KATHOLIEKE UNIVERSITEIT LEUVEN

partners in Hogeschool-Universiteit Brussel

Vlerick Leuven Gent Management School

35TH ANNUAL ORAHS CONFERENCE

JULY 12 – 17 2009 LEUVEN BELGIUM

RETHINKING HEALTH SERVICES MANAGEMENT

35th International Conference on Operational Research Applied to Health Services

TABLE OF CONTENTS

Dear participant,

It is with great pleasure that we welcome you to Leuven for the 35th Meeting of the European Working Group on Operational Research Applied to Health Services (ORAHS 2009). It is the first time that the ORAHS Working Group gathers in Belgium and we really hope that you will have a splendid time in Leuven and this both on a scientific as well as a social level.

Regular visitors to the ORAHS meetings will find a familiar format in which the sessions include plenty of time not only for the presentations themselves, but also for the discussions at the end of each presentation. Moreover, a stimulating social program is planned, including a welcome drink in a typical Belgian bar, a guided tour of Leuven, a reception at the gothic town hall of Leuven, a field trip to Bruges and a gala dinner at the Faculty Club.

Leuven is very much a student town, located close to Brussels. It has a rich heritage and some very nice historical buildings. During summer it might be relatively quiet, except for tourists and visitors for the old market, where the famous Belgian beer is flowing almost continuously. Very easy and fast train connections bring you to the historical cities of Antwerp, Bruges, Brussels, Ghent, Liège and Namur, while Waterloo, where Napoleon lost his battle against the allied troops, is only some 30 minutes away (by car). We surely hope that everyone will have a wonderful time in Leuven and will go back afterwards with fond memories of Belgium. Cheers!

Erik Demeulemeester and Brecht Cardoen

Organizing Committee

- Erik Demeulemeester – K.U.Leuven – Conference chair
- Brecht Cardoen – Vlerick Leuven Gent Management School – Program chair
- Jeroen Beliën – HUB – ICT coordinator
- Liesje De Boeck – HUB – Conference proceedings
- Inneke Van Nieuwenhuyse – K.U.Leuven – Conference proceedings
- Jan Colpaert – HUB – Sponsoring and public relations
- Marc Lambrecht – K.U.Leuven – Sponsoring and public relations
- Nico Vandaele – K.U.Leuven – Sponsoring and public relations
- Nicole Meesters – K.U.Leuven – Conference coordinator

International Program Committee

- Jeroen Beliën (Belgium)
- John Blake (Canada)
- Sally Brailsford (UK)
- Brecht Cardoen (Belgium)
- Michael Carter (Canada)
- Erik Demeulemeester (Belgium)
- Brian Denton (US)
- Erwin Hans (The Netherlands)
- Paul Harper (UK)
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- Jan Vissers (The Netherlands)
- Xiaolan Xie (France)

We would like to thank the following sponsors for their kind and generous support of the ORAHS 2009 International Conference:

KATHOLIEKE UNIVERSITEIT LEUVEN

KATHOLIEKE UNIVERSITEIT BRUSSEL
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EURO
The Association of European Operational Research Societies

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Welcome reception at Domus café (Sunday, from 5 pm on)

You are most welcome at the conference opening reception at Domus café (*Address: Tiensestraat 8 - www.domusleuven.be)*. During this reception you can already register for the conference and get all the information needed for a wonderful stay in Leuven. Moreover, each participant gets 3 drinks for free.
At the beginning of this century, Belgium possessed more than 4000 breweries. The majority of beers brewed during this period could be traced to particular regions or even cafés. Domus is more than a café, it is a so-called home brewery. What kind of image do the words home brewery conjure up in your mind? The name says it all: a small brewery directly linked to a pub. This concept allows beer lovers to sample the brew under the ideal conditions. In the Domus home brewery, modern small scale equipment is used to produce quality authentic beer. The Con Domus and the Nostra Domus are the only beers that can be sampled the whole year round, Nen Engel is a seasonal beer. Of course, next to these home beers, Domus serves many other drinks, including a wide variety of Belgian and non-Belgian beers.

Conference venue information

The conference takes place at the HOG building of the Faculty of Business and Economics of the K.U.Leuven (*Address: Naamsestraat 69*). The opening plenary session (Monday 8.30 am - 10.30 am) takes place in HOG 02.28. The parallel sessions go on in HOG 02.28, HOG 00.85 and HOG 01.85. The coffee breaks take place in the Chapel (HOG 00.50). Please consult the HOG map for the location of these rooms. All rooms are equipped with a laptop and projector.

Lunches

The conference lunches take place in the student restaurant Alma 2 (*Address: Van Evenstraat 2C*), situated on a 5 minutes walk from the conference venue (see map Leuven1). Tickets will be provided upon registration (in the conference bag). Each participant gets a soup, a main dish, a dessert and a drink (possibly beer or a glass of wine). A vegetarian alternative or a sandwich based lunch is also possible.

Registration

You can register on Sunday during the welcome reception at Domus café or on Monday before noon in the Chapel (HOG 00.50) at the conference venue. On Tuesday and Thursday registration is possible during the before noon coffee break in the Chapel (HOG 00.50). Please note that we do not accept credit cards for on-site payment, you will have to pay cash.

Guided Tour of Leuven (Monday 5 pm - 7 pm).

We leave immediately after the closure of the sessions at the main entrance (*Address: Naamsestraat 69*) of the HOG building (conference venue). Please be on time!

Reception at the Town Hall (Monday 7 pm - 8 pm)

The guided city tour finishes at the beautiful gothic Town Hall of Leuven where a reception is offered by the city of Leuven. Don't miss this!

Leuven Town Hall (City centre)

Social program for accompanying persons

- Monday July 13: Trip to Ghent including a boat tour of the historic city.
- Tuesday July 14: Trip to Brussels including a guided tour of the Art Nouveau buildings.
- Thursday July 16: Trip to Antwerp with a view on Rubens.

During the welcome reception on Sunday in the Domus, directions will be given where to meet for each of the visits. If in doubt, please contact Leen Demeulemeester (mobile 0032 485 30 80 61). Please wear good walking shoes.

Hospital tours (Tuesday 3.30 pm - 6.30 pm)

Conference registration automatically includes registration for the hospital tours at the UZ Leuven Campus Gasthuisberg. The busses leave at 3.30 pm at the main entrance of the conference venue (*Address: Naamsestraat 69*). The participants will be divided into four groups. Everyone will do four tours (in different orders):

- The blood transfusion centre of the Red Cross
- The surgical day centre
- The operating room theatre
- The clinical biology lab

Visit to Bruges (Wednesday)

Known as the Venice of the North, Bruges is one of the most beautiful cities in Europe. It was a justified motive that prompted UNESCO in 2000 to include the entire historical city centre on the World Heritage list. Walking along the maze of winding cobbled alleys and romantic canals, you imagine yourself to be in medieval times. The wealth of museums is a striking image of this city's stirring history. The busses leave at 8.30 am at the main entrance of the conference venue (*Address: Naamsestraat 69*). We expect to be back in Leuven at 7.30 pm. Don't miss this once-in-a-lifetime experience!

Organ concert (Thursday, 6.30 pm - 7 pm)

Just before the conference dinner we will enjoy a wonderful organ concert by one of the participants, Prof. Dr. Guido Dedene, in the Great Beguinage church, situated in the Great Beguinage, at a one minute walk from the conference dinner location (*Address: Faculty Club, Groot Begijnhof 14*).

Conference dinner (Thursday, from 7 pm on)

The conference dinner takes place at the Faculty Club in the Great Beguinage (*Address: Groot Begijnhof 14*). The Beguinage (Dutch: 'Begijnhof'), was founded in the 13th century outside the town wall of the time. The oldest houses date from the 16th century when the original houses were replaced by brick structures. The 72 houses are generally named after a saint or a Biblical event. The church, dedicated to St. John the Baptist, is early Gothic. The date of construction, 1305, is carved into the right buttress of the north portal. Approximately 300 'Begijns' lived in the 'Begijnhof' in the 17th century. The beguines (Dutch: 'Begijnen') were women who lived a religious life but kept their own property and supported themselves. They did not make perpetual vows. The movement was very strong throughout the Low Countries.
The 'Groot Begijnhof' is now a University residential quarter for students, professors, and employees of the University. Foreign guests are also housed here. There is room for 500 people. The Infirmary of the 'Begijnhof' has been converted into the Faculty Club, a place for the academic, scientific, administrative and technical staff of the University to meet. The Chièvres Convent (Nr. 39) has been converted into a congress center. On March 31, 2000, it was officially recognised as an UNESCO World Heritage site.

Leuven Great Beguinage

ORAHS executive meeting (Friday, 12 am - 1 pm)

The ORAHS executive meeting (HOG 02.28) closes the conference. In this meeting we evaluate the ORAHS conference, discuss practical issues and make plans for the future. Don't be imposed by the word "executive". We invite every ORAHS participant to take part in this meeting and hope to see many of you!

Internet access

Internet access is possible in two ways:

- Using the PC's in the PC rooms inside the library (at the main entrance hall of the conference venue). Please consult the HOG map for the location of these rooms. The library will be open each day from 9 am to 5 pm (not during the weekend). Please show your conference badge to get entrance to the library.
- Using your own laptop using the ECON wireless internet network inside the buildings of the Faculty of Business and Economics (conference venue). To gain access to the ECON wireless internet network you need to authenticate with your individual userid and password, communicated to you on a separate sheet in the conference bag. On this sheet you can find further instructions on how to log in.

Conference proceedings

The CD-ROM (with ISBN nr) distributed upon conference registration in the conference bags contains the conference proceedings (only those who have submitted a full paper).

Special Issue International Journal of Health Management and Information (IJHMI)

After the conference, all participants have the opportunity to submit a full paper for publication in the International Journal of Health Management and Information (IJHMI). These papers will be reviewed under a normal reviewing process. Detailed instructions will be sent to all participants through email after the conference.

Emergency

In case of emergency you can call the following numbers:

- Erik Demeulemeester: 0032 486 61 99 21
- Brecht Cardoen: 0032 497 94 44 00
- Nicole Meesters: 0032 498 46 41 30
- Jeroen Beliën: 0032 472 08 89 02

Or the general university emergency numbers:

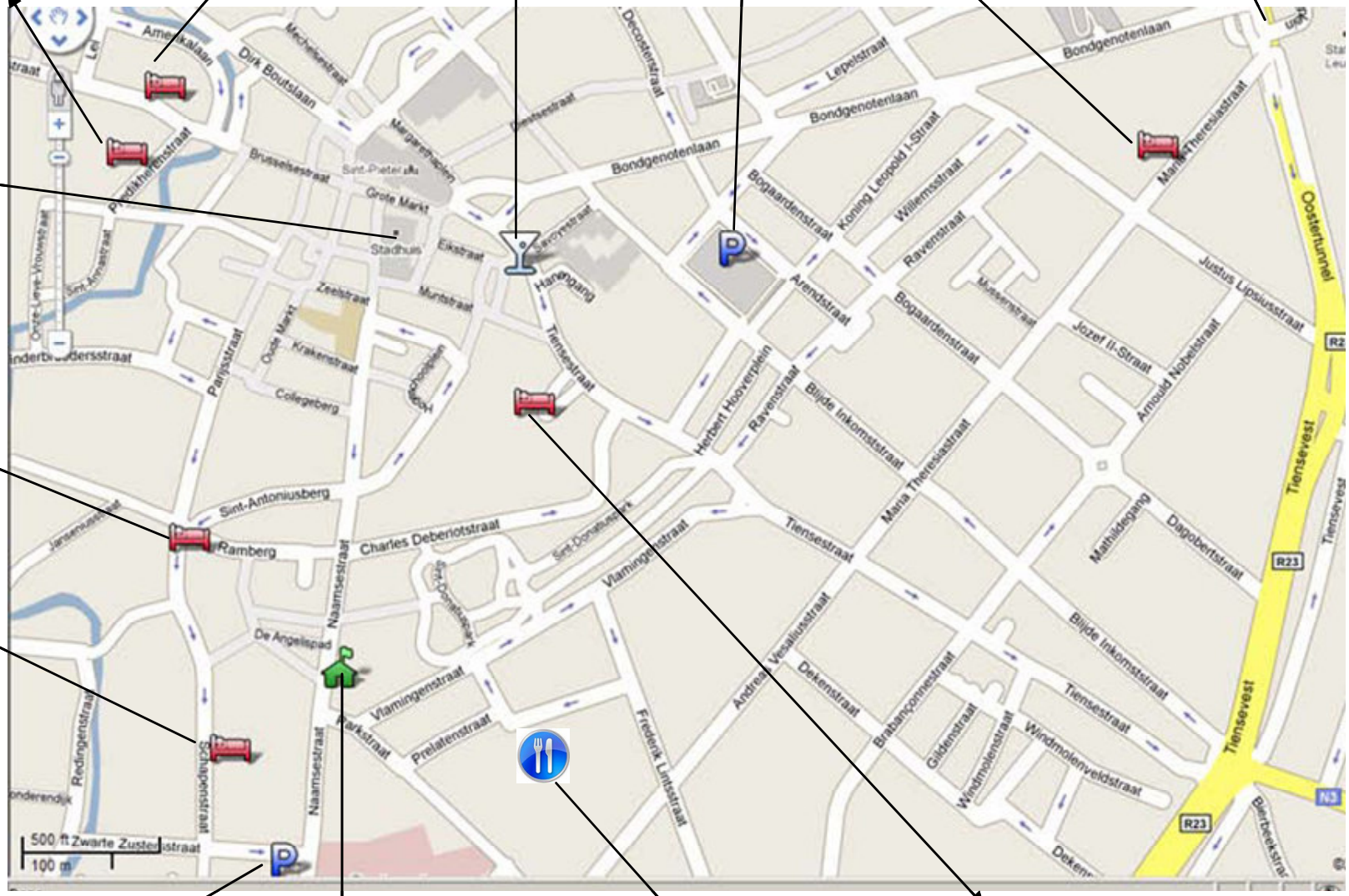
- 2222 internal phone (using a phone within the buildings of the conference venue)
- 0032 16 32 22 22 external phone (using your own mobile)

Taxi

In case you're interested in taking a taxi (cab) to arrange your trip to the airport or to make any other visit in the wider region of Leuven, you can find some contact information below:

- Taxi Breckpot
  Maria-Theresiastraat 55
  3000 Leuven
  Phone: 0032 16 22 88 88

- Taxi Jenny
  Diestsesteenweg 489
  3010 Kessel-Lo
  Phone: 0032 16 25 35 65


Hotel Kloosterhof
Predikherenstraat 22
Hotel IBIS
Brusselsestraat 52
Welcome drink
Domus café
Tiensestraat 8
Parking
"Ladeuze"
Ladeuzeplein
Hotel Binnenhof
Maria-Theresiastraat 65
Railway station
Town hall
(Monday evening reception)
Hotel
New Damshire
Schapenstraat 1
Student homes
"Holleberg"
Schapenstraat 37
Parking
"Heilig Hart"
Naamsestraat
Conference venue
Hogeheuvel college (HOG)
Naamsestraat 69
Conference lunches
Alma 2
Student restaurant
E. Van Evenstraat 2C
Hotel Holiday Inn
Alfons Smetsplein 7
Bondgenotenlaan
Tiensestraat
Naamsestraat
Brusselsestraat
Grote Markt
Stadhuis
Sint-Antoniusberg
Ramberg
Charles Deberiotstraat
Vlamingenstraat
Parkstraat
Prelatenstraat
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Mathildegang
Dagobertstraat
Bijlde Inkomststraat
Maria Theresiastraat
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Arnould Nobelstraat
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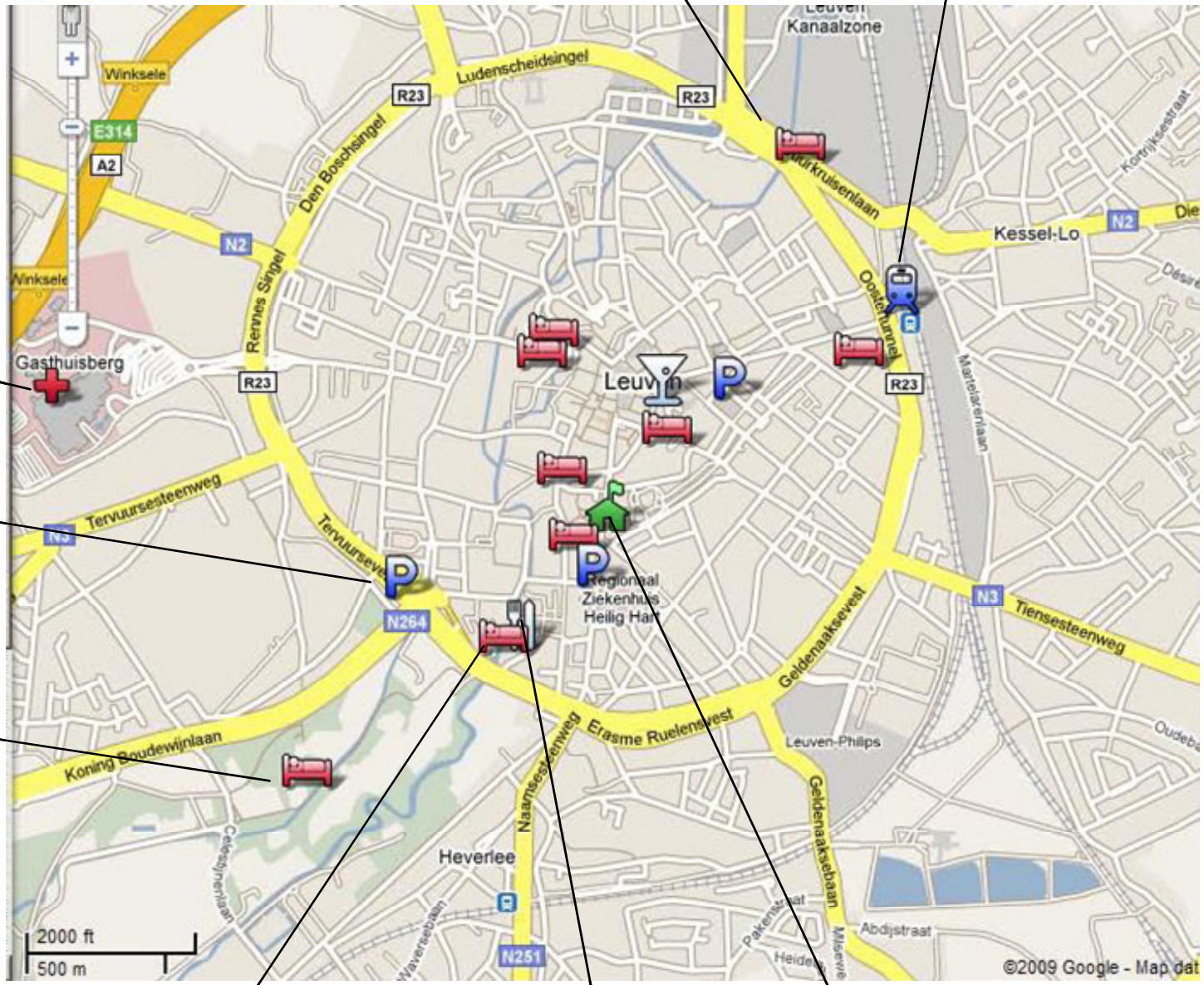
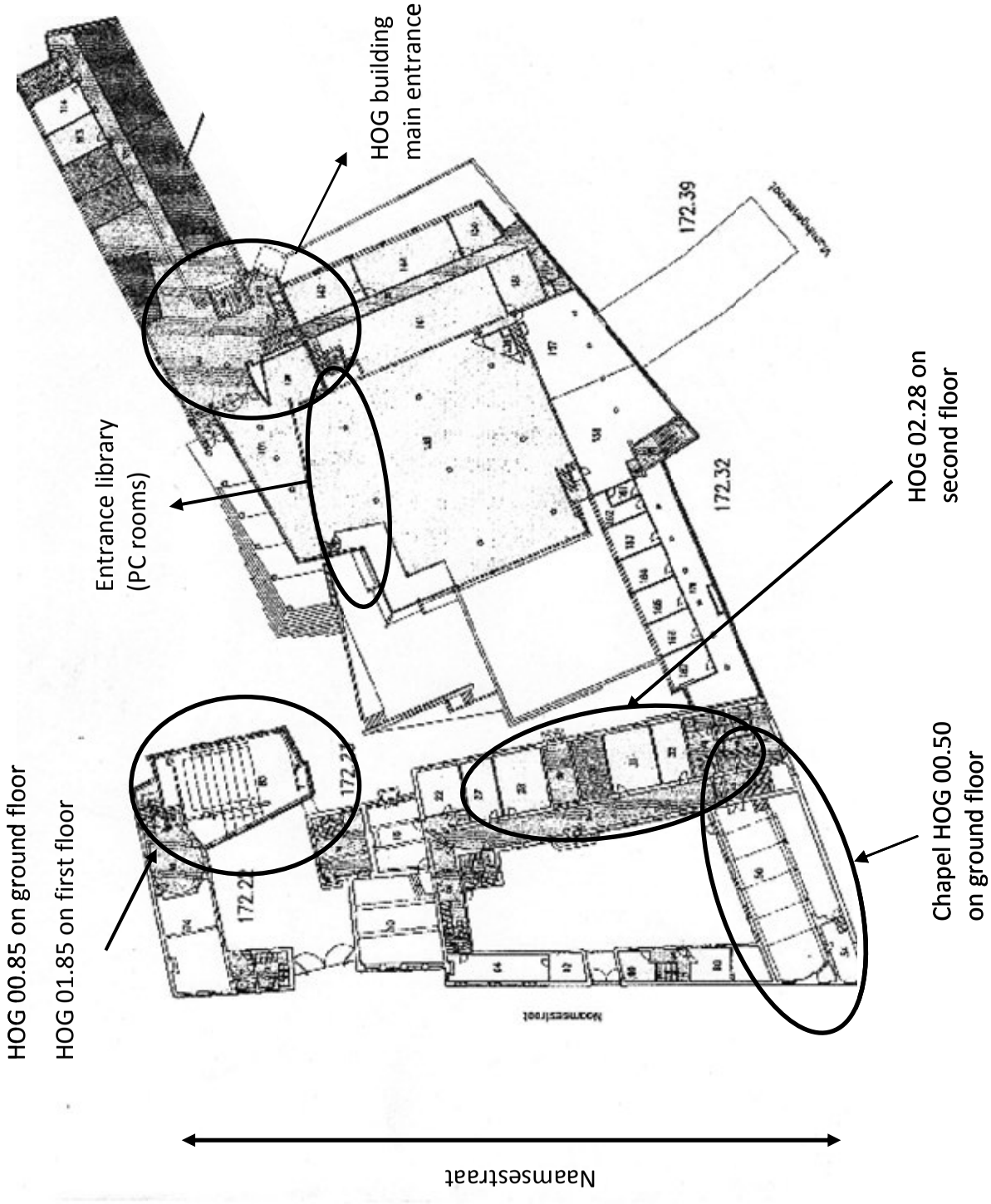
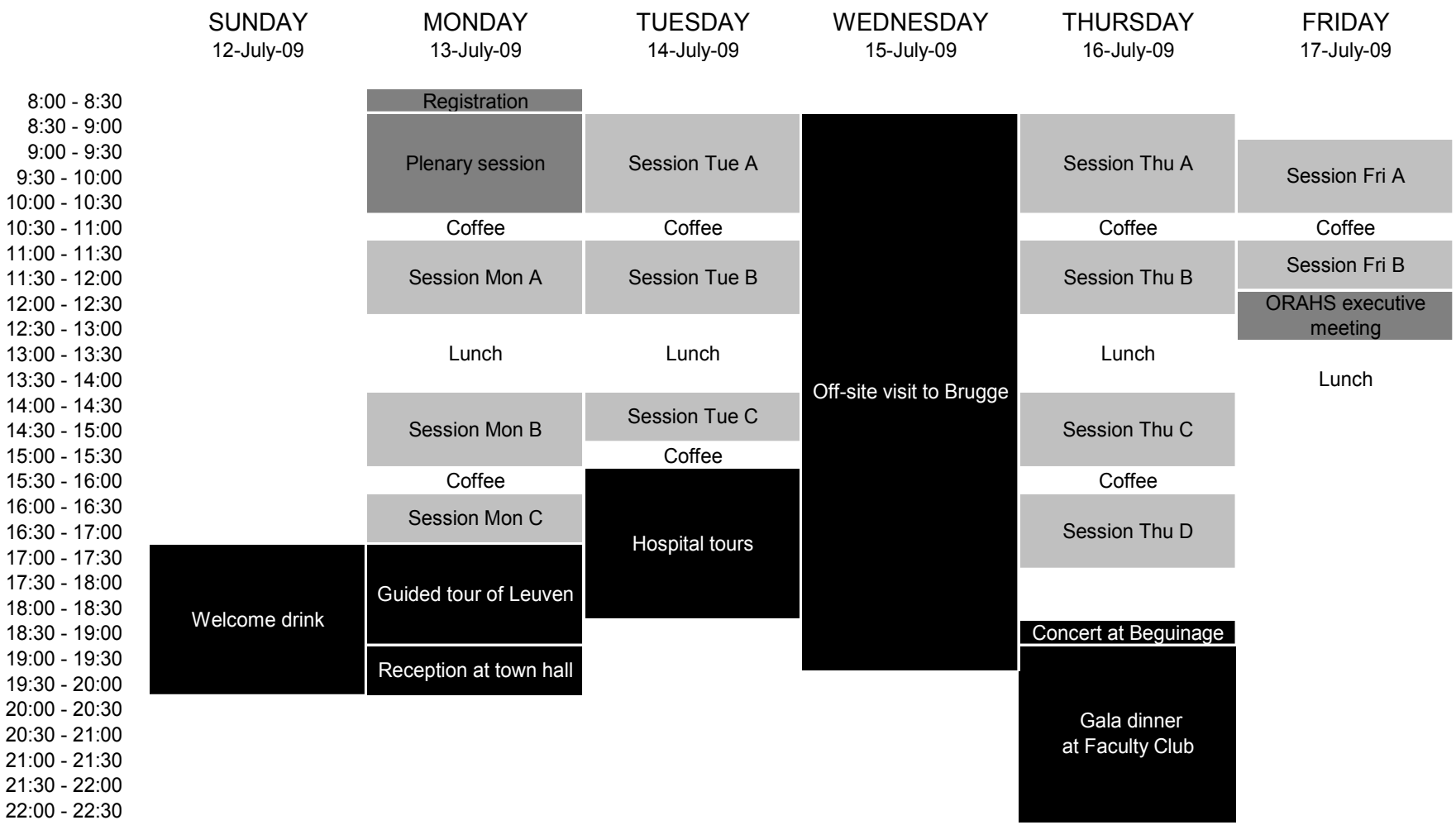
Map Leuven 2


Hotel Novotel
Vuurkruisenlaan 4
Railway station
Hospital
UZ Leuven
Tuesday
afternoon visit
Parking Bodart
Free of charge!
Student homes
Arenberg
"Vesuvius"
Building nr 25
Begijnhof congres hotel
Groot Begijnhof 15
Conference dinner
Faculty club
Groot Begijnhof 14
Conference venue
Hogeheuvel college
Naamsestraat 69
Kanaalzone
Ludenscheidsingel
Vuurkruisenlaan
Kessel-Lo
Gasthuisberg
Leuven
Tervuursesteenweg
Regionaal Ziekenhuis Heilig Hart
Tiensesteenweg
Geldenaaksevest
Erasme Ruelenslaan
Leuven-Philips
Koning Boudewijnlaan
Heverlee
Naamsestraat
Abdijstraat
2000 ft
500 m
©2009 Google - Map dat

Map HOG building




SUNDAY
12-July-09
MONDAY
13-July-09
TUESDAY
14-July-09
WEDNESDAY
15-July-09
THURSDAY
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FRIDAY
17-July-09
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Registration
Plenary session
Coffee
Session Mon A
Lunch
Session Mon B
Coffee
Session Mon C
Guided tour of Leuven
Reception at town hall
Welcome drink
Session Tue A
Coffee
Session Tue B
Lunch
Session Tue C
Coffee
Hospital tours
Off-site visit to Brugge
Session Thu A
Coffee
Session Thu B
Lunch
Session Thu C
Coffee
Session Thu D
Concert at Beguinage
Gala dinner
at Faculty Club
Session Fri A
Coffee
Session Fri B
ORAHS executive meeting
Lunch

