This control system will also be useful to manage interactions between actors in order to change dynamically the system organization (scheduling of tasks, preemption, etc.). Holonic systems may be a relevant tool to complete our model.

## **Getting OR tools into the hands of users: development of a blood donor clinic simulation**

*John T. Blake, Candy Lipton.*

Dalhousie University, Halifax, Nova Scotia, Canada.

**Background:** In all parts of Canada, except the Province of Québec, blood products are collected by Canadian Blood Services (CBS) from unpaid volunteers and provided free-of-charge to accredited health care facilities. Total expenditures for CBS in 2005/06 were \$823 million (\$CAN).

CBS runs approximately 20,000 blood donor clinics annually. In 2005/06 CBS collected 871,000 units of whole blood, 52,000 units of plasma via plasmapheresis and 30,000 units of platelets via plateletpheresis. The cost of operating the blood program during this period was approximately \$400 million (CBS, 2006).

**Problem Statement:** Collecting blood from donors is a key element of Canadian Blood Service's business. As stewards of the countries blood supply chain, CBS must ensure that sufficient blood and blood products are available to meet the needs of all Canadians. However, as a publicly funded agency, CBS has a duty to ensure that the blood system is managed in the most efficient manner possible. Optimizing the flow of donors through blood clinics is a difficult management task because of the competing objectives of minimizing donor delay (and thus keeping donors satisfied and likely to return) while containing the cost of operations.

In this paper we present the results of a project designed to give clinic planners tools to assist them in the complex task of balancing customer service requirements with cost minimization strategies. The tool is centred around a clinic planning spreadsheet that is supported by a discrete event simulation. The tool is designed to help

clinic planner identify good schedules for donors, staff, and resources.

**Literature Review:** The literature on donor clinic operations is very sparse. Pratt and Grindon (1982) use a simulation model to study work flow and queuing problems in blood collection. They study a variety of scheduling strategies but note that control of queues required keeping donor arrivals from exceeding the system capacity. Brennan, Golden, and Rappoport (1992) employ a simulation model to study customer service and productivity issues for the American Red Cross. They conclude that a scheduled appointment system should be implemented to reduce variation in donor arrivals.

**Methodology:** Donor clinic scheduling provides a unique opportunity for the practical, everyday application of operational research. We believe that by supporting clinic planners we can help the key decision makers develop schedules that are both efficient and customer focused. Thus, the most appropriate methodology is a desktop tool that clinic planners can use in a variety of situations to schedule staff and donors. Accordingly, we are developing a dedicated discrete event simulation shell that functions within MS-Excel to evaluate proposed clinic schedules.

**Conclusions:** We will present the results of our work over the past year to build, test, verify, and validate the donor scheduling model. We conclude with discussions about future research and opportunities for other areas of exploration.

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## **13 Wednesday, 9:20am - 10:50am**

### **Staffing and Capacity Planning II**

Chair : Arjan Shahani

#### **Capacity planning issues in neonatal care networks in UK: a case study on North Central London Perinatal Network**

*Md. Asaduzzaman, Thierry J. Chaussalet, Haifeng Xie,  
Nikki Robertson and Daniel Wood.*

University of Westminster and University College London,  
UK.

Neonatal care is one of the major components of health care in United Kingdom that aim to offer high quality care for the vulnerable babies. Every year over 80,000 (approximately 10%) babies are born premature, very sick, or very small and require some form of specialist support at birth in the UK and are admitted to a specialist neonatal unit for care. Many of these babies 1-3% are born extremely premature (under 27 weeks) or have a low birthweight (under 2,500g) those require Neonatal Intensive Care. The North Central London Perinatal Network (NCLPN) is one of the 24 neonatal/perinatal networks across England established in early 2004 with six hospitals. The underlying aim of the network is to 'Improve standards and achieve capacity so that 95% women and babies can be cared for within the network'. In 2006, a common information system called SEND (South England Neonatal Database) was established in 4 out of the 6 hospitals and NCLPN Transfer Audit which is

also running in parallel to monitor the transfers of mothers and babies throughout the network.

Most perinatal centres in UK are now regularly unable to meet the demand. The BLISS Baby Report 2, published in June 2006, reported that about 78% of all units had to close to new admissions at least once in the last six months. From all recent reports published related to neonatal care, it is very clear that issues of capacity, transfers and staff shortages all exist in neonatal system. Therefore, solving these issues by means of analytic or simulated models is essential.

In this study, we present the organisation and current issues of neonatal networks in UK. We outline a discrete-event simulation model to examine the performance of the North Central London Perinatal Network to estimate the key performance measures: (1) level of congestion at each of the units in the network (2) number of transfers (3) level of staff workload under steady-state condition. The results from the simulation model may provide a guidance to neonatal care managers to operate cost-effectively the NCLPN with better performance.

## **The dynamic forecasting of short to medium term workload based on current case mix**

*Christina Pagel, Martin Utley and Steve Gallivan.*

Clinical Operational Research Unit, University College London, UK.

Variability in demand for health care services presents a substantial problem to managers. Short term fluctuations in the number of patients requiring a particular service can result in a system being overloaded or, alternatively, seemingly inefficient in its use of resources.

A key contribution to the variability in demand for many health services is the variability in "length of stay", whether this is a physical stay on a ward or occupation of a weekly slot in an appointment diary. We will describe methods for using knowledge concerning the length of stay characteristics of the case mix of patients within a system at a particular point in time to generate estimates of capacity requirements over the short to medium term. Potential applications of this approach will be discussed with relation to a paediatric intensive care unit and the distribution of cases among mental health workers.

## **A sizing tool for allocation planning of hospital bed resources**

*Tao WANG and Alain GUINET*

Institut National des Sciences Appliquées de Lyon, France.

This paper focuses on bed resources allocation in a hospital taking into account hospitalization demands, bed capacity, and Activity-Dependent Price (T2A) incomes. The data used in this research work combines the elective patient flow and the acute patient flow from emergency department. A mathematical model based on a dynamic dispatching approach is developed and experimented respectively with Lingo and Cplex. Our objective is to maximize the incomes based on T2A and to minimize the cost to use supplementary beds. As a result of this model, the bed allocation planning calculated from the best objective value is presented.

## **Detailed Models for Capacities and Organisation of Critical Care Units for Cardiac Patients**

*A. K. Shahani, J. Harbord and M. S. Nielsen.*

University of Southampton, UK.

Patients admitted to a hospital in the UK can receive four levels of care. Most of the patients need Level 0 or Level 1 provided in normal wards. Some patients need more specialised care at Level 2 (also called High Dependency Care) and/or Level 3 (also called Intensive Care). Patients needing Level 3 care have serious, often life threatening, conditions. The description Critical Care covers Level 2 and Level 3 care.

Expansion of Critical Care capacities is a part of the plans for major developments in Cardiac Services over the next five years at Southampton University Hospitals NHS Trust. At present Critical Care for the Cardiac patients is organised in three units called CTITU, Surgical HDU, and Cardiology HDU. CTITU provides Level 2 and Level 3 care and the other two units provide Level 2 care. Detailed data analysis and detailed mathematical models at the level of individual patients can provide the necessary quantitative information for making good decisions about the capacity and the organisation of Critical Care Units. In this paper we discuss the use of this data analysis and modelling approach for evaluating a variety of options for the capacities and the organisation of CTITU, Surgical HDU, and Cardiology HDU.

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## **14 Wednesday, 9:20am - 10:50am**

### **Emergency Care**

Chair : Mario Jorge Ferreira de Oliveira

### **Identifying and modelling decision problems for emergency network in France: a literature review and analysis**

*Aissam Belaidi, Béatrix Besombes, Eric Marcon and Alain Guinet.*

University of Saint-Etienne, France.

**Aims:** The purpose of this paper is two-fold. Firstly, to show the interest of modelling emergency network organization in France. Secondly, to characterize the different issues related to the steering of the Emergency Supply Chain (ESC) and positioning the literature dedicated to health emergency issues. This allows to propose a modelling of the network organization and to support the development of long-lasting solutions to ESC problems.

**Methods:** We have attempted to characterise the network structure by identifying the principal key players, classifying those players according to their function and mission, and characterising the co-operation between those key players. This allowed us to build a macro conceptual model of the French emergency network. We called it: the emergency supply chain (ESC). This supply chain was modelled using graph theory.

In a second time, we used the enterprise modelling approach, especially the GRAI methodology to pilot the ESC. GRAI methodology allows representing activities of the system with the goal to improve performance, according to several views: Functional and Physical view, Decisional processes, flow patient Processes, and Informational view. In this paper, we focused only on decision processes in ECS. GRAI Grid model is a powerful tool for representing the overall decision centres of the ESC in a single grid. This enabled to represent the decisions made in the ESC from the strategic to the operational level, for all the identified key functions. The GRAI grid allowed verifying the coherence and the dynamics of the ESC functioning, pointing the problem of coordination and synchronisation between decision centers.

Finally, we positioned the literature review on the GRAI Grid, and analysing the situation of the state of the art in this field.

**Results:** An approach for modelling and analysing the ESC has been defined. This approach was applied for modelling and analysing the French ESC. We identified four classes of key actors characterising the French ESC. We classified them by function: regulation function, transport; treatment of urgency, and the care follow-up coordination function.

The relationships between the key players of those four functions were defined and classified in a systems approach based on Organization theory concepts (vertical integration and horizontal co-operation). By positioning the literature review on the grid, we characterised the different research problematics identified and addressed in the field. That gave us an idea about possible future research tracks. The analysis of the literature review showed that, the past research efforts were focused on the operational level, and especially for a few actors of the ESC. Many studies were conducted to resolve local problems, especially overcrowding problems in emergency departments. However, we found very little literature related to transversal and systemic approaches to solve the problems of integration, co-operation and collaboration. There are also few works referenced in the literature in relation to the design and configuration of the ESC.

**Discussion:** This study shows that; the major of the previous works have treated local problems, for single actors, and focused on operational-level issues. For this reason, we stress the need to develop global solutions taking into account a global overview of the ESC. This analysis conducts us to focus our future research on the design and configuration problems of the ESC. To support this issue and to face the coordination problems, we will experiment, in transversal way, different scenarios through the use and the development of Meta simulation models.

## **Evaluation of ambulance transfers into urgent care centres to improve ambulance availability & reduce offload delays**

*Ali Vahit Esensoy and Michael W. Carter.*

University of Toronto, Canada.

Ontario Hospital Emergency Department and Ambulance Effectiveness Working Group has proposed an initiative based around the use of Urgent Care Centre (UCCs) as

destinations for ambulances to help alleviate the problem of excessive ambulance offload delays and emergency room wait times. Through this initiative, select patients with minor medical conditions and low risk of inpatient admission traveling via ambulance will be transported to a UCC instead of being sent to an emergency department where they are expected to experience much shorter delays due to the low acuity patient mix and patient volumes.

In our study, we first develop record linkage between ambulance dispatching database and the national ambulatory care database using a probabilistic matching algorithm. Then we use the combined dataset to determine patient groups that could be seen in these facilities given the constraints of UCCs such as their lack of inpatient beds and the portfolio of clinical and social services that they provide. These patients groups are then used to propose changes to the patient mix, operating hours and catchment areas of the UCCs as well as recommendations for expansion of this initiative across key areas in Ontario.

## **Analyzing large scale emergency medical systems on highways using an approximated hypercube queuing model**

*Ana Paula Iannoni, Reinaldo Morabito and Cem Saydam.*

Federal University of São Carlos, Brazil.

We present an approximate hypercube model embedded genetic algorithm to determine the optimal primary and secondary response areas for the ambulances (districting problem). The hypercube model, which is based on spatially distributed queuing theory, has been one of the most effective descriptive approaches used to analyze emergency systems. Embedding the hypercube into a genetic algorithm, we can support design and operational decisions, such as, determining the optimal districts for the system in order to minimize the mean user response time and the ambulances' workload imbalances as well as generating a Pareto efficient frontier between these measures. The main drawback of the previous studies using the exact hypercube model integrated into a genetic algorithm is the runtime requirements to solve moderate-to-larger problem instances. In an effort to address larger problems, however, this study explores the feasibility of utilizing a fast hypercube approximation algorithm embedded in a genetic algorithm (called GA/approximate algorithm). In our GA we implemented a recent hypercube approximation model proposed in the literature based on the single dispatching and partial backup system. The use of the approximate method presents a reasonably accurate alternative while reducing the CPU requirements needed to estimate the system performance measures of larger systems. We compare the GA/approximate hypercube algorithm with a counterpart exact hypercube model (called GA/exact hypercube algorithm). Computational results are analyzed by applying the two algorithms to the case study on a Brazilian highway and comparing the resulting approximate solutions with the corresponding exact solutions found by exhaustive enumerative procedures. We also apply the GA/approximate hypercube algorithm to larger problem instances and provide computational statistics. The approximate solutions presented relatively small deviations from the corresponding exact solutions.



In particular, it was shown that different system performance measures or objectives, such as the mean user response time and workload imbalance among the ambulances, could be improved by simply modifying the atom sizes of the system without relocating ambulances and without requiring additional capacity investments.

## **The accessibility and quality of the emergency service of a public hospital in the municipality of Resende, Rio de Janeiro**

*Francisco Santos Sabbadini, Antônio Augusto Gonçalves and Mario Jorge Ferreira de Oliveira.*

Federal University of Rio de Janeiro, Brazil.

The difficulties to access emergency services and the excessive patient's wait time are some characteristic problems of most public hospitals in Brazil. The admission of emergency patients is a complex process that involves high risk and costs. The service efficiency is fundamental as the agility in guiding the patients who need medical care is a critical factor for the reduction of risk and to increase possibility of recovery. The management of service capacity becomes important, as well as the adjusted allocation and sizing of resources. This paper proposes a simulation model that aims at evaluating alternative scenarios of the emergency sector of the Henrique Sergio Gregory Hospital, which is public hospital in the municipality of Resende, in the State of Rio de Janeiro. The principle of capacity management of services is applied and the theory of constraints is used to identify bottlenecks in the treatment flow. Based upon these theoretical aspects, a proposal of improvement for the reduction of the time between the registration of the patient and the beginning of the effective treatment has been drawn up.

The model is actually a decision support tool that evaluates the impact of changes in the admission system. The developed exercise is based upon the flow of emergency patients and also accounts for possible improvement on the quality of the service level. It is expected that the implementation of the proposed strategy leads to a reduction in the patients' waiting time.

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## **15 Wednesday, 11:10 – 12:40am**

### **Operating Rooms Planning I**

Chair : Erik Demeulemeester

#### **Surgery planning with uncertain operating times**

*Mehdi Lamiri and Xiaolan Xie.*

École Nationale Supérieure des Mines de Saint-Étienne, France.

Uncertainty is inherent to the operating rooms' environment; it concerns essentially surgery durations, emergency patients' arrivals, and equipments and medical staff availability. So the planning of surgical procedures must take into account these uncertainties; otherwise, they may impact the quality of service toward patients, and generate additional costs for the hospital.

This paper addresses the elective surgery planning under uncertainties related to surgery durations and emergency surgery demands. Surgery durations as well operating rooms' capacities used by emergency surgery are assumed to be random variables. The planning problem consists of assigning elective patients to operating rooms (ORs) over a planning horizon in order to minimize patients' related costs and expected ORs' overtime costs. The planning problem is first modeled as a stochastic integer program. Monte Carlo simulation is then used to approximate the problem by a mixed-integer program. A column generation reformulation in which each column represents a possible assignment of elective patients to a particular OR in a particular day is then derived. The linear relaxation of the latter formulation is then solved via column generation. Feasible plan is derived from solution of the relaxed problem by a heuristic, and improved by using local improvement heuristics. Computation experiments show that the solution approach results in near-optimal solutions in a reasonable computation time.

#### **Determining surgery schedules on the operational level through column generation**

*Brecht Cardoen, Erik Demeulemeester and Jeroen Beliën.*

Katholieke Universiteit Leuven, Belgium.

