ORAHS 2018 CONFERENCE
CONNECTED CARE

44th International Conference of the
EURO Working Group on
Operational Research Applied to Health Services

29th July – 3rd August 2018
Oslo Science Park
Oslo, Norway

HØKH

AKERSHUS UNIVERSITY HOSPITAL

UiO : Institute of Clinical Medicine
Faculty of Medicine

Oslo
University Hospital

The Research Council
of Norway

C3 CENTRE FOR
CONNECTED CARE

SINTEF

HELSE SØR-ØST

Nasjonalt nettverk for
helsetjenesteforskning
Norwegian Health Services Research Network

Norway
Health Tech
Incorporating Oslo Medtech

OSLO AND AKERSHUS
UNIVERSITY COLLEGE
OF APPLIED SCIENCES

PROGRAMME AT A GLANCE

	Sunday 29.07.2018	Monday 30.07.2018	Tuesday 31.07.2018	Wednesday 01.08.2018	Thursday 02.08.2018	Friday 03.08.2018
09:00		Opening Session	Parallel sessions		Free	Free
09:30					Plenary session	Plenary session
10:00		Poster session				
10:30			Coffee		Coffee	Coffee
11:00		Plenary session	Parallel sessions		Parallel sessions	Parallel sessions
11:30				Boat trip to Drøbak 10:00-18:00		
12:00						
12:30		Lunch	Lunch		Lunch	Business Meeting / Lunch
13:00						
13:30		Plenary session	Parallel sessions		Parallel sessions	
14:00						
14:30						
15:00		Coffee	Coffee		Coffee	
15:30		Parallel Sessions	Parallel Sessions		Parallel Session	
16:00						
16:30						
17:00						
Evening activities	Welcome Reception Oslo Science Park 18:00-20:30	Reception Oslo City Hall 19:00-20:30	Walking tour		Conference Dinner Ekeberg Restaurant 19:00-24:00	

Contents

WELCOME

Dear Colleague,

On behalf of the organizing committee of ORAHS 2018, I welcome you to the 44th annual meeting of the EURO-ORAHS working group. It is 17 years since ORAHS was last held in Norway, and it is the first time that the Health Services Research Unit (HSRU) at Akershus University Hospital is hosting the event. The hospital is located in Lørenskog, just outside of Oslo, but for the benefit of our guests we have chosen a venue that is closer to the city centre.

One of our sponsors is the Centre for Connected Care (C3), which is a centre for research based innovation in health care, and the theme of this year's conference is "Connected Care". C3 aims to accelerate adoption and diffusion of patient-centric innovations, i.e. innovations that change patient pathways and delivery systems and increases growth in the healthcare industry. The OR group of HSRU contributes to C3 by modelling, simulating and hopefully even optimizing the ways that patient-centric innovations can be implemented in real life. We see this as the an important role for OR in health care, now and in the future, and hope that ORAHS 2018 will inspire other OR research groups to focus (even) more on optimal implementation of innovations in health care.

In keeping with ORAHS tradition, we offer an extensive social program, including the mandatory boat trip. The conference dinner will be held at the excellent Ekeberg restaurant, with a panoramic view of the city.

Needless to say, the conference would not have been possible without the help of our sponsors, and we are grateful for their contributions. I will also thank the organizing committee, and Joe Viana and Tone Breines Simonsen in particular, who have put in an enormous effort in all stages of the planning and implementation of the conference.

I wish you an interesting and pleasant stay in Oslo!

Fredrik A. Dahl

ABOUT ORAHS
ORAHS provides a network for researchers involved in the application of systematic and quantitative analysis in support of planning and management in the health services sector. The meeting is open to anyone with a quantitative background and those who have interest in the subject area. For more information about ORAHS please visit the website.

ABOUT THE ONE DAY CONFERENCE – INNOVATION AND HEALTHCARE
A one day event is organised for Monday the 30th July where delegates from innovative and healthcare organisations in Norway will be invited to interact with the ORAHS delegation. More information about the plans for this day can be found on the conference website.