SUNDAY JULY 12

17:00 - 20:00	**WELCOME DRINK @ DOMUS CAFE**

MONDAY JULY 13

8:00 - 8:30 — **REGISTRATION**
HOG 00.50

8:30 - 10:30 — **PLENARY SESSION**
1 HOG 02.28
Erik Demeulemeester - Conference chair
Marc Vervenne - Rector K.U.Leuven
Bruno Holthof - CEO ZNA hospital - *Rethinking health services management*
Jan Vissers and Sally Brailsford - *The story of ORAHS: A review of 35 years of ORAHS meetings*
Brecht Cardoen - Program chair

10:30 - 11:00 — **COFFEE**

11:00 - 12:30 — **SESSION MON A**

2 Emergency management
Room HOG 00.85
Chair: Maria Fanti

Rene Alvarez - A simulation study to analyze the impact of different emergency physician shift…

Alexandre Mazier - Bed allocation with uncertain patient arrivals

Maria Fanti - A petri net model for performance evaluation and management of emergency cardiology departments

3 Case-based reasoning
Room HOG 01.85
Chair: Oguzhan Alagoz

Daniel Gartner - Early DRG-classification of inpatients in hospitals

Nishikant Mishra - A non-linear case based reasoning approach to radiotherapy dose planning

Oguzhan Alagoz - A Markov decision process model to optimize breast biopsy decision making for women undergoing mammography screening

4 System dynamics
Room HOG 02.28
Chair: Paul Harper

Mariagrazia Mecoli - Modelling the diffusion and control of mosquito-borne diseases

Dileep De Silva - Operational research in dental workforce planning

Joe Viana - STIGMA - Sexually Transmitted Infections GUM Management toolkit

12:30 - 14:00 — **LUNCH**

14:00 - 15:30 — **SESSION MON B**

5 Operating room scheduling
Room HOG 00.85
Chair: Erwin Hans

Maartje Zonderland - Planning and scheduling of semi-urgent surgeries

Issam Nouaouri - Reactive operating rooms scheduling

Erwin Hans - Emergency ORs or not? Size matters…

6 Capita selecta
Room HOG 01.85
Chair: Sally Brailsford

Pamela Chan - How long will an emergency room patient wait? An estimation and analysis of factors influencing wait times

Sylvain Housseman - Optimizing a new refilling activity within biobanks using RFID technologies

Syed Mohiuddin - Enabling health, independence and wellbeing for psychiatric patients through personalised ambient monitoring (PAM)

7 Discrete event simulation
Room HOG 02.28
Chair: Peter Vanberkel

Adrian Fletcher - Generic simulation modelling of A&E patient flows through the whole hospital

Deborah Loach - A generic simulation model for assessing efficiency improvements in endoscopy suites

Peter Hulshof - Redesigning ambulatory care with flexible consultation rooms

15:30 - 16:00 — **COFFEE**

16:00 - 17:00 — **SESSION MON C**

8 Vehicule routing problems
Room HOG 00.85
Chair: Olivier Péton

Yannick Kergosien - A genetic algorithm and a simulation tool for the design of hospital material flows

Olivier Péton - A tabu search based heuristic for the transportation of mentally disabled people

9 MRI optimization
Room HOG 01.85
Chair: Rainer Kolisch

Na Geng - Time slots allocation and real-time control of MRI examinations of stroke patients

Hans-Jörg Schütz - A multi-period capacity allocation problem for MRI scanners

10 Health information systems
Room HOG 02.28
Chair: Catherine Crenn Hebert

Thourava Guizani - On the choice of modelling tools for "Business Architecture" in the hospital systems

Catherine Crenn Hebert - Assessment of the restructuration of perinatal care in the Ile de France region (1998-2009): Creation of…

17:00 - 19:00 — **GUIDED TOUR OF LEUVEN**

19:00 - 20:00 — **RECEPTION @ TOWN HALL**

TUESDAY JULY 14

SESSION TUE A

8:30 - 10:30

11 Care pathways
Room HOG 00.85
Chair: Joris van de Klundert

Maria Barton - Survival analysis and simulation modelling of stroke patient hospital pathways

Ellen van Vliet - Identifying the delivery gap in a lean cataract pathway: It is not how good you are, it is how good you want to be

Ellen Even - Monitoring patients in their care pathways

Joris van de Klundert - Measuring clinical pathway adherence

12 Safety and service quality
Room HOG 01.85
Chair: Peter Williams

David Puga-Bolio - Soft-systems methodology for implementing patient safety initiatives: A theoretical approach

Penelope Mullen - Successful health and safety, successful business - What happened in the Expert Delphi study?

Hui Tao - Resource allocation for patient satisfaction improvement in considering non-linear factors

Peter Williams - Service quality improvement in a clinical directorate: Leveraging opportunities for latitude in a multiplicity of constraints…

13 Home care services
Room HOG 02.28
Chair: Ettore Lanzarone

Elena Gutiérrez - Combined routing and staff scheduling model for home health care

Paulien Out - Optimal patient and personnel scheduling policies for car-at-home service facilities

Tian Zhang - Evaluation and configuration of a care network for chemotherapy at home

Ettore Lanzarone - Value of perfect information in home care human resource planning

10:30 - 11:00 **COFFEE**

SESSION TUE B

11:00 - 12:30

14 Operating room scheduling
Room HOG 00.85
Chair: Jose M. Molina Pariente

Arnauld Hanset - A constraint programming model for operating room scheduling

Cheryl Voake - Investigating trauma hip fracture hospital activities

Jose Manuel Molina Pariente - Testing planning policies for solving the Elective Case Scheduling phase: A real application

15 Benchmarking
Room HOG 01.85
Chair: Stefano Villa

Susanne Brown - Taking quality of care into account when benchmarking hospitals using the DEA technique

Mohammad Yarmohammadian - Assessing organizational needs of MRD staff via people capacity maturity model (PCMM)

Stefano Villa - A framework for the analysis of hospital patient flows: The results of an Italian benchmarking study

16 Ambulance management
Room HOG 02.28
Chair: Roberto Aringhieri

Leanne Smith - Resource planning and deployment of Welsh ambulance services

Ali Esensoy - Evaluation of the demonstration project to direct low acuity ambulance patients to urgent care centres to improve ambulance…

Roberto Aringhieri - Simulation models for EMS management

12:30 - 14:00 **LUNCH**

SESSION TUE C

14:00 - 15:00

17 Process modelling techniques
Room HOG 00.85
Chair: Guido Dedene

Hongying Fei - Modelling the radiology workflow in a Belgian university hospital

Edward Peters - Business process discovery & workforce intelligence techniques with healtcare applications

18 OR&Health: lessons learned
Room HOG 01.85
Chair: Michael Pidd

Andrzej Ceglowski - Economics, supply chains and the management of health care

Michael Pidd - Some reflections on the DGHPSim project

19 Ambulance management
Room HOG 02.28
Chair: Patrick Soriano

Karen Cairns - Assessment of the benefits of discrete conditional survival models in modelling ambulance response times

Patrick Soriano - iSOAP - A flexible hybrid algorithm for scheduling paramedics and ambulances

15:00 - 15:30 **COFFEE**

15:30 - 18:30 **HOSPITAL TOURS**

WEDNESDAY JULY 15

8:30 - 19:30	**OFF-SITE VISIT TO BRUGGE**

THURSDAY JULY 16

8:30 - 10:30 — SESSION THU A

20 Staffing and rostering
Room HOG 00.85
Chair: Stefanos Zenios

Julien Crowe - Flexible heuristic decomposition approach for personnel scheduling in health services

Bart Veltman - From capacity driven to demand driven workforce management

Egbert van der Veen - Rostering from staffing levels: A branch-and-price approach

Stefanos Zenios - Operating room staffing: Implementing the newsvendor model with heterogeneous demand

21 OR&Health: tools and methods
Room HOG 01.85
Chair: Marion Rauner

Paul Harper - The RIGHT project: The right tool for the job

Martin Dlouhý - Operational research in health care: Applications, methods, software

Martin Pitt - The TORCH project: Developing a curriculum in OR for health commissioning

Marion Rauner - The potential of health care management games for teaching and policy decision making

22 Demand forecasting
Room HOG 02.28
Chair: Michael Carter

Sonya Vanderby - HHR forecasting - Using system dynamics to model the future need for general practitioners…

Mitul Shivam Desai - Modelling the future demand for long-term care

Lisa Brouwers - Microsimulating the demand for health care and old age care in Sweden (LEV)

Andriy Kolos - Systemic therapy demand model in Ontario

10:30 - 11:00 — COFFEE

11:00 - 12:30 — SESSION THU B

23 Operating room scheduling
Room HOG 00.85
Chair: Jeroen Beliën

Saeedeh Ketabi - Bed balancing in surgical wards via block scheduling

Angela Testi - Including uncertain surgery times in operating room management

Brecht Cardoen - A classification scheme for operating room planning and scheduling problems

24 Care system comparison
Room HOG 01.85
Chair: Marten Lagergren

Sima Ajami - Ordering of performance criteria at the MRD by an Analytical Hierarchy Process…

Adisak Sakphisal - Analysing outpatient tasks for different-size hospitals

Marten Lagergren - A comparison between Japan and Sweden with regard to the provision of long-term…

25 System dynamics
Room HOG 02.28
Chair: Shirin Geranmayeh

Mehmet Cagri Dedeoglu - Understanding the role of family doctors using system dynamic…

Steven Burnell - Re-thinking health services management - The system dynamics of dementia

Shirin Geranmayeh - Capacity analysis of critical hospital resources using a system dynamic approach

12:30 - 14:00 — LUNCH

14:00 - 15:30 — SESSION THU C

26 Emergency management
Room HOG 00.85
Chair: Erhan Kozan

Lupe Pizan - A Peruvian pre-hospital attention model oriented to doctor-patient interaction

Joumana Hermassi - Modelling and performance analysis of the network of pre-hospital care emergency…

Mel Diefenbach - Constructive heuristics for optimum scheduling of emergency departments

27 Capita selecta
Room HOG 01.85
Chair: Honora Smith

Guangfu Tai - A novel characterisation of the patient arrival process in healthcare facilities

Mario Jorge Ferreira de Oliveira - Multiple views of the medicine distribution in a pharmacy of a Navy hospital

Honora Smith - Relocation of health facilities: Modelling the implications

28 Queue management
Room HOG 02.28
Chair: Antti Peltokorpi

Bojan Ramadanovic - Performance metrics and service discipline in a system-scale model

Peter Vanberkel - Organizing care delivery with function departments or around patient diagnosis…

Antti Peltokorpi - Optimal queue length for orthopaedic surgery with surgeon-specific queues and max…

15:30 - 16:00 — COFFEE

16:00 - 17:30 — SESSION THU D

29 Admission scheduling
Room HOG 00.85
Chair: Alexander Rutherford

Peter Demeester - A hyper-heuristic approach to the patient admission scheduling problem

Jonathan Helm - Improved cost and quality of care delivery through patient flow modelling and hospital…

Alexander Rutherford - A queueing theory model for emergency and booked elective hospital admissions

30 Spending, saving & funding
Room HOG 01.85
Chair: David Bensley

Harald Buhaug - Allocating funds to hospitals in a health region

Ali Attafar - The study of "per-case" plan and its effects on utilization of treatment capacities…

David Bensley - Here are some models I prepared earlier: Operational research to the rescue

31 Queue management
Room HOG 02.28
Chair: Nico Vandaele

Thierry Chaussalet - Capacity planning of a perinatal network through a loss network framework

Jie Song - Queueing network models to improve patient flow in a hierarchical health care delivery system

Nico Vandaele - Aggregate planning in a laboratory environment

18:30 - 19:00 — CONCERT @ BEGUINAGE

19:00 - 22:30 — GALA DINNER @ FACULTY CLUB

FRIDAY JULY 17

9:00 - 10:30

SESSION FRI A

32 Mathematical programming
Room HOG 00.85
Chair: Erik Demeulemeester

Onur Ozturk - A mixed linear programming framework for optimizing the makespan of washing operations…

Guoxuan Ma - Solving the strategic case mix problem optimally by using branch-and-price algorithms

Jeroen Beliën - A hybrid simulated annealing linear programming approach for treatment planning in HDR brachytherapy…

33 Capita selecta
Room HOG 01.85
Chair: Gabriella Balestra

Mohammad Yarmohammadian - Designing a model for estimating needed manpower for Iranian hospitals

Christos Vasilakis - Development of an impact assessment tool to assist emergency planning within strategic health authorities

Gabriella Balestra - Modeling a regional network of clinical engineering departments

34 Simulation
Room HOG 02.28
Chair: John Blake

Paula Escudero - SD and ABM is assessing hospital performance

Fermin Mallor - Statistical modelling and simulation for intensive care units. A case study

John Blake - Platelet ordering: A random walk with Ponce De León

10:30 - 11:00 COFFEE

11:00 - 12:00

SESSION FRI B

35 Appointment scheduling
Room HOG 00.85
Chair: Marc Lambrecht

Juan Pedro Sepúlveda Rojas - Decision rules for selection of appointment systems based on patient and clinical panel characteristics

Stefan Creemers - Appointment-driven queueing systems

36 Radiotherapy scheduling
Room HOG 01.85
Chair: Yoan Jacquemin

Truword Kapamara - A hybrid heuristics and tabu search approach to radiotherapy patient routing and scheduling problem

Yoan Jacquemin - Towards an improved resolution of radiotherapy scheduling

37 Diabetes modelling
Room HOG 02.28
Chair: Sally Brailsford

Crina Nicolescu - Diabetes modelling - A stylised system dynamics model

Abdullah Alshehri - A model to evaluate quality, effectiveness and influencing factors of diabetes self-management in Saudi Arabia

12:00 - 13:00 ORAHS EXECUTIVE MEETING
Room HOG 02.28

13:00 - 14:30 LUNCH

1 – PLENARY SESSION

Rethinking health services management **1**

Bruno Holthof - bruno.holthof@zna.be

MON | HOG 02.28 | 8:30 – 10:30

Keywords: Operational excellence

Curriculum Vitae:

Bruno Holthof is the Chief Executive Officer (CEO) of ZNA, the Antwerp Hospital Network. This hospital group treats about 6000 patients per day and employs about 6000 health care professionals.
Before becoming CEO of the Antwerp Hospital Network, he was a partner at McKinsey & Company. During this period, he has served a wide range of healthcare clients in Europe and the United States and has gained significant expertise in the areas of strategy, organisation and operations.
Bruno Holthof holds an M.B.A. from the Harvard Business School and an M.D./Ph.D. from the University of Leuven.

Abstract:

The presentation will start with a brief overview of ZNA. This Hospital Network in Antwerp, Belgium is undertaking a significant transformation program. Based on this program and previous programs in other health care organizations, Bruno Holthof will introduce two important dimensions of operational excellence: practice management and patient management. The key performance indicators along these dimensions are very different, and potentially in conflict with each other. Successful organizations however, continuously improve on both dimensions. This can require significant changes in current working habits of the health care professionals, which will be illustrated by case examples from the health care field. Researchers and managers who can support these changes will have great impact on the quality and efficiency of health care provision.

The story of ORAHS: A review of 35 years of ORAHS meetings **1**

Jan Vissers, Sally Brailsford

MON | HOG 02.28 | 8:30 – 10:30

Keywords: Review, survey

ORAHS is one of the domain specific EURO Working Groups installed by EURO - the umbrella organisation for Operational Research in Europe. In this presentation we report on the development of ORAHS as a platform for OR in health. We propose a two-way framework for analysis, where one dimension is the nine stages of the product life cycle: identifying consumer requirements, designing a new service to meet these requirements, forecasting demand for such a service, securing resources for it, allocating these resources, developing programs & plans to use these resources for delivering the service, establishing criteria for service delivery, managing the performance of the service, and finally, evaluating its performance. The other dimension is a three-level classification into broad application areas referring to processes at different levels in healthcare: patients & providers, units & hospitals, and regional & national. We have used this framework to carry out a quantitative analysis of all the papers presented during the meetings of ORAHS since its inception in 1975. We then describe developments over this 35 year period in applying OR approaches and techniques to health care, and present an overview of the main application areas and challenges.

2 – EMERGENCY MANAGEMENT

A simulation study to analyze the impact of different emergency physician shift structures in an emergency department

2

R. Alvarez, G. Sandoval, S. Quijada, A. Brown

MON A | HOG 00.85 | 11:00 – 12:30

Keywords: Computer simulation; emergency department; emergency physician shift structure; patient turnaround times; physician utilization rates

Hospitals need to provide timely access to emergency departments in an effective and efficient way. Computer simulation has become a widely accepted tool for evaluating different operational schemes and support managerial decision making processes. We report a simulation study to analyze the impact of different emergency physician shifts structures in the emergency department (ED) performance.
Two objectives are considered. On the one hand, we want to improve emergency physician utilization rates, measured as the total time spent by the emergency physician attending patients divided by the duration of the shift. On the other hand, we want to improve average patient turnaround times, measured as the time elapsed between the instant the patient arrives at the ED and the instant the patient leaves the ED.
We constructed a discrete event simulation model that considered the following aspects: type of patients, the paths that each patient follows throughout the ED, the emergency physicians' schedule and the amount of physicians attending patients simultaneously. We evaluated 6 different scenarios including the actual operation.
By changing the emergency physician shift structure and the amount of emergency physicians attending patients simultaneously, the model showed a 49.5% reduction on patient turnaround times, and a 71.8% increase in physician utilization rates. At the same time, the ED requirement of emergency physician hours per day decreased by 38.1%. As such, simulation showed that it is possible to increase emergency physician utilization rates, decrease the number of emergency physician hours per day and, at the same time, decrease patient turnaround times.

Bed allocation with uncertain patient arrivals

2

A. Mazier, X. Xie

MON A | HOG 00.85 | 11:00 – 12:30

Keywords: Bed allocation, emergency flow, MILP

Patients who need to be hospitalized from emergency care units face many difficulties during their stay. The waiting time before the transfer is responsible of the main problem. This leads to an unjustified number of patients waiting in the emergency unit. It is an inconvenience for the patient and for the staff during high activity period. Regular units have to take into account, and to try to satisfy, both elective patients and emergency patients request. Finding the best bed allocation planning is a crucial issue, in many aspects, for healthcare systems. However, the problem is hard to solve and becomes harder if we consider, in addition, the random nature of the emergency flow. A good bed allocation planning has to reduce the waiting time of emergency patients, reduce the number of patients in the wrong unit, reduce the number of patient's transfers from one room to another,… By definition, we can not change the emergency flow. The elective patient flow can partially be re-arranged by changing, in some cases, appointment day. An adequate elective patient flow is a good point in order to construct a good planning. However, it is not sufficient. The random nature of emergency imposes a real-time reallocation of beds. We focus on this last point. We consider a quite large horizon in order to grant the quality of future day planning. A good planning at a particular time is rarely the best for a larger horizon. The proposed method takes into account future arrivals for both kinds of patients. The approach, based on an ILP, aims to solve the problem in real-time. We present the case of a French hospital.

A petri net model for performance evaluation and management of emergency cardiology departments **2**

M. P. Fanti, G. Amodio, A. M. Mangini, L. Martino, W. Ukovich

MON A | HOG 00.85 | 11:00 – 12:30

Keywords: Hospital emergency department management, modelling, simulation, performance evaluation

Providing high quality healthcare calls for improved organization and management in hospital departments. In particular, the management of Emergency Department (ED) has become an important issue in the past decade. In such systems, the main problems may be classified as follows:
1) dimensioning the system, i.e., determining the type and number of resources to provide (staff, rooms, beds, etc.);
2) analyzing the workflow and detecting anomalies such as bottlenecks, waiting times, etc.;
3) improving efficiency, i.e., adequate use of resources, by limiting patient's length of stay, reacting to problems such as staff absence, etc.;
4) studying system reactivity with respect to increased workloads.
Simulation and performance evaluation provide useful tools for capacity planning and efficiency improvement. In particular, the hospital system may be effectively described as a Discrete Event System (DES). Among DES models, Petri Nets (PNs) may be employed to model emergency medical services and hospitals. PNs are analytical and graphical tools suitable for modeling asynchronous, concurrent processes in communication, computer and manufacturing systems.
This paper presents a model describing in detail the structure and the dynamics of a critical emergency department of the general hospital in Bari (Italy): the Emergency Cardiology Department (ECD). Patient management is performed according to the guidelines of the European Society of Cardiology / American College of Cardiology and consists of two phases. First, an early anamnesis based on a physical examination and an ECG is urgently performed. If the patient is considered a critical one, he is hospitalized in a suitable department. Otherwise, the patient is successively submitted to a complete cardiac examination. If the doctor decides that he is in a serious health condition, he is admitted in a hospital department; otherwise, he is submitted to a series of examinations in the ECD. In the second phase, the doctor decides if the patient can be discharged or if he needs a follow-up of 24 hours in the Chest Pain Unit of the ECD. During the short observation of maximum 48 hours the patient conditions can worsen so he needs a hospitalization, otherwise he undergoes an echo-stress examination. On the basis of examination results, the patient may be admitted in a hospital department or he may be discharged.
The structure and the dynamics of the system are modeled in a Timed Petri Net (TPN) framework: "places" with finite capacities model the medical and nursing staff as well as resources such as the available beds and medical devices. Instead, "transitions" describe the flow of patients and all that is needed to carry out hospital procedures. Moreover, indications of suitable performance are singled out in order to detect and solve anomalies such as bottlenecks and waiting times. Some simulation studies and a suitable validation show that the model is able to efficiently describe the ECD. Moreover, the TPN model allows to foresee the impact of key design parameters such as the number of beds, doctors and inspection devices in order to guarantee efficiency and maximize the patient flows.

3 – CASE-BASED REASONING

Early DRG-classification of inpatients in hospitals **3**

D. Gartner, R. Kolisch, R. Padman, D. Neill

MON A | HOG 01.85 | 11:00 – 12:30

Keywords: Machine learning, classification, diagnosis related groups

Diagnosis Related Groups (DRG) are used to classify inpatient hospital cases in a prospective payment system. When a patient is discharged from the hospital, a DRG is calculated by using all available clinical, treatment, and demographic data of the patient. In this study, we apply machine learning methods to identify how individual hospital patients can be assigned, on admission, to appropriate DRGs. This assignment can subsequently be used to optimize allocation of scarce hospital resources while maintaining high quality of care.

In an experimental investigation we employ data of roughly 32,000 patients in a mid-size community hospital. The data contains clinical and demographic information as well as patient flows and required resources.

A non-linear case based reasoning approach to radiotherapy dose planning **3**

N. Mishra, S. Petrovic, S. Sundar

MON A | HOG 01.85 | 11:00 – 12:30

Keywords: Radiotherapy, prostate cancer, case based reasoning, fuzzy sets

Prostate cancer is the most common cancer in the male population and often includes radiotherapy as a means of treatment. The main aim of the radiotherapy is to kill the cancer cells while trying not to impair the organs near to the cancer cells. Generation of dose plans is a time consuming and tedious task. Oncologists usually look for a trade-off between risks and benefits and in some cases go beyond the prescribed maximum dose limit. This constitutes a complex decision making problem which requires both expertise and experience. In this research, a non-linear Case Based Reasoning approach is used which takes into consideration the trade-off between risk and benefit of the proposed radiation and thus determines the dose to be delivered in two phases of a treatment. Each case describes a patient treated in the past and the dose used for his treatment. The case most similar to the new patient is retrieved from the case-base and is used to recommend the dose for the new patient. Performance of the proposed method is validated on the real data sets obtained from the City Hospital Nottingham University Hospital, NHS Trust, UK.

A Markov decision process model to optimize breast biopsy decision making for women undergoing mammography screening **3**

O. Alagoz, J. Chhatwal, E. Burnside

MON A | HOG 01.85 | 11:00 – 12:30

Keywords: Breast biopsy decision making, Markov decision processes, mammography, control-limit policy, breast cancer

Mammography is the most commonly used screening tool for early diagnosis of breast cancer, the second leading cause of cancer death among U.S. women. If a mammogram looks suspicious, then a biopsy is required to decide whether an abnormality is in fact a breast cancer. No structured guidelines exist for radiologists to decide when to recommend biopsy to a specific patient based on her risk of cancer. Around 700,000 breast biopsies are performed annually in the US; 55-85% of these biopsies turn out to have benign breast lesions. As a result, an estimated 250$ million is spent every year on the false-positive biopsies. In addition, a false-positive mammogram exposes the patient to unnecessary anxiety, pain, and possible complications.
We develop a finite-horizon discrete-time Markov Decision Process (MDP) model that finds the optimal timing of breast biopsy for an individual patient while maximizing her total expected quality-adjusted life-years. Our MDP model determines whether to biopsy the patient or wait for the next annual mammogram based on her current breast cancer risk, i.e. the probability of breast cancer. We used a Bayesian network to estimate patient-specific probability of cancer based on the demographic risk factors and mammographic findings collected by radiologists. We derive the analytical properties of the MDP model, including sufficiency conditions that ensure the existence of a control-limit type policy and non-decreasing control-limits with age.
We use clinical data that come from the mammography database of an academic tertiary care referral hospital recorded between 1999-2004. The optimal policy of our model shows that the decision to biopsy should take the patient's age into account; particularly, an older patient's risk threshold for biopsy should be higher than that of a younger patient, which suggests that biopsy should be recommended less often for older women. In current clinical practice, radiologists do not take age into consideration when making biopsy decisions.
We compare the performance of our MDP model's optimal policies to the decisions made by radiologists on real-life mammography data and find that our model may reduce the number of biopsies significantly while detecting approximately the same number of cancers as radiologists.

4 – SYSTEM DYNAMICS

Modelling the diffusion and control of mosquito-borne diseases

4

M. Mecoli, S. Brailsford, V. De Angelis, R. Berchi

MON A | HOG 02.28 | 11:00 – 12:30

Keywords: Aedes albopictus, system dynamics, Mosquito-borne diseases

System Dynamics (SD) is particularly suitable for the analysis of infectious diseases because it can model properly the feedback effect between the populations of susceptible and infected people. Recent applications of SD to model more complex mosquito-borne diseases include the works of Flessa related to malaria in Tanzania, and of Ritchie-Dunham and Méndez Galván related to dengue fever in Mexico, both published in 1999. The present paper tackles an application to other mosquito-borne diseases, such as dengue and Chikungunya, which are on the increase throughout the world. Aedes albopictus (Ae. albopictus) is a competent vector for about 24 arboviruses (mosquito-borne viruses) as well as for Dirofilaria parasites. It is one of the world's most invasive species, aided by the global growth in the used tyre industry, since mosquito eggs are transported in the water contained within the tyres. It is spreading rapidly in Europe, although to date it has only proven to be an efficient vector for the Chikungunya and Dengue viruses. An outbreak of Chikungunya occurred in Italy in summer 2007 due to Ae. albopictus in the areas of Ravenna, Forlì-Cesena, Rimini and Bologna, with 196 cases plus other sporadic cases.
The authors are involved in the construction of a SD model to study the diffusion and control of Ae. albopictus-borne diseases in Europe. Ae. albopictus is not present throughout all of Europe but it is gradually spreading, owing to its adaptability to climate and temperature and to the particular phenomenon of the delayed hatching of winter eggs in spring, known as diapause. The authors, starting from the unpublished model built by Berchi, involving several major submodels representing the mosquito life-cycle, the human infection process, the mosquito's feeding and infection process and the potential control strategies, propose a further development that takes into account spatial differences, through geomapping approaches. Such a model is of research interest and also practical application, as it could be used to study the growth of an epidemic from an initial focus of infection, the role played by a "high-risk" area, and the effects of various control strategies. It can be applied either at an urban level – considering, for instance, the movement of people between an area of high infestation, such as a cemetery or a park, and areas of lower infestation – or at a interregional or international level, considering longer distance travel, due to globalisation of travel and transportation. In this talk we present work to date and outline future model developments.