In this paper we will investigate how to sequence surgical cases in a day-care facility so that multiple objectives are simultaneously optimized. Among these objectives are the leveling of the bed occupancy in two recovery wards and the avoidance of unplanned hospitalizations when patients need care after closing time of the day-care center. The limited availability of resources, such as instruments and their corresponding sterilization time, and the occurrence of medical precautions, such as an additional cleaning of the operating room after the surgery of an infected patient, are taken into account. It can be shown that this optimization problem is NP-hard and hence hard to solve. With respect to the solution methodology, we developed a column generation approach, i.e. variables represent groups of sequenced patients. In particular, column generation is applied to optimize the linear programming formulation of the scheduling problem. Both a dynamic programming approach and an integer programming approach are specified in order to solve the pricing problem. A computational experiment, though, revealed that the dynamic programming approach outperformed the generation of columns through integer programming. Since column generation cannot guarantee that the solution values of the column variables will be integer, this procedure will be extended to a branch-and-price methodology and will hence be combined with various branching schemes that are either time-based or sequence-based. Moreover, speed-up techniques will be introduced and evaluated on their contribution. The evaluation and testing of the diverse exact and heuristic branch-and-price algorithms is based on real-life data of the surgical day-care center at the university hospital Gasthuisberg in Leuven (Belgium). Instances are generated according to different patterns and sizes (up to 85 surgeries). Since the scheduling problem that is the subject in this paper

actually originated from this major hospital, a steady cooperation was maintained during the development of the problem setting and the algorithms. Computational results indicate that it is hard to prove the optimality of the solutions within

a limited time setting. This, though, does not imply that the procedures do not succeed in generating surgery schedules for which the objective value (nearly) equals the eventual optimum. By the end of the paper, conclusions are summarized and ideas for future research are mentioned.

## **Planning surgical activities: a societal point of view**

*Angela Testi, Anna Sciomachen and Elena Tanfani.*

University of Genova, Italy.

In this paper we deal with the problem of planning surgical activities among different surgical units (wards) with the aim of maximising the societal benefit by improving patients satisfaction and reducing hospital costs. In particular we develop a heuristic procedure for determining the Master Surgical Schedule (MSS), i.e. the assignment between wards and surgery rooms, together with the set of patients belonging to the waiting lists of the wards to be operated during each day. Different resource constraints related to the length of the operating session, maximum overtime allowable by the current labour collective agreement and legislation, type of equipment available in each operating room, number of surgeon for each ward available for operating in each day, the number of stay and ICU beds have been considered. Firstly, we develop a 0-1 linear programming model intended to minimise a cost function based upon a priority score that takes into proper account both the waiting time and the urgency status of each patient. Successively, we present a heuristic approach that enables us to embody some preassignment rules for being able to solve this NP-hard combinatorial optimization problem and including the hospital costs in the objective function. In particular, we force the assignment of some wards to a subset of days depending on the expected patient length of stay of patients (short or long stay) so that it will be possible to close some stay areas during the week end and reduce the overall hospitalisation cost of the department. The results of an extensive computational experimentation are given and analyzed.

## **Limited-time decision making with Tabu search for an operating theatre daily scheduling problem**

*A. Hanset, O. Roux, H. Fei, D. Duvivier and N. Meskens.*

This paper addresses the operating theatre's daily scheduling problem. The operation of an operating theatre should take into account multiple constraints, such as the schedule of specific surgeons, their competences, the availability of recovery beds, etc. Few of existing work take into account the impact of the limited number of recovery beds on the efficiency of an operating program. In this research, we are interested in the daily scheduling problem with a strategy named "open scheduling strategy". Considering this strategy all operating rooms are available for all possible surgical cases and their time blocks are not reserved for specific

surgeons, i.e., once a set of surgical cases are assigned to one day one or several weeks in advance, we schedule these surgical cases into a set of multifunctional operating rooms so as to fulfill the restrictions of the recovery room and surgeons and aim at minimizing the daily operating cost of the operating theatre. Consequently, the objective is to minimize the weighted sum of occupation time of the recovery room and that of operating rooms. In addition, if there exist several daily operating programs with the same objective value, an auxiliary criterion, the weighed sum of occupation time of the recovery room and the average occupation time of operating rooms, is applied in order to find the final solution. Since the concerned problem is NP-hard and no efficient method can be found to systematically find the optimal solution for all (or even real life) instances of the NP-hard problem, many researchers focus on developing heuristic methods to generate an approximate solution with good quality in a reasonable execution time. In this research, we propose a Tabu search method in order to obtain a feasible and efficient operating program for one scheduling day. It results that our method can find a solution of good quality within reasonable execution time. However, since the Tabu search is non-deterministic, the decision-maker must choose between a few long executions or shorter runs in a predetermined amount of processing time. In the context of this time-limited decision making problem, we also give some clues to make an efficient usage of available time. We present the obtained results on the described problem.

In our future research, we will take into account the setup time between two surgical cases, especially the necessary time for changing materials and preparing the equipments, the availability of other necessary human and material resources. We will also study some specificities of the Belgian healthcare system.

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## **16 Wednesday, 11:10 – 12:40am**

### **Modelling and Simulation II**

Chair : Martin Pitt

#### **An examination of preoperative assessment using simulation modelling**

*Philip Ruttle and Peter Williams.*

University of Limerick, Ireland.

It has been reported that the use of a pre-operative assessment is a viable means of reducing cancellations on the day of surgery. Pre-operative is where the surgeon/anaesthetist or nurse examines and talks with the patient to explain their role and responsibility leading up to the operation as well as performing all the necessary medical checks to insure that the patient is fit for the required operation. The examination is performed some time before the operation so that it is not so far ahead that the patients' condition can considerably change and not so close that planning for disturbances is impossible. This opportunity also gives the surgeon a better chance to recognise any complications which may arise and account for them before they occur, for example another piece of equipment may be necessary.

However it is widely sited that the main cause of surgical cancellation is due to time constraints, operating rooms are often overbooked and cases run late, so does implementing pre-operative assessment have the potential to reduce cancellation rates, reduce key performance indicators like waiting time, waiting list quantity and utilisation. In previous studies such KPI's have not been fully analysed.

Presented is a simulation model that investigates the impact of pre-operative assessments on operating room performance. This model may be used as a decision support tool, to choose between alternative strategies. Some preliminary results indicate that under some circumstances implementing a pre-operative assessment clinic may not be the best alternative. This is true where there is a low co-efficient of variation and there is a pool of patients or in a situation when the variation is high, operations regularly overrun. The reason for this is that if a operations constantly over run there is a change that the last patient will be cancelled due to time constraints, however if a patient is cancelled due to medical reasons, time is freed up assuming that the next patient is available.

## **The multi-user simulation of the emergency department of Brazilian hospital: three views of the admission process**

*Adriana Bandeira Moraes, Mario Jorge Ferreira de Oliveira and Sheila Monteiro Elias Espósito.*

Federal University of Rio de Janeiro, Brazil.

The field of discrete event simulation has developed in such a way that is now possible to visualize the results of a model combining objects, sound and movements in a way that approaches reality. The objective of this paper is to show the results of an experiment that uses a multi-user simulation to study the admission system of a major teaching hospital in the state of Rio de Janeiro. This new approach to simulation enables one to see the interaction between people located in distant places with simulated agents within a three-dimensional environment that represents the most important characteristics of the emergency sector of the hospital. The focus of the experiment is on the integration of three different and subjective views of the most important entities involved in the admission process: the administrator, the medical staff and the patient. A triage system with five levels of severity is used to select patients and several scenarios are evaluated with the objective to improve the admission process of this hospital. The results had shown a reduction of the average patient's waiting times that are compatible with the patient's emergency severity level and human and material resources of the hospital.

## **Modelling and simulation of logistic flows**

*Virginie André, Nathalie Grangeon and Sylvie Norre.*

Université Blaise Pascal – Clermont-Ferrand II, France.

In this paper, we study the modelling and simulation of logistic flows for a new hospital at Clermont-Ferrand (France), named New Hospital Estaing (NHE). The buildings of the actual hospital are old and dispersed in the city centre; the staff is faced to a lack of place; many

standard settings are necessary. However, major modifications of buildings are impossible because of their historical value. Consequently, this hospital will be replaced by the NHE. Many studies are carried out for the setting up of this new hospital. Our study concerns the logistics flows: linen, meal, medicines, sterilization, hotel...

We implement the ASDI (Analysis, Specification, Design, Implementation) modelling methodology, proposed and improved by our laboratory since 1991. This methodology allows to understand the system, to collect the data and to organize them in order to build models. It is based on the building of two consecutive models: a knowledge model and an action model. The knowledge model describes the system by using three complementary sub-systems: the physical subsystem (SSP) which identifies the structure (rooms, services, resources, ...), the logical subsystem (SSL) which describes the flows and the decisional subsystem (SSD) which gives the management rules of the activities carried out by the system. The action model is the translation of the knowledge model into an evaluation model such as simulation one.

Our knowledge model is composed of class diagrams (UML) for each subsystem and ARIS models for the activity process.

The action model is designed by using Witness software and the parameter setting is done with Excel files directly linked to Witness software. Parameters concern the flows: quantity, management rules, required resources, planning ...

The main objective of this paper is to present the translation between the knowledge model and the action model. A semi-automatic link between the UML diagrams and the Witness model allows to describe the SSP and a part of the SSD. An automatic link between ARIS models and Excel files permits to translate the SSL and a part of the SSD into parameters for the Witness model. This automatic link is done using the programming language Perl which is well suited for the data extraction in a text file.

Our action model can take into account 39 flows to deliver 380 rooms divided into 4 levels by human resources (11 operatives and external agents).

In this paper, we describe one utilisation of this action model. It concerns the comparison of two politics concerning hotel products. The units of care are delivered daily from the logistic centre of provisioning. The first politic is based on the full/empty mode: for each unit of care, the human resources distribute the full cupboards and take the ones emptied the previous day. In the second politic, human resources carry out rounds and arrange products in the shelves in each delivered unit of care. Results prove that with the first politic, products are more quickly distributed but the care personal is more occupied by these flows and less available for the patients. In the second politic, human resources take more time for delivery products but it has no impact on the treatment of other flows. So, this second politic will be implemented in the new hospital.

## **Addressing the model-decision making interface – a key requirement for operational research in healthcare**

*Martin Pitt.*

Peninsula Medical School, Exeter, UK.

Although there is considerable interest in the use of Operational Research (OR) methods in health care, successful uptake of these methods (eg. modelling and simulation) within health care organisations themselves remains disappointing.

This presentation will critically examine of this lack of conversion of OR research into healthcare practice. It will argue that the primary cause of this failure is a fundamental neglect of the interface between the research community and decision/policy makers. Each of these communities operates under very different cultural constraints and expectations which need to be fully understood before successful conversion from research into practice can be undertaken. Given the lack of attention paid to date in bridging this cultural divide, it is unsurprising that the potential of OR in healthcare is still unrealised.

A useful analogy in this context is the early days of software development; here the potential functionality of systems was frequently under-used (or unused) due to a critical failure of developers to address interface design. The advent of graphical, user-friendly interfaces in computing not only radically altered the ways in which software was used but also spawned an enormous interest in the field of human-computer interaction. In healthcare OR the current interface between modellers and users can be compared to the days of the C> prompt. What is required is a comprehensive revision of our research and design methods to ensure the functionality and outputs of our models respond to user needs, and are more readily understood and accessible to the potential user communities in the health services. Far greater emphasis needs to be placed on making our outputs accessible and usable and this may demand a radical change in the way we carry out research.

Some examples will be presented to illustrate potential ways in which model outputs can be made more accessible to decision makers drawing on the specific field of modelling in health technology assessment in the UK.

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## **17 Thursday, 9:00am – 10:40am**

### **Operating Rooms Planning II**

Chair : Eric Marcon

#### **Exploring the analogs and differences between the industrial logistic system and the patient support system in the operating theatre**

*Hongying Fei and Nadine Meskens.*

Catholic University of Mons, Belgium.

Health care absorbs such a large proportion of public finances that unsurprisingly it has become a pressing need to review health care practices, aiming to carefully manage public funds and meet requirements of stricter and stricter public accountability, improve hospital operations and bolsters their efficiency and effectiveness. As is known, logistics can be a major source of competitive advantages. It involves all activities related to

the procurement, maintenance and transport of people and goods that are crucial to an industrial or service enterprise. In hospitals, logistics don't cover just supporting services such as purchasing, stores and the pharmacy, but also health care services such as patient care units and operating rooms. Since operating theatre, consisting of operating rooms and recovery rooms, is one of the most costly sectors in the hospital, its manager always aims to improve its efficiency and productivity.

What's more, studies show that from 30% to 46% of hospital expenses have been invested on various activities concerned with the patient support system, where the operating theatre is the kernel, it can be concluded that one efficient hospital logistic system can help the operating theatre improve its performance and thus to make medical supplies and pharmaceutical products be delivered efficiently to patients (Etienne (2007)). Since labor accounts for about 60% of a hospital's costs and the primary element affecting cost calculations is the time spent by personnel on various logistical activities, the quality of the logistics process should be considered in the measurements of the operating theatre's performance.

Yet how can the patient support system in the operating theatre be improved? What is the actuality in the hospital logistics, especially in the operating theatre's patient support system? Though there are some literatures devoted to the hospital logistic (De Vries et al., (1998), Maruster et al. (2002), Combes et al. (2006)), few of them have given practical suggestions for the improvement of hospital logistics concerned with the operating theatre. Considering that the studies of industrial logistics have sprung out in the recent decades (Cohen et al. (1997), Handfield and Nichols (1998), Ronald (2003)) and many achievements have been made, we might use those achievements as reference for the hospital one.

Considering that the health sector stands out specifically because of the critical nature of the service levels associated with logistical activities: the lack of an item or a drug in the operating room could, for example, greatly influence the work performed by health care workers and threaten the health of a patient. The quality of support services must be maintained. What should be noticed when some practical ideas of industrial logistic systems are applied to the hospital one? In order to answer those questions, in this paper, we explored not only the analogs but also the difference between the industrial logistic system and the patient support system in the operating theatre. The objective is to introduce the practical ideas of logistic management into hospitals so as to enable the evaluation of the current process, which aims to decrease delays and increase logistic service effectiveness and productivity.

#### **Solving the multi-criteria next-day elective surgery scheduling problem**

*R. Velasquez and M. T. Melo.*

Fraunhofer Institute for Industrial Mathematics ,  
Kaiserslautern, Germany.

Finding a schedule for next-day elective surgeries in hospitals is a task that many healthcare institutions and research groups have been investigating to improve the use of hospital facilities, the quality of care and staff satisfaction, while reducing variable direct and indirect

costs. Due to the increasing demand for efficient healthcare services and substantial expenditures that are a large component

of a hospital budget, finding efficient solutions for the short-term surgery planning level is of key interest for hospitals. Finding such a plan is complex and time consuming, and hospital common practices often provide inefficient solutions. The literature on the short-term operating theatre scheduling problem focuses on different aspects that create bottlenecks in practice (e.g. utilization of intensive care unit beds, operating rooms, number of available nurses). Generally, only a single criterion is optimized. When several criteria are considered they are combined into a single objective function, which does not fully detail the complex scenario arising in practice (conflicting interests by management and staff, irregular staff availability and the rostering problem itself, uncertain surgery duration, and the possibility of occurrence of emergency cases). All these factors are addressed in this talk which describes a new multi-criteria semi-stochastic mathematical programming model for the next-day surgery scheduling problem. Furthermore, a new multi-criteria solution heuristic is presented to find a pool of weakly non-dominated and non-dominated solutions. Some of these solutions are then selected using practice relevant metrics, to find good solutions for the problem at stake. The benefit of this approach is that it is not only applicable to a real world hospital scenario, but also useful as an integral part of an interactive decision support system which can be used by a hospital. The model and its solution procedure were tested with real data provided by mid-size hospitals in Germany and solved using a commercial solver. The results obtained show a large optimization potential for this planning level, suggesting that hospital common practices can be considerably improved.

## Different workflow models and resource allocation for operating room

*Riitta A. Marjamaa and Paulus M. Torkki.*

Helsinki University Central Hospital, Helsinki, Finland.

**Motivation:** Parallel induction of anesthesia seems to improve operating room (OR) efficiency (1-3). Several approaches for parallel induction have been suggested: Block rooms (4,5) before surgery; induction rooms with additional personnel for one (2,3) or several operating rooms (1) or surgeons administering local anesthetics in the holding room while the OR is prepared for surgery (6). All these models have reduced non-operative time enough to allow more operations be performed per day. Resource allocations per OR and workflow models seem to be somewhat different in each of the models.