COMMITTEES

Organising Committee

Hilde Lurås, HØKH
Fredrik Dahl, HØKH
Mathias Barra, HØKH
Kim Rand, HØKH
Meetali Kakad, HØKH
Angela Labberton, HØKH
Lene Berg Holm, Oslo Met
Kari Hengebøl, C3
Atle Riise, SINTEF
Anita Moe Larsen, Norway Health Tech
Tone Breines Simonsen, HØKH
Joe Viana, C3

International Programme Committee

Sally Brailsford, University of Southampton, UK
Roberto Aringhieri, University of Turin, Italy
Marion Rauner, University of Vienna, Austria
Leonid Churilov, Florey Institute of Neuroscience & Mental Health, Australia
Mike Carter, University of Toronto, Canada
Erwin Hans (2012) University of Twente, The Netherlands
Evrim Didem Güneş (2013) Koc University, Turkey
Tuğba Çayirli (2013) Ozyegin University, Turkey
Inês Marques (2014) Universidade de Lisboa, Portugal
Maria Captivo (2014) Universidade de Lisboa, Portugal
Patrick Soriano (2015) HEC Montreal, Canada
Fermin Mallor (2016) Universidad Publica de Navarra, Spain
Christos Vasilakis (2017) University of Bath, UK

PRACTICAL INFORMATION

More detailed information can be found at the VisitOslo and the VisitNorway websites.

Evacuation of Oslo Science Park (Forskningparken)
- There is no scheduled fire drill for the Forskningparken during the week.
- Please make yourselves aware of the location of the fire exits.
- If there is an alarm, please follow the instructions of the members of the local organising committee and/or members of staff from the Oslo Science Park.

Emergency telephone numbers
- 110 Fire
- 112 Police
- 113 Ambulance and Emergency Medical Assistance
- 116 117 or less serious medical or health related issues contact Oslo kommunale legevakt

Currency/Exchange
- Norwegian Kroner (NOK)
- Tipping at restaurants is at your discretion, nit tips of "rounding up", or up to around 10% are not uncommon. Tipping is generally restricted to resaurants, and is uncommon for other services.
- Payment method: Cash is acceptable but most people use debit/credit cards.

Ruter Travel Card
- A Ruter travel card will be given to each delegate on the Sunday welcome reception.
- Most public transport in and around Oslo is covered by the Ruter travel card.
- The conference is primarily in zone 1. Find out more about the zones at the Ruter website.

Climate
- Summer (Min = 6.1°C; Average = 15.8°C; Max 30.5°C)
- YR is a Norwegian weather forecasting service, others are available.
- We advise that you check the weather forecasts daily and dress accordingly.

Electricity
- In Norway the power sockets are of type F, typical for most of Western Europe. The standard voltage is 230 V and the standard frequency is 50 Hz.
- Electric appliances use continental-style two-pin plugs

VAT refund
- In a number of shops in the Oslo area will issue a VAT refund once you have left the country. Most of these shops carry a Tax Free logo displayed in the shop window or on their counter, but you are advised to ask the sales assistant whether tax free shopping applies to the shop in question, as not all shops carry the tax free logo.
- More information about VAT refunds can be found here.

Local committee contacts
- Selected committee members contact details will be made available at the conference, for emergencies.

CONFERENCE INFORMATION

Conference Venue – Oslo Science Park

The conference will be held at the Oslo Science Park (Forskningsparken) a modern hub for innovative research in Norway, which has many facilities including modern seminar rooms and restaurants. It is next to the University of Oslo (a 5 minute walk).

Getting to Oslo Science Park
See also www.ruter.no

T-bane (metro) line 4 or 5, stop Blindern or Forskningsparken.

Tram 17 or 18 direction Rikshospitalet, stop Forskningsparken.

The Oslo Science Park entrance is where the StartupLab marker is on the map on the right.

Registration & Conference help desk

On Sunday for the Welcome the Reception at the Oslo Science Park the registration desk will be on the left as you enter the Toppsenter venue.