Operational research in dental workforce planning

4

D. De Silva, S. Brailsford, P. Harper

MON A | HOG 02.28 | 11:00 – 12:30

Keywords: Dental workforce, supply, planning

Operational Research (OR) methods have been widely applied to a range of healthcare issues; however there has been relatively little application to dentistry. OR techniques include simulation and optimisation, and are typically employed to provide greater understanding of complex processes and systems. The 'what-if?' scenario capability of developed tools allows for the consequences of different system configurations and interventions to be quantified, thus assisting decision-makers. This paper discuss recent collaborative work in application of System Dynamics in Dental Workforce Planning, between the University of Southampton UK and the Department of Health in Sri Lanka.
The planning of health human resources in general and therefore in dentistry is a difficult task. It is because for the amount of variables and elements that interoperate in a nonlinear complex dynamic fashion. Therefore in attempting to manage supply and demand, policy makers have to deal with a complex dynamic socio-political system. Application of System dynamics provides perspectives for an adequate integration of policy options in a complex dynamic social system.
The paper illustrates a "supply model" for dentists in Sri Lanka. It is very important that a useful model bears resemblance to the situation at hand. Therefore it is an interesting question where to draw the line

on realism, particularly in models of complex and poorly understood systems. The authors hope the model is robust enough to catch most of the variables but still simple to apprehend. It will be a "powerful transitional object" for better understanding the complex oral health issues in Sri Lanka, which is interrelated and intertwined with economic growth, peoples' perception on oral health and training and employment of dental workforce. Further this model could be easily modified to suit health systems in many developing countries.

STIGMA - Sexually Transmitted Infections GUM Management toolkit **4**

J. Viana, S. Brailsford, P. Harper, V. Harindra

MON A | HOG 02.28 | 11:00 – 12:30

Keywords: Sexually transmitted infections, chlamydia, discrete event simulation, system dynamics simulation, composite simulation

Chlamydia is one of the most common Sexually Transmitted Infections (STI) in the world. A System Dynamics (SD) simulation is being developed, to determine how prevention strategies and new developments influence the prevalence of Chlamydia within a population. A Discrete Event simulation (DES) of a Genito-Urinary Medicine (GUM) clinic is being developed in Simul8 to assess clinic design and evaluate current and proposed processes and patient pathways. The SD model will be combined with the DES model, to produce a composite model in a healthcare setting. The SD model will provide monthly demand figures which will be translated into arrival patterns based on data analysis of historical arrival patterns to be incorporated in the DES model. The DES model will then in turn provide monthly figures of the number of treated patients back into the SD model incorporating the stochastic nature of DES models. The aim of the research is to link the strategic focus of SD models to the operational focus of DES potentially combining the benefits of the two approaches.
This project will also incorporate Geographical Information Systems (GIS) principles and social science methodology with the primary goal of producing a toolkit of Operational Research techniques for Healthcare professionals within GUM. The research is funded by the Engineering and Physical Sciences Research Council (EPSRC).

5 – OPERATING ROOM SCHEDULING

Planning and scheduling of semi-urgent surgeries **5**

M. E. Zonderland, R. Boucherie, N. Litvak, C. Vleggeert-Lankamp

MON B | HOG 00.85 | 14:00 – 15:30

Keywords: Surgical scheduling, operating rooms, emergency patient flow, queuing theory, markov decision processes

Semi-urgent surgeries, that have to be performed within the regular operating room (OR) schedule shortly but not necessarily today, pose an uncertain demand on available hospital resources, and interfere with the planning of elective patients. For a highly utilized OR, reservation of a fraction of OR time for semi-urgent surgeries avoids excessive cancellation of elective surgeries, but may also result in unused OR time, since arrivals of semi-urgent patients are unpredictable.
We consider the trade-off between cancellation of elective surgeries and unused OR time. First, using a queuing theory framework, we evaluate the OR capacity needed to accommodate every incoming semi-urgent surgery. Second, we introduce another queuing model that enables a trade-off between the cancellation rate of elective surgeries and unused OR time. Third, based on Markov decision theory, we develop a decision support tool that assists the scheduling process of elective and semi-urgent surgeries. We demonstrate our results with actual data obtained from a department of neurosurgery.

Reactive operating rooms scheduling 5

I. Nouaouri, J.-C. Nicolas, D. Jolly, S. Hajri-Gabouj, N. Dridi

MON B | HOG 00.85 | 14:00 – 15:30

Keywords: Disaster, mathematical model, operating rooms, scheduling, reactivity

Disaster like terrorist attack, earthquake, and hurricane, often cause a high degree of damage. Thousands of people may be affected. In such situations, hospitals must be able to receive, in a short period, injured persons for medical and surgical treatments, using available resources and facilities. For that reason, hospitals are required to have a disaster plan, called white plan in several countries like France and Tunisia. Emergency managers do have to find an optimal schedule for assigning resources.
Our works focus on reactive operating rooms scheduling. In case of a disaster, victims are evacuated to an immediate established pre-hospital, triage and dispatching structure which is set up near to the damaged zone. The triage allows classifying victims according to the urgency of the medical and/or surgical cares they need. Then this structure routes victims to the nearby admitting hospital. We consider victims that require surgical cares with predefined a processing time and a ready date in the operating theatre. Each victim is characterized by an emergency degree which is defined by the latest starting time of its surgical care. Therefore, the surgical care must be planned before the vital prognosis of the victim is being overtaken.
Contrary to a normal situation where the objective is to reduce costs, in a disaster situation the purpose is to save a maximum of human lives. The operating rooms scheduling have to determine the set of operations to undertake by allocating proper resources, operating room and medical staff, and to specify the time of their execution.
One of the challenges of the operating rooms scheduling in a disaster situation is to take into account perturbations which occur during the scheduling time horizon. In fact, some unexpected victims can arrive to the admitting hospital at any time, requiring urgent operations. Furthermore, the state of several victims can deteriorate or improve, thus reducing or lengthening the latest starting time of their surgical care. These unforeseen events disrupt the established scheduling and need to be considered in a reactive way. Facing the complexity of this problem, the performance of a medical system is strongly related to the quality and the velocity of decisions.
So, we propose reactive programming models in a disaster situation with the objective of treating the maximum of victims in operating rooms. The proposed models are integer linear programs performed by the Cplex solver. Computational experiments show that a substantial aid is proposed by using these programs. They are considered as a decision support for the emergency manager.

Emergency ORs or not? Size matters… 5

E. W. Hans

MON B | HOG 00.85 | 14:00 – 15:30

Keywords: Operating rooms, capacity planning, simulation

Large hospitals with a trauma function face the choice of operating emergency patients either in dedicated ‘emergency’ operating rooms, or in the regular / elective program. The former case may lead to underutilization of operating rooms, and waiting time of emergency patients when more patients arrive than there are operating rooms. In the latter case, the emergency surgery is planned in the first elective operating room that becomes available. Remaining surgeries in that room have to be rescheduled / postponed.
In an earlier study, we demonstrated that a large academic hospital in the Netherlands could improve utilization and emergency surgery waiting time by closing their emergency ORs and operating emergency patients in the elective program (12 elective ORs). When the number of elective ORs becomes lower however, the number of “break-in moments” for emergency surgeries decreases as well, and at one point, emergency ORs will be more efficient again.
Using historical data from several hospitals, through scenario simulation we investigate the trade-off between size of the elective OR-department and whether or not having emergency ORs is more efficient.

6 – CAPITA SELECTA

How long will an emergency room patient wait? An estimation and analysis of factors influencing wait times

6

P. Chan, M. Carter, T. Chan

MON B | HOG 01.85 | 14:00 – 15:30

Keywords: Statistical methods, forecasting, emergency room, waiting Times

As Ontario hospitals operate under tight fiscal constraints and reduced number of hospital resources, it is not surprising that the phenomenon of emergency room (ER) overcrowding has been widely experienced throughout the province. Today, one of the top healthcare concerns is access to ER services. Unfortunately, as a consequence, patients experience prolonged waiting times, which are a symptom of a much larger hospital systems issue.
In order to address these problems in the ER, the Scarborough Hospital recently launched an initiative to enhance ER services through the implementation of a decision support triage system and patient kiosks to improve the access to care. More specifically, kiosks would allow patients to reassess themselves based on their presenting chief complaint. One useful feature currently not available on the kiosk, is providing an approximate wait time for non-urgent patients given real-time hospital factors. If patients are provided with a minimum wait time, the benefits are three-fold. It would: (i) manage the patient's expectations, (ii) provide motivation for patient reassessment and thereby increase nurse vigilance on the patient's health condition, and (iii) reduce congestion in the waiting room.
The objective of this research is to develop an understanding of factors influencing wait times given the conditions in the hospital and calculate an estimate of a predicted wait time by applying a combination of classification and regression trees and regression techniques using data from a large, urban community hospital in Toronto.

Optimizing a new refilling activity within biobanks using RFID technologies

6

S. Housseman, N. Absi, D. Feillet, S. Dauzère-Pérès

MON B | HOG 01.85 | 14:00 – 15:30

Keywords: RFID, biobanks, optimization, refilling

Contactless technologies can improve the production and supply chains at different levels. An important point when estimating the relevance of their implementation is that they can allow new activities and working schemes. This study presents the case of inserting contactless technologies in biobanks.
Biobanks have to sustain the tasks of storage, converting and handover of human, fast perishing and potentially infectious samples. Due to extreme cold chain constraints, database and inventory inaccuracies and the time for inventorying, biobank managers hesitate to refill boxes where sockets have been set free. In addition to the operational gains of accuracy and performance, introducing new auto-ID devices may allow this activity and generate large savings that may legitimize the costs of their development and/or implementation. The subject of the presentation will be the optimization problems involved by the refilling activity in biobanks.
This new activity is mainly constrained by the fact that samples must not be exposed to room temperature for a too long amount of time. Other constraints come from the fact that biobanks optimised their processes to improve their efficiency and quality of service according to the inaccuracies they know their database is subject to. As auto-identification should reduce significantly error probabilities, some of those auto-imposed constraints will not be taken into account.
Different models and properties of these problems will be presented.

Enabling health, independence and wellbeing for psychiatric patients through personalised ambient monitoring (PAM) **6**

S. Mohiuddin, S. Brailsford

MON B | HOG 01.85 | 14:00 – 15:30

Keywords: Bipolar disorder, activity signatures, personalised monitoring

Mental illness is one of the most common diseases worldwide. Bipolar disorder is a chronic mental illness associated with two types of serious recurring episodes: mania and depression, which can damage a patient's quality of life. The illness is treatable that allows affected people to lead constructive lives through self-awareness and long-term monitoring. Early detection of transitions between the normal, manic and depressed stages is a crucial treatment issue to prevent both full-blown episodes and hospital admissions. Paper-based self-management to recognise early warning signs of an imminent episode is common today, although such self-management has downsides and has been shown to have come short of reducing depressive relapses in some studies. Using mobile phones and sensors, the PAM system is being developed to issue early automatic alerts before both manic and depressive relapses. PAM is a 3-year EPSRC-funded multi-disciplinary project involving researchers in operational research (OR), engineering, biomedical signal processing and computer science since this mix is essential to the overall success of the project.
Due to energy limitations, to prolong the network lifetime, to reduce naturalistic disturbances, to the characteristics of our selected patient group and to its economic implications in mind, the number of active sensors should crucially be kept to a minimum. Therefore, OR modelling is a key aspect of PAM. We shall present the OR modelling approach adopted to help design the architecture of PAM determining a limited set of sensors required to provide a robust personalised monitoring system. Whilst ensuring that the patients' activity signatures are meaningful and relevant, a computerised disease state transition model is being developed. This model will fully analyse the data and compute the activity signatures to detect an imminent transition. A three-month technical trial is in progress to assess system acceptability and reliability. In this talk, we shall progress to date.

7 – DISCRETE EVENT SIMULATION

Generic simulation modelling of A&E patient flows through the whole hospital **7**

A. Fletcher, D. Worthington

MON B | HOG 02.28 | 14:00 – 15:30

Keywords: Accident and emergency, discrete event simulation, generic, whole hospital modelling

This paper describes the development and early use of a generic discrete event simulation model. The overall aim of the model is to improve understanding of the generalised A&E patient flows into and through A&E departments and how they are affected by all other key "whole hospital" departments (including inpatient beds) through to either admission or discharge.
Firstly, the concept of generic models is discussed and a framework of the key issues to be considered by modellers when developing generic models is introduced (generated from a literature search and an informal survey of OR academics and practitioners). Then an earlier published generic simulation model developed by the author to understand and improve A&E patient flows is evaluated against the framework. Potential improvements to the model are identified.
Then we identify important issues faced by A&E departments using two major national surveys and published literature. We describe the process of designing and building the improved model. Data sources are identified. The validation process, using "black box" and "open box" techniques is discussed, and some initial example uses and insights are introduced. We present results from an 'experimental design' which uses runs with different combinations of variability/non variability of demand and/or processes, capacity constraints and time of day and day of week demand profiles across the key three departments – A&E, diagnostics and inpatient beds. We then discuss the potential use of mathematical queueing models in combination with simulation as a structured method of running improvement scenarios.

The paper concludes by offering some insights into the potential of generic simulation modelling (and mathematical queueing theory) to identify generalised issues and solutions faced by hospitals in meeting time based A&E patient completion targets.

A generic simulation model for assessing efficiency improvements in endoscopy suites 7

D. Loach, M. Carter, G. Woodward, N. Berger, A. Lau

MON B | HOG 02.28 | 14:00 – 15:30

Keywords: Generic discrete event simulation, endoscopy suite, colonoscopy, colorectal cancer

Colorectal cancer (also known as bowel cancer) is the third most common cancer worldwide, but with regular screening there is a 90% cure rate of this disease. Thus, in 2007 the first Canadian screening program for CRC was implemented by the province of Ontario, a region where less than 25% of the eligible population participates in CRC screening, despite having one of the world's highest rates of this disease. This program, called ColonCancerCheck (CCC) recommends that those between the ages of 50 and 74 at average risk of CRC be screened biennially using guaiac fecal occult blood tests (g-FOBTs). Those with positive g-FOBT results or who have a family history of CRC are recommended for colonoscopy: a type of endoscopic procedure that involves investigating the colon using a surgical viewing tube.
The implementation of the CCC program has created additional demand for colonoscopies. In addition, Cancer Care Ontario (CCO), which implemented and regulates the program, created wait time targets for program colonoscopies. The objective of our research is to enable Ontario hospitals to meet the increased colonoscopy demand and wait time targets by determining the most efficient ways to increase capacity in their endoscopy suites.
We accomplish this goal in two ways: through direct observation of six Ontario endoscopy suites and by creating a generic discrete event simulation, which models patient flow through the endoscopy suite from booking to discharge. CCO, in collaboration with the Centre for Research in Healthcare Engineering, observed and compared the endoscopy processes in three sites of a teaching hospital, two large community hospitals, and one small community hospital in Ontario to determine potential efficiency improvements. Recommendations for improvement included scheduling procedures according to physician specific average times, rather than using a fixed procedure length; reducing the time it takes to turnover the procedure room and prepare it for the next patient; and decreasing delays in the recovery area by releasing patients as soon as they meet the necessary discharge criteria.
Our research draws upon these observations to develop a generic discrete event simulation model for assessing the capacity gains obtained from each improvement. The simulation accommodates differences at multiple sites by using site-specific hospital data read in from an Excel file. In this way, the same model can be used to assess multiple sites and determine the improvements that will yield the greatest capacity gains.
The generic simulation model is based on direct observation of only six Ontario hospital endoscopy suites, and hence may be limited in its range of applicability. Despite this, it still provides insight to help hospital managers determine the best ways to increase their colonoscopy capacities to meet the demands of the CCC program. As such, this simulation aids in colorectal cancer prevention.

Redesigning ambulatory care with flexible consultation rooms 7

P. Hulshof, P. Vanberkel, M. van Houdenhoven

MON B | HOG 02.28 | 14:00 – 15:30

Keywords: Outpatient clinic, flexible consultation rooms, discrete event simulation

In many hospitals ambulatory care is organized such that physicians remain in dedicated offices while patients come and go. This arrangement, which is preferred by many physicians, has historically served hospitals well. However, with hospitals growing it is becoming increasingly difficult to ensure that physician offices, which double as consultation rooms, are located in logical and easily accessible areas of the hospital. To overcome this, it may be advantageous to redesign how Ambulatory Care is organized and delivered by introducing flexible consultation rooms in more patient friendly areas, and having patients wait in consultation rooms while physicians come and go. This approach to hospital re-design leads to many capacity questions for hospital management and physician concerns regarding the

productivity of their clinic. Using discrete event simulation a model is developed to address the dimensioning concerns of management and performance concerns of physicians. In a case study for the department of internal medicine of Beatrix Hospital, Gorinchem, The Netherlands, the proposed changes are discussed. Multiple hospitals in the Netherlands are considering the pros and cons of flexible consultation rooms. Our model can be used as a decision support tool in these hospitals.

8 – VEHICULE ROUTING PROBLEMS

A genetic algorithm and a simulation tool for the design of hospital material flows

8

Y. Kergosien, C. Lenté, J.-C. Billaut

MON C | HOG 00.85 | 16:00 – 17:00

Keywords: Vehicule routing problem, genetic algorithm, simulation, hospital logistic

The Hospital Centre of Tours (France) is reorganizing the logistic services between its hospital units, located at different places in the city. Each hospital unit has to be supplied with clean linen, tray meals, medicines, sterile equipments for operating theaters, medical patient records (paper files), and other various supplies. At the same time, dirty linen and waste have to be collected from each unit. At the moment, these flows are managed separately by specific services which implies a lot of vehicle routing without much coordination and pooling. In addition, one of the hospital units consists of several buildings through which the progression of vehicles is difficult and easily disrupted when a truck is parked too long to perform its delivery (the driver of the vehicle performs the delivery). A project of reorganization of this hospital unit is currently in progress and plans the creation of an independent team of warehousemen. Thanks to this team, the vehicles will load and unload only in one dock, facilitating the traffic. The team will help loading and unloading trucks and will mainly support the delivery and pick up at the buildings of the units as fast as possible, using eventually the Fenwick and underpass.
We focus on the vehicle routing problem (VRP) between these units and these hospitals on a week period, and also on the design of a warehousemen team inside a particularly large hospital unit. The design of this team (composition, planning, etc.) is strongly related to the routes of vehicles between hospital units. In addition, the total number of drivers and warehousemen cannot increase since it is not possible to hire a new person. The whole problem can be seen as a two-level pickup and delivery problem with time windows, where two VRP interact. The flows of commodities are important. For example the hospital units use more than 15 tons of linen per day, and they also consume more than 4500 tray meals per day. We focus only on the number of trucks to be used for the delivery or pickup of each kind of commodity. Each truck has a delivery point which is a building or a hospital unit. A delivery point is characterized by a demand for each kind of truck with a quantity and a time window during which the delivery must be performed. Finally, the delivery time depends on the type of truck, the number of trucks, the mode of transport, and the delivery point.
To solve this two-level pickup and delivery problem, we propose a genetic algorithm. Our objective is to plan the routing and size the teams (drivers and warehousemen). The sum of drivers and warehousemen is data of the problem. We try to maximize the overall time spent on site by the warehousemen to enable them to perform other tasks in the hospital such as internal transportation of drugs, machines, files, etc. A simulation tool with a graphical representation has been developed to test different scenarios and to validate the final decision.

A tabu search based heuristic for the transportation of mentally disabled people

8

O. Péton, F. Lehuédé, C. Pavageau

MON C | HOG 00.85 | 16:00 – 17:00

Keywords: Tabu search, transportation, vehicule routing problem

Transportation of mentally disabled persons is subject to many specific constraints due to medical or organisational reasons. We consider the problem of the daily transportation of persons from their home to specialized medical or social institutions. This concerns either mentally disabled children who attend specialised schools, or adults working in vocational rehabilitation centres. Most of them are unable to

travel on their own, so that a dedicated transportation system must be managed by the centres. Daily inbound and return trips for dozens of persons are generally performed by costly taxis or minibuses.
We model the underlying optimisation problem as a multi-periodic vehicle routing problem with time windows, heterogeneous fleet and additional constraints. The main characteristic of the model is to mix closed routes (that form loops from the centre) and open routes from the driver's home to the centre. We propose two objective functions aimed at minimising the transportation cost or finding a trade-off between the cost and the quality of service respectively.
Our approach for solving this problem efficiently and rapidly is a three phase heuristic. The first phase addresses a so called standard problem where every person is located at their main address with the most classical time window. Initial routes are built through a best insertion procedure based on a regret calculation. The second phase is a tabu search that combines several classical moves of the literature: customer relocation, customer exchange, cross-exchange, string exchange etc. The third step considers the real daily demand of every person. This step integrates possible daily variations in the demand: possible absence, variations in the time windows, daily changes in the addresses (pick-up or delivery at the parents, home family, nurse, etc.).
The algorithm has been embedded in a decision support system called Marika. This decision support system seeks both technical efficiency and the satisfaction of human concerns. We present numerical results obtained from both test instances from the VRP literature and real instances. We show that the average of the individual travelling times as well as the total travelling time of the vehicles can be reduced by around 15% for real instances.
We finally enumerate some research perspectives. A first improvement is to obtain consistent schedules for every person. The idea is that daily variations in the demand of some transported persons should have limited impact on the schedules of other persons. This issue is important when applied to a fragile population. A second objective is to look for a trade-off between the cost, the quality and the consistency of service through a multi-objective optimization. The last project research concerns the possibility for distinct centres to organize common transportation services in order to reduce the costs.

9 – MRI OPTIMIZATION

Time slots allocation and real-time control of MRI examinations of stroke patients **9**

N. Geng, V. Augusto, X. Xie, Z. Jiang

MON C | HOG 01.85 | 16:00 – 17:00

Keywords: Magnetic resonance imaging, neurovascular, contract, Markov decision process

Quick diagnosis is critical for the patients in the neurovascular department. Diagnosis of these patients needs the assistance of expensive and heavily used imaging equipment, which results in long waiting time and potentially threatens patient's life. It is very important for the neurovascular department to improve the service level by reducing the waiting time for imaging examinations. To deal with this problem, this paper proposes a new reservation process between the neurovascular department and the imaging department. The neurovascular department reserves a certain number of time slots in advance for different imaging techniques, more specifically for magnetic resonance imaging (MRI) in this paper. This ensures that the stroke patients can receive the examination more quickly. However, this new reservation process might also lead to unused MRI time slots if there are not enough patients to fill the contracted time slots. Further, if the queue length for these contracted slots is too long, it may be preferable to direct stroke patients to regular time slots. Therefore, it is important to allocate the neurovascular patients among contracted time slots or the regular time slots. As a result, two decisions at different levels need to be sorted: (i) the number of contracted time slots for each day; (ii) the optimal control policy for allocation of patients. A Monte Carlo optimization approach is proposed to determine the optimal contract. The optimal control is formulated as an infinite Markov decision process and we prove properties of the optimal policies. Using field data collected in a French university teaching hospital, numerical experimentation was conducted to show the efficiency of this optimal control policy.

A multi-period capacity allocation problem for MRI scanners **9**

H.-J. Schütz, R. Kolisch

MON C | HOG 01.85 | 16:00 – 17:00

Keywords: Magnetic resonance imaging, multi-period capacity allocation, approximate dynamic programming

We consider magnetic resonance imaging (MRI) scanners with a given capacity measured in time slots per examination period. Demand for different examination types (e.g. head, knee) on these devices comes in advance (i.e. before the examination period) from different patient classes (e.g. inpatients and outpatients) and is stochastic. The examination types differ w.r.t. their duration and for each type-class combination (e.g. knee scan for an inpatient) there is a specific revenue if the request is accepted and a specific cost if it is rejected. Each patient has a preference for a specific examination period but can be assigned to any period within a rolling horizon of T periods. If the assigned day deviates from the requested day, penalty costs accrue. Furthermore, patients, who have been accepted, might cancel the appointment in advance or not show up for the appointment at the examination period with given probabilities. The question is then which requests should be denied and which assigned to one of the examination periods in order to maximize the expected long-run average profit.
Only a limited number of publications treat the question of capacity allocation for diagnostic devices in health care. To the best of our knowledge there are no approaches which take into account all aspects of the capacity allocation problem described above.
We model the capacity allocation problem for MRI scanners as a continuous time Markov decision process. Furthermore, we propose a simulation-based approximate dynamic programming approach to derive good policies. In an experimental study these policies are analyzed and compared to simple heuristic policies.

10 – HEALTH INFORMATION SYSTEMS

On the choice of modelling tools for "Business Architecture" in the hospital systems **10**

T. Guizani, M. Moalla, P. Ladet

MON C | HOG 02.28 | 16:00 – 17:00

Keywords: Hospital information system, architecture framework, enterprise architecture, business process, Modelling tools

The recent mutations of the healthcare systems require the evolution of the hospital information systems (HIS) in terms of functionalities, integration and opening on the external environment of these establishments. The HIS are particularly complex, notably because of the variety and the volume of information to be treated, the diversity of the users and their needs (administrative, doctors, nurses, technicians ...), the security of information to be ensured, etc. They must guarantee the support of the quality of services and interactions between internal and external actor entities. For that, their design must take into account in a very detailed way the business specificities and processes, in coherence with definite orientations and strategic objectives.
The concept of “Enterprise Architecture” has been developing since the late eighties to sustain such design approaches. It consists of an abstract description relating, on one hand, to the business architecture which defines the strategy, the organization, the services and the processes of the enterprise and, on the other hand, to computing architecture covering the three aspects of data architecture, application architecture and infrastructure architecture. This description facilitates the exchanges between the various actors and therefore constitutes a common support for discussion and decision, thanks to a global, coherent and shared vision of the organization, processes and role of the information system. However, the implementation of this concept of enterprise architecture was slow to emerge to a significant way, undoubtedly because of the lack still noted in the development of the design approaches and the integration of the necessary supporting tools. The present communication deals precisely to this aspect.
To develop such an architecture, three components are necessary: (i) an architecture framework which helps to manage the complexity of the enterprise, to collect the bases of its organization and to guide the development of the architecture, (ii) modelling techniques/tools to meet the needs for description of the

architecture and (iii) an integrated software tool to support development and the maintenance of this architecture. We develop these needs and we introduce the current state of the art. Then we mainly focus on the problem of the modelling tools choice through a comparative study of the possibilities provided by UML, OSSAD and ARIS.

Assessment of the restructuration of perinatal care in the Ile de France region (1998-2009): Creation of a health information system in partnership with the regional health authority and perinatal health professionals **10**

C. Crenn Hebert, C. Menguy, E. Lebreton, G. Echardour, A. Serfaty, J. Zeitlin

MON C | HOG 02.28 | 16:00 – 17:00

Keywords: Perinatal health, regionalisation of perinatal care, data collection system, health services monitoring, professional practice evaluation

Over the past 15 years in France, there have been marked changes in the organization of perinatal care and medical practices as a result of government policies to adapt health care provision to the level of risk of each pregnancy and to implement perinatal health networks. In the Ile-de-France (IDF) region (8 districts, including Paris), where one-fifth of babies are born, a survey in 1998 found that only 60% of very preterm babies were born in a level III perinatal centre (maternity with on-site neonatal intensive care - PCIII) with a variation of 40% to 80% between districts. Perinatal health was selected as a priority for the regional health authority's 5 year plans in 1994, 1999 and 2006. In order to evaluate changes in perinatal health care, an information system using validated and routinely available data was established from existing databases with the involvement of perinatal health professionals.
Health certificates are filled out in maternity units for each live birth and sent to the maternal and child protection services in the district of residence. A common regional database including the certificates from all districts was constructed beginning in 2002. Hospital discharge summaries are available for all hospital stays in a maternity unit (mothers and babies, both live and stillborn) and in a neonatal unit (hospitalised newborns). Analyses of these data by the department and health care facility have been available on-line since 2006. More detailed analyses start to be transmitted to the 12 perinatal health networks in the IDF region.
Completeness of the data, assessed by comparing inclusions with civil birth registration data, was 93,3% for the health certificates and 95,4% for hospital discharge data. In 1998, 170 000 births took place in 135 maternity units with 8 PCIII, while in 2007, 179 000 births took place in 105 maternity units and 25% occurred in 12 PCIII. Seventy-eight percent of very preterm babies and 80% of babies weighting less than 1500g, were born in a PCIII with a variation between districts from 74 to 84%. An analysis of two networks situated in the same district made it possible to identify differences in need (higher very preterm birth rates and multiple birth rates in one network, for instance) and the impact of not having a PCIII located within the geographical catchment area of the network (inborn rates were 74% without a PCIII and 91% with a PCIII).
In addition to providing a regional vision of restructuration over the last 10 years, this work underscores the importance of analysis on the level of the perinatal network in order to assess population needs and the adequacy of health care provision. Extension of these analyses to all networks within the department will contribute to better evaluation and planning of maternity and neonatal care.