**Problem addressed:** To support decision-making as to optimal facilities and optimal use of resources, we compared the output (operations/resources) of several parallel workflow models to that of the traditional model.

**Methodology/approaches:** The three parallel workflow models and the traditional model were investigated by discrete-event simulation. For the analysis, data on the duration of all procedures performed in one year were obtained from the hospital information systems. The 1) Traditional model was compared with 2) Centralized-induction-team model, 3) Individual-induction-rooms model and 4) Three-surgeons-per-four-ORs model. In

the traditional model, anesthesia was induced in the OR. In the centralized model, all anesthesia inductions were performed in holding area by an additional induction team (1 anesthesiologist, 2 nurses). In the Individual-induction-rooms model, each OR had its own induction room and team (2 nurses). In the fourth model, there were four teams in four rooms for three surgeons. The following parameters were assessed: average number of procedures performed, mean surgery time, raw utilization of OR and personnel utilization.

**Results:** The Centralized model was most productive (operations/resources). Daily number of operations and raw utilization were largest in the individual induction room model ( $p < 0.01$ ). The utilization of surgeons was 26-33 % greater in the parallel models ( $p < 0.01$ ). Three surgeons in model 4 performed an equal number of operations as did four in the traditional model.

## Design and implementation of heuristic procedures for multi-objective master surgery scheduling

*Jeroen Beliën, Erik Demeulemeester and Brecht Cardoen.*

Katholieke Universiteit Leuven, Belgium.

This paper presents a decision support system for assisting in the development of master surgery schedules. The system aims at three objectives. A first important objective is the visualization and 'optimization' of the resulting bed occupancies at the wards, which should be leveled as much as possible. Second, surgeons prefer to share an operating room with their direct colleagues, i.e., with surgeons having the same specialty, for instance, ophthalmology or oncology. Finally, in the case that the cycle time is two or more weeks, the schedule should be as repetitive as possible within the individual weeks of the cycle. In other words, the changes in the schedule from week to week should be minimized. Depending on the hospital's situation, and in particular on the problems it is facing, a procedure can be chosen to build a new master surgery schedule. Additionally, the system can provide managers with important insights into the opportunities or limits with respect to the master operating room schedule. The system relies on mixed integer programming techniques involving the solution of multi-objective linear and quadratic optimization problems. Unfortunately, dealing with the three objectives simultaneously leads to such a large mixed integer program that the problem becomes computationally intractable. As the system is designed to support the decision making process, it is crucial that users get quick answers to what-if questions. Therefore, alternative heuristic solution procedures have been developed. First, we discuss

the results of a simulated annealing metaheuristic that simultaneously aims at the three objectives. A second attempt to obtain good solutions in small computation times resulted in the development of hierarchical goal programming models. These models first concentrate on one objective after which the next objective is optimized. A first important simplification concerns the cycle time. Even when changes from week to week are, to small extent, allowed, the algorithm starts with developing a one-week schedule. This schedule is then copied to the second week, after which some modifications can be

# Technical Presentations

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made in a post-optimization step. We discuss the results of a case study in a medium-sized Belgian hospital.

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## **18** Thursday, 9:00am – 10:40am

### **Location and Transportation Planning**

Chair : Stefan Nickel

#### **Location modelling for community healthcare facilities**

*Honora K. Smith, Paul R. Harper and Chris N. Potts.*

University of Southampton, UK.

Policy changes are taking some healthcare services out of centralised locations into facilities closer to residential areas. Location modelling offers opportunities for assessing the effects of alternative scenarios on service delivery. We present experiences from studies in regions as diverse as rural northern India and Leeds metropolitan area. We are encouraged that our approach can form a valid part of the process of planning community health schemes.

In general, community healthcare is part of a hierarchical supply of health service. We have developed a range of location models that reflect possible access to such hierarchical systems. For example, the UK NHS generally requires patients to access facilities at the GP level, with subsequent referral if necessary. In rural India, however, fee-paying patients choose the level of access they require, whether at village, community or hospital level. A further differentiation is given by replication at different levels. Services such as maternity ante-natal checkups, for example, may be available in India at both local and hospital locations; other specialist services are available only at the highest levels. Our location models reflect such differing access to hierarchical health systems. Locations of particular at-risk patient groups can also be incorporated.

Healthcare facilities may be considered as delivering an essential service, such as emergency treatment, or a non-essential, optional service such as preventive care. Planning objectives for such services will differ: we model these differences using techniques based on classical location models.

The final element incorporated in our models is that of equitable or fair distribution of services. We use the concept of a service standard by which to judge different scenarios. Such a standard might be specified in terms of a desirable distance to be travelled by patients to facilities, or a desirable number of patients expecting treatment at one of several facilities. Trade-offs between efficiency and equity produce interesting comparisons.

We base our hierarchical mathematical programming models on  $p$ -median and set covering theory. We have implemented the models in Visual C++.net, which gives the advantage of graphical display of different facility locations and relative local populations. Commercial optimising software Xpress-MP is also used.

We acknowledge the assistance of:

- Dr. Ann Thyle, Regional Director for Northern Region, Emmanuel Hospital Association, India;

- Mike Davidge, Director for Resources, Analysis & Modelling, Making Leeds Better Programme.

#### **Ambulance location through optimization and simulation: the case of Milano urban area**

*Roberto Aringhieri, Giuliana Carello and Daniela Morale.*

Universita degli Studi di Milano, Italy.

An Emergency Medical Service system is a service providing pre-hospital (or outof-hospital) acute care to patients with illnesses and injuries. The key factors in a successful treatment of an injury are: early detection, early response, good on scene care, care in transit, transfer to definitive care.

One of the basic stage is the early response: different features have to be considered while managing similar services, such as ambulance location and relocation, ambulance routing, assignment of ambulances to each call. To provide a good performance of the system, the limited resources must be carefully managed and mathematical techniques are worthy to be studied to provide decision aided tools to the emergency service management.

In this paper we deal with the problem of locating the ambulances in agreement with the official Emergency Medical Service, says also 118, over the urban area of Milano, Italy. We present an approach combining different mathematical techniques and skills: statistical analysis, optimization and simulation. Starting from the statistical analysis of these data aimed to estimate some basic variables needed for possible models describing the activity, the aim is to find the optimal location of the ambulances in agreement with the operation center.

We perform the study both via optimization and simulation tools. To the best of our knowledge, this is the first approach combining different methods developed for this problem. Moreover, although many optimization models have been developed on the ambulance location and relocation problem, to the best of our knowledge none is related to the Italian legislation about emergency services.

#### **Designing a decision support system for the transportation of disabled persons**

Olivier Peton, Pierre Dejax, Fabien Lehuède, Marc Marhadour and Claire Pavageau.

*Ecole des Mines de Nantes, France.*

Transportation is the second most important expense factor for specialised French medical or social institutions such as the Instituts Médico-Educatifs (schools for disabled children) or the Centres d'Aide par le Travail (vocational rehabilitation centres). Due to medical reasons, most of the concerned children or adults are unable to travel on their own from their home to their centre. Thus, every centre has to organise the daily inbound and return trips for dozens of persons. They generally rent costly taxis or minibuses. In this presentation, we describe the project of building a decision support system for the transportation of disabled children or adults in the region of Nantes (France). This study is led in collaboration with the ADAPEI 44, an association regrouping about twenty centres.

We modelled the transportation problem as an open vehicle routing problem with time windows, heterogeneous fleet and supplementary constraints. In the open vehicle routing problem, the vehicles do not return to the depot after visiting the customers, so that the trips are not loops but directed paths. We face this situation since the taxis or minibuses begin their service at the driver's home, which is generally unknown. Some of the centres own a few vehicles that are used in priority, and do complete loops starting from the centre and returning there. Thus, our problem appears to be a mixed open and classical vehicle routing problem.

One of the complicating constraints is the potential incompatibility between some users, that cannot travel in the same vehicle. Another frequent constraint is that the transportation duration of every person is limited, either for legal or health reasons. Other constraints are related to time windows for the pick-up of persons, travellers with wheel chairs, and some preferences for the design of satisfying tours.

The objective function tries to find a trade off between two antagonist goals : minimising the transportation costs and maximising the quality of service to the users. We use the idea of loss of time, that is the difference in time between a direct trip from the user's home to the centre and a trip within a tour. We aim at minimising the average loss of time while keeping each individual loss of time under a given maximum limit.

Our approach to solving this problem efficiently and rapidly is a two phases heuristic. The first phase builds initial tours with a best insertion procedure based on a regret calculation. The second phase uses classical moves of the literature that improve the solution obtained in phase 1. We also discuss post-optimisation procedures that consist of modifying a solution in order to adapt to variations of the dataset (persons that have several potential addresses, new users) or to build coherent outbound and return trips. The main characteristics of these modelling and optimisation procedures is that both technical efficiency and the human concerns must be addressed. The optimisation algorithm will be embedded into a decision support system with a graphical interface.

## Planning patient transports in hospitals

*Alexandre Beaudry, Gilbert Laporte, Teresa Melo and Stefan Nickel.*

Saarland University, Saarbrücken and  
Fraunhofer ITWM, Kaiserslautern, Germany.

Planning transport processes in hospitals is quite a complex and involved task. On the one hand very different kinds of transports have to be managed: meals have to be delivered, beds have to be relocated upon the arrival and departure of patients, drugs and blood need to be made available in time, and patients have to arrive punctually at treatment rooms. On the other hand, there is a high uncertainty in the data available. This is not only due to the occurrence of emergency tasks but also because of the still underdeveloped availability of well-maintained and accurate data in hospitals.

This talk is devoted to an online dial-a-ride problem arising in the transportation of patients on a hospital campus. The talk will focus on routing and scheduling vehicles (e.g., ambulances, transport teams on foot) that

serve requests for transporting patients between wards and examination rooms. The efficient organization of these transports strongly affects the planning of activities in other hospital wards (e.g., operating room planning). Based on real-life cases we will show that the problem complexity is increased by a number of specific service-related constraints in addition to those encountered in typical dial-a-ride problems. Hospital inherent aspects include, among others, accounting for transport priorities (e.g., emergency requests), for transportation aids (a patient transport may generate additional transport requests for material and/or personnel that have to accompany the patient), for different vehicle types and personnel skills, and for soft time windows with respect to the desired pickup and/or drop-off times of the patients. Such constraints significantly complicate the construction and modification of high-quality feasible schedules. Therefore, a heuristic approach will be proposed and the results obtained using real data from two German hospitals will be discussed. Moreover, we will briefly present the software tool Opti-Trans in which the optimization algorithms are integrated.

## Optimization of the transport of blood products

*Geerhard de Vries.*

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## 19 Thursday, 11:00am – 12:30am

### Optimization of Core Hospital Resources in the Netherlands

Chair : E. W. Hans

### Simulation of appointment-based systems in hospitals

*Jan A.M. Hontelez and Sylvia G. Elkhuisen.*

University of Amsterdam (UvA), the Netherlands.

In this paper we consider appointment-based systems in hospitals. When a patient makes an appointment at a department, a reservation is made. Depending on the type of the complaint (urgency) of the patient, the expected duration of the consult, the capacity of (assistant) doctors, there will be a certain delay until the patient has his consult, which can vary from a couple of minutes until a couple of weeks. In the Netherlands, most outpatient departments as well as hospital facilities use an appointment system for its patients.

This waiting time between making an appointment and actually consult is called the access time. Appointment-based hospital departments and facilities deal with the problem to minimize the access time:

- how to use and design the available capacity of doctors, nurses and medical equipment and
- how to design an effective appointment system, that is how much time must be reserved for each type of need/demand,

when dealing with all kinds of patient requests.

Of course, the total capacity must be sufficient with respect to the demand, but as we know, the variability in

demand and capacity has a strong influence on the length of the access times. Our presentation deals with this question.

It is insufficient to use only analytical queuing models, because of the fact that:

- demand varies by different kinds of requests (different kinds of customers with different urgency and different need for capacity);
- available capacity varies during the day and during the week;
- in appointment systems like these, several blocks are reserved for different urgency and needed capacities, but of course, urgent patient requests may also make use of available capacities for less urgent patients.

To investigate how the capacity must be assigned to, a simulation model can help. Despite the departments has its own specific properties, the concept of the model is the same, but rather complex in execution.

With the use of a developed simulation model, we carried out several studies for several departments and hospital services, which results briefly will be discussed. A comparison will be made with an analytical approach. It appeared that studies like these are very useful to determine how much and which capacity is needed to decrease (long) access times, and in addition, to stabilize the access time.

## Applying simulation to reduce access times for radiotherapy treatment

P. Joustra, R. Kolfin, P. Bakker.

In the past years the radiotherapy department of the Academic Medical Centre in Amsterdam had to deal with service level agreements. Several attempts to reduce the throughput times however failed to reach previously established service level agreements (SLA).

A simulation model was developed in order to gain quantitative insight into the problem and compare different scenarios by what-if analysis.

**Methods:** The logistic process at the radiotherapy department was analyzed using process mapping. The flowcharts of the three main components of the process (first consultation, preparation and actual treatment) were used to construct a simulation model. The preparation process was modelled as a black box because this part was not considered a bottleneck in the treatment process.

Discrete event simulation incorporated the fluctuations in number of referrals per week, the capacity for new patients at the outpatient department (OPD) of radiotherapy, the number of fractions a patient needs and the duration of each treatment session. The fluctuating workload for the different components was modelled as in the real-life situation. The model was validated successfully by comparing different percentiles and the average throughput time.

**Results:** The model indicates that the main reason of not reaching the SLA is the strongly fluctuating capacity at the OPD and not the - relatively stable - demand. The management was not able to compensate for the decreased number of appointments for new patients due to e.g. bank holidays or otherwise cancelled appointments. Also in the holiday season the number of appointments for new patients was too low, even for multiple weeks in a row. This causes high access times which they were unable to compensate for.

Simulation showed that by reducing the variance of OPD capacity for new patients to half of the current variance, the SLA will be met. In general the capacity can drop with one new patient per week with the same performance as reached with the high, current variance. The more stable demand at the preparation process before the actual treatment makes sure that the resources are used more effectively which leads to lower waiting times before the second step in the process (preparation). This reduction can be used to lower the pressure on the OPD so less capacity is needed there while the SLA of the total throughput times will still be met.

**Conclusions:** The primary measure to be taken by the management is to reduce the variance of OPD capacity for new patients. One solution is to introduce an overview of the total number of appointments for new patients per week for the next quarter. All bank holidays, holidays of doctors and otherwise cancelled appointments are incorporated in the overview so the management notices - in advance - when the capacity will be too low and doctor holidays have to be postponed and/or appointments for new patients have to be compensated by other radiotherapists.

If the management succeeds in reducing the variance of the weekly number of appointments at the OPD, the rest of the supply chain does not have to be changed.

## Focused factories in hospital care? Using OR/OM to study feasibility and impact

E. Bredenhoff, W. van Rossum.

University of Twente, Enschede, The Netherlands.

Costs of health care are rising, while the quality of care is questioned. The focused factory concept is proposed as an organizational approach to increase both efficiency and quality of hospital care. The concept is also controversial: "cherry picking"/ "cream skimming" in the US have lead to a moratorium on specialty hospitals.

In the Netherlands an increasing number of hospitals are setting up focused factories, especially, ambulatory surgery centers (i.e. elective day surgery clinics). Although this is hardly founded, the idea is that it will make hospital care more efficient. In our research we investigate whether, and how, focusing affects the quality and efficiency of hospital care.

To study the effects of the focused factory concept on the efficiency and the quality of hospital care, we have followed and will present the following steps. (1) The development of a definition of "focus", and a classification of focused factory types in hospital care. (2) The development of measures to evaluate the degree to which a hospital has implemented focus. (3) A comparative study of hospitals in the Netherlands. We considered the degree of focus and its effects on efficiency and quality of care. (4) A case study (Reinier de Graaf Groep Hospital) regarding the creation and optimization opportunities of a focused factory.

Regarding step (4), in the subsequent presentation of E.W. Hans we present joint work in which we study the efficiency optimization opportunities in an ambulatory surgical center.

## Integrated planning of operating rooms and wards in an ambulatory clinic



*E.W. Hans, E. Bredenhoff and J. van Oostrum.*

University of Twente, Enschede, The Netherlands.