The registration desk for Monday-Friday is located opposite the FORUM and next to the poster presentations and will be manned during conference hours. If the desk is unmanned and you require assistance, please contact numbers that will be available at the conference desk, or check the conference office (AQUA).
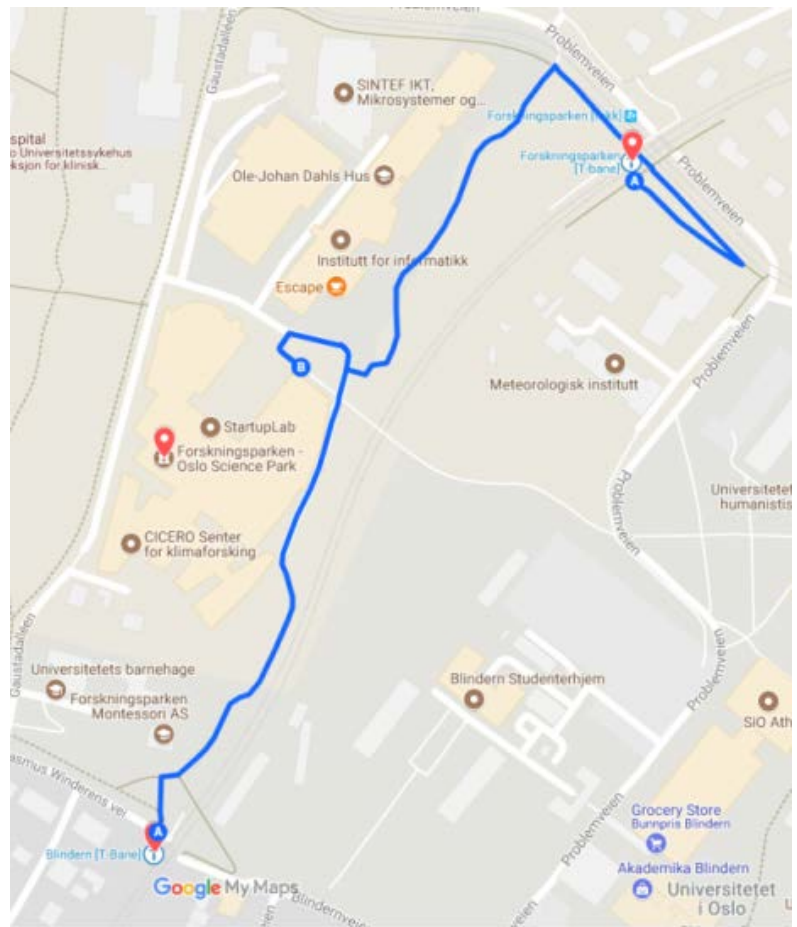
Poster display

Posters will be displayed outside the FORUM. There is a poster session on Monday from 10:00 – 11:00, and posters will be displayed until the end of the conference. Poster authors are expected to be available in the afternoon coffee breaks to respond to any questions.

The poster competition will be judged by Professor Sally Brailsford and other members of ORAHS board, and members of the local organising committee. The poster prizes will be presented during the conference dinner on Thursday evening.

Internet

Oslo Science Park (Forsningsparken) has excellent Wi-FI coverage. The guest login details are clearly stated throughout the building.

Computer support

Adapters are provided to connect computers to the room projectors. Members of the local organising committee will be able to provide some support. If more major support is required the local organising committee will contact our Oslo Science Park conference support .

Guidance for chairs

Please familiarise yourself with the room that you are chairing, the technology and the authors in your session. We recommend that you arrive at your session 5-10 minutes early to connect your computer to the room's projector.

You are responsible for distributing the certificates of presentation to the authors in your session. These will be available at the conference help desk. A member of the local organising committee will endeavour to deliver the certificates to you. If they do not, please request the certificates from the help desk.

Please ensure that the authors keep to time, see guidance for authors below. If an author misses a session we will be keeping to the conference schedule. Do not rearrange the talks in your session.

Guidance for authors

Oral presentations
- Oral presentations are scheduled for 30 minutes. Please limit your talk to 20 minutes. The additional 10 minutes are for questions, comfort breaks and moving between rooms.