11 – CARE PATHWAYS

Survival analysis and simulation modelling of stroke patient hospital pathways **11**

M. Barton, S. McClean, L. Garg, K. Fullerton

TUE A | HOG 00.85 | 8:30 – 10:30

Keywords: Survival analysis, simulation modeling, health care, length of stay, efficiency gains

Stroke disease is the third leading cause of death in the UK, placing a heavy burden on society at a cost of £7 billion per year. Due to the debilitating nature of stroke, such costs are partly incurred by a

prolonged length of stay in hospital, considered to be a wasteful use of hospital resources. We present results of survival analysis using length of stay and destination as outcome measures, based on 5 year retrospective data of patients admitted to the Belfast City Hospital with a diagnosis of stroke. Survival probabilities were determined using Kaplan Meier survival curves and log rank tests. Multivariate Cox proportional hazards models were fitted to identify independent predictors of length of stay including age, gender and diagnosis. Elderly patients showed a decreased hazard ratio of discharge. Gender was not a significant hazard risk for length of stay in hospital. Those patients with a diagnosis of cerebral haemorrhage showed an increased hazard ratio and hence were more likely to have a shorter length of stay and to die in hospital. Kaplan Meier curves were performed to examine the relationship between length of stay in hospital and the destinations to which the patients were discharged. Those who were eventually discharged to a Private Nursing Home had the lowest probability of early discharge.
On the basis of these results we created twelve groups, stratified by age, gender, diagnosis and destination. These groups were then used to form the basis of a simulation model, using the software package SIMUL8, where each group is a patient pathway within the simulation. Phase type models were fitted to each group starting with one phase (the exponential). In each case the Coxian phase type distribution was then used to model the length of stay for each group. Mean duration of length of stay of stay in hospital was estimated from the simulation - separately for each of the absorbing destinations, Private Nursing Home, Death and Other. Various scenarios were tested by adjusting the expected length of stay for each group of patients who were later discharged to a Private Nursing Home with a particular focus on the potential efficiency gains if length of stay in hospital for these groups could be reduced. A reduction in the length of stay in hospital of patients discharged to a Private Nursing Home resulted in an overall reduction of length of stay in hospital for all stroke patients.

Identifying the delivery gap in a lean cataract pathway: It is not how good you are, it is how good you want to be **11**

E. van Vliet, W. Sermeus, C. van Gaalen, K. Sol, J. Vissers

TUE A | HOG 00.85 | 8:30 – 10:30

Keywords: Access and service quality, performance measurement, care pathways, lean management

The demand for cataract surgery is rising, calling for pathways that have good access and are cost-effective. Lean thinking is a management strategy, aimed at improving quality while reducing costs. Lean production processes are designed to identify gaps between expected and actual performance. In contrast with Toyota's robust production processes, care processes often lack reliable mechanisms for coordinating care across departments. Differences between expected and actual care delivery have not been studied. The aim of this study was to investigate possible delivery gaps of a lean cataract pathway by measuring its efficacy and efficiency. We formulated the following research questions:

1. What is the efficacy of the lean cataract pathway, i.e., how many patients received care according to specifications of the lean pathway design?
2. What is the efficiency of the lean cataract pathway, i.e., did the implementation of the lean pathway decrease the number of hospital visits per patient and increase access to the pathway?

Therefore we performed a comparative study in the cataract surgery clinic of the Rotterdam Eye Hospital, the Netherlands. We compared a historical cohort of all 591 patients who underwent cataract surgery in October and November 2004, with a prospective cohort of all 616 patients who underwent cataract surgery in February and March 2007. No patients were excluded. Patients in the historical cohort received care in a traditional cataract pathway. Patients in the prospective cohort received care in a lean cataract pathway. To evaluate efficacy, we analyzed how many patients received care that adhered to the lean pathway's specifications. To evaluate efficiency, we analyzed how often patients visited the hospital and how many additional patients could access the pathway.
We found that the lean pathway significantly outperformed the traditional pathway. The number of visits individual patients made to the hospital decreased by 23%. Furthermore, access to the cataract pathway increased with 42%. A 40% decrease of patient visits and a 76% increase of access could have been realized if healthcare staff would have adhered perfectly to the lean pathway's specifications.
We concluded that lean pathways can realize large improvements, and still have a significant gap between expected and actual care delivery. The main reasons we found for delivery gaps were ignoring decision rules, indirect or ambiguous communication, and allocation of shared resources. Challenge for healthcare teams is not to improve care delivery by using lean pathways as opposed to using traditional pathways, but to strive for optimal performance by consistently adhering to the specifications of the lean pathway.

Monitoring patients in their care pathways **11**

E. Even, S. Brown

TUE A | HOG 00.85 | 8:30 – 10:30

Keywords: Monitoring, logistic care pathway

In healthcare, the design of care pathways (from different point of views) is a well known concept. Logistic care pathways comprise the activities of a patient in the hospital from first to last visit. By describing the logistic steps in a care pathway, new possibilities arise to use the pathways for optimization purposes. With the help of scenario analysis care pathways can be redesigned and effects of these changes can be measured upfront, i.e. decreasing the time to diagnosis or specialist's time needed.
Based on the calculations the new and optimized pathway can be implemented in the hospital, knowing the effects it will have.
However, currently hospitals do not have the possibility to monitor whether the realization of the redesigned care pathways meets the expectations. The reason for this is that the current available IT tools do not offer sufficient support to follow (groups of) patients in their pathways and control whether they follow the pre-designed pathway. Therefore, we are developing a monitoring tool that can measure realizations of care pathways and compare them with the norms specialists define per pathway.
The focus and research of this paper describes the difficulties we encounter by developing a method to monitor the time to diagnosis of patients in the diagnostic phase. Important issues are

- How to assign registered activities concerning patient visits to the care pathways?
- What monitoring results will give the best insight in each of the care pathways?
- Can we develop a uniform method to monitor all groups of patients?

Later research will focus on the complete pathways in throughput time and resource capacities.

Measuring clinical pathway adherence **11**

J. van de Klundert, S. Zeemering, P. Gorissen

TUE A | HOG 00.85 | 8:30 – 10:30

Keywords: Clinical pathways, adherence/compliance, dynamic programming

Over the last decades clinical pathways have received considerable attention in health care management, because of their promise to jointly increase quality and efficiency of care. Introductions have however not always been successful, and medical doctors have been reported to not always adhere to the pathways. The reported variations in results of implementing clinical pathways further emphasize the importance of adherence measurement. In this paper we propose a model to measure clinical pathway adherence. The actual measurement turns out to be an optimization problem in itself, which we solve using matching and dynamic programming techniques. We apply the model and solution methods to real life data from the years 2001-2005 of the Cardiovascular Center of MUMC.

12 – SAFETY AND SERVICE QUALITY

Soft-systems methodology for implementing patient safety initiatives: A theoretical approach **12**

D. Puga-Bolio, M. Pidd, J. Busby, A. Smith

TUE A | HOG 01.85 | 8:30 – 10:30

Keywords: Patient safety, soft-systems methodology, systems approach, safety programmes

The issue of safety is and has been integral to the concept of Health Care since the beginnings of medical practice, and in the past decade Patient Safety efforts have seen an exponential increase in both

research and funding. It is now widely accepted that a systems approach to patient safety is needed in order for these initiatives to succeed.
Addressing patient safety in healthcare organisations has been the subject of several initiatives: from establishing reporting systems with the idea of learning from medical errors to developing a culture of safety, patient safety advocates have been involved in the implementation of different strategies with the aim to reduce harm to patients caused by errors within the healthcare system.
Implementing Patient Safety initiatives in Health Care organisations represents a major challenge for those involved, but especially to those who are in charge of leading such programmes. Within the medical literature it is possible to find a number of models and frameworks that have been designed to cope with the complex and uncertain nature of clinical practice especially in patient safety research. Some of the models are intended to be used as a framework to assist practitioners to both understand the situation, whereas others provide a more straightforward guide as to how to proceed with the implementation. However and even though these models represent a valuable guideline, they are limited in their incorporating the various perspectives of those involved in the Patient Safety process, and certainly those leading patient safety initiatives are faced with challenges unique to their particular site:, i.e. resistance to change from certain groups, cynicism towards proposed measures, varying degrees of support from managers, the need to balance what resources are made available with what is actually needed in order to accomplish the task, to mention a few. It is important that safe practices are embedded in actual, daily routines and as part of this it is important to understand how issues of patient safety are seen by different professional groups. Thus concepts from Checkland's Soft Systems Methodology (SSM) are being used to structure this problematic situation with a view understanding how practices vary. While SSM also produces a model with the intent to understand the problem, the desired outcomes and the activities through which these will be reached, it is the process of searching for information and disseminating that information among all those involved that produces the desirable result, in this case, an agreement with which all those involved can work with.
This presentation explores how such a model could be constructed within the context of the Patient Safety First Campaign, a nation-wide initiative about to be implemented at the proposed study site. This initiative aims to increase the level of implementation of Patient Safety activities at different levels throughout the organisation: from leadership to front-line practitioners and provides an excellent opportunity to study the way in which Patient Safety initiatives are being put in place, the challenges it poses and the way in which leaders tackle them.

Successful health and safety, successful business - What happened in the Expert Delphi study? **12**

P. Mullen

TUE A | HOG 01.85 | 8:30 – 10:30

Keywords: Expert Delphi, health and safety

An article “Delphi: myths and reality”, based on a paper presented at the ORAHS Conference in Glasgow in 2000, led to an approach from the UK Health and Safety Executive (HSE) in late 2007 to carry out an Expert Delphi study as part of a wider study on ‘Effective Management for Successful Health and Safety Performance’. Delphi has a long history and has proved versatile in a number of forms – Futures Delphi, Expert Delphi, Policy Delphi etc. However, the impetus behind the original paper and article was to attempt to dispel myths which had arisen over recent years with many authors appearing to take an over-narrow view of the purpose of Delphi and/or advocating a single prescriptive approach to the conduct of Delphi studies, especially in the field of health care. The HSE study gave the opportunity to exploit and demonstrate the versatility of Delphi - in the form of an Expert Delphi – in a related, but somewhat different, context.
As the study was still on-going at the time of the 2008 ORAHS conference in Toronto, my paper there reported the background to this study and gave an insight into some preliminary findings from Round One. Round Two questionnaires, which contained the same 52 potential impact ‘factors’ and seven statements concerning business and health and safety (H&S) but with the addition of the aggregated results from Round One, were sent in July 2008 to the same expert panel (which was drawn from ‘four constituencies’; academic; business; regulators; and health & safety experts). The preliminary findings from that round were reported to, and discussed at, two national events in the autumn of 2008, and the final technical report completed. The policy implications of the findings, which are outside the remit of the Delphi study, are under consideration.
Whilst this paper will provide an update on the study and present some findings from Round Two, its main focus will be on more technical aspects of the effect and implications of using a Delphi approach in this

type of study. There will be particular attention on comparing the claimed characteristics and the theoretical strengths and advantages of Delphi with the processes and outcomes in practice. There will also be reflection on the extent to which it is appropriate or even possible to divorce analytical aspects from the context.

Resource allocation for patient satisfaction improvement in considering non-linear factors **12**

H. Tao, B. Li, J. Song, S. Wu

TUE A | HOG 01.85 | 8:30 – 10:30

Keywords: Patient satisfaction, service quality, resource allocation, community healthcare service

Community healthcare centers (CHCs) are considered more and more important in China for improving patients' access to healthcare service. In urban areas, the network of CHC facilities with extensive coverage is well-established. One of the major challenges faced by CHCs now is to deliver high quality service in order to achieve high level of patient satisfaction while controlling for costs. The purpose of this paper is to present an approach for addressing the challenge.
The approach develops a model to determine the set of community healthcare service process operational variables to be improved and desirable target improvement levels, where the goal is to maximize incremental patient satisfaction, given a limited budget. The approach enables the CHC managers to take specific actions toward patient satisfaction improvement.
Other than traditional view of linear relationship between attribute performance and overall satisfaction, the existing of non-linear factors is considered, which is based on Kano's theory. A general expression of Customer satisfaction Index (CSI) is developed for all three kinds of attributes: attractive, one-dimensional and expected.
Five basic steps are involved in the approach: (1) determine items of the most important customer perceived quality attributes, their current performance level and overall satisfaction based on a scale rating customer survey; (2) estimate parameters of general CSI expression for each attribute by regressing satisfaction on performance; (3) match customer perceived quality attributes with relevant operational variables and establish relationships between them with the help of service providers; (4) determine the cost of implementing a service operational variable improvement; (5) solve the incremental customer satisfaction maximization model with the constraint of budget limitation to identify desirable target improvement level of process operational variables.
We demonstrate the applicability of the approach in one CHC in Beijing, China. Impact of incorporating Kano's theory is analyzed. Sensitivity analysis to provide additional managerial insights is also performed. Model limitations and future research are also discussed.

Service quality improvement in a clinical directorate: Leveraging opportunities for latitude in a multiplicity of constraints, perspectives, objectives under system reform **12**

P. Williams, S. de Burca, C. O'Hara, C. Murphy

TUE A | HOG 01.85 | 8:30 – 10:30

Keywords: Continuous quality improvement, clinical directorate, clinical governance, intent and realisation, hospital operations management

This paper reports a mapping exercise of quality and service governance in one Clinical Directorate (CD) of an acute academic teaching hospital, covering multiple participant perspectives, setting espoused theory against theory-in-use. The wide purview of performance may interest the broader audience concerned with contextual characterisation for engineering healthcare operations. The study is set in a publicly funded hospital. The directorate, aimed to engage clinicians and management, broadly references the John Hopkins/ NHS tradition. It comprises three departments, around 100 beds and 400 staff.
A literature review relates policy and context, and field research comprised three Strands - Documents, Quantitative (clinical governance extent/ climate), and Qualitative (interviews) - drawn together in a Triangulation. Semi-structured interviews (8) and focus groups (2) of one hour each included ward floor to top management. Lugon and Secker-Walker's Clinical Governance Survey, and Freeman's Clinical Governance Climate Questionnaire were administered to all staff; MARQuIS was competed for the hospital.

The rich hospital document base was categorised by intent (strategy, planning, evaluation) and realization (structure, process, outcomes), cross-cut by level (hospital … patient). Manifest complexity was observed in the multiplicity of coordinative threads to Functions (Finance/ HR/ Facilities/ ISIT/ Q&R), hospital committees, and professional lines. Qualitative thematic Template Analysis yielded five emergent domains: 1. CD Origins and Scope, 2. Performance Management, 3. Quality Management, 4. Constraints, and 5. What Needs To Change?. Leadership and cohesion within the CD, and accountability have improved considerably from the old structure. Quantitative data suggested that there is good perception of a planned and integrated QI framework, presence of risk management, good working relationships, and good awareness of important elements of Clinical Governance. In triangulation it emerged that the hospital has a well developed vision/mission, and strategy/ planning processes and PIs, covering CQI, Quality and Risk. This is enabled by directorate structure as a coherent focal point. Tensions related to autonomy remain, but empowerment is evident. The participative approach has led to major staff engagement. Success in departmental ISO, national Accreditation, awards and citations, e.g. Baby-Friendly/ Best Place To Work, are affirming. Patient feedback is well channeled at ground level. There appears no overarching performance or quality model in use. To staff, the directorate is a beneficial focus for negotiating improvements, handling patient comments/ complaints, IT / training developments, and generally getting things done collaboratively. Management perceive a coherent, visible and effective focal point for planning, accountability/ evaluation. Hospitals encounter increasingly directive centralisation of decision-making.
On reflection, the directorate form poses a reverse force, drawing back locus of control into the hospital, improving connectivity and latitude. Addressing socio-technical as well as strictly technical, aspects of acceptance of innovative technical change is a key enabler to progress. Connectivity is a central system issue, and synchronicity especially in articulation of erratic illness pathways remains a challenge. Sustainability and future development require a more robust and defensible explication of values, enabled by reference to frameworks such as WHO-PATH/FQM-PATH, which focus on responsiveness, stewardship/leadership, level and distribution and so forth, not just efficiency.

13 – HOME CARE SERVICES

Combined routing and staff scheduling model for home health care **13**

E. Gutiérrez, C. Amaya, C. Guéret, O. Péton, N. Velasco

TUE A | HOG 02.28 | 8:30 – 10:30

Keywords: Home health care logistics, routing, scheduling, mixed integer linear programming

The combined routing and scheduling problem has become a relevant issue in health care logistics as demand for cost effective and quality health services rises. The main challenge of this problem is to combine aspects of routing and staff scheduling. Both composing problems are well known as combinatorial optimization problems and there is an extensive literature of exact and heuristic methods for each of them. Although combined routing and scheduling problems arise in many applications, only few works have been developed in the field of home health care logistics.
We consider a set of patients with different geographical locations who require different medical treatments composed by a list of medical procedures. For each patient, the duration, frequency and hours in which the medical treatment must be applied are known. Each medical procedure must be performed by a medical staff who has the adequate qualifications. Medical staff professionals are also located in different geographical points, and each staff member is assigned to work shifts while respecting work legal guidelines. The problem that arises in this system is scheduling the activities of each staff member and sequencing visits to patients such that overall logistic costs are minimized and a high quality service is performed.
Desired conditions that must be satisfied in the system include the accomplishment of customer medical treatments in terms of time windows, and precedence and synchronization constraints of medical procedures. In terms of medical staff, work shifts must be respected, geographical location must be considered, assignment of visits must respect required qualifications, and balanced work loads are expected.
The overall objective of this work is to propose a formulation of the combined routing and scheduling problem in the context of the home health care services. We propose a mixed integer linear program and demonstrate the high complexity of the resulting problem through computational experiments. Research and improvement opportunities in the field are also detailed.

Optimal patient and personnel scheduling policies for car-at-home service facilities **13**

P. Out, S. Bhulai

TUE A | HOG 02.28 | 8:30 – 10:30

Keywords: Home care services, Markov decision processes, patient admission scheduling

Home-care agencies are constantly faced with the complex personnel planning problem in which one needs to determine how much personnel should be scheduled and hired.. The complexity arises because patients differ both in the duration of their care and in the intensity, measured in time per week, they need to receive home care. In order to keep the waiting times short, overcapacity is needed, but due to the increasing need for efficiency this is not really an option. Prioritisation of patients can help to solve this problem, but due to the complexity of the problem, existing models are not suitable for these analyses.
We study a model in which different classes of customers or patients arrive according to a Poisson process, and there are more than one servers, or number of hours of care available per week. There are holding and rejection costs for the customers, and there is a (finite) waiting room.
We model this problem as a Markov Decision Process and determine optimal patient admission strategies. We do this both for the case with no waiting list, and for the case with a finite waiting room. We find that for both cases a threshold policy is (near) optimal. We present numerical examples that show that these policies work well.

Evaluation and configuration of a care network for chemotherapy at home **13**

T. Zhang, E. Marcon, M. Di Mascolo

TUE A | HOG 02.28 | 8:30 – 10:30

Keywords: Health care, home care services, chemotherapy at home, simulation

Legally recognized in France since the Seventies, Home care services (HC) are deemed now as an alternative to the traditional inpatient stay, with respect to reducing costs, hospitals decongestion, care production rationalization and patient's wellbeing improvement. Home care services contain twenty-two care types, one of them being the home-based chemotherapy, which represents currently two percents of French home care activities and reinforces conventional chemotherapy cures in hospitals.
Chemotherapy At Home is submitted to strict legal constraints in terms of its organization and traceability that make its implementation very difficult. However, Chemotherapy At Home must ensure the same care quality and safety level as conventional hospitalization. Furthermore, it enables to provide the comfort at home to the patients, which is an obvious advantage. This work is based on a project of home-based chemotherapy activities deployment for a HC service in France. The aim of this project consists in supporting an oncology center (i.e., Institut de Cancerologie de la Loire, or ICL) which is currently overloaded. The central point of this problem consists in the management of the different physicians and caregivers, functionally and geographically varied in a care network composed of hospitals, HC and primary medicine. Besides, the home-based chemotherapy represents only a little proportion in the daily work of those participants. In this context, the resource configuration becomes then a major preoccupation for progressing correctly the chemotherapy at home.
In our work, a decision support tool has been proposed for the home-based chemotherapy management in which the patient treatment process is spread over three consecutive days. Our approach is composed of a complete patient treatment process modeling, together with a set of simulation scenarios in order to perform suitability test of the theoretical treatment process model. The discrete-event simulation model takes into account not only the resources mobilization and their availability scheduling, but also the uncertainty of accomplishment dates for some activities and decisions fulfilled by non-staff participants (i.e. Biological laboratory, family doctor, ICL pharmacy…). The performance indicators measure, on the one hand, the model robustness, the decision making efficiency and the treatment costs, and, on the other hand, the capability of rescheduling chemotherapy cure process. This model evaluates different configurations of the material and human resources in terms of workload variation and resource availability scheduling. The simulation results highlight that there exists an optimal resource configuration which can improve the organization of Chemotherapy At Home. Therefore, the results of this work can be used as a reference for decision makers in order to optimize the process design, to give some preventive advices before project implementation, and to redesign their organization. In future work, we are about to

accompany the project implementation through the application of our decision support tool in the care network.

Value of perfect information in home care human resource planning **13**

E. Lanzarone, A. Matta

TUE A | HOG 02.28 | 8:30 – 10:30

Keywords: Home care service, workload balancing, continuity of care, mixed integer linear programming

Home Care (HC) includes medical, paramedical and social services delivered to patients at their domicile. Many resources are involved and the service is delivered in a usually vast territory. Moreover HC providers usually preserve the continuity of care: only an operator for each category follows the whole patient care pathway providing all the visits pertinent to his category. High randomness affects the service delivery, mainly in terms of unexpected changes in patient conditions, making the activity amount highly uncertain and mining the feasibility of plans.
Therefore a reliable resource planning, including the estimation of health progression of the assisted patients, is crucial for HC organizations to respect the continuity of care, while avoiding poor quality service level, treatment delays and process inefficiencies. The main purpose is to avoid overloaded operators with consequent organization inefficiencies and operator problems.
Aim of this paper is evaluating the value of the perfect information in this balancing problem characterized by high variability and uncertainty of data.
A mixed integer linear programming (MILP) algorithm for balancing the workload among the operators of a specific category (physicians, nurses,...) was implemented, satisfying the requests of all the assisted patients and preserving the continuity of care. The peculiarity of the continuity of care makes this algorithm different from the classical literature models.
Inputs are patients and operators data. The requests of patients along the time (number of visits provided by the considered operator category) are estimated by means of a stochastic model, developed in a previous work, or directly determined by historical data. This allowed the comparison between the solution under expected, simulated or real data.
Patients are divided into already assigned and new arrivals. The first class has the assigned operator which is not changed, the latter must be assigned to an appropriate operator. New patients are assigned considering the operator skills (types of patients he can take care) and the territorial distribution of patients (each operator can only care patients resident in a specific territory); therefore the operators are divided into subgroups. Operators are characterized in terms of availability (maximum number of weekly visits under optimal work conditions).
The MILP algorithm allows to balance the ratio between the weekly workload and the availability among the operators, considering a certain number of following weeks.
The algorithm was applied to one the largest Italian public HC providers. It was run over a period of 26 weeks, with patient data coming from the stochastic model, the real scenario and a set of simulated scenarios. The capability of balancing the workload among the operators was firstly verified. Then the value of perfect information on future patient requests was estimated by comparing the expected value solution with the wait and see solution, calculated by assuming to know in advance the patient requests generated in each scenario. The results show that a significant higher balancing is obtained using perfect information. Therefore stochastic algorithms for workload balancing can improve the HC human resource planning.

14 – OPERATING ROOM SCHEDULING

A constraint programming model for operating room scheduling **14**

A. Hanset, D. Duvivier, O. Roux, N. Meskens

TUE B | HOG 00.85 | 11:00 – 12:30

Keywords: Constraint programming, scheduling, human resources, skills

The scheduling of the operating theatre is critical for an efficient hospitals management. So it is not surprising to notice that the literature of the domain abounds in approaches based on mathematical models and metaheuristics. However, in this presentation our aim is to build a model which is able to take real life constraints into account when considering this scheduling problem. More precisely, it comprises human aspects (preferences, skills) and material constraints (availability of renewable and not renewable resources).
The data set related to the experimental part of this presentation came from a Belgian hospital. However our approach wants to be generic and will be used to build the core component for an effective scheduling solution. This solution may integrate several components corresponding to the constraints of the target hospital(s). Therefore, we developed a model based on the constraint programming paradigm. Considering a physical structure, a surgical unit composed of surgeons, anaesthetists, nurses, our model is used to schedule a set of operations in an operating theatre.
Constraint programming aims to solve constraint satisfaction problems, it is also able to simultaneously optimize an objective function using a branch and bound approach. Constraint programming is built upon constraints and constraint solving. Therefore, some knowledge of different constraint domains and algorithms for constraint manipulation are needed.
In a first time, we must describe all the constraints relative to the human aspects. The surgeons are characterized by their surgical specialities but also by preferences in term of staff or operating rooms. The availability of their assigned time window is also important if the schedule is based on a “block scheduling” or “open scheduling”, depending on the fact that available time is distributed by service pool or by individual. For the nurse staff, the constraints are expressed in terms of skills, law arrangement, collective agreement, workload, vacations, and coverage constraints. The anaesthetists are shared between the operating rooms and the recovery rooms. And finally, some operations require a specific material that cannot be used twice at the same time or that must be cleaned during a long time.
In a second time, the constraint programming depends on the choice of the search strategy (sequence of branching object). So, the decision maker determines the best choice among them guided by an objective function.
The model is able to quickly generate feasible solutions. The obtained results are encouraging. We hope in perspective to include the recovery room and bottle neck(s) in patient flow.

Investigating trauma hip fracture hospital activities **14**

C. Voake, J. Griffiths, J. Williams

TUE B | HOG 00.85 | 11:00 – 12:30

Keywords: Simulation, hip fracture, operating theatres

Hip fractures are becoming an increasing problem in hospitals due to the ageing population. Due to overcrowded operating theatres, many patients do not undergo surgery promptly. The effects of operative delay on mortality and length of stay are investigated.
Statistical techniques were employed to assess any other important factors influencing mortality and length of stay in this group of patients. These include Classification and Regression Trees (CART) and Categorical Principal Components Analysis (CatPCA).
A simulation model is being built to model the flow of admissions of trauma hip fracture patients through a large teaching hospital. It was an additional requirement of the hospital that they could focus particularly on a patient’s journey through theatre, from the time the surgeon asks for them from the ward, to the time they leave recovery. Effective utilisation of the operating theatre is essential here and retrospective results are displayed. A number of what-if situations relating to the simulation are discussed.