Resulting from a merger, the Reinier de Graaf Hospital operates on multiple locations. It has decided to dedicate one of its locations to routine elective procedures. Our research considers this location, which is an ambulatory surgical center that is closed during weekends. That means that all procedures and inpatient stays must take place during regular working days.

We consider the integrated planning of the surgical procedures and subsequent inpatient stay in the wards. The aim is to simultaneously optimize the utilization of the operating theatre, level the bed usage during the day, and during the week, and to prevent that patients have to be transported to another location in the weekend. We present an integer linear programming approach, based on previous work regarding Master Surgical Scheduling in Erasmus Medical Center. We present the scheduling results, and the results of a simulation study with real life data.

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## 20 Thursday, 11:00am – 12:30am

### Performance Assessment

Chair : Martin Pitt

#### Modelling readmission: a multilevel transition model approach for new performance indicators

*Eren Demir, Thierry Chausailet, Haifeng Xie and Peter H. Millard.*

University of Westminster, London, UK.

Rate of readmission is a key indicator in the performance rating framework for National Health Service (NHS) trusts in England. Currently the NHS performance ratings define readmission as an emergency or unplanned admission to the same hospital within 28 days following discharge. The current adapted statistical methodology by Department of Health (DoH) is to standardize (age and sex) readmission for each trust, and use statistical significance to compare the observed rates of readmission of a trust with the national average rate. Five bands are used to grade trust values i.e. A1 (poor performance), A5, W, B1 and B5 (good performance). First, in the literature, age and sex are the two predictors that are mostly insignificant to account for variations among patients, including the national Hospital Episodes Statistics (HES) dataset, which is the data, used by DoH for banding trusts. Therefore, the standardization process does not necessarily take into account variations between populations treated by individual trusts. Second, although there are considerable variations in the rates of readmissions between trusts, very few are banded outside grade W, and thus, variability between the trusts is not captured. Here, we develop a new methodology that has the ability of capturing this variability and also contribute to the variation in differences in case-mix, beyond that accounted by the standardization process, for example severity of illness (comorbidity) and the

differing socio-economic mix of local populations (index of multiple deprivations).

Firstly, it is based on the idea that discharged group of patients can be divided into two groups – “high” and “low” risk groups. This classification is based on the definition of readmission, where authors have also introduced a modelling approach to determine the appropriate width of a time window in defining readmission. Using this time window we classify readmitted patients as “high” or “low” risk group. We assumed that the propensity of patient transitions between the groups (high and low risk) varies across hospitals. We therefore extended a method known as transition models with a *logit-link* function to a multilevel transition model approach. The model assumes that every hospital has its own propensity for a patient being in “high” risk given patients past readmissions i.e. each hospital is given a ‘hospital-specific’ effect on patient transitions between “high” and “low” risk groups, which can be regarded as a performance measure where high hospital effects (deviation from the “estimated” population average) are considered as poor performance.

From the 196 NHS acute and specialist trusts in England, using chronic obstructive pulmonary disease patients dataset, extracted from HES, the estimated population-averaged first order transition effect is 1.16, which is the log-odds ratio. Highest first order hospital specific effect is 0.431, where the odds ratio  $\exp(1.16 + 0.431) = 4.91$  means, those patients who was previously in the high risk group at this hospital has 4.91 times the odds of being in the high risk at their next readmission than patients who was in the low risk previously. The lowest hospital specific effect is estimated to be -0.685.

With the introduction of hospital-to-hospital diversity, we provide a new methodology to aid healthcare commissioners, in the understanding of the underlying determinants of readmission (hospital effects), as an indicator within the performance measuring framework. Furthermore, heterogeneity can be explicitly modelled across hospitals on patient transitions between “high” and “low” risk groups for different diagnosis groups. Therefore, this can be a valuable tool in understanding variability between and within hospitals for different diagnosis groups.

#### The use of Data Envelopment Analysis (DEA) for evaluation of brazilian teaching hospitals

*Yasar A. Ozcan, Marcos Estellita Lins, Maria Stella de Castro Lobo, Angela Cristina Moreira da Silva, Roberto Fiszman and Basilio Bragança Pereira.*

Virginia Commonwealth University, Richmond, USA.

To demonstrate how DEA modeling is helpful for hospital performance assessment according to the Brazilian Teaching Hospital Policy, we develop a case study with 30 general hospitals linked to Brazilian Federal Universities. Using the software IDEAL (Interactive Data Envelopment Analysis Laboratory) as a tool for measuring hospital unit efficacy evaluation, we consider data on assistance (medical model) and teaching and research (teaching model). In the medical model, the inputs considered are physicians, full-time-equivalent non-physicians, beds, operational Costs, and service mix. The outputs considered are admissions, surgeries and outpatient visits, with all of them adjusted by the

complexity degree of the hospital. In the teaching model, the inputs are Ph.D. professors, other professors, and physicians, while the outputs are medical residents, medical students and post-graduate students. Both models are output oriented. A benchmark of the teaching hospitals is presented for both models, with results (outputs) that consider the structural and regional input differences. According to the virtual share of the multipliers, a minimum participation of each variable is guaranteed by the introduction of weight restrictions. In this phase, it is very important to hear from the specialists and decision makers regarding their opinions about the relative importance of the variables. Each hospital is then categorized according to their relative efficiency in the medical and teaching models so that one might consider the units one-hundred percent efficient in both models to be the benchmark to be pursued. Finally, the mode also indicates the necessary changes for the inefficient units (input/output vector modification), and generates recommendations for public financing based on quality/efficiency, which account for the two core dimensions of a teaching hospital: assistance and teaching/research.

## **A modelling technique for evaluating operational performance of capacity balance in a multi-level healthcare system**

*Guangfu Tai and Peter Williams.*

University of Limerick, Ireland.

In today's world, healthcare almost becomes a daily service open to public, and it also became a large part of total individual consumption and government budget. Optimization schemes on capacity balance of healthcare delivery resource are highly desired to ameliorate the pressure from government finance and patients' requests. To evaluate optimization benefits, proper performance measures have to be established, and corresponding modeling technique is also required for performance simulation of healthcare delivery system. In this paper, modeling technique for multi-level healthcare system with both resource and time domains is presented, and measures of system performance are provided as well based on analysis from investment and external society perspective. Besides mathematical and verbal descriptions, modeling samples are given as well for better clarification.

## **Obstetrical theatre suite modelling and simulation**

*Michelle Chabrol, Michel Gourgand, Sophie Rodier.*

LIMOS CNRS UMR 6158, Clermont-Ferrand, France.

The consideration carried out on the University Hospital Center (UHC) of Clermont-Ferrand reorganization resulted in making the choice of a complete transfer of one of its hospital activities, the « Hôtel Dieu », on a new site involving the construction of a new structure : the "Nouvel Hôpital Estaing" (NHE). Thus Technical Equipment of the Hospital will be restructured in order to allow a regrouping of the various operating theatre suites currently localised in distinct buildings, on two floors of the NHE. A first floor will make it possible to gather the surgical operating theatre suites while the obstetrical

operating theatre suite will be localised on the second floor of the building, between Obstetrics services and Paediatric intensive care unit. UHC direction must reconsider its obstetrical operating theatre suite organization which will gather in a single place two obstetrics units now distinct: maternity and polyclinic.

One distinguishes two principal types of structure for an obstetrical area:

- the obstetrical area only made up of one childbirth area and which has often a reserved room in another operating theatre suite, in particular for the Caesareans;
- the obstetrical area which integrates, in addition to the childbirth area, an operating theatre suite.

The Clermont-Ferrand UHC maternity is classified level III (maternity gathering all the pathological pregnancies and having a neonatal intensive care unit) and the obstetrical areas of maternity, polyclinic as of the future hospital integrate each one an operating theatre suite. The literature on obstetrical area, except purely medical publications, is not very important. If many works were interested in the operating theatre suites, it does not go from there in the same way for the obstetrical area. This "literary poorness" is partly explained by this system complexity which gathers very different activities (urgency consultations, childbirth, pregnancy medical interruption...) but especially not easily foreseeable.

In this paper, we propose a knowledge model of the obstetrical theatre suite. This model represents a first essential stage for the action models design which will be able to couple optimization methods and performance evaluation. This tool must make it possible to confirm the sizing of the future obstetrical theatre suite (number of birth rooms, allocated resources...) and to test the future working rules planned in order to be able to intervene for possible developments before the opening of the "Nouvel Hôpital Estaing", planned for the end 2009. It should also make it possible, in the long term, to improve the service and the various intervention rooms working by an adjustment of manpower in the various sectors, identification of possible bottlenecks, optimization and synchronization of the exchanges with the other services or processes in touch with obstetrical theatre suite...

The knowledge data collection and formalization of the system are done by an extraction of the system entities, relations between these entities, working rules and system load. The modelling process recommends a systemic vision with a decomposition of the studied system in three communicating subsystems: the Physical Subsystem (PSS), the Logical Subsystem (LSS) and the Decisional Subsystem (DSS). The formalisms retained for the knowledge model design are UML and HSAEL language (Hospital Systems Analysis and Evaluation Language), extension of SAEL language (Systems Analysis and Evaluation Language), adapted to the hospital systems study. The knowledge model that we conceived for the obstetrical theatre suite is generic for two principal reasons:

- the two obstetrical theatre suite which are currently located at maternity and polyclinic are completely independent structures;
- the future obstetrical theatre suite of the "Nouvel Hôpital Estaing" is not built yet and the working rules which will be observed must be able to move.

For this study, we implemented a step in several stages which consists in analyzing the studied system by splitting it in subsystems formalized using diagrams UML:

- PSS of the obstetrical theatre suite comprises units of transport, one or more waiting rooms (patient, accompanying...), one or several area care, technical buildings (decontamination, storage), personnel rooms, human resources, material resources, sensors.
- LSS of the obstetrical theatre suite is composed of human, material, financial and informational flow.
- DSS is composed of sensors, a decision-making centre (Obstetrical Theatre Suite Council), of a piloting centre.

Then, we specify the studied system by using HSAEL. The interest of this language is mainly to combine a global view easily comprehensible by the people not initiated with a detailed view making it possible to answer specificities of the study field (various shared resources, dynamic attribution of resources according to the state of the system...);

The following stage consists in translating the knowledge model into an action model which is in this study a simulation model. We proposed passage rules of HSAEL towards Witness simulation software, in order to design software bricks essential to the final design of the simulation model. We also conceived entry and exit interfaces in order to communicate with the simulation model.

Elements, resulting from the knowledge model, are provided in order to feed starting model from these interfaces: number of patients, distribution by types of childbirth, personal manpower... For each scenario, the parameters to vary are: personal manpower, patient latency, cycle times of intervention rooms, maintenance policy...

The awaited results of this tool are of the type: a number of operations with distribution by room, occupancy rate of the rooms, occupancy rate of the resources according to opening planning...

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## 21 Thursday, 1:40pm – 3:40pm

### Disease Modelling and Clinic Pathway

Chair : Zhibin Jiang

#### Diabetes network modelling: a system dynamics approach

*Crina Tabita Nicolescu and Ann van Ackere.*

University of Lausanne, Switzerland.

Nowadays health systems are confronted with increasing health expenditure, due to an increased prevalence of chronic illnesses, the increasing use of innovative technologies in health care and an ageing population. There is an increased preoccupation for a reorganisation of health systems, which could improve the quality of care while reducing costs: the creations of health networks. WHO statistics and forecasts indicate a silent epidemic of diabetes worldwide. There is an abundant number of studies developing models and focusing on different aspects of chronic diseases, including diabetes: prevention, cost-effectiveness analysis of different interventions, and epidemiology of diabetes. Few quantitative studies analyse the impact of a chronic illness network organisation on the quality of care and

health expenditure while trying to gain insight in the system's structure and levers that could be triggered in order to achieve improved care provision at lower expenses.

Our research is bringing two contributions. On the one hand, we model the evolution of diabetes type II disease using System dynamics, as a dynamic stock and flow process. The stocks represent stages of the disease and the flows in and out of these stocks represent transition rates between different health states. We aim to gain insight in the impact of a network organisation on the flow rates, i.e. disease progression and associated costs.

On the other hand, we use a qualitative approach based on causal loops to identify the factors affecting the incentives for the stakeholders (general practitioners, patients and policy makers) to becoming part of a diabetes network organisation.

#### Process improvement in hospitals – Clinical pathways and appointment planning

*Stefan Nickel and Ursula-Anna Schmidt.*

Saarland University, Saarbrücken, Germany.

Due to constant reforms on the health care sector in Germany hospitals have to face a rigorous competition and a strong cost pressure. Especially during the past few years since the introduction of the new system of hospital financing based on Diagnosis Related Groups (DRG) the cost pressure on German hospitals has furthermore increased. But already before the introduction of the DRG-system in January 2007 throughout the whole of Germany the hospital sector has been going through radical changes. The annual data collection concerning the number of German hospitals by the Federal Statistical Office of Germany shows a clear trend to cutting capacities and reducing inefficiencies on the health care sector. In 1999 there were still 2411 hospitals in Germany whereas in January 2007 only 2139 hospitals were counted. This corresponds to a decrease of 11.28% within 13 years. A change of this trend is not to be expected.

The main objectives are on the one hand guaranteeing a high quality level of care, and on the other hand covering costs and the maximization of profits. In this context the aspect of process optimization is usually neglected. Meanwhile process optimization has advanced to an essential competitive factor for a hospital within the DRG-system. Hospitals are forced to reveal inefficient organizational structures and to replace them by appropriate efficient processes.

Clinical Pathways are a way of optimizing processes in hospitals. Amongst other things their objective consists in planning, standardizing and optimizing medical treatment processes, increasing quality of care, minimizing costs and making them transparent, and improving documentation and patient's satisfaction. In current implementations of Clinical Pathways the aspect of optimization and logistical integration along these paths is omitted despite the fact that logistical problems appear in many phases of a path. A coordination of the individual processes with regard to the schedule is required to guarantee punctuality of appointments along the pathway. For this reason appointment planning will be the focus for the following considerations.

In order to gather some information about topical appointment systems in Germany we conducted a case study at a German university hospital, which contains more than 30 clinics and institutes on a large campus. Due to the extension of the clinic, unfit patients have to be transported by a vehicle transportation service across the campus, which can considerably influence the punctuality of the patients' arrivals to their appointments. Within such a complex environment a decision support tool is helpful. Simulation models have meanwhile advanced to a common and popular tool to tackle this problem area. By modelling different scenarios it is possible to easily compare and assess distinct alternatives. The health care sector offers a great variety of applications for discrete event simulation such as models to simulate emergency departments or staffing, to help determining optimal bed capacities or planning the optimal layout of a clinic.

In order to analyze the patient flow we have designed and implemented a straightforward simulation model, geared to that university clinic.

In the course of our presentation we will first mention some of the objectives and problems concerning Clinical Pathways in Germany, and then describe deficiencies in appointment planning on the basis of a case study in a radiology department of a German university clinic. After that we will present first results and possible improvements that could be achieved by means of the mentioned simulation model.

## **The framework of clinical pathway adaptive workflow management system**

*Gang Du, Xiaodi Diao, Zhibin Jiang and Yan Ye.*

Shanghai Jiao Tong University, Shanghai, China.

As a treatment process oriented clinic management mode for improving medical quality by the predefined medical care plan, clinical pathway can not only achieve the desired treatment results, but also shorten the average hospital days and thus reduce the medical expense. This paper presents the framework for adaptive workflow based clinic pathway management system. Since the clinical pathway variations are difficult for the current workflow technology to deal with, the framework proposes the reconfigurable modeling method of the clinical pathway workflow based on the Colored Petri net with Changeable Structure (CPNs-CS). To cope with variations to clinical pathway, the clinical pathway knowledge is represented and classified based on Web Ontology Language (OWL), and adaptive measures are determined by adopting the generalized fuzzy event-conditions-action (GFECA) rules. Moreover, to improve the efficiency and speed up the response to variations, autonomy and coordination mechanism based adaptive control method is applied, where all the instances of clinic pathway workflow of different diseases types are autonomously and concurrently controlled, and coordination is established among them to ensure the global optimization of the whole system.

## **A decision support system for clinical pathways analysis**

*Véronique Deslandres, Haytham Elghazel, Kassem Kallel and Alain Dussauchoy.*

Université de Lyon, LIESP, France.