- Authors should introduce themselves to the chair of their session and where possible take their presentation on a USB stick, to transfer to the chair's PC.

Poster presentations
- Poster authors are required to give a 2 minute presentation about their poster for the poster competition committee who will be walking around the posters in the poster session on Monday morning.

- Example questions: Who are you? Where are you from? What is your research about and what is your poster about?

OPENING SESSION

Monday 30.07.2018   **09:00 − 10:00**   **FORUM**

Sally Brailsford
Professor of Management Science, University of Southampton

Sally is chair of the EURO Working Group on OR Applied to Health Services (ORAHS) and Professor of Management Science at the University of Southampton. She has a background in mathematics but also worked for many years in the UK National Health Service as a nurse. Her second career, in academia, began in the late 1980s, and since then she has worked in the area of healthcare operational research (OR), mainly using discrete-event simulation and system dynamics. She has applied both approaches to a wide variety of healthcare-related problems. Her current research interests include hybrid simulation methods and behavioural OR. She is the only person to have won the UK OR Society's Goodeve Medal three times, for the best paper published in the Journal of the OR Society (JORS) that year: in 2004 for modelling emergency healthcare services in Nottingham, in 2006 for modelling chlamydia infection, and in 2015 for modelling the dental workforce in Sri Lanka. She is a co-Editor-in-Chief of the OR Society journal Health Systems and is on the Editorial Boards of Health Care Management Science, the Journal of Simulation and Health Care Operations Research. In 2016 she was made a Companion of OR by the UK OR Society in recognition of her contribution to health OR.

Kathrine Myhre
CEO of Norway Health Tech

Norway Health Tech is a cluster of more than 240 members (companies, businesses hospitals, municipalities and other health organizations). Katherine will introduce Norway Health Tech and how the cluster facilitates connections and collaboration between the different stakeholders in the health system to develop innovative health care solutions.

PLENARY SESSIONS

Monday 30.07.2018   **11:00 – 12:30**   **FORUM**
An introduction to the Centre for Connected Care (C3)
Kari Kværner
Director of the C3 and Professor at Oslo University Hospital

Systems Oriented Design: Design for health care systems
Birger Sevaldson
Institute of Design, Oslo School of Architecture and Design

Systems Oriented Design (SOD) is an approach and methodology in design for coping with very complex, fuzzy and wicked problems. It is based on designerly skills and ways of working more than theories and models. The techniques developed in SOD are easy to learn and practice for designers and non-designers alone or in

collaboration. The lecture will briefly go through the basics of SOD and show a few examples from the health care sector.

Communicating and collaborating across professional disciplines: The role of metaphors and affordances in tangible tools used in the co-design of healthcare services
Karianne Rygh
PhD Fellow in Service Design at the Oslo School of Architecture and Design

Healthcare is one of many contexts where the need for collaboration across disciplines is rapidly increasing. Communication tools used in service design processes have become an important means to establish a common terminology and common ground across various professional fields that are in need of collaborating. But how such tools should and could be designed specifically for the healthcare sector, is less known. This presentation explores the role that design can play in the tools we use to communicate and negotiate expectations and goals amongst diverse actors. Furthermore, it questions the design of tangible communication tools for co-design workshop facilitation and how affordances and metaphors can be designed to foster collaboration and support innovation in multidisciplinary teams.

Monday 30.07.2018   **13:30 – 15:00**   **FORUM**
Mathematical simulation models in economic evaluation of health care interventions
Eline Aas
Associate Professor - Department of Health Management and Health Economics, University of Oslo

In several countries, reimbursement decisions in the health care sector are based on economic evaluations. Economic evaluations quantify the health benefits and expected resources use for a given intervention or combination of interventions. No single clinical trial is sufficient to capture all the short and long-term health and economic consequences needed to inform complex policy decisions. An advantage of modelling is the ability to synthesize available evidence (e.g., RCTs, observational studies, registry data) from multiple sources, extrapolate data beyond the time horizon of studies, reflect parameter and process uncertainty, and identify the most influential factors on the decision. In evaluations of screening for cancer, modelling is the preferred method. I will address the reasons for this during my talk.