Testing planning policies for solving the Elective Case Scheduling phase: A real application **14**

J. M. Molina Pariente, J. M. Framinan Torres

TUE B | HOG 00.85 | 11:00 – 12:30

Keywords: Planning, scheduling, operating room, mixed integer programming

Surgical processes are amongst the most important activities in hospitals, not only from a medical and social perspective, but also from an economic viewpoint, as they generate around 70% of revenues and represent 40% of costs in a hospital. The most expensive facility involved in the surgical process is the

Operating Room (OR), as it consumes between 10-15% of the budget in a hospital. Therefore, adequate decision-making for planning and scheduling ORs is of vital importance. This process can be decomposed in three phases: session planning problem (SPP), master surgical schedule (MSS) and elective case scheduling (ECS). In general, ECS is solved into two steps: a first step (Advance Scheduling) refers to the allocation of patients to an OR shift, while the second step (Allocation Scheduling) sequences operations within an OR shift.
The objective of this paper is to develop mixed integer programming models to solve the advance scheduling step and to test different planning policies. The problem consists of determining a surgery schedule that specifies the number of surgical cases that would be performed in the considered planning horizon, together with the date of the intervention and the OR in which the surgical case will be performed. The surgery schedule should maximize the quality of service of the surgical unit, while the date of intervention of each patient in the waiting list is lesser than the exogenous deadline of the intervention. The quality of service is defined as the sum of the quotients between the patient's clinical weight and the date of the intervention. The clinical weight depends on the medical priority and the number of days in which the patient is in the waiting list. Regarding patient's exogenous deadline, the regional healthcare authority establishes, based on patient's disease, a maximum number of days in which the patient must be operated. In order to reach the objective, we can consider different criteria: one may be to schedule as many surgical cases as possible in the planning horizon. Other may be to plan the maximum number of patients with greater clinical weight as soon as possible in the planning horizon.
We analyse three different policies corresponding to different surgical service models. In the P-S-OR policy, patients are first assigned to a surgeon and subsequently the set "patient-surgeon" is allocated to an OR shift. In the P-OR-S policy, patients are first assigned to an OR shift, and later a surgeon is assigned to each OR shift in the planning horizon. Finally, we propose a hybrid policy in which there are patients who are scheduled based on the so-called P-S-OR policy and others one are scheduled based on the P-OR-S. These three policies are tested using real surgical data from a surgical unit in a Spanish hospital. The results yielded by the P-OR-S policy suggest the latter to be more flexible than P-S-OR, as the patient doesn't have assigned a surgeon and therefore he/she does not depend on the surgeon's availability.

15 – BENCHMARKING

Taking quality of care into account when benchmarking hospitals using the DEA technique **15**

S. Brown, M. Jungman

TUE B | HOG 01.85 | 11:00 – 12:30

Keywords: Benchmarking, data envelopment analysis, quality of care

Benchmarking between hospitals is an effective means to measure performance and gain insight into the relative positions of hospitals. There are many ways to perform such a benchmark. One such method used is Data Envelopment Analysis (DEA). This method determines the most efficient production combination using multiple inputs and outputs. The use of DEA results in a single score of overall efficiency for every hospital in the benchmark, thus allowing an overall ranking.
However, hospitals are not only interested in measuring their efficiency. They also want to score highly on quality of care, and want to make sure that this quality of care is not compromised on for the sake of efficiency. There is therefore a widespread wish amongst hospitals to include quality in benchmarks. ORTEC has done this in its hospital benchmarks by including a so-called 'quality score' as one of the inputs for the DEA analysis. The ways in which this quality score was built up, the difficulties encountered, and the way in which it was assured that this measure of quality was taken into account sufficiently in the DEA analysis, will be the subject of this presentation. Furthermore, since benchmarking is an ongoing process for ORTEC we would like to improve and expand upon the measurement of quality in our benchmarks. This presentation is therefore also open to discussion upon this matter.

Assessing organizational needs of MRD staff via people capacity maturity model (PCMM) **15**

M. H. Yarmohammadian, F. Hatempour, S. Ajami, N. Tavakoli

TUE B | HOG 01.85 | 11:00 – 12:30

Keywords: PCMM, needs assessment, hospital, health records

Nowadays, most of organizations and specifically health organizations are trying to maturate their capabilities in developing their processes. PCMM is one of the most applied and functional models both for assessing organizational needs and planning for developing services. This applied research aims to assess organizational needs in health organizations in Isfahan, Iran, using PCMM. The scope of the study included 9 teaching hospitals affiliated to EUMS and the target population was all medical records staff, but sampling was conducted to gather data from purposive staff who have adequate education certification and experience. Researchers first gathered basic information about the current processes through observation and content analysis of written documents as well as electronic ones. Then data was gathered by using a questionnaire and processed by SPSS software. Finally, we obtained gaps between the current maturation situation and the ideal situation and we identified areas for improvement as maturity organizational needs.

A framework for the analysis of hospital patient flows: The results of an Italian benchmarking study **15**

S. Villa, G. Bensa, A. Prenestini

TUE B | HOG 01.85 | 11:00 – 12:30

Keywords: Patient flows, hospitals, benchmarking, variability

There is growing evidence that many of the problems that characterize modern hospitals (such as, bottlenecks, queues and delays, workload variability, waste of resources and errors) are due to badly designed patient flow logistics systems.
Patient flow logistics has to do with the complicated set of decisions related to the physical movement of patients throughout the healthcare chain since the first access to the structure until the discharge and first follow-up.
In the recent literature several studies have presented and analyzed a series of models, and managerial and technical solutions to better support patient flows management focusing specifically on single production units such as operating room, emergency department, radiology and so on. However, few studies have suggested a thorough, system-wide and solid methodology to help hospitals in the diagnosis of their own specific patient flows problems, an essential starting point to carry out effective patient flows improvement strategies.
With the present contribution we intend to provide a four-steps methodology to assess hospital patient flows problems. The findings presented are the results of a cross-sectional study that has involved six different hospitals that have shared, with the research team, all their data in order to understand the causes of their problems and perform a benchmarking analysis.
The methodology developed to assess hospital patient flow problems is developed around four different levels:

1. Hospital-wide system
   The study compares the six hospitals along a series of standard indicators such as beds occupancy rate, number of beds turns, percentage of emergency cases and average length of stay.
2. Hospital pipelines
   We have distinguished five different physical pathways (that we called pipelines): 1. emergency patients; 2. surgical patients; 3. medical patients; 4. day-surgery and 5. outpatient. For each of these pipelines, we computed the temporal distribution of cases and we mapped (with the tool of a flow-chart) the flow of phases and activities.
3. Production lines
   Once that the five different pipelines have been identified, we further narrowed down the analysis and we identified the clinical macro processes that characterize each pipeline. For example, the surgical patients' pipeline can be characterized by different possible production lines such as orthopedics, vascular or ear-nose-throat and so on.
4. Production Units

Finally, each production line is characterized by the utilization of a series of specific production units. The final step of the analysis is dedicated to analyse the capacity utilization patterns of these units paying particular attention to the different horizontal interdependencies that exist between one another.

Besides proposing a sound and thorough methodological approach to assess hospital patient flow problems the study sheds a light on two important issues:

1. hospitals are characterized by a quite large component of artificial variability in the way patient flows are planned and managed, variability that can be eliminated and is often cause of several typical hospital problems.
2. the source of variability is often far from the area where problems are actually recorded. For example the study shows that, in a specific structure, ED problems were actually associated to variability in the discharging process.

16 – AMBULANCE MANAGEMENT

Resource planning and deployment of Welsh ambulance services **16**

L. Smith, P. Harper

TUE B | HOG 02.28 | 11:00 – 12:30

Keywords: Priority queueing theory, EMS, location analysis, GIS

Current Government response time targets for Ambulance services in Wales are not being satisfied. This talk introduces some of the existing research made in location theory towards vehicle routing and location-allocation models, particularly with regards to Emergency Medical Service (EMS) vehicles. Priority queueing theory lends itself well to EMS research due to the differing categories of emergency calls and so is developing into a key focus of this study.

By receiving data from the NHS Welsh Ambulance Service Trust, some analysis has been conducted on response times of the ambulance service in rural Wales and it is hoped that the location of these EMS vehicles on a network will be determined in order to optimise and model the operation of the service.

It is apparent that there may exist boundary issues on networks structured by zones; also, reallocation of servers can often present problems. Queueing theory will play its role through analysis of the service and waiting times of the patient in the system.

The study is expected to lead to a geographical representation of the location of emergency medical vehicles and the population demand on a network.

This presentation intends to deliver a brief overview of the research to be conducted, the reasons for it, and the ambition of the theory.

Evaluation of the demonstration project to direct low acuity ambulance patients to urgent care centres to improve ambulance availability **16**

A. V. Esensoy, M. Carter

TUE B | HOG 02.28 | 11:00 – 12:30

Keywords: Ambulance services, geographic information systems, data linkage, ambulance off-load delay

The Ontario Government initiated a demonstration project in Toronto where select patients with minor medical conditions travelling via ambulance will be transported to Urgent Care Centres (UCC) instead of emergency departments (ED) to improve ambulance availability in the city. We conducted the evaluation of this project to determine the feasibility of this strategy in improving ambulance availability. The study utilizes a dataset generated via the probabilistic linkage of ambulance transport database and ED patient records for the entire city to determine time savings achieved by this initiative and how they could be improved by making changes to the patient selection criteria, geographic boundaries and operating hours. The quantitative analysis was supplemented by focus groups and structured interviews to capture change management challenges.

It was found that the demonstration project reached 50% of potential ambulance volumes and reclaimed 855 hours of ambulance time over two years. Twenty-four hour operation of the sites and acceptance

patients with psychosocial problems stand out as changes that can significantly improve ambulance availability benefits of the UCCs. Implementation of paramedic field triage protocols is the primary challenge of the initiative.

Simulation models for EMS management **16**

R. Aringhieri

TUE B | HOG 02.28 | 11:00 – 12:30

Keywords: Emergency medical services, discrete event simulation, agent based simulation, ambulance management

An Emergency Medical Service (EMS) system is a service providing pre-hospital (or out-of-hospital) acute care to patients with illnesses and injuries. One essential key in the performance of an EMS system is the early response, i.e., the emergency service, via an ambulance, must rescue the patient very quickly. This is the reason why organizing and planning emergency medical service in an urban area is an important problem arising everywhere in the world. Different features have to be considered while managing similar services, such as ambulance location and relocation, assignment of ambulances to calls, personnel scheduling and dimensioning. In many real life systems, different problems are solved via the experience of the operators.
In this paper, we deal with some management problems arising in the management of the EMS of Milano, Italy. The city of Milano provides an interesting case due to the dimension of the city and to the population. Milano is the largest city in North Italy, has a population of about 2 million of inhabitants, and receives about 1 millions of commuters per day. Besides, the number of emergency calls is expected to increase, as the population is aging. The EMS system management wants to improve the service provided to the citizens. Thus it has started, about 10 years ago, to collect data on the number of calls received, on the time spent in each mission to reach the patient, on the time needed to rescue the patient and carry him/her to the hospital, etc., in order to study and to evaluate the EMS performance.
The EMS of Milano is essentially organized as follows. The calls requiring an emergency service are managed by the operators working at the Operation Centre: when a call arrives, the operator performs i) the scene localization and the collection of some basic information, ii) determines the triage, and iii) assigns an ambulance to the emergency request. Ambulances are deployed in order to guarantee the coverage of the area: each ambulance waits for a new assignment in a pre-defined ambulance post when it comes back at the end of each mission.
We have developed several simulation models to analyse the EMS of Milano in order to support the decision process of the EMS managers. First we present a standard discrete event simulation model to provide a tool for the workflow analysis taking into account especially the resource dimensioning (the number of operators and ambulances required) and to identify bottlenecks in the system and their impact on the overall performance. Then we present two agent based simulation models especially developed to ambulance management: these models have the original characteristic to model for real the ambulance movement as agents moving on the area instead of using a delay as usually done in literature. Finally, we discuss the integration of these three models in one single model and its integration with optimization methods.

17 – PROCESS MODELLING TECHNIQUES

Modelling the radiology workflow in a Belgian university hospital **17**

H. Fei, N. Meskens, C.-H. Moreau

TUE C | HOG 00.85 | 14:00 – 15:00

Keywords: Healthcare management, process modelling, radiology workflow, patient care process

Always regarded as a special service organization, healthcare system serves the patients, the most important customers whose health status are regarded as the most important “output”. In order to deal with the pressure of the bugetary limitation and increasing demand of services as well as gain competitive advantage in their field, hospitals have laid more and more emphasis on streamlining their patient care

processes rather than enhancing their "hardware" because the former is regarded as the newest streamengine for improving the efficiency and productivity of their services. Due to the fact that the healthcare system is characterized by highly complex and extremely flexible patient care processes, it is reasonable to start the analysis with some important sub-processes rather than the immense overall patient care process. Since the workflow related to the radiology service is one of the most important parts of the patient care process, which enables the doctors to make a further analysis of their patients' disease and is reported with relatively low patient satisfaction in one Belgian University Hospital, we have focused on the improvement of this sub-process for the targeted hospital here.
Known as one kind of information and communication technologies, process modelling techniques are able to assist critical analysis in understanding the organization by viewing it as a network of interdependent events and activities, theoretically, the analysis utilizing those techniques can provide a structured approach to manage current and future resource requirements, design and implement information systems as well as establish key performance indicators for the goals of continuous improvement. Therefore, one process modelling language, UML 2.0 activity diagrams, is implemented in this study to construct an event-driven process model for the targeted radiology workflow, which begins with the demand of appointment by the patient and ends up when the doctor receives the necessary radiology report. Afterwards, analyses are performed based on the constructed process model with a set of performance indicators so as to reveal the current status of service quality in this department. In the end of this paper, suggestions for possible improvements of the targeted radiology department are made, and a standard framework is proposed to enable an effective and efficient workflow for the targeted radiology department.
In conclusion, the constructed process model can be used to not only show the visible elements involved in the considered healthcare process, such as the activities of each actor involved in this sub-process, but also visualize the invisible parts, such as the coordination between the actors involved in this sub-process. In consequence, it enables healthcare managers to inspect their service in a more specific and global view and hence to find out some further improvement potential. What's more, the constructed model can be further transformed into a simulation model for performing further quantitative analysis.

Business process discovery & workforce intelligence techniques with healtcare applications **17**

E. Peters, G. Dedene

TUE C | HOG 00.85 | 14:00 – 15:00

Keywords: Process discovery, business intelligence, hidden Markov model, workflow analysis, event log

This paper presents recent developments in Business Process Discovery and Workforce Intelligence with relevant applications in Healthcare Services. In contrast to traditional process and data mining, process discovery requires the combination of hybrid analysis techniques for the detection of process inefficiencies, the root causes for these inefficiencies and process improvements. This allows to identify value leaks in processes, as well as best practices in process variations in the way they are used in the workforce. The analysis starts from a structured representation of event logs in an event – object – actor format. Next processes are represented as Hidden Markov Models (in contrast to the traditional Petri Net workflow models, which are less adequate for process analytics). Sequence clustering is used to discover the process variations. A normalised process format (similar to data normalisation) is used for the supervision of the clustering. Finally process patterns are used for the identification of inefficiencies, and remediating process improvements. Two applications to healthcare are presented in detail. In the first case study a large scale medical claims processing service is presented. It is demonstrated how 7 process variations were discovered in the workforce handling the claims. One of the process variations emerged as a significant value saving best practice for processing the medical claims, enhancing the first-time pass rate in the claims service. The second case study uses the process discovery for visualisation of surgeries, searching for time inefficiencies as well as risks in the surgery processes. Two more (ongoing) applications are briefly discussed: the analysis of clinical paths (searching for cancer treatment efficiencies) and the monitoring of contact center services. At the end of the paper, the discovery techniques are discussed in view of the application of Enterprise 2.0 to the Healthcare sector, that is evolving from a reactive episodic care into a proactive patient-oriented and population-wide care.

18 – OR & HEALTH: LESSONS LEARNED

Economics, supply chains and the management of health care

18

A. Ceglowski

TUE C | HOG 01.85 | 14:00 – 15:00

Keywords: Agile, system dynamics, behavioural economics

The OR profession has made great strides in healthcare management services by improving access to care, in keeping costs down, and in explaining the complex dynamics of many aspects of healthcare. The efficiency measures recommended by the panoply of OR tools has allowed organisations to treat more people without increasing resource needs and so helped contain the creep of healthcare expenditure as a percentage of GPD.
The improvements have been carefully calculated to provide the best solution within an economical range of variances from the average. Excess capacity that was seldom needed has been decommissioned or redeployed. This removing the overhead that permitted systems to withstand short term shocks such as unforeseen spikes in demand or shortages in medical supplies. The drive towards efficiency has resulted in (sub-) systems that are more susceptible to shocks when events fall outside the relatively narrow range of parameters defined by the optimisation heuristic or algorithm. While fine for “average” operations, there is a finite chance that a confluence of circumstances can occur that will overwhelm the available. While such events are rare, they are far more likely to occur than the thin (or thick) tails of probability distributions lead us to believe.
The OR profession has been at the forefront of recommending that healthcare management needs be viewed holistically. This has arisen from realisation that projects to optimise one area of a hospital or a single health service quite often results in a new problem in another area. These problems may manifest in the sub-system as the increased frequency of the confluence of unfortunate events discussed above.
The objective of this paper is to discuss broadening of the OR efficiency and effectiveness objective. The paper looks at supply chains and logistics for lessons applicable to healthcare management. Rather than looking at the supply of materials, it considers the movement of patients from “not well” to “more well”. It may seem somewhat ironic (even silly) to take operations management ideas that started out as OR solutions and to bring them back to OR as “lessons”, but operations management, the marketplace and many OR professionals have worked on supply chain concepts in a wide variety of industries (arguably more amenable to amendment than healthcare systems). The profit imperative has motivated the creation of alternate strategies and adoption of new technologies. Through these measures supply chains have been driven to be highly coupled “lean” systems, yes, but also to be resilient and agile – desirable characteristics for healthcare systems. It is the intention of this paper to discuss how the maturity of supply chain concepts can inform lean and agile OR solutions for healthcare systems and to extend the discussion to look at how these ideas allow more creative ways of viewing the problems faced by healthcare services.

Some reflections on the DGHPSim project

18

M. Pidd

TUE C | HOG 01.85 | 14:00 – 15:00

Keywords: Hospital performance, waiting time, computer simulation

A few months ago, Murat Gunal and I completed the DGHPSim project. This was funded by the UK’s Engineering and Physical Sciences Research Council and aimed to build a simulation model that encompassed whole hospitals, with a focus on their performance as measured by patient waiting times. The UK government has greatly increased the finance available to the National Health Service (NHS) and, reasonably enough, expects to see improved performance. This pressure seems likely to increase as we enter a time of financial austerity.
As a consequence of the NHS waiting time target regime, waiting times have dropped substantially in England. For example, waits in A&E are often under 2 hours and virtually all patients are treated or admitted within 4 hours. Likewise, waits for simple procedures such as cataracts have almost

disappeared. However there is a widespread suspicion that the targets are sometimes being met by heroic or anomalous behaviour that is either not sustainable in the long-term or has consequences for patient care.
In the DGHPSim project we built a whole hospital simulation model, using discrete event methods, which simulates the treatment pathways of individual patients. Most of the data required for the DGHPSim suite comes from existing data sets, either within a hospital or from national sources. The simulations show the effect of different resource configurations and policies on waiting time performance, including side effects. Thus, the DGHPSim suite can be used by regulators to investigate heroic or anomalous behaviour or by local managers to investigate options for improvement.
This presentation considers the lessons learned during and after the DGHPSim project that may be of relevance to others developing fairly complex models of health system performance. Issues include, access to appropriate data, ways to generate co-operation and the degree of interest shown by healthcare professionals in this type of work.

19 – AMBULANCE MANAGEMENT

Assessment of the benefits of discrete conditional survival models in modelling ambulance response times

19

K. Cairns, A. H. Marshall

TUE C | HOG 02.28 | 14:00 – 15:00

Keywords: Discrete conditional survival models, distribution fits, data mining, clustering

Many of the challenges faced in health care delivery can be informed through building models. In particular, Discrete Conditional Survival Models, recently under development, can provide policymakers with a flexible tool to assess time-to-event data.
The Discrete Conditional Survival Model is capable of modelling the survival curve based on various underlying distribution-types and is capable of handling the influence of multiple discrete variables external to the distribution fits. The flexibility of the model comes through the choice of data-mining techniques that are available in handling the discrete variables and in the choice of distribution-types available in modelling informed subsets of any dataset.
A Discrete Conditional Survival Model has been utilised to model ambulance response times from the Northern Ireland Ambulance Service (NIAS). The challenges faced by NIAS reflect those of any Emergency Medical Service (EMS). While ambulance activity and demand for emergency ambulances continue to increase, NIAS still aims to maintain and improve the speed of their responsiveness to emergency incidents in general, and to life-threatening incidents in particular. The size of their challenge is vast, with NIAS currently responding to over 100,000 emergency calls in a year, through a fleet of over 240 ambulances, operating from 32 ambulance stations and sub-stations. It serves a population of over 1.7 million, with an operational area of 14 000 square kilometres.
The dataset considered contains dispatch event details (e.g. the date/time of an event, its geographical position, and the perceived severity categorisation of the emergency call) together with response time information (e.g. response time(s), type of emergency vehicle(s) responding), for all emergency calls in Northern Ireland in 2003.
Results from the Discrete Conditional Survival Model for a Local Government District of Northern Ireland illustrate the technique involved. For example, distinct clusters of observations were determined, based on hierarchical clustering techniques, utilizing dissimilarity measures. Distinct clusters were then fitted with a variety of distribution fits (such as log-logistic, Coxian Phase-type, log-normal, gamma), depending on the underlying distribution shape in each case.
This model is contrasted against use of a parametric accelerated failure-time model. In particular the impact of the choice of model used for ambulance response times is assessed through integration and comparison of both choices into a simulation model used to assess a novel public health scheme. (The additional benefits of the novel public health scheme being considered depend crucially on the underlying ambulance response, thus reliable modelling of ambulance response is essential if subsequent conclusions are to inform policymakers reliably.)
An assessment has also been made of whether the Discrete Conditional Survival Model can additionally identify combinations of covariate values that often lead to longer response times (that thus could inform NIAS of possible emergency calls to target with future strategic responses).

iSOAP - A flexible hybrid algorithm for scheduling paramedics and ambulances **19**

P. Soriano, J. Crowe, M. Gendreau,

TUE C | HOG 02.28 | 14:00 – 15:00

Keywords: Personnel scheduling, emergency medical service vehicles, paramedics, hybrid algorithm, tabu search

This paper presents iSOAP, a hybrid solution approach developed to solve the paramedic personnel scheduling problem at Urgences-Santé, the corporation in charge of ambulance services in the greater Montréal region. The approach is based on a two phase decomposition strategy. The first phase deals with the major strategic issues of the problem by solving a simplified model that focuses on the paramedics' individual preferences and optimises the overall ergonomic quality of the schedule while ensuring demand coverage on an a coarse time scale. The second phase then improves the first phase schedule and makes it implementable by taking into account the more detailed aspects of the scheduling problem that were left out in phase 1, i.e. detailed demand coverage, scheduling of ambulance arrivals and departures from operational centers, individual breaks, etc. The first phase is solved by a tabu search algorithm incorporating a variable neighbourhood search procedure, while the second is solved by mixed integer linear programming. Computational experiments with real data as well as randomly generated instances are presented. These experiments show that the proposed solution approach is very efficient being able to reproduce current schedules and improve upon them in terms of demand coverage and ambulances required in a limited amount of time. The approach is also quite flexible being capable of solving variants of the problem with wide ranging changes in scheduling policies. These results seem to indicate that iSOAP can be a very useful decision-support tool for the management of emergency medical service vehicles personnel.

20 – STAFFING AND ROSTERING

Flexible heuristic decomposition approach for personnel scheduling in health services **20**

J. Crowe, P. Soriano, M. Gendreau

THU A | HOG 00.85 | 8:30 – 10:30

Keywords: Personnel scheduling, health organizations, heuristic decomposition

Health organizations worldwide must deal with complex personnel scheduling environments: continuous service availability, restrictive collective agreements, and strong variations of real service demand throughout short periods of time, are examples of challenging factors for practitioners on a day-to-day basis. Furthermore, limited resources in both public and private systems, as well as a stressful and sometimes dangerous work environment, are factors that on the other hand make long-term personnel scheduling management also challenging. Clearly, all these elements are challenging for OR researchers too, in the sense that they increase the complexity of the personnel scheduling problems to be solved and therefore of the algorithms needed to do so. Most likely, they also constitute one of the main reasons why the OR community has studied real-life personnel scheduling constraints with intensity over the last two decades. However, a challenge for both practitioners and researchers which has not received much attention until recently, regards the portability and flexibility of personnel scheduling systems. For instance, nurse and physicians operating in the same ER will usually face different scheduling rules, while physicians operating in different sections of a hospital will also be scheduled differently. Furthermore, these differences are amplified when compared with ambulance officers or other health practitioners working mostly outside of a hospital environment. Hence, the management of personnel scheduling in health organizations is very complex and hard to integrate and centralize, and one consequence of this is the formation of human resources silos within the hospital that reduce management efficiency. As such, flexibility and portability of personnel scheduling algorithms will be our main topic here.
We propose a foundation for an algorithm that goes further than iSOAP (initially presented at ORAHS 2008, Toronto) in terms of portability and flexibility. Length of work shifts, number of time slots for work shifts, possibilities for days-off / days-in patterns, and overall schedule structure are our main concerns in terms of flexibility. Meanwhile, solution time and considering typical health organization scheduling

constraints are our main concerns in terms of portability. What we propose is a multi-phase heuristic (or heuristic decomposition) approach that we hope will prove to perform well in the future, in regards to the objectives of simplifying and improving personnel scheduling management in health organizations, as well as linking together their human resources management silos.

From capacity driven to demand driven workforce management **20**

B. Veltman, W. Luijten, F. Timmers, E. van der Veen, N. Weterings

THU A | HOG 00.85 | 8:30 – 10:30

Keywords: Demand driven workforce scheduling, patient acuity, workforce formation planning, workforce scheduling, advanced planning software

As supplier of workforce scheduling software, we observe a change in attitude on workforce planning and scheduling among our Healthcare customers. Where, in the recent past, the workforce of Healthcare professionals (like nurses) was primarily scheduled on basis of availability of capacity, operations management is stimulating a move towards demand driven workforce scheduling. This implies that workforce schedulers have to start with collecting information on patient acuity (the need for service capacity as a result of expected patient flows and care demands per patient). In addition, planning and scheduling software providers, like us, are adapting their solutions to support processes where planned/scheduled workforce capacity is matched against expected capacity demands. We present adaptations software providers, like us, are currently making to support a demand driven workforce scheduling process within Healthcare.

Rostering from staffing levels: A branch-and-price approach **20**

E. van der Veen, B. Veltman, S. de Vries

THU A | HOG 00.85 | 8:30 – 10:30

Keywords: Personnel rostering, staffing levels, branch-and-price, column generation

During this presentation a method to solve personnel rostering problems is discussed. The method discussed creates rosters directly from staffing levels and employee preferences. This is opposed to lots of other rostering methods that first create shifts based on the staffing levels and after that create rosters from the set of created shifts. Via an example it is stressed that this `two-step' approach is suboptimal and sometimes even unable to find a solution. To create rosters directly from staffing levels and employee preferences we modelled the rostering problem as a Branch-and-Price problem.
To assess the quality of the Branch-and-Price model we compared an implementation of it with the implementation of an integer linear programming formulation of the rostering problem. This comparison is based on a significant number of generated data sets to explore the strengths and weaknesses for these models. From these results the Branch-and-Price model looks very promising, because both implementations perform almost equally well. However, opposed to the integer linear programming approach, the Branch-and-Price method is more open to improvements and more flexible towards implementations in practice.

Operating room staffing: Implementing the newsvendor model with heterogeneous demand **20**

S. Zenios, P. Biyu He, A. Macario, F. Dexter

THU A | HOG 00.85 | 8:30 – 10:30

Keywords: Operating room capacity planning; newsvendor model; data mining; heteroskedastic regression

This paper studies the problem of setting operating room (OR) staffing levels for multiple surgical cases, where a hospital has to balance under-utilization with paying the staff at overtime rates to minimize total labor costs. We develop empirical models to explore how information, data and estimation techniques can be used to facilitate the staffing decision, and how these elements affect cost performance. Specifically,

we develop a heteroscedastic regression model that takes as its input the types of cases performed. Using data from a teaching hospital, we calibrate the regression model and conduct out-of-sample testing on the total staffing costs. We use two benchmarks commonly used in practice: non-parametric empirical distribution and lognormal distribution. Our heteroscedastic regression model lowers the mismatching costs by over 30%. The prospective cost results show that a hospital could potentially achieve substantial cost savings by deferring the staffing decision until the procedure-type information is available. The higher the underlying uncertainty in the demand for OR staffing time, e.g., a more diversified procedure portfolio, the more substantial the cost saving.