**Introduction: the PMSI context.** In French hospitals, the Diagnosis Related Groups (DRGs) system was introduced in the eighties with the Information Systems Medicalisation Program (PMSI). According to the PMSI, public and private hospitals are required to point out each year which activities have been performed so that the performances can be assessed. Evaluation is based on the production of a Standard Discharge Summary (RSS) for each hospital stay. The RSS contains information related to the nature of the treatments, medical exams, diagnoses and patient information. The RSS is then integrated into one predefined patient group (called DRG). The DRGs are used for hospital stays classification and are reappraised every four years. Mapping task is performed using a supervised approach according to a decision tree based on some RSS information considered as parameters. These parameters are either *classical data* (e.g.: numeric values for age, length of stay) or *symbolic data* (e.g.: set of values for medical diagnoses or treatments).

**Healthcare services requirements and decision support system.** The PMSI system, which involves both economic and medical data, offers a good starting point for designing a suitable strategic information system according to healthcare quality and cost control. As an internal management tool, the PMSI allows performances assessment and may play an incentive role when suitable feedback is performed. Nevertheless, another interest would be to provide strategic decision-making for future activity planning and management. The purpose of our approach is to anticipate future trends of clinical pathways, in order to facilitate resources planning and management within health centers.

First, specific dissimilarity measure has been defined according to the various nature of variables composing the clinical pathways. Then different groups of pathways have been identified and a typology of clinical pathways is obtained with at least one representative element within each group. Finally a forecasting approach is proposed based on these groups, which allows to statistically determining the next step (hospital stay) for the patient considering his historic pathway. The forecast also gives the main features of the next step: type of hospital stay (class), medical diagnosis, medical treatment that would be considered and the probable output of the stay (back home, hospital service transfer, death).

Our approach based on a new clustering method and Markov models has given good results on real clinical pathways. A software tool has been designed for our approach. It allows the healthcare manager to group, forecast and characterize patient clinical pathways. These new functionalities should facilitate internal resources planning as well as cost evaluation of the future stay when a new patient arrives.

## **Better out than in? The use of a simple mathematical model to assess the evidence concerning resection of lung metastases from colorectal tumours.**

*Martin Utley and Tom Treasure.*

University College London, UK.

Many patients that have had radical treatment of primary colorectal cancer subsequently present with metastatic deposits in the lung. The practice of surgically removing these lung metastases is becoming increasingly common despite there being is no firm evidence for patient benefit. Those that advocate the practice make favourable comparisons between survival among patients that have had lung metastases removed and survival among the broader population of patients that have surgery for primary colorectal cancer. We have constructed a simple mathematical model that can be used to assist in determining the validity of such comparisons. In this presentation we will discuss the arguments put forward both for and against the surgical removal of lung metastases, describe the mathematical model that has been developed and discuss the potential implications of our study.

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## **22** Thursday, 1:40pm – 3:40pm

### **Health Information Systems II**

Chair : Joseph Tan

#### **Evaluating user acceptance and user satisfaction of healthcare IT using formal models**

*Kai Zheng and Joseph Tan.*

The University of Michigan, Ann Arbor, USA.

As healthcare costs continue to spiral upward, healthcare institutions are under increasing pressure from regulatory bodies, insurers, and the public to use information technologies to increase efficiency, reduce cost, and improve quality of care. However, healthcare IT cannot achieve these desired goals if they are not being used. User acceptance to healthcare IT applications is a crucial factor in determining their success. Unfortunately, end user resistance by medical professionals has been a pervasive problem. Even if a healthcare IT application is optimized as much as technically possible, practitioners may not acknowledge that use of the system would add value to their practice, and thus may be reluctant to incorporate it into their daily routine. It is thus of vital importance to understand the antecedents of end users' IT adoption decisions and the psychological properties associated with user satisfaction assessments, in order to better predict, explain, and increase healthcare IT usage.

In this presentation we review several formal models derived from social psychology and information systems research, which have been applied in studying user acceptance and user satisfaction of healthcare IT applications, namely: reasoned action (TRA, 1967), theory of planned behavior (TPB, 1988), technology acceptance model (TAM, 1989), diffusion of innovations (DOI, 1983), social cognitive theory (SCT, 1963), model of PC utilization (MPCU, 1991), task technology fit (TTF, 1995), and the DeLone and McLean model of information systems success (D & M, 1983). We also discuss the applicability of these models in the professional context of clinicians, with a review of studies that have applied these models in healthcare settings.

#### **Home health care system for dependent people: application to Alzheimer disease**

*Ali Larab, Ali Rammal, Sylvie Trouilhet, Jean-Marie Pecatte and Nicolas Singer.*

CUFR Champollion – IRT, Castres, France.

The introduction of microprocessing and Information Technologies (IT) within the habitat made possible to facilitate and improve the living conditions of its occupants. It brings them to all the modern services and techniques they need. These techniques tend to integrate into a usual habitat with all the automatisms of communication, safety and security, energy management and assistance, in order to simplify the daily tasks and allow its occupants to be in contact with the outside.

With increasing of the life expectancy and aging of population, the home health care for old people or people suffering with chronic diseases become increasingly important. To be able to continue to live alone, these people must be assisted in their daily environment by medical centres specialized in remote monitoring. Telemedicine, generally, allows creating mediation between the medical staffs and the person who should be taken care.

The work presented here is part of the ISIS project. One of the axes of our research work is to propose the tool which allows the home care of dependent people or people who lost their autonomy. This tool must connect the remote monitoring centres with their patients and generate differentiated alarms when the anomaly is observed.

In our paper (short paper), we apply our work to the case of the Alzheimer disease. The person suffered with this disease, encounter several problems. Among these problems, there is a space confusion problem. The patient leaves his home and can not manage to return any more, because he does not know where he is. In addition to this external confusion, the patient can also be lost at home. He then will turn around without remembering what he wants to do. He will repeat the same gestures or the same way for a long period. The goal of our system is to detect this state and to generate an alarm in the nick of time.

In the complete version of our paper, we will explain how to acquire the necessary data and how to treat them in order to detect an anomaly.

**Data acquisition:** In order to acquire the necessary data for our analysis, it is advisable to insert some sensors in the habitat of the patient. By using these sensors, we are able to detect the movement and location of the person. For this we use the method of signal triangularisation. This method allows locating the people in space by using two or several sensors. It is a method used with the 2D cameras for a 3D localization. In our work, we used sensors instead of cameras, because cameras are expensive, not easy to handle and do not let the patient indifferent to the changes brought by the remote monitoring system. This can be stressful for him still more.

**Data processing and alarm management:** When the data are gathered, our system constructs the through path traversed by the supervised person. This way is represented by a directed graph. An abnormal behaviour can have different characteristics from the healthy one. If the characteristics of the abnormal behaviour appear in

the graph, the remote monitoring system must then generate an alarm and send it to the remote monitoring centre. The centre can confirm or cancel this alarm (doubt removing). If the alarm is validated, a response should be necessary (sound intervention, staff intervention...).

## **Modelling and information technologies for funding hospital care system at Lower Silesia in Poland (current issues, classifications, priorities, allocation)**

*Marek Lubicz.*

Wroclaw University of Technology, Poland.

This paper presents final results of a long-term implementation project of restructuring healthcare financing system, based at evidence-based cost control and healthcare standards diffusion, as experienced in restructuring healthcare system in the Lower Silesian region of Poland. The project was started in 1998 with my involvement in the Lower Silesian Regional Sickness Fund (followed by National Health Fund from 2003) and expired in the end of May, 2007, with my leave. The aim of the project, initiated at the start of the formal transformation of the Polish healthcare system, following legal changes in 1999, was to perform a full-scale systematic, OR based study of the regional health care system (this presentation will be restricted to hospital care only). Our specific goals included development of a set of health policy assumptions, health financing models and health information systems.

Partial results of the running project had already been presented during ORAHS meetings in Glasgow, Vienna and Southampton. This presentation will include first retrospective conclusions, related both to formal approaches and quantitative methodologies applied, as well as to health care and public health outcomes. The general assumptions of the modelling approaches dealing with hospital care sector will be described. The contribution of the models to the improvement of the decision making and to the healthcare results, measured by population indices will be demonstrated. Also the main pitfalls and suggestions for the coming health finances allocations will be formulated.

## **Fall detection for elderly people: state of the art and open issues**

*Nathalie Cislo, Natalie Smith-Guerin and Selma Arbaoui.*

Orléans University, France.

In this paper, are synthesized in one part a state of the art in existing technology for the detection of falls in elderly people and in another part results from recent studies about the impact of this gerontechnology on users and their human environment and especially about its acceptance. This synthesis is performed in order to propose requirements and specifications for fall detection systems dedicated to elderly people at their homes or in institutions.

In industrialised countries where the aging population is increasing, the risk of falling of elderly people tends to become a major concern with consequences on morbidity and mortality at an individual scale, but also on hospitalisation costs at a national scale. Indeed, falling is

the main risk for elderly people at their home or in institutions. It can induce severe complications if appropriate health care is too late. Since 1989, the World Health Organization (WHO) has been promoting the "Sure Community" concept, which particularly focuses on prevention and falling risk limitation among seniors. Worldwide, a hundred of communities are declared, following the Swedish model of the Karolinska Institute (Stockholm), in order to reduce the number and gravity of traumatism.

In this context, researchers and manufacturers have already looked into the problem of fall detection. In this paper is first presented a classification of the already proposed solutions: from the single detector placed on the body, with accelerometers that give information about person motions, to the most complex fall detection systems existing, with automatic call for medical help for instance, and/or combinations between vision, audition, sensors...

Then, emerging studies are taken into account first on the impact of gerontechnology, and especially of fall detection systems, on elderly people and their carers, and secondly on the degrees of acceptance of different devices. Indeed, from the studies performed on users and providers of solutions, it appears that the benefits and shortfalls of providing such equipment are not so obvious. For instance, the results of the acceptance by users and providers, which are often contradictory, lead to the conclusion that no fall detection device can be easily integrated (without any rejection) into a human environment and even less on human body, especially when it deals with elderly people.

Thus is required a fall detection system that takes into account both the available technology and the users' and providers' requirements.

No fall detection system will be used:

- if users are not confident in it, calling it "Big Brother" as reported in some studies,
- if knowledge of the devices is poor,
- if immaturity or imperfections of installed devices lessen users' disposition...

In a final part, from the comparison and fusion between the existing systems and the results from the live tests of gerontechnology, an optimum set of requirements and specifications for fall detection systems dedicated to elderly people at home or in institutions is proposed, and open issues are listed.

## **Approach based on patterns for the mediation between hospital information systems**

*Ikram Elazami, Driss Doukkali, Ouçamah Cherkaoui.*

Sidi Mohammed Ben Abdellah University, Fez, Morocco.

The computerization led, in the medical domain, to the development of a considerable number of Hospital Information Systems (HIS) heterogeneous asked to store, to organize, to question and to restore data relative to the medical file of the patient. These systems have to collaborate to allow cooperation on various levels: cooperation of the information stemming from new or existing HIS, cooperation between the actors of health or cooperation between the establishments of health. The solutions answering these needs base on the notion of Cooperative Information System (CIS).

This paper presents our approach based on patterns for the cooperation between the Hospital Information systems; we adopted a mediation architecture which proposes a modular organization of information systems to take advantage of the access to numerous sources of data connected by networks. The architecture of mediation is based on three levels: the first level concerns local sources (database of HIS), the second level contains the various tools to treat the requests and resolve the conflicts and the third level is dedicated to applications and users. Our approach allows the exploitation of the strategic reuse of patterns at the level of the mediation (second level) between HIS.

The basic principle of the concept of pattern consists in capitalizing a recurring problem of a domain and his solution so as to facilitate the reuse and the adaptation of this solution during a new occurrence of the problem. It allows decreasing costs of development and maintenance, reducing delays and improving the quality of the software. A pattern thus constitutes a base to know:

- allowing to identify the problem to be resolved,
- proposing a consensual if possible and correct solution to answer it,
- offering the means to adapt this solution of a specific context.

Mediators and adapters patterns are the constituents of the second level of our system of mediation. To every source of data (Hospital Information System) is associated an adapter. Every adapter supplies the same interface of access towards the sources of data and so masks the heterogeneousness of the associated source. The mediator supplies a point of unique entry and a uniform sight on a set of sources of data (he resolves the problems of heterogeneousness related to the differences of models of data and languages of requests by presenting the data in the model of mediation). The application subjects declarative requests to the mediator so as to obtain the data asked by the user.

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## **23 Thursday, 4:00pm – 6:20pm**

### **Organisational Issues**

Chair : Marion Rauner

#### **Checks and balances**

*Lucas Delesie, Kristof Eeckloo and Arthur Vleugels.*

Faculty of Medicine, K.U.Leuven, Belgium.

Hospital governance refers to the complex of checks and balances that determine how decisions are made within the top structures of hospitals. Financial pressures, changing technology and clinical knowledge, changes in demography and shifting patterns of disease, changing expectations from the public, changes in the workforce, internationalisation of health systems, etc. are driving the hospital systems and the decision-making processes within it. Translated in governance terms: a shift is needed in the *checks and balances* that determine how the decision-making processes in the hospital are directed, coordinated and evaluated. Several countries took legislative initiative recently: "*Plan Hôpital 2007*" in

France, regionalization of the National Health Service in Greece in 2001, the introduction of the *Health Service Executive* in Ireland in 2005, Portugal in 2002, the 10 *strategic health authorities* in the UK in 2006, etc.

Following these re-organisations, the European Association of Hospital Managers (EAHM), the European Hospital and Healthcare Federation (HOPE) and the Centre for Health Services Research jointly started an European study to research the reality of *checks and balances* in the European hospitals in 2005-2006. The experimental data are 16 checks and balances variables and their relationships with some 22 hospital performance indicators for a set of 1372 governing bodies in 522 participating hospitals. This contribution exemplifies the quantitative methods, the modeling and problem structuring applied to examine the variable assumptions, to facilitate an in-depth understanding of the variable associations and to decide on practical action: a perfect match with the OR definition of the UK Operational Research Society.

#### **A little knowledge is... a good thing**

*Penelope Mullen.*

University of Birmingham, UK.

Throughout the history of OR in health and healthcare, a recurrent theme has been concern about the (perceived?) lack of influence of OR and the many ways have been sought to increase that influence. Where OR is employed in strategic studies in policy and planning at national level, for example work within the UK Department of Health, its influence can be far-reaching. However, there remains considerable scope for increasing input and influence at a policy level. At a more local level, whilst individual OR studies and applications are usually well received and can make a significant and beneficial impact within hospitals and healthcare systems, widespread adoption and system-wide application is often elusive.

Does an explanation lie in problem-focused orientation of OR, seeking solutions to problems rather problems to fit solutions. A problem-focused approach can be labour intensive, usually needing specialist skills. Attempts have been and are being made to produce generic models with the intention that they would be used more widely – but can they be used without specialist skills.

At a policy level, unlike economists, operational researchers often appear hesitant about entering policy debates drawing on theories of OR. In many aspects of health and healthcare, there would appear considerable scope for OR contributions to the policy debates over and above the potential OR contribution to solving particular problems. But could and should operational researchers contribute to policy debates in this way?

A number of organisations are being commissioned to implement their ready-made solutions or standard approaches to problems in the UK and English health service, possibly without prior analysis of the situation. In addition, a number of relatively simple self-implementation problem-solving 'tools' are being advocated and marketed to health service managers and planners. Is OR ceding ground to such organisations and 'tools'? And if it is, does that matter? Are simple standard approaches better than nothing and, whilst not leading to optimum solutions, are they 'good enough'? Could and should OR develop better standard solutions and self-implementation 'tools'. Or can

# Technical Presentations

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relatively simple, standard, approaches to complex problems do more harm than good?

This paper will explore some of the issues raised by these questions focusing on a number progress including modelling and priority-setting.

## Using operations research techniques for internet-based hospital games

*Marion S. Rauner, Markus Kraus, Joerg Gesslbauer and Sigrun Schwarz.*

University of Vienna, Austria.