Thursday 02.08.2018   **09:30 – 10:30**   **FORUM**

Watson technologies applied in medical research
Loek Vredenberg
CTO of IBM Norge
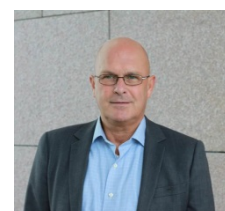
Loek Vredenberg is the CTO of IBM Norge and works with IBMs technologies across the different business units. Loek has long experience with technical leadership roles within IBM internationally and for deliveries of complex IT solutions. Loek has in recent years focused his attention to artificial intelligence and IBMs cognitive technologies that go by the name of Watson. Also Loek is working in the area of industry platforms. Loek contributes to public debate around AI and gives lectures and key notes on this topic in many different settings.

This talk will show the need for cognitive technologies and how they can be applied in the area of research. IBM uses its Watson technologies in partnership with many health organizations across the globe to find patterns in data and extract new knowledge out of these patterns. The advent of ubiquitous "Internet Of Things" technologies gives us a golden opportunity to monitor all kinds of events, understand their context and enable us to act on this contextual knowledge in totally new ways.

Friday 03.08.2018   **09:30 – 10:30**   **FORUM**

QALYs in simulation modeling: the basics, and why you should care
Kim Rand
Senior researcher at Health Services Research Unit, Akershus University Hospital

Dr. Rand is a clinical psychologist with a varied experience within quantitative analyses and computer programming. Driven by curiosity that ignores the delineation between scientific disciplines, Rand is involved with projects within statistics, medicine, epidemiology, health-economics, demographics, psychology (clinical, organizational, and ideological), and simulation modelling. Following a series of papers critically appraising the validity of methods used to measure and model preferences for health, Rand has become a central figure in the field of health-preference research. He is the Vice Chairman of the EuroQol Research Foundation – the international research group behind the most-used instrument worldwide for measuring health-related quality of life for use in calculating quality-adjusted life-years (QALYs). Promoting an eclectic perspective on modelling, Rand seeks to enrich health-economics and health-related operational research by combining aspects of both.

BUSINESS MEETING AND LUNCH

Friday 03.08.2018 **12:30 – 13:30**   **FORUM**

Join us for the annual ORAHS business meeting including a summary of this year's ORAHS and to hear more about ORAHS 2019 in Germany. The hosts for ORAHS 2020 will also be chosen.

SOCIAL PROGRAMME OVERVIEW

More detailed information about the social programme is provided in standalone information sheets that relate to each of the social events. These are available from the conference website and will be in your conference folder.

Sunday 29.07.2018   **Welcome Reception**

Time: 18:00 – 20:30
Address: Oslo Science Park (Toppsenter), Gaustadalléen 21, 0349 Oslo (CONFERENCE VENUE)
Getting there: T-bane number 4 or 5 to Blindern or Forkningsparken.
                Tram number 17 or 18 to Forskningsparken.
Dress code: Casual

A welcome reception will be held at the Oslo Science Park Toppsenter (roof top area), with light refreshments and drinks. The Toppsenter offers a great view of the fjord and the city and is particularly nice if the weather is agreeable.

Monday 30.07.2018   **Oslo City Hall Reception**

Time: 18:30 – 20:30 (**No admission after 19:00. Remember your invitation**)
Address: Rådhusplassen 1, 0037 Oslo
Getting there: Buses to Oslo City Hall (Rådhus) 54, 31E, 32, 36E, 70, 81, 30, 83, 31, 80E and 83. Tram number 12 stops relatively close. T-bane station Nationaltheateret is a short walk from the City Hall.
Dress code: Smart casual

The reception will be hosted by the Mayor and includes a tour of this impressive building, which contains fantastic artwork and is where the Nobel Peace ceremony is held each year.

Tuesday 31.07.2018   **Optional walking tours**
Information about these will be provided during at the conference.