21 – OR & HEALTH: TOOLS AND METHODS

The RIGHT project: The right tool for the job **21**

P. Harper, S. Brailsford

THU A | HOG 01.85 | 8:30 – 10:30

Keywords: Literature survey, method selection tool, engagement with end users

RIGHT (Research Into Global Healthcare Tools) is a two-year cross-institution project funded by the UK's Engineering and Physical Sciences Research Council. It involves a team of researchers from Brunel University and the Universities of Cambridge, Cardiff, Southampton and Ulster. The ambitious aim of RIGHT was to try to understand why Operational Research modelling methods are not embedded in the mindset and culture of the UK National Health Service, in the way that they are in other sectors such as manufacturing or defence. After surveying the literature, a feasibility study was undertaken which included the development of a "Workbook" presenting these methods to novice users, and an online selection tool which enables the NHS problem-owner to specify the characteristics of their problem and then automatically select the most appropriate method. In addition, we have engaged in many different ways with the NHS, for example consultative workshops and exemplar projects.
RIGHT began in 2007 and is now drawing to a close. We are currently engaged in seeking funding for Phase 2. In this talk we shall describe the project, its main achievements and some of the challenges we have faced, not the least of which was the delays caused by recent changes in the research ethics approval process in the UK.

Operational research in health care: Applications, methods, software **21**

M. Dlouhý

THU A | HOG 01.85 | 8:30 – 10:30

Keywords: Literature review, operational research, health care, simulation

Operational research can be described as an application of scientific approach to the solution to decision problems in the management of complex systems. Operational research includes various methods, such as linear and non-linear programming, discrete optimization, discrete-event simulation, system dynamics, queuing theory, inventory theory, multiple criteria decision making, etc. Health care is a specific application field with many challenging research problems. This study explores how and where operational research is applied in health care, what methods and software products OR researchers use. For this purpose, available databases and literature reviews were analyzed. Results show that health care is one of the most frequent application fields of operational research. Discrete-event simulation is the most frequently used method of operational research in health care.

The TORCH project: Developing a curriculum in OR for health commissioning **21**

M. Pitt

THU A | HOG 01.85 | 8:30 – 10:30

Keywords: Healthcare commissioning, strategic decision support, education, training, professional development

The introduction of the NHS World Class Commissioning (WCC) programme in 2008 has highlighted the need for the development of operational research skills for those charged with commissioning health care services in the UK. Health care commissioners, such as Primary Care Trusts, have been challenged to develop more evidenced-based, proactive, locally administered and accountable procedures in the decision making underlying the commissioning of services. Associated with the WCC programme is a competencies framework that explicitly recognises the need for expertise in modelling, simulation, forecasting as well as other OR techniques to support this new vision for the role of commissioners.
The TORCH Project (Teaching Operational Research for Commissioning in Health) was commissioned by the UK NHS Institute to develop a curriculum to support the development of OR skills for health service commissioning staff. This project has adopted a strongly user centred approach and has undertaken a range of needs assessment activities with the key stakeholders. These include a range of structured interviews, and interactive workshops to ensure that the development of a curriculum genuinely responds to the needs of its potential users.
This presentation will outline the key findings from the needs assessment exercise undertaken by TORCH and outline the steps which have been taken to develop a curriculum for OR skills in health care commissioning which responds to the current need. The TORCH curriculum will be presented together with the rationale for its design and structure and an analysis of the key determinants for the effective implementation of learning resources to commissioning staff within the health services. The wider implications for teaching OR to health service staff will be discussed within this context.

The potential of health care management games for teaching and policy decision making **21**

M. Rauner, M. Kraus, J. Gesslbauer, S. Schwarz, B. Panosch

THU A | HOG 01.85 | 8:30 – 10:30

Keywords: Management games, hospital Games, decision making, strategic management

Operations Research, internet, and e-learning highly increased the potential of health care management games as a useful tool for teaching and policy making in the last years.
First, we give a short overview on general management games. We outline the history. We then discuss types of general management games along with their advantages with a special focus on internet-mediated games. Furthermore, we briefly present application areas of general management games.
We mainly analyze the potential of health care management games. We review and classify health care management games according to general/functional mode, complexity, interactivity, time horizon, participants, media of communication, evaluation, analysis, availability, application area, target groups, and decisions to be undertaken.

22 – DEMAND FORECASTING

HHR forecasting - Using system dynamics to model the future need for general practitioners in Alberta, Canada **22**

S. Vanderby, M. Carter

THU A | HOG 02.28 | 8:30 – 10:30

Keywords: System dynamics, HHR forecasting, general practitioners (family physicians), simulation, needs-based demand forecasting

Although not a new concern, awareness of the need to ensure that there will be sufficient health care providers to meet future demand of the population is heightened in environments experiencing provider shortages. In Alberta, Canada, current provider shortages prompted the provincial government's health ministry, Alberta Health and Wellness (AHW), to initiate research into health human resource (HHR) planning and forecasting, particularly regarding General Practitioners (GPs). This research involved the development of a model to forecast the future need for physicians provincially and within each of the province's nine health regions, across four sectors: inpatient, ambulatory, continuing and community care. System dynamics (SD) was selected as the modelling approach due to the changes in the system occurring over time, and the desire to develop a cohort based model due to the large populations. While this is not the first SD HHR model, our needs-based approach differs from previous research, which generally produces forecasts based on current and/or historic utilization, or desired provider-to-population ratios. Additionally, this model includes the ability to model future scope-of-practice changes among providers.
Developed with data from both national and provincial health care databases supplemented by information obtained via workshops with GPs in Alberta, the model is based on six components. The "Population Health Status" and "Population Demography" components combine with the "Health Service Requirements" component to produce the expected amount of care required. This then combines with the "Service Delivery Models" and "Workforce Characteristics" components to forecast the needed workforce.
Within "Health Service Requirements", the provincial average per-capita utilization by age, gender and sector is affected by characteristics of the population to determine the regional utilization for each cohort. This is then adjusted to reflect the need for care based on factors affecting population health. Taking into account the population size of each cohort, the total need for care in each sector can be determined. As the provision of care in each sector may be affected by future scope-of-practice changes for GPs and other provider professions, the "Service Delivery Models" component reflects the reallocation of activities both to and from GPs. These changes, combined with the average annual clinical productivity anticipated based on the demography and characteristics of the GP population, forecast the number of providers required to meet these needs, both in terms of full-time equivalents and an estimated "head count".
Developed in close collaboration with AHW, this model is intended for use by provincial workforce planners, enabling them to determine the effects of changes in population demographics, health indicators, occupation scope and the provider population over time, assisting the government with plans for the future. Thus, such HHR models have the potential to improve the provision of care and the sustainability of the health care system.

Modelling the future demand for long-term care **22**

M. S. Desai, S. Brailsford, M. Evandrou, P. Harper, H. Smith

THU A | HOG 02.28 | 8:30 – 10:30

Keywords: Long-term care, system dynamics, discrete-event simulation, contact centre, simulation

The "ageing population" presents many significant challenges for health and social care services at both a national and local level, one of which is to meet the demand for long-term care. The population of people aged over sixty five will continue to grow for some time as the baby boom generation ages. There are other challenges associated with an ageing population which will have an impact on the provision of long-term care. Increased life expectancy is one, but there has also been a reduction in the size of the working population, which has led to less money being raised by taxation, an important source of funding for long-term care, and a reduction in the size of the workforce. These issues will be investigated in further detail using approaches from the discipline of Gerontology. The aim is then to use System Dynamics to model the demand for long-term care in the county of Hampshire, England amongst those aged sixty-five years and over.
A key part of the modernisation of Hampshire County Council has been the establishment of a new contact centre. The research will address such questions as:

- How can Discrete Event Simulation be used to assist HCC to plan the development of the new Call Centre?
- How could a detailed tactical model for the Call Centre benefit from the additional use of a long-term system dynamics demographic model for population change?

Data for the discrete event simulation model will be provided by the local authority. The long-term SD demographic model will be populated from a variety of data sources, including the local authority, local area statistics and nationally representative data. Key features of the model include an attempt to model dynamic changes in the older population as well as the inclusion of health statistics.

This project takes a cross-disciplinary approach combining Operational Research modelling with Gerontology, Demography and Social Policy. The research is funded jointly by the Economic and Social Research Council and Engineering and Physical Sciences Research Council.

Microsimulating the demand for health care and old age care in Sweden (LEV) **22**

L. Brouwers, P. Johansson, A. Ekholm, N. Janlöv

THU A | HOG 02.28 | 8:30 – 10:30

Keywords: Microsimulation, health care, elderly care, scenarios

This work, undertaken at the Swedish Ministry for Health and Social Affairs, aims at delivering scenarios of the future needs for health care and elderly care. The different scenarios are compared by several measures; the resulting shares of GDP, the amount of QALYs (Quality Adjusted Life Years) and resource requirements.
The Sesim microsimulation model has during the last 20 years been used at the Swedish ministry of Finance for investigating different financial policy issues, such as pension schemes. Recently, the model has been modified towards health related policy issues. The BabyBoom project commenced this development by adding a health status to all individuals. They put focus on the elderly population and their need for assistance. Since 2007 the LEV project has continued and furthered the BabyBoom initiative by letting the 300 000 model individuals' health status affect their health care consumption and their death risks. Furthermore, we are adding focus diseases to the model. We chose four diseases that are costly to society and for which the future trends are uncertain or interesting from a changing demographic perspective; cancer, cardio-vascular diseases, dementia and diabetes. We have used official national register data to estimate the risk of acquiring the disease, the duration of the disease, and the excess death risk associated.
The health consumption in the model is divided into primary care, outpatient care, in-patient care and prescribed drugs. For all persons without a focus disease, the consumption is affected by age, sex, health status (1 – 4), education level among, and the health care consumption previous years, among other factors. Persons with a focus disease have specific models for their care consumption, based on empirical data. A person who just got cancer has a different consumption profile than the one who got cancer five years ago; we have included dynamic consumption profiles for the focus diseases.
Dementia is modeled for the elderly population. For this group, we also model limitations in daily living (ADL) and assistance divided into three groups; no assistance, living home with assistance, and living in special housing. A separate mortality model is used for persons living in special housing, since this seems to be a risk factor.
The Lev project investigates the care consumption until year 2050. The baseline scenario will assume the current technology and efficiency as well as incidence rates, health status distribution in the population of today. Death risks are aligned to the official forecasts of Statistics Sweden.
The scenarios are constructed to highlight the different theories regarding development of health status in an ageing population; expansion of morbidity, compression of morbidity, and delayed morbidity.

Systemic therapy demand model in Ontario **22**

A. Kolos, N. Berger, M. Carter, K. Woltman, G. Woodward

THU A | HOG 02.28 | 8:30 – 10:30

Keywords: Monte Carlo, systemic therapy, demand forecasting, referral patterns

Systemic Therapy Treatment (Intravenous chemotherapy) is provided as an outpatient service in over 100 hospitals across the province of Ontario. Cancer Care Ontario (CCO) is the provincial agency responsible for monitoring and improving the quality and access of cancer services in the province. To meet rising demand for chemotherapy services across Ontario, CCO is leading an initiative to achieve two key goals: improvement of patient safety and increase in the timely access to high-quality systemic treatment as close to home as possible.
As regional plans are modified to support care closer to home, patient travel patterns are expected to change. A Monte-Carlo simulation modelling tool was developed to engage regional planners and better understand the impacts of these planned changes. Expected changes in incidence and utilization rates were also incorporated.

The Demand Forecast Model enables regional and provincial planners to test different scenarios and assumptions regarding system organization and performance, as well as patient travel patterns. The model allows users to modify:

- Utilization rates by Disease Site Group (DSG)
- DSG services available at each hospital
- Distribution of case complexities and appropriate level of service required
- Patient travel behaviour
- Visit intensity
- Patient Re-treatments
- Customizable maps that graph catchment areas by facility

During the past 2 years, the tool has been successfully used by CCO and the regions to examine the zones of influence surrounding each cancer centre, community and satellite hospital. It has allowed planners to identify areas of need including health human resource and infrastructure.

23 – OPERATING ROOM SCHEDULING

Bed balancing in surgical wards via block scheduling

23

S. Ketabi, M. Carter

THU B | HOG 00.85 | 11:00 – 12:30

Keywords: Stochastic integer programming, Monte Carlo simulation and random sampling, operating room planning, master surgical schedule, bed balancing

Operating room planning is to create the master surgical schedule, in which surgical services will be assigned specific operating rooms on specific days of the week, and can be used repeatedly by the hospital. The purpose of this study is to generate a 2-week rotation where the surgeons are assigned to the blocks, in such a way that the limited OR capacity is distributed based on smoothing the expected demand for resources (primarily beds). This study concentrates on the service level scheduling at Sunnybrook Health Care Sciences Centre, Toronto, for which the number of blocks for surgical services are given, and the case mix groups for surgeons are chosen by random sampling based on the historic data. The goal is to control and flatten the bed occupancy throughout the week at the wards as much as possible by changing the day of inpatient surgeries for surgeons. The planning problem is first formulated as a stochastic integer programming. Then an approach combining Monte Carlo simulation with branch and bound method gives an approximate solution.

Including uncertain surgery times in operating room management

23

A. Testi, E. Tanfani

THU B | HOG 00.85 | 11:00 – 12:30

Keywords: Operating room planning, block scheduling, stochastic operating times, chance-constrained model, Monte Carlo simulation

The problem of determining Operating Rooms (ORs) plans in a hospital department using a block-scheduling system, is herein addressed. Planning ORs involves different decisions and can be viewed as made up of three main problems. Firstly, the available OR time capacity, that is split into a given number of OR block times (usually one half to one full day in length), must be divided over the different surgical sub-specialties or surgical units, that is the Case Mix Planning Problem (CMPP). Secondly, once the ORs time allocated to each surgical unit has been chosen, the cyclic timetable that determines the surgical unit associated with each OR block time is developed, that is the Master Surgical Schedule Problem (MSSP). Finally the assignment of a subset of patients to each block time and their sequencing must be decided, that is the so called Surgical Case Assignment Problem (SCAP).
In this paper an integrated approach to solve in a concise framework all the above presented problems assuming operating times to be random variables is proposed.
In particular, given a hospital department made up of different surgical sub-specialties sharing a given number of ORs, the model herein presented determines, over a given planning horizon, the allocation of

OR blocks time to surgical sub-specialties, i.e. the MSSP, together with the subsets of patients to be operated on in each block time, i.e. the SCAP. The number of block times to be assigned to each surgical unit, i.e. the solution to the CMPP, is determined by means of a 0-1 Min Max integer programming model aimed at leveling the resulting weighted waiting list of the surgical units belonging to the department. The solution of the CMPP is used as input data for the MSSP & SCAP model working as demand constraints for each surgical unit. Capacity constraints limit the availability of operating time on each block, while different operational constraints related to surgeons preferences, patient availability depending on surgery date, number of surgical teams available on each day, etc., have been considered.
The problem is first formulated by a chance-constrained stochastic model with probabilistic capacity constraints. The model has been proved to be strongly NP hard, consequently we propose Monte Carlo simulation to verify the feasibility of the base solution obtained approximating the stochastic model by the corresponding deterministic optimization model. Using K independent random samples for each random variable the solution model for each sample is evaluated in terms of ORs capacity utilization and risk of overtime.
The framework has been tested by applying it to a case study about a Department of General Surgery of a Hospital sited in Genova (Italy). Computational experiments show that the knowledge of historical distributions on surgery times can improve the department operating rooms management.

A classification scheme for operating room planning and scheduling problems **23**

B. Cardoen, E. Demeulemeester, J. Beliën

THU B | HOG 00.85 | 11:00 – 12:30

Keywords: operating room, classification scheme, scheduling, planning

The increasing interest in the domain of operating room planning and scheduling leads to a proliferation of problem types. The statement and the scope of the particular problems, however, are often unclear. In this presentation, we report on a scheme to classify operating room planning and scheduling problems using multiple fields. Each field describes a specific set of characteristics of the particular problem by means of parameters, elements and optional further specifications. We also elaborate on the use of delimiters to separate the entries in the classification notation. Next to the formulation of the scheme, we examine its applicability on a range of problems that are encountered in recent literature. With the development of the classification scheme, we hope to structure and to clarify forthcoming research in this domain.

24 – CARE SYSTEM COMPARISON

Ordering of performance criteria at the MRD by an Analytical Hierarchy Process (AHP) approach in the selected hospitals in Isfahan, Iran **24**

S. Ajami, S. Ketabi

THU B | HOG 01.85 | 11:00 – 12:30

Keywords: Performance, medical records department, Analytical Hierarchy Process

The Medical Records Department is important for the evaluation and planning of care services. The major aim of this study is to evaluate the performance of the Medical Records Departments of hospitals using an Analytical Hierarchy Process (AHP) approach in the selected hospitals in Isfahan city, Iran. This is a descriptive and cross-sectional study that is done in spring 2008 in Isfahan, Iran. The statistical population consisted of Medical Records Departments of Alzahra, Kashani and Khorshid Hospitals in Isfahan. Data were collected by forms and through brainstorm techniques. To analyze the data, Expert Choice software was used. Results show that the relative weight of the archiving unit was more than others on the aspect of information management. But with respect to the customer aspect, the relative weight of the admission unit was more than others. The relative weight of the Medical Records Departments of Alzahra, Kashani and Khorshid Hospitals in Isfahan respectively were 0.394, 0.342 and 0.264. It is necessary for managers to allocate and to prioritize resources according to AHP ranking at every unit of the Medical Record Department.

Analysing outpatient tasks for different-size hospitals 24

A. Sakphisal, P. Higgins

THU B | HOG 01.85 | 11:00 – 12:30

Keywords: Operations management, human-centred planning, lean operations, functional allocation, task analysis

In Thailand, a welfare agenda has been implemented mandating hospitals to treat patients without charge from 2001. This universal coverage has encouraged Thai people to visit hospitals. Increasing demand for services has forced hospitals to grow rapidly without commensurate increase in funding. For many services, hospitals are enticed to trim the length of stay through a public policy that only reimburses costs for outpatient treatment. Consequently, while upholding or improving the flow time for treating patients, outpatient departments have to identify how to cope with drastically increased demands. A universal characteristic of outpatient departments is waiting rooms full of patients. Toleration of long waiting times challenges enfeebled patients. Indeed, for some sick people, impatience leads them to not seek hospital treatment. To meet performance measures of cost and accessibility by decreasing waiting and treatment times, the service providers, such as doctors and nurses are suffering from increasing workload near the limit of the human performance.
The first stage of this study was a pilot that focused on a medium-size hospital. Its purpose was the identification of the elements of the model. It covered, inter alia, patient flow, work activity and information flow at workstations, service time and material flow, such as specimens and documentation. Examination of each workstation embraced physical layout and equipment, staffing levels, job descriptions, task analyses and service demands. Service demand is a critical constraint, as the hospital is compelled to treat anyone who seeks medical treatment. This includes information behaviour, the context in which they work, and the reasons for their actions. It encompasses why and how they collaborate through the series of treatment phases in managing the health of patients.
This paper presents the second stage of the study: the operational processes and service patterns for treating outpatients of three hospitals that range in size from medium to large. The expected outcome is discovery of the similarity and differences of outpatient departments. The objective is to reveal the defining characteristics of various hospitals by exploring, more broadly, the elements of the model from the pilot study.
In the next stage, the model will be extended using analysis tools from industrial engineering and, in particular, lean operations. Process improvement includes identifying the functions of personnel and the possibility for reallocation, for example, from medical consultant to triage nurse, so the hospital can become more responsive to the needs of patients. By applying a model that extends its purview to human aspects of the planning and control of outpatient services, obstacles to patient flow may reduce. The authors will present findings of the outpatient service operational process of the three hospitals categorized in the different levels based on a study of more than 100 patients of individual level. The outcome of the study is a planning model for reorganising outpatient departments. This model is to act as an exemplar for the many small hospitals across Thailand.

A comparison between Japan and Sweden with regard to the provision of long-term care in relation to needs 24

M. Lagergren

THU B | HOG 01.85 | 11:00 – 12:30

Keywords: Long-term care, elderly, comparison

Japan and Sweden share many features when it comes to the systems of care for frail elderly persons. Both countries have a high and increasing number of elderly people and both countries acknowledge a public responsibility to provide access to long term care and services for those in need. But there are also great differences in, e.g., social conditions, cultural traditions and the role of women and family. The differences and similarities make it interesting to make comparisons with regard to the provision of long-term care in relation to needs.
Using datasets collected in the assessment of care needs for the Japanese long-term care insurance system in Handa municipality, Japan, and data from the Swedish National Study on Ageing and Care,

Kungsholmen district, the recipients of care in the two countries have been compared with regard to different variables describing needs. Moreover, a comparison has been made of the allotted care and services given these needs.
The comparison shows that on average the Handa care recipients are more dependent than the Kungsholmen-population. A possible explanation for this could be differences in household patterns with far fewer elderly persons living alone in Handa than in Kungsholmen.
Patterns of services provision also differ substantially. In Handa, Japan, where many elderly people live with their extended family there are many more community services outside the home. In Kungsholmen, Sweden, where many elderly persons live alone the emphasis is on home help. The costs of care given level of disability are much higher in Sweden.
Social and cultural differences between the two countries affect perceived needs as well as the patterns of service provision even if general conditions with regard to age structure and political ambitions are similar.

25 – SYSTEM DYNAMICS

Understanding the role of family doctors using system dynamic simulation

25

M. C. Dedeoglu, E. D. Gunes

THU B | HOG 02.28 | 11:00 – 12:30

Keywords: Patient flow, gate-keeping, system dynamic methodology, general practitioner

In this study, a two-tier health service system is modeled with the objective of understanding the impact of family doctors in the health system in Turkey. A stock-flow model is constructed to simulate patient flows in the system based on interviews with health officers and data obtained from Düzce for the time period 2006-2007. System dynamic methodology is used to formulate the relations between the components of the system with the purpose of analyzing both the role of the General Practitioner in this primary health care system and the effects of system components' decisions to the system's performance. The general practitioner is the primary health care provider in the system that acts like the gate-keeper or not during the simulation period; state and private hospitals are secondary health care providers and these primary and secondary cares constitute the two-tier health service system. Dynamics of service quality, word-of-mouth, referral rates, doctor's salary contracts and number of available family doctors are investigated in different scenarios. We are trying to define implications of changing policy parameters (referral policy, ideal panel size, hospital capacity and pay rate per individual) on the system performance measures which are demand at general practitioner, healthy population and waiting times at the general practitioner and the hospital.

Re-thinking health services management - The system dynamics of dementia

25

S. Burnell, B. Wherry

THU B | HOG 02.28 | 11:00 – 12:30

Keywords: Dementia, system dynamics, simulation modelling, NHS, world class commissioning

The Client's Key Question:

"How can we optimise our local investments for People with Dementia?"

What is Dementia?

Structural and chemical changes in the brain – symptoms include a decline in memory, reasoning, and communication skills, and loss of ability to carry out activities of daily living. Alzheimer's Disease is the most common type @ 62% with Vascular & Mixed Dementia @ 27% and Frontotemporal & Lewy Bodies @ 11%. Nearly 98% of people with Dementia (700,000 in UK in 2007) are over 65 years old.

What are the issues with which we must grapple?

1. Dementia is a progressive condition - symptoms become more severe over time – annual Economic Costs of Care increase from £17,000 to £37,000 per person. Currently, £17Billion every year.

2. There are generally 4 Tiers of Care:
   - Information & Self-help
   - Early Interventions
   - Increased Community-based Support
   - Continuing Care (NHS & Residential)
3. Incidence Rates increase with age & UK Population Life Expectancy is increasing. There will be more people aged > 85+ with severe Dementia & needing Intense Care. Dementia has a disproportionate impact on independent living. Prevalence Rates can vary by region.
4. About 60% of Care Home Residents have Dementia but 2 out of 3 People with Dementia live with their Family. Only about 1 in 3 People with Dementia get a medical Diagnosis & are formally recognised by Dementia Services. Stigma is a big problem.
5. To what extent are Death Rates of People with Dementia worse than the background population?
6. If the situation is not hopeless, what might we do?
   - Vascular Dementia is associated with similar [avoidable] life-style risks as Stroke & Heart Disease – Should we invest more in the 'scatter-gun' of Public Health?
   - Early Diagnosis & Medication of Dementia can defer the need for more intense Support – Can we afford more people in Tier1 & Tier2 if they still progress to Tier3 & Tier4?
   - Support of Family Carers can defer the need for Residential Care – Can we afford to deliver the help they need?
   - Funding is rationed – How do we test the good investments in Healthcare to reduce later spend on Social Care?

Move towards 'World Class Commissioning'

The UK Department of Health prescribes simulation modelling as a technique which Commissioners of Health & Social Services should use to stimulate & lead this 'market' and the UK National Audit Office prescribes a strategy of Invest-to-Save. Commissioners must, therefore, seek High Impact Interventions & test & choose between quantified and financially competing Strategies.

Summary:

- How can we spend less & help more People with Dementia enjoy longer independent lives at Home?
- Health & Social Care organisations must jointly optimise a mix of Care & Prevention Strategies.
- System Dynamic simulation Modelling can help you to re-think this difficult problem.

During this short presentation we plan to show you how we have structured the data & the model in a way that Commissioners and Consultants are finding powerful & easy to use.

Capacity analysis of critical hospital resources using a system dynamic approach **25**

S. Geranmayeh, Sivakumar Appa Iyer

THU B | HOG 02.28 | 11:00 – 12:30

Keywords: System dynamics, hospital supply chain, simulation

System Dynamics (SD) is a continuous simulation method, which is helpful in modelling large, complex and high level systems, with different interactions and relationships. SD provides insight over the whole system, and thus, it is useful for policy making through the complex systems, by the broader overview that it provides. That is why SD seems as a suitable method to be used to model hospital systems. Hospitals are made of lots of interconnecting routes and different patients must go through different passages of the system.

In this paper, we are going to simulate the flow of patients from different categories, regarding critical constraints e.g. special equipments and services and also required specialists. As an example, to clarify it more, heart related patients and lung related ones need separate treatments, and thus different kind of critical equipments, services and obviously specialists. Shortages of any of these critical variables and entities may cause longer delays for the patients. That is in a ward, as the patient's treatment may take longer, he/she needs more resources because of poorly controlled conditions. A very consequence, of the delay, could be the change of the patient route, in hospital, or the addition of a new disease to the current status of the patient. In a more catastrophic incident, the patient might undergo unrecoverable medical conditions.

The SD plays its role in modelling patient flow throughout the healthcare system (or hospital), and investigates the effect of the availability level of critical supplies, services and specialists on the actual length of stay of patients and, at the same time, rate of bed blocking, based on the real status of the patients and their corresponding statistical data. The model is also able to predict the average capacity

required, in hospital and departments, over time, with respect to patient flow. The latter is done by assuming a certain service level. Service level, here, is defined as the level of availability of critical supplies for patients.
This paper provides a methodology, based on the SD approach, to analyse the relationship between service levels committed, by the hospital to the patients, and the capacity that they have to provide. Simultaneously, the smoothness of the patients flow is under scrutiny. Sensitivity analysis may bring out the effect of any changes, in service level on the patients flow and capacity requirements. Consequently, the sensitivity analysis is a part of the current research. It can help managers to make decisions, regarding the patient capacity planning, procurement of critical equipment, and hiring of the necessary specialists.

26 – EMERGENCY MANAGEMENT

A Peruvian pre-hospital attention model oriented to doctor-patient interaction

26

L. Pizan, M.J. Ferreira de Oliveira

THU C | HOG 00.85 | 14:00 – 15:30

Keywords: Discrete simulation, emergency models, attention quality

In this work we present simulation models of attention to patients in state of emergency of the Pre-hospital system. The most frequently pre-hospital emergencies, focusing on the interaction between patient and medical teams, have been included in order to measure the quality of the attention. In first instance we studied the state of the art of the different systems of pre-hospital attention in our region and the epidemiology of the performances of the emergency teams, taking the emergencies presented in the Emergencies Hospital, Casimiro Ulloa (Lima-Peru) as a reference. A talkative model of the functional vision and scenes of the system is presented and the model details of the interrelation between patient and medical teams were developed with the tendency of the programming guided to the object. The most frequently use-cases were introduced into the discrete event simulation system as process. Finally, we analyze and evaluate the quality of the attention offered to the pre-hospital patient. It is important to stand out that the measure of quality is based on the interrelation between patient and medical teams of the most frequently pre-hospital emergencies.