We have developed an internet-based management game to illustrate the economic and organisational decision making process in a hospital by using discrete event simulation. Up to six hospitals compete against each other for inpatients with different disease categories and budget depending on hospital mission, regional health policy, inpatient reimbursement system (day-, case- and global-budget based) as well as labour and radiology technology market for twelve decision periods. Players can evaluate alternative actions for capacity planning as well as patient scheduling and control problems depending on different game situations. The uniqueness of COREmain hospital game consists of the internet-based framework, the combination of resource, process and financial result management, the competition of hospitals within a region and the consideration of different inpatient reimbursement systems. The deployment of this game in teaching, policy and research might improve policy making both at a hospital, regional and national level and also induce further research in these fields.

## Planning and control in outpatient mental health care

*I.J. Baars, G.G. van Merode and A. Arntz.*

Maastricht University, The Netherlands.

**Introduction:** Within a regulated market, mental health care providers in the Netherlands have to compete for clients. Consequently they have to achieve results that compare favorably to other providers that provide similar services. According to Porter and Olmsted Teisberg competition on results is an effective way to create accountability, increase process performance and drive up patient value. Performance based integrated planning and control offers possibilities for such competition and in addition, increased transparency in care.

Outpatient mental health care centers (OMHCC) feel the need to optimize their current process organization to be able to produce efficient and effective outcomes. Therefore, we studied the opportunities for four OMHCC in The Netherlands to optimize their processes to be able to compete in the regulated market based on results.

**Process organization:** The most optimal organization structure from the point of view of quality control, combines a high level of patient integration in which process management is possible, with a high level of standardization with which integrated planning and control can be reached.

There are several factors which make integrated planning and control difficult and hamper efficiency and quality of processes. The first factor is complexity of coordination.

Secondly, there is uncertainty of demand, supply and service processes. The last factor is the inflexibility of staff and resources. To determine the best opportunities for integrated planning and control and to optimize efficiency and quality, processes have to be analyzed according to the level of standardization and patient integration.

**Method:** Process mapping is a technique by which processes can be understood which makes it easier to determine where and how to improve processes. To study the opportunities for four OMHCC to optimize their processes, we mapped processes of two patient populations (depression and schizophrenia) through observations, interviews and data analyses. Next, we have analyzed these process descriptions, paying particular attention to uncertainty, complexity and inflexibility in order to assess the level of standardization and patient integration.

**Results:** The results show differences in the processes of the four OMHCC in complexity, uncertainty and inflexibility. Differences in complexity relate to the coordination of the process as represented by the number of professionals and departments patients contacted in their treatment. Also the 'waste' as present in the care processes and the use of Information Technology (IT) differ. Furthermore, relating to the uncertainty of processes, the number of contacts between professionals and patients varies both within and between the centers. Also, the present variation in number of contacts differs between the centers. The results show differences in patient integration and standardization of processes. Due to these differences, the centers vary in efficiency and quality.

**Discussion:** The differences in complexity of coordination and in the presence and use of standardized processes results in different outcomes in the four OMHCC. The use of guidelines and IT reduces complexity of coordination and increases the possibility for integrated planning and control. This results in less variation in the number of contacts, and a better continuity of care with higher patient integration. To optimize processes in OMHCC we recommend the centers to decrease complexity and uncertainty by rearranging their processes. Most centers need to describe their processes from a patient point of view and thereby using criteria for the routing of a patient. Furthermore guidelines and IT should be used for integrated planning and control. However, due to the present inherent variability and stochasticity in the processes of mental health care, standardization and use of IT must support reactivity to be able to deal with the variability and stochasticity.

Therefore, the OMHCC need to experiment with standardization and flexibility. This is needed to find a fit between those two in order to increase predictability of processes and to be able to react to variability, stochasticity and to a changing environment. Only then are the OMHCC able to increase efficiency and quality and to plan and control processes on results as needed in the regulated market.

## The 48 hour access target for Genitourinary Medicine Clinics: a generic discrete event simulation model.

*David Bensley and Lorna Sinclair.*

Department of Health, Quarry Hill, Leeds, UK.



Genitourinary Medicine ("GUM") clinics in the United Kingdom provide services for sexual health, and in particular the diagnosis and treatment of sexually transmitted infections. Clinics may also see patients with HIV/AIDS, contraceptive (family planning) needs, or other related services.

With sexually transmitted infections on the increase, the demand on GUM clinics continues to be greater than their capacity. In 2005, there were 1.8 million attendances at sexual health clinics in the UK, with an increase of 268% in the total workload since 1996. The government has set a target for England that, by March 2008, 100% of patients contacting GUM clinics must be offered an appointment within 48 hours. Latest results from February 2007 show that only 70% of patients are currently seen, and 81% of patients are offered an appointment, within 48 hours.

Operational Research analysts within the Department of Health have been commissioned to develop a generic discrete event simulation model for GUM clinics that will allow clinics to try out potential changes (often within tight financial constraints) to the way that their clinics run before implementing them. The model shows the impact of various changes, including different processes for seeing patients, changing clinics opening times, and changes to resources.

The main challenge of this project lies in the generic nature of the model needed, as the model must be adaptable (by inputs to a user-friendly interface alone) to represent the workings of almost any GUM clinic in the country.

This presentation will outline the project's progress including the issues of creating a generic model that can be used throughout the country and consider the scenarios that GUM clinics wish to explore with the model.

## **Operations research and health care: an opportunity assessment in the Indian context**

*N. Ravichandran.*

Indian Institute of Management, Ahmedabad, India.

Indian health care scenario is at best complex. The health care delivery process in the country is a combination of state funded subsidized care, market driven price based delivery system. The insurance sector in the context of health care provision is in its infancy. In this paper we provide an opportunity assessment of formal operations research model in the context of Indian health care system. This paper is organized in five segments. A brief review of each of the segment is described below.

The first segment of the paper outlines the complex and unique challenges of the Indian health sector. It surveys the disease pattern related to infection, non-communicable and life style and others related to socio economic factors. The various stakeholders of the Indian health care system and their expectations and contributions conclude the first segment of this paper.

The second segment of the paper review the major state funded projects in health care sectors and identifies opportunities for formal methods related to resource allocation, project finance, review and monitoring, import assessment etc.

The third segment of the paper enunciates the concept of value chain in the health care setting. It identifies various opportunities for formal methods in improving either efficiency or effectiveness or both related to quality and affordability of health care. Several illustrative examples are presented to illustrate potential applications.

The fourth segment explores the opportunities available in the (Indian context) in terms of setting policy parameters related to health care issues and new initiatives related to public private partnership.

The final and fifth segment outlines the need for formal methods in areas related to emerging and complimentary industries related to health care like insurance, medical tourism, business process outsourcing and clinical trials etc.

To conclude, this paper is primarily India centric. It underlines and highlights the need for formal methods in improving health care policy, health care delivery and support services. It is aimed at both practitioners and academicians, so that they can work together in synergy to contribute to this important emerging sector in India.

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## **24 Thursday, 4:00pm – 6:20pm**

### **Work Organisation I**

Chair : Hari Balasubramanian

#### **A metaheuristic simulation-optimization approach to improving primary care access**

*Hari Balasubramanian, Ritesh Banerjee and Brian Denton.*

Mayo Clinic, Rochester, USA.

Primary care providers (PCPs) provide the majority of care patients receive during their lifetime. We consider the problem of determining the size and composition of physician panels in primary care. A physician's panel consists of a set of patients and each patient belongs to one of many different health-related categories. Using real data collected at the Mayo Clinic at Rochester, we propose a multi-period metaheuristic simulation optimization model for determining the panel design of a set of physicians working in a primary care environment. The model seeks to maximize patient visits to their own providers and reduce waiting times.

#### **Reconfiguring the operations of a Pediatric Intensive Care Unit (PICU)**

*Korina Katsaliaki, Sally Brailsford and Terry Williams.*

University of Middlesex, UK.

This study is concerned with the analysis of patients flow in the Pediatric Intensive Care Unit (PICU) and Intermediate Intensive Care Unit (IICU) of the Children's Hospital of Wisconsin (CHW). The study was undertaken by the School of Management at Southampton University. The objective of the project was to experiment with different resource and capacity scenarios of the current Care Units as well as to propose alternative ways of designing a new Intensive Care Unit in the hospital.

Observation of the system and extensive data analysis helped to identify the important factors that impact on the system's performance. Experimentation of the proposed scenarios was carried out with the use of discrete-event-simulation modelling. A summary of the results and the recommendations of this research are presented here.

## **Scheduling preparation of doses for a chemotherapy service**

*Alexandre Mazier, Jean-Charles Billaut, and Jean-François Tournamille.*

François-Rabelais University, Tours, France.

A chemotherapy service of a French hospital has to provide some treatments for patients. A production center in the hospital has to realize the preparation of doses (18000 per year, around 80 per day).

A prescription is a set of doses associated to a patient with time constraints concerning the delay between two doses and the duration of the injection. A set of prescriptions with approximate release dates is known in advance for some patients that come for one forecasted day at the hospital. The prescription is known after the validation by the physician (after visiting the patient). Other prescriptions, for patient in conventional hospitalization, arrive during the day and have also to be taken into account. The delay between the validation of the first kind of prescription and their delivery time is bounded by one hour, and the delay between the validation of the second kind of prescription and their delivery time is bounded by one hour and a half. The resources of the chemotherapy service are limited in terms of machines (two sterilizers, four isolation chambers) and pharmacy technicians (at most four at a time). In addition, the number of available technicians changes during the day.

Avoiding stress and getting the patient relax is an important aspect of the treatment procedure in a chemotherapy service. The aim of this work is to propose a schedule to the production center taking account of the limited capacity of the resources and the due dates of doses so that the delivery to the patients can be done on time.

The problem is modeled as a real time parallel machines scheduling problem. Two criteria have to be minimized: the maximum tardiness, i.e. the maximum waiting time of the patients and the number of tardy jobs, i.e. the number of doses delivered tardy. A resolution method based on constraint programming and a heuristic has been developed. Results on real-life instances show that this method allows to drastically reduce both the maximum waiting time of the patients and the number of doses delivered tardy.

## **Generating master surgical schedule using integer programming**

*Farida Bouhamou, Sondes Chaabane, Christian Tahon and Sylvain Piechowiak.*

Valenciennes University, France.

This paper addresses the problem of building the master surgical schedules in a multidisciplinary surgical suite. The study is undertaken within the framework of a

collaboration with the hospital of Valenciennes (HV), in a project of reorganization of the sector "operating theatre suites". The objective is to propose a tool for generating the master surgical schedule of the multidisciplinary operating theatre suite of the Hospital of Valenciennes. Now, this complicated task is performed manually by surgeons and operating room managers and it lasts about one month and half. In this paper, we propose a mathematical model for generating a master surgical schedule subject to operating room availability and a surgical group demand. probabilistic constraints are used to deal with the uncertainty of the demand of each surgical group. The objective of the model is to minimize cost of under and over utilization of operating rooms.

## **Improving access to psychological therapies**

*Steve Burnell.*

"Improving Access to Psychological Therapies" may prove to be one of the most important strategies of the National Health Service for people who suffer some of the more common mental health problems such as anxiety and depression.

Success could provide quicker and more sustained improvements in health and well-being, substantially improving people's chances of staying in / returning to work or enjoying greater community participation.

At South Tyneside NHS Primary Care Trust we have recognised that if our Stepped Care Plan is to deliver greater care to those Patients suffering Mental Health problems, then we need to re-design how we deliver our Services. Some of our key questions included:

1. How could we better engage with our General Practitioners?

2. How could we prove that our service improvement ideas deserved the full support of their Practice Based Commissioning?

3. How could we design, develop, and deliver Patient pathways that substantially improved Patient choice and provided quicker access to Psychological Therapies?

4. How could we optimise the availability of Staff and the development of their clinical skills for the benefit of our Patients?

5. To what extent did we need to engage skills best offered by the Voluntary Sector or via Service Level Agreements with Independent providers?

6. How could we test the impact on Service delivery if our talents and time were focused more on one Therapy, such as CBT, and less on another?

7. What-if our GP's changed their referral behaviour as access to psychological therapies improved?

These were questions that our traditional planning tools were not able to answer - we needed to find new ways of designing processes that achieved better Patient Flow, delivered greater Care, were supported by our Staff, and provided better value-for-money.

We decided, therefore, to engage the expertise of an external organisation, 'Focused\_On Health', and to bring their PatientFlow Planning and simulation FlowModelling tools in-house. This has already been acknowledged as an excellent decision.

We have used the PatientFlow Planning software to design and document when and where Therapy Services are going to be delivered as part of our Stepped Care Plan, and this has helped us to secure clinical support at the outset. In addition to data that quantify the number,

duration, and frequency of Therapies, our process maps actually provide GP's and staff with electronic access to key documents like PHQ9 and CORE.

We quickly gained a more detailed and more rigorous understanding of which skills and resources were currently available and where the gaps in services were, but this in itself could't help us to plan how to optimise the skills and experience of our Staff alongside external Advisors and Counsellors.

We have, therefore, used our PatientFlows and the professional services of 'Focused\_On Health' to design and calibrate a simulation FlowModel which means we can actually see the likely impact of our decisions on the process dynamics.

Now, we can quickly and easily measure the Queues & Wait Times likely to be experienced by Patients and test the expected benefits of sharply focused recruitment, dedicated Service Level Agreements, and investing in our Staff and deploying their new skills for the benefit of our Patients.

With these new tools and our new ways of working, it will be much easier in future to optimise our Local Delivery Plans with the Mental Health Services demanded by local Practised Based Commissioning.

We are confident that extending the PatientFlow and FlowModelling work that we have already done will help South Tyneside NHS Primary Care Trust to improve significantly Patient access to psychological therapies and that greater levels of Care will be sustained through better value-for-money processes.

## **Assessing probable risks in hospital medical record department via FMEA model**

*M.H. Yarmohamadian, Sh. Tofighi, S. Saghaeian and T. Naaseri.*

Isfahan University of Medical Sciences, Iran.

Today, all businesses using risk management to protect themselves from many risks that surrounded them. Healthcare environment as well as their subsets needed risk management. Medical Record Department is one of the most important places in each health care facility. Because it has main role in providing services to patients, physicians, hospital administrators in education, research and treatment continuity aspects.

FMEA is one of the most useful techniques for this aim. We conducted FMEA techniques in medical record department in one of the biggest teaching hospital in Iran. First, we designed flowcharts of the processes, which performed there based on exact observation. After preparing educational material, we assembled FMEA team, which consist of a leader, an advisor, and medical record personnel from four major units (Admission, Coding, Statistics and Filing units). We determined failure Modes through focus group discussion, and assigned severity, occurrence and detection rates by brainstorming and wrote our findings in standard FMEA worksheet. Afterwards, we calculated risk priority number for each failure mode and ordered them from less to more, then formed a session for decision making about corrective procedures.

Our findings showed that the most important reasons that cause the most failures were the lack of procedural documentation in department and lack of staff training programs.

As a whole, we can say error prevention is ongoing quality improvement process that requires institutional commitment and support, and medical record personnel play a main role in this process.

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## **25 Friday, 8:40am – 10:10am**

### **Stochastic Models**

Chair : Martin Utley

#### **A study on the discharge process at Kashani Hospital, Isfahan, Iran, via computer simulation**

*S. Ketabi and S.Ajami.*

University of Isfahan, Iran.

It has been shown that one bottleneck in the hospital procedures lies in the discharge process; from when the attendant issues the discharge permission until the patient leaves the hospital. In most centers the complication in discharge process and unnecessary routines have caused discharge delay, and dissatisfaction of patients. Whereas the discharge process is the final step of contact of patient and his/her fellows, with hospital and the outcomes of all procedures done for the patient are appeared in this step, so improving the quality of the discharge process can increase patient's satisfaction.

On the other hand, hospital beds are the most important sources of hospital and the length of stay in hospital is important. The unnecessary occupation of hospital beds and rooms induces waste in health care sources, and heavy cost for both hospitalization of patients and insuring organizations and causes low turn over of beds in hospital.

Improving the discharge process is the main strategy that covers many hospital activities. In this research, the main objective is analysing the discharge process at Kashani Hospital, Isfahan, Iran. Kashani Hospital as an emergency hospital, has 5 wards and 394 beds with the average length of stay of 5.69 days. Results showed that average time for patients in discharge process was 4.93 hours. Findings showed there was queue in medical records completeness in nurse and medical equipments stations. It is necessary to study the cause of discharge process and find bottlenecks to improve discharge process in the hospital.