Wednesday 01.08.2018   **Oslo Fjord tour to Oscarsborg Fortress and Drøbak**

Time: 09:30 – 18:30
Address: Rådhusbrygge, 0160 Oslo (meet by the fountain in the centre of the square)
Getting there: Use public transport to get to Rådhusplassen
Dress code: Casual (bring some warm/waterproof clothes)

ORAHS would not be complete without a boat trip. We have chartered a boat to sail us south through Oslo fjord to the island where the Oscarsborg Fortress is located. We shall have time to explore the fortress and have lunch on the island before sailing on to Drøbak to explore this picturesque town (know as a very Christmassy town) before returning to Oslo City Hall.

Thursday 02.08.2018   **Conference Dinner at Ekeberg Restaurant**
Time: 19:00 – 00:00
Address: Kongsveien 15, 0193 Oslo
Getting there: Tram number 18 or 19 to Ekebergparken stop
Dress code: Smart

The conference dinner will be held at the Ekeberg Restaurant overlooking the city of Oslo. The original restaurant was established back in 1916 by the Tiedemann Tobacco factory. In 1927 the

Oslo-based architect Lars Backer won the competition to design the new restaurant. Two years after one of Europe's most regarded functionalist style buildings emerged. The Ekeberg restaurant is today a protected building and all renovations to be made must safe keep the classic aspects but with a modern twist.

Oslo City Hall

Oscarsborg Fortress & Drøbak

Ekeberg Restaurant

CONFERENCE VENUE MAP

Posters
Coffee and Lunch

LEVEL 0

F

G

H

VIA

AQUA

FORUM

Mingleområde

Conference
help desk

D

E

HAGEN 3

HAGEN 1+2

A

B

C

Entrance (Level 1)

Main reception (Level 1)
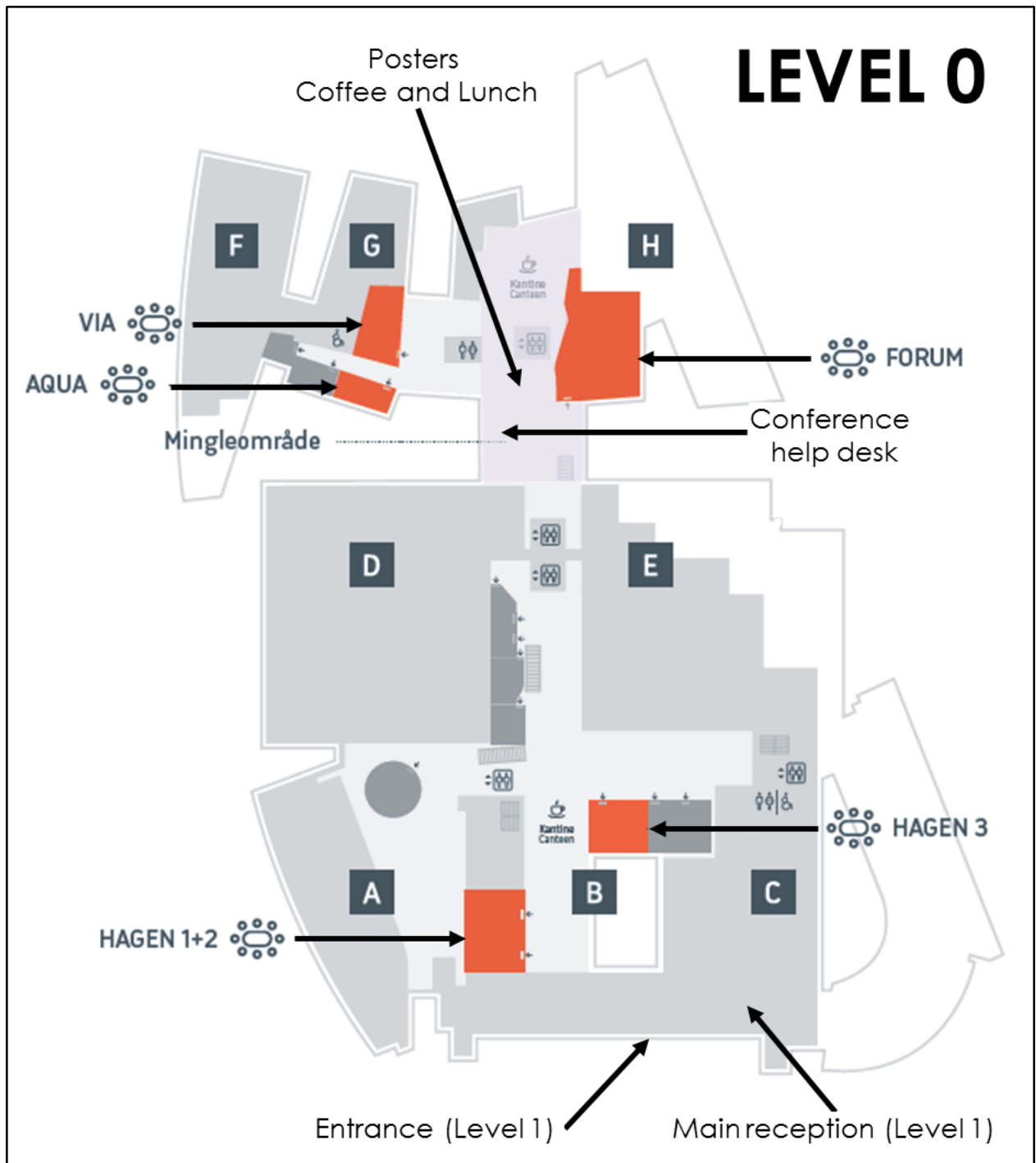
SCIENTIFIC PROGRAMME OVERVIEW