Modelling and performance analysis of the network of pre-hospital care emergency services

26

J. E. Hermassi, P. Ladet

THU C | HOG 00.85 | 14:00 – 15:30

Keywords: Pre-hospital care, SAMU (service of urgent medical help), patient flow, petri nets

The network of pre-hospital care emergency services is assured by the collaborative work of many services, e.g., in France, the network of SAMU (Emergency Medical Assistance Service), SMUR (Emergency and Resuscitation Mobile Service), SDIS (Firemen) and private ambulances. This network guarantees the sorting of patients with respect to their diseases and avoids the overloads of emergency services.
The SAMU plays an important role in this network as it receives and sorts out emergency calls, gives the appropriate response and sends the suitable means of transport (medical/non medical) corresponding to the medical condition of the patient.
Because of the limited resources of the SAMU, it is facing lots of burden with increasing emergency calls. This problem encourages the patients to go directly to acquire emergency services without informing the SAMU. This situation creates long hours wait for patients before being treated, thereby decreasing the quality services and increasing the treatment costs. All these conditions encourage us to improve the performance of this system.
The main purpose of this work is to improve the effectiveness of the network of the pre-hospital care emergency services by identifying the potential bottlenecks and proposing the strategies to alleviate them.

We studied the case of the network of pre-hospital care emergency services of Grenoble because it is a typical urban site. It is characterised by a wide variety of services capable to respond to medical emergencies which work together.
Petri nets are used to model and analyse the performance of the network of pre-hospital care emergency services. For this purpose, an ordinary Petri nets is developed to cover the complete flow of the patients through this net. This allowed us to analyse this system as previously it has not been discussed in detail. After ordinary nets are built, time variables are added in order to study system performance and detect anomalies such as bottlenecks and long waiting times. CPN Tools was used to make simulations.
Then, alternative solutions are proposed to improve the system performances. Our performance analysis is based on:
- Dimensioning of the system: nature and number of resources to provide (PARM (Permanent Auxiliary of Medical Regulation, doctors…)
- Studying new service organizations (relationship between the different services and staff scheduling)
After computational analysis and comparing our results, we found that the MR (Doctor who treats non urgent calls) plays an important role because lots of patients wait for their turn. We also found that by making appropriate adjustments to doctors' number, the patient's queue time can be shortened. Further analysis and all the results will be presented in the final version of our article.

Constructive heuristics for optimum scheduling of emergency departments **26**

M. Diefenbach, E. Kozan

THU C | HOG 00.85 | 14:00 – 15:30

Keywords: Scheduling, emergency department, flowshop, heuristic

This paper looks at scheduling the Emergency Department (ED) more efficiently. The aim is to increase patient flow resulting in reduced waiting times while optimising resource utilisation. Studies have shown excessive waiting times to impact not only the suffering and discomfort for the patient but to increase the likelihood of more treatment required, increase the inpatient length of stay required and overall use more resources. The ED system is set up like a parallel machine flow shop problem with patients and dual resources (i.e. doctors and beds) being synonymous with jobs and machines respectively. The following multicriteria objectives: access block, tardiness, length of stay and utilisation of resources, are used to optimise the ED. The mathematical model and numerical analysis of CPLEX solutions are presented. CPLEX could not handle real-life problems because of the complexity and the size. Therefore constructive heuristics are developed, compared and applied for a case study. Efficient scheduling heuristics are proposed for the different objectives of the system.

27 – CAPITA SELECTA

A novel characterisation of the patient arrival process in healthcare facilities **27**

G. Tai, P. Williams

THU C | HOG 01.85 | 14:00 – 15:30

Keywords: Patient unpunctuality, maximum likelihood estimation test, fitted distribution

A review of some published patient arrival patterns indicated certain consistent irregularities in their distribution densities, in particular where some localised modes or near-nodes appear on the distribution tails. This raised an interesting question as to how technically to model such aberrations.
Patient arrivals often vary from patient scheduled appointment times. This either contributes to clinician idle time or expands patient waiting lists. In previous practice, scheduled patients' unpunctuality (i.e., the deviation from the scheduled appointment time) is often modelled in a way that may excludes these persistent underlying features in clinical observations, such as in forcing data onto a normal distribution. Also, the fitted distribution may be excessively complex adding to difficulty to simulate and analyze (e.g. the Pearson type and Johnson type distributions). From re-examination of published observations drawn from detailed workflow analyses of community clinics, we can find that many families of distribution consistently neglect possibly these important features in the original data.

In this paper, a distribution modelling technique is proposed to capture these local peculiarities for scheduled patient arrivals, a method which balances accuracy and complexity by combining some common distributions. These modified forms are presented and a demonstration is made of their use to represent various patient unpunctuality patterns. This proposed modelling technique takes into accounts of the aspects of patient arrival behaviour and thus more precise and accurate in modelling clinical activities, and also it does not increase modelling complexity, because it is created by combining some common distributions and their modified forms, which simplifies parameter extraction under computer programming. The proposed modelling technique might provide useful for improvement of modelling appointment schemes in practical applications.
The adequacy of this model is assessed by variation and standard error comparison with normal and Pearson type distributions using a set of clinical observation records drawn from the literature. Tentative simulation results suggest some significant response to the proposed model. The steps of validation are as follows: firstly, parameters of normal, Pearson and the proposed fitted distributions that are 'most' suitable to clinical records are extracted. This process is done using MATLAB programming with MLE (maximum likelihood estimation) test; secondly, the standard error (SE) and variation between measured data (clinical observation data) and three sets of modeled data are worked out. Three sets of modeled data is extracted respectively using normal, Pearson and the proposed distribution; finally, a comparison of the variation and SE gained from the proposed model with the variation and SE gained from normal and Pearson distributions is made.

Multiple views of the medicine distribution in a pharmacy of a Navy hospital **27**

M. J. Ferreira de Oliveira, L. Garcia, R. Collazo, S. Espósito

THU C | HOG 01.85 | 14:00 – 15:30

Keywords: Visual distributed simulation, entity oriented experiments, pharmacy, public hospitals

The field of simulation has developed in such a way that is now possible to build a model that approaches reality. The technological advances grant our move ahead to see the results of a simulation experiment merging the formal approach with virtual scenarios. A method that allows one to imagine a particular hospital service, formulate a discrete-event model, evaluate and execute a formal simulation experiment is used in this context. Earlier details of the method can be found in previous ORAHS proceedings. Recent results points to the direction to considering different views of the most important parties involved in the models.
The objective of this paper is to propose a new model focused on the medicine distribution system at the pharmacy of a Navy Hospital in Rio de Janeiro. The model is based upon the integration, at the same level of importance, of the viewpoint of three of the most important entities involved in the medication distribution process. It is argued that the synchronization of the life cycle of the most important entities could contribute to improve the performance of the models. The developed method has theoretical interest and provides useful information to the elaboration of a complex model. It produces feedback that can be used by the parties involved with this particular service and has been widely used to show different aspects of the operation of Brazilian hospitals.

Relocation of health facilities: Modelling the implications **27**

H. Smith

THU C | HOG 01.85 | 14:00 – 15:30

Keywords: Healthcare modelling, locational analysis, demand, customer choice

The relocation of healthcare services and facilities is often a contentious matter, as different stakeholders compete for favourable locations of what may be scarce resources. Mathematical modelling can provide support to decision making which might otherwise be based solely on considerations such as finding suitable premises. Moreover, public justification can be made transparent by such means, once a final decision has been taken. From the viewpoint of a commissioning authority, there may be different objectives to be satisfied. Suitable proxies for forecasting future demand have to be found and different scenarios tested as to possibilities for population growth and changes in at-risk groups in particular geographical areas.

This paper presents modelling of situations affecting UK primary care trusts (PCTs) of both choice of location for new facilities and relocation of existing services to a new site. Some services previously offered only at hospital level are now under consideration for relocation into the community, under the care of general practitioners. Several competing interests may thereby be affected, as responsibility changes for services provided and patient access is altered. Relocation of existing hospital services to new sites, with upgraded buildings and improved patient pathways, causes changes to existing patterns of demand. Importantly, there are financial implications for the authorities responsible for making payments to those providing services. In areas of closely-packed metropolitan boroughs, there may be trade-offs to consider between the costs shouldered by any one authority and the neighbouring trusts.
Models are presented here that address the problems of location of new facilities, with a number of different options made available to the decision maker. Hierarchical levels and referral between levels can be included in the analysis. Different types of efficiency objectives are available, based on classical locational models. Equity objectives may also be employed, addressing an equitable distribution of services. Experiences are discussed of using the model in the process of locating new facilities in a UK metropolitan borough.
Forecasting future demand patterns for relocated services may be approached in several different ways. It may be that patients will simply travel to the nearest such facility after the move of services. However, a new building may attract business from further afield by providing improved service. Approaches used in making predictions for a UK PCT are discussed. Future research is under consideration into modelling choices made by patients in travelling to distant healthcare facilities.

28 – QUEUE MANAGEMENT

Performance metrics and service discipline in a system-scale model

B. Ramadanovic, I. Rongve, A. Rutherford, A. van der Waall, L. Vertesi, Y. Wang

THU C | HOG 02.28 | 14:00 – 15:30

Keywords: Waiting list, service discipline, performance metrics, elective surgery

In collaboration with the Ministry of Health Services of British Columbia, Canada we developed a model of surgical wait lists that operates on a provincial/regional level encompassing a large number of individual surgeons and hospitals.
This system is characterized by the extremely complex service discipline resulting from a network of related servers (surgeons, operating rooms etc.) and priorities. For the modelling purposes, it is very useful to abstract this network by a single server queue applying a consistent service discipline.
There are two main candidates for the service discipline of the system. One is service in order of arrival (FIFO), which is the underlying discipline, before priorities are taken into account, of the constituent servers within the system network. The other is service in random order (SIRO), which assumes that the complexities of the system seen from a sufficiently macroscopic level can be treated as randomness.
We have studied the dynamics of the system separately for both of these potential disciplines. Of special interest was the consequence of server discipline choice to the distributions of waiting times for different groups in the system, in particular waiting times as seen from the point of view of the administrator (census wait times) and from the point of view of an individual patient (wait times to service). These distributions are often used as a basis of practical performance metrics.
Our conclusion is that the abstracted single queue with SIRO discipline matches the reality of the system very well; considerably better then the one applying FIFO discipline. Also, in the case of the SIRO queue, performance metrics that are easily observed from the administrator point of view correspond exactly to the ones reflecting individual patient experience. We have studied in detail how the two diverge as the system goes from SIRO to FIFO discipline.

Organizing care delivery with function departments or around patient diagnosis. Factors and influences **28**

P. Vanberkel, R. Boucherie, E.W. Hans, J. Hurink, N. Litvak

THU C | HOG 02.28 | 14:00 – 15:30

Keywords: Simulation, queueing theory, resource pooling

Hospitals traditionally segregated resources into centralized functional departments such as diagnostic departments, ambulatory care centres, and nursing wards. In recent years this organizational model has been challenged by the idea that higher quality of care and efficiency in service delivery can be achieved when services are organized around patient groups. Examples are specialized clinics for breast cancer patients and clinical pathways for diabetes patients. Hospitals are grappling more and more with the question, should we become more centralized to achieve economies of scale or more decentralized to achieve economies of focus. In this paper service and patient group characteristics are examined to determine conditions where a centralized model is more efficient and conversely where a decentralized model is more efficient. Using quantitative models from the Queueing Theory and Simulation disciplines the performance of centralized and decentralized hospital clinics are compared. The study results in a model measuring the tradeoffs between economies of scale and economies of focus.

Optimal queue length for orthopaedic surgery with surgeon-specific queues and maximum waiting time **28**

A. Peltokorpi, J.-M. Lehtonen, P. Torkki, T. Moilanen

THU C | HOG 02.28 | 14:00 – 15:30

Keywords: Operating room, queue management, productivity, surgery, simulation

Lengthened waiting times to surgical operations lead to a diminished patient satisfaction, deteriorated medical quality and increased costs. From a patient perspective, optimal waiting time to elective surgery is between three to eight weeks. In order to avoid long queues, authorities e.g. in Sweden and Finland have enacted care guarantees that define the maximum waiting time to services. From a service provider perspective, some queues are needed to maximize the use of fixed operating room (OR) capacity. Optimization of OR efficiency becomes more problematic when surgeons have own patients and queues. In this study, the effect of queue length and care guarantee of maximum waiting time on OR productivity was analyzed and discussed.

The research was carried out in a Finnish orthopaedic specialist centre performing joint replacement surgeries as a limited company. The hospital has five ORs, performing annually about 2600 operations. Data for the analysis and simulation model included 5726 operations. Optimal queue lengths were defined for the “Base” scenario where four case duration categories were used in the case scheduling and for the scenario “All” with six case duration categories. Productivity (cases per OR session) was calculated by a simulation model with queue lengths of 1, 2, 3, 4, 5 and 6 months. Care guarantees of 3, 6 and 12 months were used as a maximum waiting time. Patients who had to wait longer than a care guarantee were scheduled to a first open slot regardless of the effect on the total productivity.

With 6 months care guarantee the optimal average queue length in the scenario “Base” was 3 months and productivity 2.22 cases per OR session. In scenario “All” the maximum productivity was 2.47 cases with optimal queue length also 3 months. With shorter queues there existed problems in finding appropriate cases to fulfill the OR session. With longer queues, cases with over 6 months waiting time disturbed the optimal daily scheduling. The tighter the care guarantee, the lower the maximum productivity: for 3 months care guarantee the maximum productivity was 2.37 cases and for 12 months 2.51 cases. Loosening the care guarantee, however, didn’t have an effect on optimal queue length: For 12 months care guarantee, the optimal average queue length was also 3 months.

The results showed that in surgical services the optimal waiting time from service provider perspective is only few weeks longer than patient preferences. The study proved also that in a situation of very long queues, the introduction of care guarantee might deteriorate the overall efficiency and increase the average waiting time. On the other hand, more sophisticated scheduling algorithms to find appropriate cases with expiring cases might solve this problem.

The study also highlights the question of maintaining a constant queue length. Capacity flexibilities are needed in order to keep the waiting time near optimum. In surgical services surgeons can be allocated between outpatient clinics and ORs based on the queues in different phases in the process.

29 – ADMISSION SCHEDULING

A hyper-heuristic approach to the patient admission scheduling problem

29

P. Demeester, M. Misir, B. Bilgin, K. Verbeeck, P. De Causmaecker, G. Vanden Berghe

THU D | HOG 00.85 | 16:00 – 17:30

Keywords: hyper-heuristic, patient admission scheduling

Operations research has been progressively used in health organizations. In this paper, we study the Patient Admission Scheduling Problem (PASP) which aims at providing an efficient schedule for assigning patients to beds of a hospital based on availability and the required treatment with the needs and preferences of the patients.
Solving distinct combinatorial optimisation problems and finding state of the art results is often possible by utilizing problem specific approaches. These fine-tuned approaches increase the solution quality but at the same time decrease the level of general applicability. So, there is a trade-off between quality and generality. Hyper-heuristics are generic search strategies that look for the most appropriate steps to solve a problem or instance of a problem. The traditional (improvement) hyper-heuristics are defined as "heuristics to choose heuristics", since they search for the best way of solving a problem by employing different heuristics at each step. This characteristic distinguishes them from problem-dependent or solution-based search techniques.
In this study, we apply different hyper-heuristic strategies which are generated by combining distinct 1) heuristic selection mechanisms that perform the selection process and distinct 2) move acceptance mechanisms that decide on whether to accept a new solution produced by the selected heuristic(s). We present a comprehensive study and show how it is possible to increase the quality and generality at the same time. For solving the PASP, we determine different hard constraints and optimise against some soft constraints. To differentiate between the constraints, different weights are utilized during the fitness evaluation. In the presentation, experimental results on the PASP will be presented and the effect of using different sub-mechanisms, heuristic selection with or without learning and some threshold accepting move acceptance mechanisms, will be discussed.

Improved cost and quality of care delivery through patient flow modelling and hospital admission control

29

J. Helm, M. Van Oyen

THU D | HOG 00.85 | 16:00 – 17:30

Keywords: Patient flow modelling, hospital admission control, queueing networks, Markov decision processes, hospital systems engineering

Hospital care services are frequently subject to significant and unnecessary detrimental fluctuations in inpatient census and associated workload. This variability in census results in congestion and chaos in the emergency department (ED), radiology backlogs, strains on medical staff, and inpatient overcrowding. Such congestion leads to compromised quality of care, emergency patient diversions, elective patient cancellations, excessive length of stay (LOS) as well as significant understaffing and overstaffing costs.
One of the primary controllable drivers in this census variability is the way in which patients are admitted to the hospital for an inpatient stay. The fact that every admitted patient contributes to the load on the network of hospital care resources means that variability in the admitting process propagates to all downstream care resource such as inpatient beds, nursing staff, ancillary services, ICU and PACU. Though hospitals have little control over variability in emergency arrivals, they can control elective patient admissions. In most hospitals elective surgeries are scheduled without considering the downstream resources needed to care for the patient post surgery. As a result hospitals experience overcrowding of critical resources like the ICU and PACU and unnecessary and unpredictable swings in hospital occupancy. To understand the consequences of admissions and scheduling decisions (e.g. elective surgery scheduling) on the hospital, one must understand the path a patient follows through the system from the decision point forward. This is our perspective on patient flow. To the detriment of the hospital,

most admissions decisions are made considering only the first resource in a patient's care pathway and not the entire flow through the hospital. Among other things, this results in high census variability and the associated waste and inefficiency.
This talk attempts to quantify the potential inefficiencies generated by admission decisions made without considering patient flow. We present a patient flow modelling approach and complementary decision support methods that can significantly reduce these inefficiencies. This approach considers two levers for controlling patient flow into the hospital: 1) scheduling of elective admissions and 2) dynamic census adjustment in the form of cancellation of elective procedures or the call-in of patients from a waiting list. Scheduling elective admissions based on patient flow can dramatically reduce the variability in census level. In concert with the schedule planning model, the dynamic census adjustment model reacts to the realization of a schedule and associated census level at a given decision point by either admitting extra patients from a queue or cancelling elective admissions to maintain a capacity buffer for future emergency arrivals.
Scheduling and control problems that consider a network of resources such as a patient care pathway are inherently complex and difficult. As such, our novel approach combines several modelling techniques including Markov Decision Processes (MDP), queueing networks, mathematical programming and simulation.

A queueing theory model for emergency and booked elective hospital admissions **29**

A. Rutherford, P. Bastani, B. Ramadanovic, L. Vertesi, Ya. Wang, Yi. Wang

THU D | HOG 00.85 | 16:00 – 17:30

Keywords: hospital admission standards, emergency department admissions, booked elective hospital admissions, multi-server queueing model, discrete event simulation

Many hospitals must balance the need to provide timely access for emergency department (ED) admissions with the requirement to maintain a schedule of booked elective (BE) admissions. Both types of admissions must be accommodated within the hospital's available bed resources. The first step in determining how to meet these competing needs is to establish appropriate access metrics for the two classes of admissions. The different character of these two types of admissions dictates two different types of access metrics.
For emergency admissions, it is not always the case that an inpatient bed will be immediately available when the decision is made to admit the patient. It may be necessary to hold the patient in an ED bed for a short period of time until an inpatient bed becomes available. Therefore, we define the access metric for ED admissions as the percentage of patients that receive an inpatient bed within a specified target time. For example, we might choose a target of 80% of admitted patients receiving an inpatient bed within 6 hours.
Management of booked elective admissions is quite different from ED admissions. If a hospital bed is not available when a patient is scheduled for admission, it is necessary for the hospital to cancel the booking and reschedule the procedure for a later date. Hospital management will typically work with a cancelation window in which they plan bed allocations. A typical cancelation window would be about 16 hours. The access metric that we use for BE admissions is the percentage of bookings that are cancelled.
We develop a multi-server queueing model with two input streams corresponding to ED admissions and BE admissions. Each arrival stream is modelled as a nonstationary Poisson processes. The distribution of arrivals is quite different for the two streams. The queue for ED admissions has exponentially distributed reneging, which models the medical care that patients receive in the ED. Patients who renege from the queue correspond to hospital patients who are discharged directly from the ED. The queue for BE admissions has a fixed deterministic reneging time, which corresponds to the cancelation window employed by the hospital. The length of stay or service time for the patients is assumed to be exponentially distributed. However, the two classes of patients have different mean length of stay.
Using this model, we determine how many beds a hospital needs and the maximum rate at which elective admissions can be scheduled, while simultaneously achieving given access targets for both ED admissions and BE admissions. Analytical solutions for the model will be presented for special cases at stochastic equilibrium. The full model outside of stochastic equilibrium is analysed using discrete event simulation. Numerical line search optimisation is used to determine the required bed count and rate at which elective admissions can be scheduled for given access targets.
Development of this model is part of a wider project on access to acute care in British Columbia, Canada.
This research is supported in part by the British Columbia Ministry of Health Services.

30 – SPENDING, SAVING & FUNDING

Allocating funds to hospitals in a health region

30

H. Buhaug

THU D | HOG 01.85 | 16:00 – 17:30

Keywords: Hospital funding, cost efficiency, equal access

Helse Midt-Norge RHF is one of four regional health authorities in Norway. Its primary obligation is to provide secondary health care for a population of 650 000. Long term care, GP-services, and other primary health care, is provided by the municipalities.
Most secondary care is provided by eight public hospitals and a number of district medical and district psychiatric centers. These facilities are organized in four hospital trusts, one in each of the four districts that constitute the region. The trusts are legal entities owned by Helse Midt-Norge. In addition, services are provided by a number of private providers - hospitals, rehabilitation facilities and consultants - according to contracts with Helse Midt-Norge.
Hospital trusts are funded according to a mixed model. Each year, the trust receives a grant from Helse Midt-Norge. This is a fixed amount of money that covers some 65-70 percent of the budget. In addition, patient care is reimbursed according to a national, DRG-based prospective reimbursement system. Reimbursement rates are uniform across the country, and are supposed to cover some 40 percent of average cost.
The annual allocation of funds to the hospital trusts is one of the most important decisions made by the trustees of the RHA. Until recently, the grants to each hospital trust were largely decided according to population size and other objective data. Two years ago, a new allocation model was implemented. In the new model, the grants are decided on the basis of the following parameters:
Activity targets, targets for economic efficiency, and targets for operating earnings.
The paper presents and discusses the structure and logic of the new model, and illustrates the way it is used to determine activity targets and other control parameters in a way that supports major objectives like equal access, structural changes and cost control.

The study of "per-case" plan and its effects on utilization of treatment capacities and on hospital personnel efficiency

30

A. Attafar, N. Simar Asl

THU D | HOG 01.85 | 16:00 – 17:30

Keywords: Per-case plan, efficiency, hospital capacities, reward systems, hospital

This paper aims to investigate the Per-Case plan (Payment of extra money per extra work) and its effects on the utilization of treatment capacities and on hospital personnel efficiency in hospitals under the supervision of Social Security Organization of Isfahan Province, Iran. Research population includes hospitals' staff consisting of doctors, paramedicines and other employees. The research data was gathered via questionnaire, interviews and library document analyses. The findings indicate that the implementation of Per-Case plan affects the level of hospital staff motivation and also increases the number of hospital beds occupied by patients and the number of surgeries operated. Based on the view points of doctors and paramedicines who participated in this plan, Per-Case resulted in a decrease in the time period of patients' stay in the hospital and increased patients' satisfaction of the services rendered. Also, implementation of Per-Case plan influenced the efficiency of the personnel; however, its effect on doctors' efficiency was more significant. Based on the results, by using this method, the speed of rendering services to hospital customers increased but the service quality was not satisfactory. At the end of the presentation some recommendations are given based on research findings including the necessity of bridging the gap between services tariffs in public and private sectors and providing much control and supervision on the delivery of services.

Here are some models I prepared earlier: Operational research to the rescue **30**

D. Bensley

THU D | HOG 01.85 | 16:00 – 17:30

Keywords: Linking existing models, measurement of impact, public health interventions, use of structured workshops

In the UK Health and Care System the Department of Health (DH) does not directly deliver healthcare services to the public. Rather these are implemented by local health commissioners and providers and increasingly by local decision making and incentives as opposed to central directives or targets. The role of the DH includes setting direction, supporting delivery, leading health and well being for Government and accounting to Parliament and the public. Absolutely central to the role of the DH is that of securing and the allocating of almost all funding to the NHS. Uniquely in the UK every three years there is a Spending Review which covers all public expenditure and determines three year allocations to all Government departments.
Sexually transmitted diseases, smoking, alcohol and drug misuse are seen as being a burden on the Health Care system and public health interventions to prevent such behaviours are typically perceived as producing much of their benefit over long time scales. Some, however, can generate sizeable short term gains.
The pivotal contribution of Operational Research to the establishment of a Public Health workstream in the last Spending Review will be described.
In addition to helping to establish that Public Health was included in the search for savings the work raised the credibility of Public Health both in the wider Department and with the Treasury: “Helped to change the perception that Public Health is only about the long term and is not relevant in the short term”. The work led directly to identifying significant savings across the Health Care system and to a focussed one to one meeting with the Minister for Public Health.
The case study is to be used in two high profile exercises in marketing OR within the DH. Firstly it has been selected as one of a very small number of OR Case Studies for a forthcoming pack aimed at marketing Operational Research to Senior Policy Managers within the Department . Secondly it has been chosen for two high profile analyst days aimed at policy managers to promote analysis the first of which is to be opened by the Cabinet Secretary and Head of the Home Civil Service.
The value of both quantitative and qualitative analyses will be described including the use of exemplar analyses to win support from policy colleagues, linking together of existing simulation models and the use of Structured Workshops to identify enablers and barriers to delivery of savings. Finally some lessons will be drawn about successfully initiating high impact analysis in the future.

31 – QUEUE MANAGEMENT

Capacity planning of a perinatal network through a loss network framework **31**

T. Chaussalet, M. Asaduzzaman

THU D | HOG 02.28 | 16:00 – 17:30

Keywords: Capacity planning, perinatal network, queueing network model, overflow, rejection

Every year 8-13% babies are admitted to a neonatal unit and 2-3% require intensive and/or high dependency care in the United Kingdom (UK). Neonatal care in the UK has been organised through ’Managed clinical networks’ (MCN’s) since 2004 so that service improves and care can be provided locally. Yet over a six month period in 2006/07, neonatal units were shut to new admissions for an average of 24 days, and one in ten units exceeded its capacity for intensive care for more than 50 days. The National Audit Office reported that capacity and staffing problems at unit level continue to constrain neonatal service. The North Central London Perinatal Network (NCLPN), one of the 5 networks in London, consists of six hospitals, including University College London Hospital (UCLH). The pressure on neonatal units in the NCLPN is growing very fast, in particular at UCLH, where the rejection of admission of neonates from neonatal intensive care unit (NICU) and high dependency unit (HDU) is now very high due to capacity shortage.

In this paper, we develop a loss network model with overflow, based on a continuous-time Markov chain framework, to tackle the capacity planning problems of a perinatal network, with specific application to the NCLPN. We derive expressions for overflow and rejection probabilities for each neonatal unit of the network based on a decomposition approach. Results obtained with the model are very close to those observed for the UCLH. They also show that a substantial number of intensive care cots are required to keep rejection level low. Using the model, decisions on number of cots can be made for specific level of admission rejection probabilities for each level of care at each neonatal unit of the network and specific levels of overflow to temporary care.