In this study, the current patient discharge process is simulated by Simul8 to determine the average waiting time and the bottlenecks in the process. Then the effective factors on reducing the delay are examined. At last, several recommendations are proposed to improve the efficiency of discharge process.

(...) It is shown that applying some managerial decisions in different departments, reduces the delay time in the process; for instance continuous completion of medical records, or a pre-planned schedule for attendants to visit patients or taking care of discharged-patients in un-staffed rooms.

#### **Markov decision process applied to the control of admissions into elective hospitals**

*Luiz Guilherme Nadal Nunes, Solon Venâncio de Carvalho and Rita de Cássia Meneses Rodrigues.*

Sarah Network of Rehabilitation Hospitals, Brasília, Brasil.

We present a new model for the sequential decision process to define the number of patients regularly scheduled in each specialty in an elective hospital setting (without emergency services). This is a complex system due to its stochastic dynamics and the dimensionality of the states and actions spaces. The objective for controlling the system is to improve hospital resource utilization. The system is modeled as a Markov decision process, which when taken together with a well suited solution method has great potential for application.

## **The impact of service epochs on waiting times in a healthcare environment**

*Stefan Creemers and Marc Lambrecht.*

Katholieke Universiteit, Leuven, Belgium.

Service processes often take place during predefined service epochs (e.g. a doctor's office that operates during specific opening hours). In many service settings, this results in excessive flow times, congested waiting lists and staff overtime. Currently, only limited tools are available to assess the impact of service epochs on these performance measures. We develop a new methodology that is able to assess the waiting time (at various stages of the process) as well as the overtime performed in a system operating during service epochs. The methodology builds on vacation models and Markov chain theory. We use only exponential distributions to model system processes (i.e. service times, interarrival times and vacation times are assumed to be exponentially distributed). The methodology is inspired from a healthcare perspective, but can be applied to a wide variety of other settings.

## **Use of stochastic models in health care: a survey**

*Khanh Ngo Cong, Maria Di Mascolo and Alexia Gouin.*

ENSIEG, St Martin D'Hères, France.

The health care delivery systems in the world nowadays approach a lot of crisis. They notably refer to the assurance of service quality and the increase in the cost of health care which has incited researchers to use the operational research techniques to propose new ways of management rule in order to improve performance and quality and to reduce cost. Among different operational research techniques that we can find in the literature, we focus here on the use of stochastic models, which can give rise to some analytical studies (compartmental model, queuing theory) or discrete-event simulation. Before 1999 there is a vast literature available on the application of stochastic models and simulation in health care. Particularly, Preater presents a bibliography of more than 160 papers on the application of queuing theory in health care and medicine. Jun et al. are interested in the use of discrete-event simulation in health care (1979-1999). Their paper is separated into two major sections: the patient flow (patient scheduling

and admissions, patient orientation, scheduling and availability of resources) and the resources design and allocation (beds, rooms, human resources). In our paper we present a survey on articles published after 1998 and we focus more especially on the application of analytical studies or the combination of analytical studies and simulation in health care. This study is complementary to the recent survey of Augusto et al. on the use of discrete-event simulation in health care. The discrete-event simulation is very often used when we need to study a system in detail in order to answer "what if" questions and for final designs. It requires a large amount of data and allows numerous solutions to be tested in order to improve performance of the studied system. In this paper, we want to show that other methods, which need less data, can also help to improve performance of a health care system. We cite many studies that used the compartmental model in the aim of analyzing patient flow between different departments in a hospital. The compartmental model is used to study the long-run behavior of a system. We can in particular estimate the expected number of patients in each department in assuming that the number of beds is not limited, which allows then to determine the required number of beds. We also cite some studies modeling health care systems by queuing networks. An advantage to the utilization of queuing theory is that it enables to establish a simple model using less data than a detailed simulation while including randomness. This model is often used to study interactions between different units as well as the phenomenon of bed blocking. We read some articles which combine simulation and analytical methods for many purposes: simulation can validate analytical models, test the robustness of analytical models or complete analytical models; the results of analytical models can also serve simulation (determine the "warm-up" times, supply data required). Our article provides a survey of stochastic models applications (more particularly the analytical methods or a combination of analytical methods and simulation). We hope that it will help to solve the problematic of our epoch in health care and show that the stochastic models can be very useful to improve performance of a health care system.

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## **26 Friday, 8:40am – 10:10am**

### **Work Organisation II**

Chair : Michel Gourgangd

#### **Queue on discharge process in Beheshti hospital in Iran**

*Sima Ajami, Saedeh Ketabi, N. Kakaee and A. Mirallae.*

College of Medical Informatics & Management, Esfahan, Iran.

**Introduction:** The hospital discharge process is a basic bottleneck in hospital management. Improved discharge process is the main strategy that covers many hospital activities. Discharge process is the last patient's contact with hospital system. Therefore, it is the most important stage affecting patient's satisfaction. If this process takes long, not only it make, patients dissatisfied but it also will

not be beneficial for the hospital. The main objective was determining average waiting time of patient discharge process at Beheshti hospital in Esfahan, Iran in the spring of 2006.

**Method & materials:** This study was a descriptive - case study and in which data were collected by questionnaire, observation and checklist. The statistical population was all personnel involved in discharge process and patients who were to be discharged throughout the spring. To analyze data SPSS and OR soft wares were used.

**Findings:** Results showed that average time for patients in discharge process was four hours and 56 minutes. According to the personnel, the main factors affecting average waiting time were patients' financial problems and un-accessibility of interns to complete the history sheet s. Findings showed that there were bottlenecks in the wards. In addition, there were queue and waiting time in accountant section.

**Conclusion:** Discharge planning is a routine feature of health systems in many countries. The aim is to reduce hospital length of stay and unplanned readmission to hospital, and improve the coordination between services following discharge from hospital thereby bridging the gap between hospital and place of discharge. Delayed discharge caused patients to stay in hospital longer than it is necessary. Now there are fewer beds, more people in need of care and more emergency admissions.

## Efficient team planning at emergency medical service of Milano

*Roberto Aringhieri.*

Universita degli Studi di Milano, Crema, Italy.

An Emergency Medical Service (EMS) system is a service providing prehospital (or out-of-hospital) acute care to patients with illnesses and injuries. A key factor for a successful treatment of an injury is the early response, i.e., the emergency services get to scene quickly. In order to guarantee a good performance of the system, the critical resources must be carefully managed. The critical resources involved are the ambulances and the staff employed at the operation center.

The *operation center* manages all the demands from the instant in which a call is received by the operator to the time an ambulance leave the hospital after the service. The statistical analysis of historical data indicates that a call last in the average more than 2 minutes before the operator is able to summon an ambulance. Notice that the Italian law states that the response has to be performed within a mandatory time of 8 minutes in the urban areas. Therefore, the reduction of the average call duration improves the overall EMS performance.

The staff employed at the operation center of Milano is organized in a set of teams, each one able to cover the same type of duty. Each team is composed by a fixed number of individuals whose characteristics are as diversified as possible in order to include the largest possible range of skills. An efficiency measure is associated to each individual which denotes the ability of the individual to process each call as fast as possible. Finally, the team efficiency evaluates the work team performance with respect to the incoming call flow during its duty.

In this paper we deal with the problem of planning efficient teams in agreement with the official EMS of

Milano. First, we propose a mathematical model in which the team efficiency is just the sum of the efficiency of each individual belonging to team. Then, we present a solution algorithm based on a metaheuristics approach tested both on real and random instances. Finally, we discuss an improved measure of team efficiency based on queuing theory and showing that its approximated version can be included in both the initial model and the solution algorithm.

## Home healthcare process: challenges and open issues

*Selma Arbaoui, Nathalie Cislo, Natalie Smith-Guerin.*

Orléans University, France.

In this paper, specific challenges for home healthcare process are highlighted, the home healthcare process being considered as one of the "human intensive processes", and open issues are listed. Indeed, existing research work on home healthcare deals more with aspects like home telehealth, home monitoring, or home telemedicine, than process aspects.

Home healthcare is part of the most crucial research and development healthcare areas. Several reasons may be invoked such as: increase in the number of elderly people and in chronic diseases, the need to reduce hospitalisation costs, difficulties to recruit personnel in the healthcare services... Moving health services outside hospitals (into patients' own homes) is performed without neglecting some objectives as: efficiency, individualisation and healthcare quality.

In this paper, focus is put on the home healthcare process, considered as one of the "human intensive processes". Indeed, such processes are « *usually long lived, distributed among various participants, made of heterogeneous components with a various level of autonomy and always subject to dynamic evolution* ». Home healthcare activities are decentralized involving different actors (e.g. the family doctor, nurses, family members) whose cooperation and coordination are absolutely required to achieve high quality home healthcare. They also integrate heterogeneous sub-services to mediate the interaction between users and service suppliers (e.g. for the delivery of health-care products, patient transportation, scheduling of medical check-ups). Besides, home healthcare activities have to be continually adapted and modified according to the situation of the patient (dynamic evolution).

We advocate that the mastering of the home healthcare process is a necessary condition to provide an efficient support for home healthcare activities. This implies a set of challenges classified within three domains that will be developed in three parts in this paper:

**Home healthcare process:** It encompasses the actual tasks and activities that are performed by home healthcare actors (doctors, nurses, sensors...).

Challenges and perspectives may concern a set of technologies used during home healthcare activities: sensors, ICT technologies such as web-based technologies...

**Home healthcare process definition:** It concerns the characterization of home healthcare processes (or fragments), and their expression in a modelling language, in terms of "how they could or should be performed?".

Examples of challenges that will be detailed are:

- which language, representation or formalism will be used to cope with the dynamic and complex nature?
- which representation will be used for all the information that concerns the situation of the patient? (e.g. from medical guidelines to information and parameters provided by the automatic health monitoring tools such as sensors).

**Home healthcare process model enactment:** It encompasses applications that support monitoring, assistance, guidance of home healthcare activities (i.e. home healthcare process performance) according to the process model.

An example of challenges that will be detailed is: which process engines and technologies to enact such human intensive processes ?

These challenges are highly dependent on the quality and efficiency of the support provided to home healthcare activities.

Clearly, some of these challenges have already been the focus of previous research work but mainly to cope with care management process inside hospitals (such as patient flow, medical staff management, emergencies management...). Even if a good cooperation is required to improve care quality inside hospitals, outside hospitals care processes are highly more complex due to several factors such as:

- rare common meetings between actors,
- distance between patient and actors,
- less patient implication,
- variability of patient environment...

In a final part, open issues from the specified challenges for the home healthcare process are discussed.

## Optimizing decisions on work organization in intellectual disability care

*E.G.E. Leers, G.G. van Merode and L.M.G. Curfs.*

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**Introduction:** The universal credo for health care today is putting patients' needs central. This trend on the macro level is influenced by the prevailing standards and values to deal with patients and how quality of life is valued. These developments cause a shift towards more integration of care towards the patient. This will have an impact on the organization of care both on the meso and micro level. A new care paradigm implies a change in strategy and as a result also a change in facilities design. According to operations management literature, facilities design is a component of facilities planning together with facilities location. Trying to optimize the fit between meta and macro level developments and meso and micro level organizational design elements, means considering a problem in a complex context of interactions between various components.

**Problem:** Health care traditionally has a strong functional structure, meaning the professional instead of the client is the starting point for organizing care. In principle a functionalistic structure does not exclude the existence of a supply which facilitates an integrated approach, however it is often very difficult. An optimal fit between strategy and the facilities planning elements supports operational performance. To be able to make optimal decisions on work organization according to the new care paradigm, it is important to have full insight into the interrelationships with other components of the system.

The general aim of our research is to develop a computational model that expresses these relations for intellectual disability (ID) care. With this model it should be possible to experiment with different scenarios and compare them by performance measures, with the goal to optimize decisions on work organization. To develop this model we studied the relationships of work organization with other facilities planning components and the fit of work organization with macro level developments for ID care in the Netherlands. The results will be presented here.

**Method:** In the first period of 2007 an exploratory study of the research setting, a large ID care institution which serves the South-Eastern part of the Netherlands, was performed. By means of the techniques of observation, interviews and analysis of documents an extensive description was made of the current work organization and the relationships with other facilities planning components.

**Results and discussion:** Clients with an ID generally have needs that require the expertise of more than one professional discipline. The needs are very diverse; depending on a client's stage of life and covering different domains of life. Our research setting offers services on the domains of care, education, labour, living and leisure for clients in all stages of life. The macro level trend of patient focused care is translated into the research setting's strategic course. This institution has its facilities positioned according to a multi location model with locations spread among two provinces of the Netherlands. The facilities design structure is functionally organized. A location is specialized in a particular part of the clients needs. Within locations there is a further subdivision into departments and/or teams. Clients and professionals are assigned to one location, department or team. Professionals are mono-disciplinary specialized to support clients. So clients need to be assisted by several professionals. Teams are compositions of professionals with the same expertise.

The far-reaching decentralization and specialization leads to fragmentation of supply which does not promote an integrated approach towards the client. Work organization does not fit strategic purposes in an optimal way. To optimize work organization a more detailed research will be performed, by means of literature review and process mapping.

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## 27 Friday, 10:30am – 12:00am

### Hospital Supply Chains

Chairs : Alain Guinet and Armand Baboli

#### What about operations research opportunities in the home care domain?

*Salma Chahed, Eric Marcon, Evren Sahin and Yves Dallery.*

Jean Monnet University, Roanne, France.

**Context:** Home care services (HC), providing care to patients at their homes, is a growing sector in the domain of health care. Its development is accelerated with the ageing of the population, the appearance of chronic

pathologies, the advent of new technologies and the continuous pressure of governments to contain health care costs. Home Care organizations provide complex and coordinated medical and paramedical cares for a limited period which can be extended depending on patients' needs. A HC organization can be seen as either an alternative or a relay of the traditional hospitalization since the patients' treatment received in hospital can be shortened and finished in hospitalization at home. The coordination of inter organizational care delivery, essentially during the patient's discharge from the hospital and admission to a home care organization, is crucial for the continuity of care.

HC delivery process can be characterized by a complete lack of visibility before the admission of patients, complexity and heterogeneity. These characteristics are a result of the shift in the delivery of care from hospital to patient home, the diversity of home care providers that are involved in the care process and the diversity of the organizational settings which each actor belongs to. As health care services move into the home setting, the need for developing innovative approaches that improve the efficiency of operations in home care organizations increases: efficient planning, scheduling and control of activities, shorter waiting times for HC admission and thus increases the patient satisfaction.

HC organizations differ from the other health organizations by the fact that they consider patients' homes as components of the health supply chain and therefore, need to take into account additional constraints such as: (i) The necessity to provide care to one patient at a fixed time: since patients are not hospitalized inside the same unit, they need to be treated individually. (ii) The necessity of synchronizing all resources (i.e., humans and materials) involved in the care delivering process. (iii) The necessity of customizing care programs: the patient home environment and the social conditions of his/her family make specific each delivery of care.

**The literature review and discussions:** This work surveys various operations research models and solution techniques which are available in nowadays HC literature and gives a general idea about unexplored research opportunities for the operations research community. Thereby, we expose and analyze the main decision's features, and identify the new open problems that arise in practice.

Basically, there are two classes of issues according to the planning horizon: long/medium term and short/very short term. Among the long/medium term related issues, we identify works dealing with the districting problem (Blais et al., 2003; Boldy and Howel, 1980); the negotiation of funding levels from government (Busby and Carter, 2006); the optimization of patient admissions to home care system (De Angelis, 1998). A synthesis of the home care literature reveals that there are three groups of decisions that are related to the short term issues. A first category of decisions concerns two hierarchical models, an assignment model (nurse – patient assignment) and a scheduling model (i.e., a weekly plan of visits for each nurse) (Begur et al., 1997; Borsani et al., 2006). A second category deals also with an assignment model and a scheduling model, however in the assignment level, jobs are assigned to nurses (Bertels and Fahle, 2006; Everborn et al., 2004, 2006). The last category is interested in the optimization of nurse schedules by minimizing the amount of overtime and part-time worked (Cheng and Rich, 1998).

The amount of existing operations research works is modest because of the recent development of HC organizations and although the concept of Home Care exists for fifty years.