Queueing network models to improve patient flow in a hierarchical health care delivery system **31**

J. Song, B. Li, H. Tai, S. Wu

THU D | HOG 02.28 | 16:00 – 17:30

Keywords: Patient flow, block, priority, health care delivery system

Improving community health services is one of the most important issues in China's health care reform today. The percentage of patients who are looking for their treatment in general hospitals is as high as 73.9%, while only 25% patients go to community health care facilities for the treatment, which made that the general hospital in the urban city is overcrowded while the utilization in community health care facilities is inefficient. In fact, the health delivery system should be hierarchical. The community health care facilities provide primary health care and the general hospitals focus on difficult illness. A recent research report from the Ministry of Health of China states that in theory 65% of the outpatients and 77% of the inpatients now in general hospitals can be well treated in community health care facilities.
The purpose of this research is to propose a method to achieve patient flow in the hierarchical health delivery system distributed more rationally in order to shift patients from overcrowded and overutilized hospitals to community health care facilities. The Chinese government now plans to implement some incentives to guide patients to community health service facilities for their treatment, so the community health facilities can take the duty as "Gate-Keeper". In this research, when patients are waiting for service from a general hospital, we consider giving the patient referral from a community health facility priority than the walk in patients.
In order to achieve the goal, we build a mathematical model to analyse the problem. In the theory part, compared to most of the previous research on patient flow where queue theory has been done in the department level, our research emphasizes the hierarchical health delivery system at a macro level. First we will set up a queuing model with block to describe the congestion in the current health delivery system, which can be used to calculate the current patients' waiting time and the utilization of congestion health delivery system. Second, with the priority incentive, we will set up a queue model with priority character. The patients' waiting time with priority order and the utilization of the health delivery system with priority character can be obtained from the model. Third, by comparing the change of waiting time and utilization of the health delivery system in the above two mathematical models, we can get the conclusion that with the priority incentive, the average patients' waiting time and system's congestion decrease. With the patients visit data from Haidian District in Beijing, the mathematical model analysis is implemented. Together we use ARENA to set up a simulation model to verify the conclusion.

Aggregate planning in a laboratory environment **31**

N. Vandaele, K. Lieckens

THU D | HOG 02.28 | 16:00 – 17:30

Keywords: Aggregate planning, laboratory operations, stochastic modelling

A laboratory environment is mostly organized and viewed as a service center, which operates in a make-to-order fashion. It is hold to provide the analysis report in a quality and timely manner. The latter is usually embedded in a Service Level Agreement.
Samples arrive according a stochastic arrival process and are processed on order. The demand process is typically only known in aggregate terms. Laboratory processes are typically characterised by a high level of uncertainty in terms of process times, setup times, rework, quality levels, etc. As a consequence, the lead times are very variable themselves making it difficult to adhere to the agreed Service Level

Agreements concerning the delivery of the analysis reports in time. Varying the number, the allocation (many operations are limited by certification) and the availability of the laboratory workforce is the main managing instrument to preserve the knocked down promised service deliveries.
We model the laboratory environment as a multi-period, stochastic queueing network. We illustrate the model with a real-life example.

32 – MATHEMATICAL PROGRAMMING

A mixed linear programming framework for optimizing the makespan of washing operations in hospital sterilization services

32

O. Ozturk, M.-L. Espinouse, M. Di Mascolo, A. Gouin

FRI A | HOG 00.85 | 9:00 – 10:30

Keywords: Sterilization service, medical device, batch scheduling, mixed integer linear programming

Just like all other sectors, hospitals are facing increased costs in their services, logistics or purchasing activities. In addition, hospitals depending on their sterilization policy of medical devices may be subjected to further costs. The higher the sterilization frequency of medical devices is within a day correlates with lower spending on the purchasing of these medical devices. However, in this case the time spent within the sterilization service becomes incrementally more important since, the faster the MDs are sterilized the more often they may be used in a given time frame. The sterilization of medical devices aims to eliminate all infectious risks in their reuse. The procedure of sterilization is regulated by some quality standards. The sterilization of medical devices is realized in a cyclic way which can be described as: use in operating rooms, pre-disinfection and transport to the sterilization service, rinsing, washing, inspection and packing, sterilization, and storage before reuse. After their use in a surgical operation, MDs are directly wetted in a pre-disinfection product. The wetting continues until MDs are brought to sterilization. The duration of wetting is important as the substance in which they are put in contact with can damage MDs after a certain time. The desired time is about twenty minutes and the maximum is about fifty minutes. After wetting, MDs are rinsed before being washed.
In this paper, we want to minimize the time spent in the washing step of a sterilization process. All the MDs used in a surgical operation arrive at the same time at the sterilization service and form the so-called set of MDs for that operation. One or more sets of MDs are put into washers for each washing cycle. In a sterilization service the washing step generally is a bottleneck. Creating suitable batches, composed of different sets of MDs, will prevent this bottleneck by minimizing the makespan in that step. MDs are washed in washers which have limited capacity. Each set of MDs, belonging to a given surgical operation, may have its own capacity requirement for washing and should be washed in the same washing cycle. In case a washer is not completely full, it is possible to put another set of MDs into the same washer without exceeding the capacity constraint. We assume that we know the arrival time of each set of MDs to the sterilization service as well as its capacity requirement. Our aim is then to model the washing step as a batch scheduling problem.
We have developed a mixed integer linear model which aims at minimizing the makespan of the washing step. We have made several tests with academic and real data using the commercial computer program CPLEX. Then, we compared the results to those obtained by using a “first come first washed” strategy and the real situation.

Solving the strategic case mix problem optimally by using branch-and-price algorithms

32

G. Ma, L. Wang, J. Beliën, E. Demeulemeester

FRI A | HOG 00.85 | 9:00 – 10:30

Keywords: Health care, case mix, branch-and-price, decomposition

This paper studies the case mix problem at the strategic level. The mathematical model aims to maximize hospital profit under the given resource capacity and outputs an optimal case mix pattern and a resource allocation method. Two exact methods, integer programming and branch-and-price, are deployed to solve the case mix problem. It is shown that the resulting branch-and-price algorithms outperform the integer

programming approach in both solution quality and computational speed. For the branch-and-price approach we propose three formulations that decompose the problem on different units, namely the wards, the surgical groups and the patient groups, among which the first two decomposition methods are suitable to be solved with the branch-and-price algorithm while the last one is not. A comparison of the computational results of the first two decomposition methods reveals that a large decomposition unit improves the solution quality and the computational speed.

A hybrid simulated annealing linear programming approach for treatment planning in HDR brachytherapy with dose volume constraints **32**

J. Beliën, J. Colpaert, L. De Boeck, E. Demeulemeester

FRI A | HOG 00.85 | 9:00 – 10:30

Keywords: Cancer treatment planning, Brachytherapy, dose volume constraints, mixed integer programming, simulated annealing

This paper presents a hybrid approach for developing radiation plans for high dose rate brachytherapy in cancer treatment. In order to take care of the computationally hard dose volume constraints, linear programming (LP) is alternated with heuristic neighborhood search which allows for a quick generation of multiple feasible treatment plans. The simulated annealing neighborhood search is guided by both the primal and dual information available after each LP optimization. The approach is very promising compared to a traditional mixed integer programming approach for dealing with the dose volume constraints.

33 – CAPITA SELECTA

Designing a model for estimating needed manpower for Iranian hospitals **33**

M. Yarmohammadian, S. Bahrami, A. Foroughi, F. Foroughi

FRI A | HOG 01.85 | 9:00 – 10:30

Keywords: Human resource management, health care, OR/MS and the public sector

The main goal of this research is estimating the manpower needed for doing health care tasks in one of the most important wards of the Emam Mosaye Kazem hospital of Isfahan, Iran. Method of this research is a kind of quantitative management research with taking advantages of analyzing the current status and developing a new weighting indicators system (WIS). In this research, we developed a WIS based on 6 key performance factors. After summing up scores for each level of management, we estimate the number of needed manpower for the middle management in this hospital.

Development of an impact assessment tool to assist emergency planning within strategic health authorities **33**

C. Vasilakis, S. Crowe, A. Skeen, S. Gallivan, M. Utley

FRI A | HOG 01.85 | 9:00 – 10:30

Keywords: Emergency preparedness, health system resilience, mathematical modelling

In this paper we present a mathematical work proposed for use in assessing the likely impact of a given set of circumstances on the capability of the UK National Health Service (NHS) to meet demand for health care services. The events and mechanisms that might give rise to short term disruption to the capability of the NHS to meet demand are not modelled explicitly but rather are characterised by patterns of demand for services and the availability of resources to meet these demands.
The analysis is conducted at the level of a local health economy consisting of “assets” at which services are provided, and assets of the supply-chain essential to the delivery of the care services considered. The

relationships that are assumed to exist between services, the resources used in the delivery of such services, and the availability and supply of these resources are made explicit. Based on these relationships and a number of simplifying assumptions, we present an analysis proposed for estimating the impact of a set of circumstances in terms of the level of unmet demand for health services. In assessing impact, it can be argued that one needs to account for the likely response of the health service to the circumstances envisaged. Thus, we incorporate in our analysis different levels of response on the part of the health service.

Modeling a regional network of clinical engineering departments **33**

G. Balestra, L. Gaetano, D. Puppato, G. Prato, P. Freda, F. Morena, F. Vajo, M. Lombardo

FRI A | HOG 01.85 | 9:00 – 10:30

Keywords: Clinical engineering, health technology management, simulation

Biomedical technology is a valuable asset that is strategically important to the operational effectiveness of healthcare facilities. Clinical Engineering (CE) Departments are in charge of healthcare technology management in healthcare facilities. During the middle of the 60s, when technology started to spread inside the hospitals the problem of its management was mostly concerned with electrical safety. During the 80s technology became more sophisticated and safer, but the number of devices increased dramatically. The principal problems became to correctly manage the devices maintenance, to purchase the most suitable instrument, planning device substitutions, ensure the correct functioning of the instruments, and guarantee the availability of critical devices every time they are needed.
Clinical engineering in Regione Piemonte in the last twenty years grew in a very diversified and fragmented way. The result is that only a few healthcare facilities have a CE Department. Two years ago AReSS (Agenzia regionale per i servizi sanitari) established a working group with the objective to design an organizational model to develop clinical engineering departments in all the healthcare facilities of the region. The working group consisted of clinical engineers working in the regional CE departments and researchers from academic institutions.
The first result was the definition of the organizational structure. The main characteristics of the proposed organization are: a) to create a network of the CE departments effective in each health facility; b) to share specialized competencies by means of clinical engineering companies which work in strict cooperation with the staff of the CE departments; and c) to implement the same basics or core activities, in other words those activities related to acquisition and maintenance of medical instrumentation.
The second question to be faced was to estimate the number of clinical engineers and biomedical equipment technicians (BMET) that will constitute the CE Department staff. According to the regional organization of healthcare facilities, each CE Department should take care of several units that may be scattered over a vast area. A model was developed to simulate the workload of the CE department and to provide a correct estimate of the staff composition. The model was constructed by means of iThink software (www.iseesystems.com) and it is based on three elements: the activities to be simulated, the characteristics of the healthcare facility, and the human resources composition.
Model inputs consisted of the number of devices, the number and characteristics of the territorial units, the presence or absence of university departments, and the number of clinical departments.
Stochastic equations were used to simulate the activities carried out daily by the CE department. Simulation was performed separately for each health facility. The number of clinical engineers and biomedical technicians that guarantee a satisfactory organization is the model output.
The proposed organization will be applied to develop the regional network and the model will be used to support each facility to define its best functional structure.

34 – SIMULATION

SD and ABM is assessing hospital performance **34**

P. Escudero, M. Pidd

FRI A | HOG 02.28 | 9:00 – 10:30

Keywords: Performance targets, waiting times, health system, system dynamics, agent based modelling

Health systems, as many public systems are complex and adaptive. The complexity involves interaction between supply and demand that engages a group of stakeholders such as patients, doctors, nurses and managers who have sometimes conflicted objectives and are looking for their own individual benefit. This context of stakeholders' interaction and decision making require usage of limited resources and shared information. Particularly, in the case of the National Health System (NHS) in the UK, there is a limited budget that must be efficiently utilized in order to supply the demand of services. Yet, since the NHS provides the services free of charge, these interactions within the system result in waiting times as a rationing device instead of prices. However, the long waiting times existed in the NHS drove the government to create a performance measure framework with specific targets that has been effective in reducing the waiting times. Nevertheless, as in many public services, the use of the performance measurements in the UK health system has created unintended consequences (for instance increasing cancelations for elective surgeries). The reason why such consequences tend to exist could be attributed to a situation where the effects of policies and decisions can not be immediately perceived, and an existing lack of understanding of the overall picture of the system.
To deal with this complexity, modelling and simulation has been mostly used by researchers. For example, Discrete Event Simulation (DES) has been used to explain the queuing process that the patient is following through the healthcare system. However, in order to better understand the interactions among the parts of the system and to deal with the problem of unintended effects, System Dynamics (SD) has been used for policy guidance. Yet, one of the simulation methodologies that is Agent Based Modelling (ABM) has not been widely used for this purpose; although it could provide a good tool for understanding the interactions of stakeholders participating in the system.
The literature has shown that improvements of waiting times are not just obtained through investments in capacity. Investments in capacity tend to reduce waiting times, but the patient´s perceptions of lower waiting times leads to raise the demand which consequently results in increments on waiting times. Moreover, each unit within the hospital is working on meeting its own performance target by comparing the actual performance with the target and then making corrective actions to improve the system. As each unit within the hospital is following the same process independently, it is important to consider that improvements in one unit tend to create problems in another.
Hence, this work attempts to look at how SD and ABM could be used to assess hospital performance by: providing a holistic overview of the system, evaluating how targets imposed in the NHS affect the system behaviour, and understanding the unintended effects of different policies over it.

Statistical modelling and simulation for intensive care units. A case study **34**

F. Mallor, C. Azcarate, S. Ochoa

FRI A | HOG 02.28 | 9:00 – 10:30

Keywords: Simulation, intensive care unit, resource management, statistical modeling

This paper deals with the problem of determining the appropriate level of resources to be assigned to the Intensive Care Unit (ICU) of a Hospital in order to balance a good health service, measured in terms of 'refusal rates' and the cost of these necessary resources (beds, nurses and doctors). From a mathematical point of view an ICU can be modelled using a queuing system, where the patients are the clients and the servers are a combination of beds, nurses and doctors. Nevertheless, the different types of patients, the statistical arrival patterns, the selection rules for admission, the statistical behaviour of the length of stay (with two outcomes at the end: recovery/death) provide a complexity to this system that prevent us to study the system by using analytical models from queuing theory. Our approach consists in developing an accurate simulation model which includes all relevant elements of the ICU as well as the adjusted statistical models to the observed data.
In our work we model the ICU of the Hospital of Navarre, which is the reference health centre for a population over 200.000 people, and also a complementary centre for all Navarre (over 500 thousand people) and other bordering regions (because of some specialities as Oncology, Neurosurgery, etc.). We have all records of patients that were admitted in the ICU in the period 2000-2008. For each patient it is known, among others, the age, sex, the level of severity, type of illness (according to an 8-group classification), length of stay and outcome (recovered or dead). We have modelled the patient arrival process by using a mix of translated Poisson distribution and a degenerated distribution in the zero value. In fact we have seen that the usual assumption of a Poisson Process does not hold. The length of stay has been modelled, for each type of patient and type of outcome, using long tailed distributions as the lognormal and loglogistic distributions. The simulation model has been validated testing the results with the real data available and implemented using ARENA software. Then we have used it to assess the

amount of necessary resources to cope with an increment of the population in the influence area of the Hospital and to test different admission rules.

Platelet ordering: A random walk with Ponce De León **34**

J. Blake, N. Heddle, R. Barty

FRI A | HOG 02.28 | 9:00 – 10:30

Keywords: Platelet ordering, perishable inventory, simulation

The search for a hospital platelet ordering policy that results in a low costs, minimal levels of outdates and high levels of availability has long been the "fountain of youth" of inventory ordering policies. The OR literature is replete with complex algorithms seeking to provide wonderous properties: low outdates, low shortages, and a simple implementation framework. In this paper, we provide perspective on the universal existence of such policies for hospitals.
Hospital demand is modelled as a Poisson process with independent, daily means. We assume that orders must be placed before demand is known and that in coming stock, while arriving instantaneously, may be several days old upon receipt. Furthermore, we assume that the age of stock on receipt changes throughout the week. In keeping with operational practice, we define a good policy as one which would result in outdate rates of less than 5% and which would yield availability rates in excess of 99%. We assume that cost minimization is of interest, but only within the constraints of an acceptable policy.
Using relatively simple mathematics, we show that for any demand profile, it is possible to calculate whether an acceptable policy exists. We also show that the "shape" of the inventory demand profile affects the existence of an acceptable inventory policy; profiles that are relatively constant are much more amenable to a "fountain of youth" solution. We provide practical examples of how operational policies such as the number of days in which platelets can be ordered and the shelf-life of platelets influences the existence of an acceptable policy.

35 – APPOINTMENT SCHEDULING

Decision rules for selection of appointment systems based on patient and clinical panel characteristics **35**

J. P. Sepúlveda Rojas, C. P. Berroeta Mauriziano, F. Baesler Abufarde

FRI B | HOG 00.85 | 11:00 – 12:00

Keywords: Outpatient scheduling, decision making, heuristics, optimization

This work addresses the problem of outpatients scheduling. This problem has been addressed in the literature primarily through the development of appointment system methods based on heuristics and optimization models. However, such models are rarely implemented. To our knowledge, one of the factors that affect this phenomenon is the understandable mistrust of the decision makers in their benefits. For example, some questions of the decision makers can be: Would the models proposed in the literature deliver better results in my institution, considering that they were tested under different conditions (eg, different number of rooms for care, demand, etc.)?, Among so many models proposed in the literature, how do I know which one is better adapted to the conditions of my institution?
Those questions are addressed in this work. In particular, we want to propose decision rules that, based on some specific conditions of the institution, indicate which appointment system method is more suitable and the expected increase in performance measures.
Some authors describe the addressed problem, the relevant variables, the patient and clinic most relevant characteristics for this type of problems, performance measures, and commonly used analysis approaches. We found in the literature some studies about decision rules. For example, a comparison of 9 different appointment systems in 27 different clinical settings, characterized by 3 environmental variables (probability of no-shows, coefficient of variation of service time and number of patients by session). The performance measure used is the weighted average of physicians' idle time and patients waiting time. Some results show that the appropriate appointment system depends on the clinical characteristics and the ratio between the medical personnel's and patients' idle time costs. This study

proposes some rules for selecting the adequate appointment system. Another work complements these results through a similar problem with fewer restrictions, new appointment systems and different performance measures. The authors increase the number or relevant variables (they add walk-ins and punctuality of patients). In relation to appointment systems, besides verifying decision rules, they tested sequencing rules. While with decision rules for appointment systems we obtain the block-size and the appointment interval, with the sequencing rules we can define the order to assign each patient (new and return) to each slot of time. Finally, in this study the performance measure includes overtime besides physicians' idle time and patients' waiting time.
In our work, we extend these previous analyses considering additional variables and performance measures, with the objective of developing a more reliable decision rule for the decision makers of outpatient clinics.

Appointment-driven queueing systems **35**

S. Creemers, M. Lambrecht

FRI B | HOG 00.85 | 11:00 – 12:00

Keywords: Waiting list, appointment system, queueing systems, overtime

Many service systems require customers to make an appointment prior to receiving service. Often, these appointments are made during so-called "arrival sessions" (e.g. during office hours). After making an appointment, customers are issued an appointment date (which takes place at some future "service session") and join an external queue which is referred to as the "waiting list". Upon the appointment date, the customer is removed from the waiting list and receives service at the "service facility" (e.g. a doctors office). The arrival and service process of a customer at the service facility are subject to various "environmental variables" (e.g. interrupts during the service process, customer unpunctuality …). We refer to these systems as appointment-driven systems. They may be found in health care, legal services, administration and many other service and manufacturing industries.
Often appointment-driven systems are characterized by a chronic backlog of customers to be served. The long waiting times involved and the inherent stochastic nature of the service process itself, result in reneging behavior, staff overtime, inefficient use of resources and missed company profits. The root of these problems may be found in a mismatch between capacity and demand. The main objective of this research is to assess and optimize the trade-off between capacity and demand in appointment-driven systems. For this purpose a number of queueing models are developed.
Appointment-driven systems are in fact a combination of two distinct queueing systems. In a first queueing system, customers make an appointment (i.e. arrive at the system), join the waiting list (i.e. are introduced in a queue) and leave the system at the start of the service session in which their service is administered. A second queueing system observes the queueing behaviour of customers during the service session itself; it deals with the operational issue of scheduling a number of customers as to optimize some set of performance measures (e.g. server overtime, customer waiting time …). We refer to both queueing systems as the Service Allocation Model (SAM) and the Customer Appointment System (CAS) respectively. Together, they may be used to analyze appointment-driven systems as a whole.
The analysis of the appointment-driven system yields four measures of interest: (1) the waiting time of a customer in the waiting list; (2) the waiting time of a customer at the service facility; (3) the amount of overtime a server performs; (4) the amount of time a server resides in an idle state. Using these performance measures, strategically important issues concerning server capacity may be addressed (e.g. how often should a server be online, when should it be online, how many customers should be served…).

36 – RADIOTHERAPY SCHEDULING

A hybrid heuristics and tabu search approach to radiotherapy patient routing and scheduling problem **36**

T. Kapamara, D. Petrovic, S. Petrovic

FRI B | HOG 01.85 | 11:00 – 12:00

Keywords: Radiotherapy, tabu search, scheduling, lateness

In this study, the tabu search algorithm is applied to a dynamic and flexible radiotherapy patient routing and scheduling problem identified in a radiotherapy department at a local cancer centre. Varying numbers of radiotherapy patients arrive daily and have to be scheduled on several machines and/or facilities. The patients follow different predetermined pathways in three or all of the four units of the department, namely: planning, physics, pre-treatment, and treatment unit that are sequential, commencing and ending in the planning and treatment units respectively. The units have multiple identical machines and facilities for conducting different treatment procedures on patients. Scheduling of radiotherapy patients upon their arrival in the centre gives patients information on when they visit the different machines and/or facilities in the radiotherapy department throughout the whole treatment. It also provides the department with crucial indications of the patient waiting times and machine utilisations achieved over a given period of time. Radiotherapy waiting time is defined as the difference between the date when the decision to treat is made and the delivery of the first fraction. Literature has shown that long waiting times have been associated with high local recurrence rates and reduced tumour control. We have developed constructive heuristics for the radiotherapy patient scheduling problem which have produced good schedules of patients. The aim of this study is to further improve the quality of the schedules generated by the constructive heuristics considering the minimum weighted lateness (that is, the difference between the completion date of the first fraction and its due date) for patients arriving on a given day. Tabu search strategies have remarkably produced solutions of good quality when applied to complex classical, dynamic and/or flexible manufacturing systems and other production scheduling problems. Therefore, this study is utilising the flexibility and adaptive characteristics of tabu search to improve the quality of solution of a complex healthcare scheduling problem. Preliminary computational results on the improvements achieved on waiting times, machine utilisations and lateness for each radiotherapy category over a given period of time are reported.

Towards an improved resolution of radiotherapy scheduling **36**

Y. Jacquemin, E. Marcon, P. Pommier

FRI B | HOG 01.85 | 11:00 – 12:00

Keywords: Healthcare services, radiotherapy, scheduling, integer linear optimization

In any cancer treatment, waiting times are critical, the faster you treat, the more effective the treatment is. Minimizing waiting times can be achieved by improving schedule efficiency. This is especially true in the context of radiotherapy where material and human resources are usually scarce. With the increase in the number of radiotherapy patients and the crucial role of short delay between the diagnostic of cancer and the beginning of the cure, accurate and reliable scheduling are strongly needed. Although healthcare scheduling is extensively documented, either in terms of human resources or surgery scheduling, few studies have addressed the specific radiotherapy problem. Among the different approaches developed, recent works suggest to solve the radiotherapy planning based on Mixed Integer Programs (MIPs) models. These approaches aim to schedule efficiently a list of waiting patients i.e., schedule efficiency is usually measured by the number of patients treated accordingly to their own priority i.e., the emergency of their medical condition. Constraints usually formulated are session-duration, number of sessions per week, availability of materials resources and already-booked patients' appointments.
In our paper we decided to pursue an exact resolution based on an integer linear optimization of a non-block scheduling strategy close to these recent works to assess the feasibility of theses approaches in real-world conditions and improve existing models accuracy.
After analyzing previous work limits and gathering actual practices from a French oncology center, we suggest a new mathematical model, which better fits the reality. Indeed, an accurate model should consider the great variability occurring in human beings care, and essential specificity of radiotherapy planning. First we increase the planning horizon to ensure efficiency over several weeks; then we take into account several previously ignored constraints such as critical human resources, pathology-dependant constraints and protocol-dependant constraints. Our model will be tested against scenarios coming from the studied hospital allowing us to obtain near real-life results. Results obtained show a potentially improved use of radiotherapy treatment room over each week, a higher number of patients treated along with a decrease in patient waiting times. We intend to implement theses methods in the collaborating oncology center to confirm efficiency, usability and accuracy of our model.

37 – DIABETES MODELLING

Diabetes modelling - A stylised system dynamics model

37

C. Nicolescu, A. van Ackere

FRI B | HOG 02.28 | 11:00 – 12:00

Keywords: Diabetes modelling, system dynamics, health expenditure, decision policies

The increasing prevalence of chronic diseases is one of the major causes of increasing health expenditure, as stated by WHO. Diabetes is becoming a major burden of disease globally and in Switzerland in particular. Many studies attempt to estimate the health expenditure attributed to diabetes, and try to identify the factors affecting it in order to identify solutions for reducing the cost caused by this disease.
We model type 2 diabetes progression using a System dynamics approach. Diabetes is an irreversible disease and over time diabetic patients develop complications. We make the hypothesis that micro vascular complications manifest themselves before the macro vascular ones. We identify several stages of disease diagnosis and progression and identify the factors influencing the transition rates from one health state to another. Our contribution resides in differentiating two essential aspects in the disease progression: the onset and the diagnosis of diabetes and its various stages of complication. The delay between onset and diagnosis significantly affects the further disease progression and represents an important policy parameter.
Policies can be aimed for prevention and earlier diagnosis. Prevention policies may delay the development of complications and result in a longer life expectancy. This has different cost implications according to the time horizon: in the short term implementing prevention policies will increase costs but these will decrease in the medium and long term as patients will live longer in a better health state and require thus less medical services. Better diagnosis policies will imply significantly increased costs in the short term, as more people will require treatment for their newly diagnosed condition, but in the medium term costs will decrease as disease progression will slow down. In the long term, costs may increase as people may have a longer life expectancy.
A major aspect of our work is the evaluation of cost parameters corresponding to each stage of disease and diagnosis. We use two approaches: “top down” and “bottom up”. The “top down” approach consists in combining data for total health expenditure and the rates of utilisation of health resources for diabetes. The “bottom-up” approach estimates the health care cost of diabetes by multiplying the average costs of specific services by the total use of these services for diabetes. We had to estimate missing Swiss data from literature and statistics provided by other countries’ health systems. The two approaches yield different results. Thus the next step consists of reconciling these.
The model will allow us to test different decision policies. Prevention and diagnosis policies will affect the evolution of the disease, the required care and resulting cost. The evolution of the disease will slow down and result in longer life expectancy and better health, but this will increase short term and eventually long term costs. We also aim at testing the impact of prevention and diagnosis policies on patient’s behaviour.

A model to evaluate quality, effectiveness and influencing factors of diabetes self-management in Saudi Arabia

37

A. Alshehri, S. Brailsford, A. Dila

FRI B | HOG 02.28 | 11:00 – 12:00

Keywords: Self-management, diabetes, Saudi Arabia

Self-management has emerged as an approach to enhance quality of care for patients suffering from long term conditions, and to control costs of health services. So far, however, the effects of this approach remain unclear. Although current models define the concept of self-management, they do not provide a systematic development or an explanatory theory of how self-management affects the outcomes of care. The objective of this research is to present a framework for applicable evaluation of self-management programmes. The evaluation model is built on patient-related intervention. The effectiveness of these interventions is affected by levels of patients’ engagement and effective participation. Thus studying

factors that influence patients' compliance with self-management activities is crucial to explain the outcomes of these interventions. Diabetes mellitus was selected as one of the most common health problems in Saudi Arabia. A cross sectional survey was conducted using a self-administered questionnaire to collect data from diabetes centres in the main five regions in the country. Analysis of data using simple, multiple and logistic regression revealed that behavioural theories support the core assumptions of self- management. This evaluation model can be used as a decision making supporting tool; to identify the components of self-management interventions, and to make comparisons between different interventions. Moreover, it supports planning for new interventions or to refine existing ones by allocating efforts and financial resources toward the most influential factors that affect patients' adherence to self-management activities.

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