For the most of the papers we surveyed, human resources planning, and especially nurses planning, represent the main treated subject, whereas home care delivery involves multidisciplinary cares which integrate various human and material resources and have a strong need of resources coordination and synchronization. Time constraints (i.e., precedence/synchronization/exclusion), traveling times and imperative cares constraint this home care characteristic. Moreover, material resource planning, i.e. consumable and non consumable planning, is an unexplored research issue.

To fill this gap, we propose a case which comes from our own development efforts. In this paper, we describe a case study which deals with production and distribution of consumables with short shelf life, more precisely anticancer drugs. This time constraint can affect the coordination between the distribution of these products and the nurses' visits (i.e. nurses have to administer the drugs to the patient at home).

**Focus on a case study:** Among the HC problems for which the operations research could be applied, the chemotherapy at home practice is an emergent problem especially in the French context. Previously, anticancer drugs with short limitation period are prepared at patient's home although there is a risk of error and toxicity for the nurse, the patient and his family. Presently, due to a recent French health regulation, the preparation of the anti-cancer drugs must be carried out within a specific unit with insulator or flow hood. This condition implies a centralized production, a transport under protected conditions and a respect of drug's shelf life.

Within this context, three stages of the anticancer drugs' supply chain have to be considered: the production of the anticancer drugs, their distribution and their administration to patients at home. We restrict the scope of this paper to discussing the various models dealing with the production and distribution of the anticancer drugs with short shelf life. This discussion is based on the following criteria:

- Production: one or multiple resources, setup sequence dependent/setup sequence independent...
- Distribution: one or multiple resources, with or without time windows (i.e., patient availabilities), ...
- Deterministic/stochastic model.

The anticancer drugs delivery can be performed by a nurse who administrates at the same time the drug to the patient, or by a deliveryman (non health personnel). In the second case, a problem of coordination between the nurse tour and the deliveryman tour is to be treated.

## Centralized and decentralized replenishment policies considering inventory and transportation in a two-echelon pharmaceutical downstream supply chain

*Armand Baboli, Julien Fondreville, Mohammadali Pirayesh Neghab and Ali Mehrabi.*

INSA-Lyon, France.

This paper studies some problems involved in a pharmaceutical downstream supply chain. Specific constraints must be taken into account. These

constraints are related on the one hand to the pharmaceutical products such as the expiry date, the regulations ... and on the other hand to inventory control such as forbidden shortage but excess inventory allowed. It seems that traditional models of inventory control and replenishment cannot optimize the total cost of the system and consequently it is important to also take into account transportation costs. We propose two models for multi-product replenishment policies, centralized or decentralized, which can be applied each one to a product or a specific family of products. Our approach is illustrated on a simple example.

## **Application of bayesian network model to a healthcare process : sterilization process of medical devices**

*Anissa Makhlouf and Jean-Pierre Grandhay.*

ENSGSI - INPL, Nancy, France.

The most significant role of the hospitals organization is to provide safety, centeredness, timeliness, effectiveness and equity of care to the patient. In addition, it has to ensure two other important missions : research and formation. These missions are carried out in a complex environment subjected to a dynamic legislative, social and technological contexts.

This complexity constitutes the result of the hospital professionals variety and of the interactions that can occur between them. Therefore, professionals concerned with patient health care have found that prescriptive and rigorous methodologies are needed in order to look for new performances on the costs, times of organizations, while evolving their level of quality and reliability, in such complex environment. Indeed, they are confronted with environmental constraints that was previously encountered in the industrial organizations. That's why, with a methodological logic of transfer, we wished to develop, in hospital organizations, tools and methods recognized for their pertinence in the industrial sector. In this study we presents a model to estimate the efficiency of a sterilization process based on the Bayesian Networks (BN's) theory. The construction of this model is made by integrating information from functioning and dys-functioning analysis of the hospital environment.

Generally complex processes of hospitals organization were studied with tools based on functioning and dys-functioning analysis of the hospital environment. Dys-functioning analysis was based on Failure mode and effects analysis (FMEA), which is a method that examines potential failures in product or processes. It is intended to evaluate risk management priorities for mitigating known threat-vulnerabilities. FMEA is an analytical method conducted by a teamwork that identifies critical components whose failure will lead to accident, injury and/or property loss. The FMEA is a proactive and prospective technique originally developed by the US military in the 1950s to classify failures according to their impact on mission success and personnel/equipment safety. FMEA has since been used in the aerospace industry in the mid-1960s, then in the automotive industry. Afterwards, in the late 1990s, numerous health care organizations experimented FMEA to the medication administration process in hospitals. Detail procedures on how to carry out an FMEA are

reviewed by Stamatis (2003). FMEA Analysis is often applied through the use of a FMEA table combined with a rating chart to allow designers to assign values to the severity of potential failures (S), likelihood of a potential failure occurring (O) and the chance of detection within the process (D). Each index ranges from 1 to 10, the highest risk. The overall risk of each failure is called Risk Priority Number (RPN) and the product of Severity (S), Occurrence (O), and Detection (D) rankings:  $RPN = S \times O \times D$ . The RPN is used to prioritize all potential failures to decide upon actions leading to reduce the risk, usually by reducing likelihood of occurrence and improving controls for detecting the failure.

The principal advantage of the FMEA method is that this method places the people questioned like experts whereas traditional methods of the hospital sector, such as clinical audit, leads those persons to smell themselves sometimes like culprits. So, the traditional FMEA has been a well-accepted safety analysis in health organizations, however, it suffers from several setbacks. Indeed, the sensitivity and the large variability of the results obtained by an FMEA analysis depends on the role of human factor. In addition, the method employed to achieve the overall risk ranking is highly criticized. Moreover, the FMEA don't takes into account the systemic aspect of complex organization. That's why bayesian networks (BN) model seems to be a good alternative to FMEA. Indeed, BN lead to a global vision of the process and it allow the exploitation of the data obtained from FMEA.

Bayesian networks are a set of methods for graphical representation and probabilistic calculation, and they are very effective in representing possible cause-effect relationships. BN are represented by directed acyclic graphs which represent a set of variables (nodes) and a set of directed edges between variables. In this graph, nodes correspond to variables of interest, and edges between two nodes correspond to a possible dependence between variables.

The aim of this study was to represent the sterilization process by a bayesian network model and to use the information obtained from the FMEA study in order to introduce the probabilistic relationships associated.

## **The effect of leadtime information sharing on safety stock in a downstream pharmaceutical supply chain**

*Ali Mehrabi, Armand Baboli and Jean-Pierre Campagne.*

INSA-Lyon, France.

In this study we examine the effect of leadtime information sharing on the global safety stock in a downstream pharmaceutical supply chain. This chain includes a central pharmacy as the warehouse and a hospital pharmacy as the retailer. The original pharmaceutical problem recently developed by Baboli et al (2006 & 2007), where the simultaneous optimization of inventory and transportation costs has been carried out. In that pharmaceutical problem, they studied two different situations: centralized and decentralized situations. In decentralized situation, each partner tries to optimize its own total cost independently, free from the other members of the supply chain (local optimization). In the centralized case, the partners try to find a global optimum for the whole system. In this study, we extend these works to information sharing problem. Contrary to



centralization that is only possible between warehouse and retailers, information sharing corresponds to exchange some information with suppliers. Warehouse or retailer by accessing to advanced production planning information of supplier, can know the leadtime for their next order. Obviously, leadtime information of next order should be affected in actual order to rectify the safety stock level at the right time.

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**28 Friday, 10:30am – 12:00am**

## Patient Safety and Quality of Care

Chairs : Thierry Chausalet

### Quality competition for screening and treatment services

*Evrin Didem Gunes, Stephen E. Chick and Luk N. Van Wassenhove.*

This paper examines how quality for one type of preventive health care services, screening services, are determined under competition and explores its links with the treatment services.

Screening tests like mammograms for breast cancer are important tools in public health. Screening programs are organized to detect diseases early, thus decrease treatment costs and increase survival rates and expected life years. Screening services can be centrally organized, as in the UK or Canada, or they can be recommended and promoted by public health authorities without being centrally organized, as in the US. Our previous research showed that sensitivity of screening tests is an important factor to improve health outcomes. It was shown that there are significant differences in the quality of mammograms in different countries (Esserman, 2002). However, the effect of competition on screening quality has not been examined before. In the health economics literature, quality competition for health care services has been studied in the context of treatment services. In this paper, we focus on the quality decision of competing providers for screening services, and we study its links with the treatment. To our knowledge, this is the first model that considers screening and treatment services conjointly.

A Hotelling type of model is introduced for this purpose. Two providers offer both screening and treatment services, and decide on their quality for both services. The equilibrium quality values are characterized assuming providers are identical and patients are free to choose providers for screening and treatment independently. The results show that quality for screening and treatment are complements; an increase in treatment quality increases the screening quality at equilibrium.

The analysis of the duopoly competition for screening and treatment services showed that quality for these two services are strategic complements. This reinforces the importance of considering these two services conjointly in policy making and health services planning. The analysis of the socially optimal screening quality shows that a social planner cares about the reduction in treatment costs while setting the quality, while for a profit

maximizing provider, the relevant variable is the reimbursement level. However, by setting the reimbursement levels of treatment at early and late stages of the disease appropriately, it is possible to achieve the desired quality level.

A sensitivity analysis describes the effect of disease characteristics, such as the prevalence and progress rate, and the effect of service characteristics, such as treatment costs and reimbursements, on the quality levels under competition. We show that screening quality increases with prevalence of the disease. The relative net revenues gained from early treatment and late treatment is an important determinant of how the providers respond to different disease characteristics. For diseases that progress quickly, high profits from late stage treatment may create incentives to reduce screening quality, if the net revenue for early stage treatment is not sufficiently larger than the net revenue from late stage treatment.

### Patient safety evaluation in Belgian hospitals starting from the AHRQ Patient Safety Indicators (PSI)

*J. Jacques, P. Gillet, P. Meeus, G. Haelterman, I. Mertens, J. Legrand, K. Wijmeersch, P. Louis, P. Kolh.*

University Hospital from Liège, Belgium.

**Context:** The quality of care, and more particularly the Patient Safety, is a major concern for the different healthcare actors: Public Authorities, Healthcare Providers and Patients. To improve the patient safety in the hospital, it is important to be able to identify and predict these events.

**Objective:** The objective was to study Patient Safety in Belgium, using relevant indicators, exclusively obtained from medical and administrative data available in acute hospitals.

**Methodology:** In Belgium, medical and administrative data are collected for hospital financing through the Medical Minimum Data Set (RCM). In 2002, the AHRQ defined a set of indicators allowing tracking down iatrogenic events susceptible to have arisen during an hospitalisation and who could be avoided by changes of practice or organisation. For this study, we chose to adapt these indicators to the Belgian situation and calculated them for all the Belgian hospitals using data available through the Ministry of Health. The work concerned more than 10.8 million in-patient stays during the period 1999-2004.

**Results:** Twenty clinical situations were targeted by the Patient Safety Indicators (PSI). Among these, the least frequent accident in Belgium for six cumulated years was transfusion reaction (99 cases among 9 002 732 stays; 0.011 cases for 1000 stays at risk). The most frequent event was the failure to rescue (deaths arisen in some clinical situations, such as acute renal failure, sepsis, deep venous thrombosis or pulmonary embolism, shock or cardiac arrest, pneumonia, gastrointestinal hemorrhage or acute ulcer) with 35 069 deaths for 212 927 stays, or a rate of 164.7 deaths for 1000 in-patient stays at risk. Between 1999 and 2004, the rates significantly increased, which could reflect a more thorough events' codification. The average rates by hospitals did reflect important variations among the events. The highest coefficient of variation concerned the intra-hospital mortality indicator among the pathologies (Diagnosis Related Groups, DRG) of low mortality (CV =

396) whereas the least varying event was deep venous thrombosis or pulmonary embolism (CV = 44).

**Conclusion:** Using AHRQ Patient Safety Indicators, this study provided insight into patient safety evaluation in Belgian acute hospitals. The PSI targets potentially avoidable iatrogenic events and thereby could improve patient safety in hospitals.

## Speed and quality in Coronary Artery Bypass Graft (CABG) surgery: is there a connection?

*Juha-Matti Lehtonen, Mikko Hippeläinen, Eija Kattainen, Juhani Kouri and Jaakko Kujala.*

Tampere University of Technology, Finland.

**Introduction:** Industrial process management techniques have been widely applied to increase the efficiency of healthcare service provision. However, these efforts have been mainly focused on process related issues such as minimizing non-value adding time during patient episodes or to improve scheduling practices for more efficient use of resources. The time required to actually perform a specific operation has been generally treated as a black box with an assumption that pressure to decrease active operation time would lead into lower quality. The objective of this research is to analyze whether there is a correlation between operation time and quality of coronary artery bypass graft (CABG) surgery. The results of our study would shed light to which extent managerial practices that focus on decreasing the length of actual operation time, such as piecework pay or setting target times for specific operations/surgeons, can be applied for CABG surgery.

### Hypotheses:

Hypothesis 1: CABG procedure time does not affect its quality.

Hypothesis 2: There is no relationship between a surgeon's procedure speed and the resulting procedure quality.

**Data:** The study makes use of a data set of 432 patients who were operated in 1999-2000 and participated in a study comparing GABG and PCTA procedures and their effects in health-related quality of life (HRQoL). HRQoL was measured with a 15D questionnaire before, after 6 and after 12 months of the operation with 343 patients participating in all stages. Results of that study were published in e.g. Kattainen (2004). The 15D is a generic, multidimensional, standardized, self-administered instrument, which has both a profile and single index score property. It is sensitive, even more sensitive instrument than the NHP (Sintonen1994, Sintonen2001). Operation times for these patients were obtained from Kuopio University Hospital (KUH) database, along with other patient data that will be used as control variables, like procedure type. Lehtonen et al. (2007) reports variables that were found affecting CABG procedure times at KUH.

**Methodology and Tentative Results:** At this moment, both data sets are available but only 224 patients' operation times have been matched with patient's 15D survey results and we are just now working on that. Once matching will be completed, the statistical analyses can be carried out properly, including controlling for covariates affecting the operation time. At this stage, without controlling for known variables affecting speed or quality, the tentative results point to direction that:

- There is a negligible ( $r^2 = 0,004$ ) negative correlation between procedure time and change in health related quality.
- No differences were found between surgeons ( $n = 13$ ) in quality (HRQoL) measured with improvement in 15D (Kruskal-Wallis test  $p=0,56$ ).

## Analysis and management of adverse events related to central venous catheter in intensive care units

*Aurélien Pourreau, Eric Piatyszek, Philippe Berthelot and Henry Londiche.*

Ecole des Mines de Saint-Etienne, France.

Our research objective is to study organization and communication as risks factors in a public health setting. We chose to study central venous catheterization, which is often necessary to treat critically ill patients hospitalized in Intensive Care Units. This procedure can lead to serious and sometimes life-threatening complications, whether mechanical, infectious or thrombotic. However, while there are many medical studies that treat this subject, few include non medical risk factors like the organization of the care, communication inter and intrateams, team experience, etc.

**Method:** A study was conducted in two intensive care units (ICU) belonging to two different university hospitals. The aim of this study was to identify the root causes of incidents related to this medical device. Part of the study is a sociological approach based on the analysis of the way clinical functions are organized and can fail. First, this sociological step generated both a description and a basic framework of daily patient care. This work was characterized by a total immersion in the two intensive care units. The method consisted of on site observations combined with interviews with the various categories of caregivers. This 3 month period was supplemented by a yearlong follow-up study of all incidents of catheter use for these two units. During this part of the study, the complications related to these devices were identified on the basis of mandatory reporting on a specific form. This led to debriefings for all of the staff involved in the care of these particular patients. The objective was to retrospectively describe the chain of events and the critical points having led to this failure.

**Preliminary Results:** We have studied around 350 patients and 600 central venous catheters. Around 10 incidents have been debriefed.

The observation of the functioning of these 2 ICU highlights their organizational differences. Those two organizational hierarchies tend to generate different types of complications each with a unique pattern of delays, errors and recovery times. The interest of this study shows that by changing organizational structure one can possibly modify patient risk. Then, in order to reduce risks related to a medical device and enhance patient safety, it is important to lead caregivers to work on their clinical functions, team work and type of communication.

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