	Scientific Programme – Monday 30.07.2018			
09:00	MA - Opening session Chair – Fredrik Dahl Room: FORUM			
10:00	MA - Poster session & Coffee Chair – Mathias Barra Room: FORUM and outside the FORUM			
	P01 – Siang Li Chua P02 – J-C Chen P03 – Emily P Williams P04 – Emma L Aspland P05 – Joren Marynissen P06 – Mary Conlon P07 – Joe Viana		P09 – Mohammad Jarrahi P10 – Thierry Chaussalet P12 – Kerry Pearn P13 – Sara Saadatmand P14 – Angela Labberton P15 – Fredrik Dahl AHO posters	
11:00	MB - C3 session Chair – Fredrik Dahl Room: FORUM Kari Kværner Karianne Rygh Birger Sevaldson			
12:30	Lunch			
13:30	MC – UiO Chair – Kim Rand Room: FORUM Eline Aas			
15:00	Coffee			
15:30	MD1 – Operating Room Scheduling I Chair – Margaret Brandeau Room: FORUM MD1-1: Lisa Koppka MD1-2: Anders Gulhav MD1-3: Margaret Brandeau	MD2 – Ambulance/Vehicle Routing I Chair – Ettore Lanzarone Room: Hagen 1 + 2 MD2-1: Samuel Ridler MD2-2: Ana Sofia Carvalho MD2-3: Ettore Lanzarone	MD3 – Blood Supply Chain Chair – John Blake Room: VIA MD3-1: Inês Marques MD3-2: Semih Yalçındağ MD3-3: John Blake	MD4 – Emergency Medical Systems I Chair – Honora Smith Room: Hagen 3 MD4-1: Davide Duma MD4-2: Mario De Oliverira MD4-3: Honora Smith

	Scientific Programme – Tuesday 31.07.2018			
09:00	TUA1 – Emergency Medical Systems II Chair – Melanie Reuter-Opperman Room: FORUM TUA1-1: Dandan Shi TUA1-2: Marion Penn TUA1-3: Melanie Reuter-Opperman	TUA2 – Ambulance/Vehicle Routing II Chair – Valérie Bélanger Room: Hagen 1 + 2 TUA2-1: David Barrera -Ferro TUA2-2: Pieter van den Berg TUA2-3: Valérie Bélanger	TUA3 – Decision Support I Chair – Thierry Chaussalet Room: VIA TUA3-1: Maria Eugenia Captivo TUA3-2: Mathias Barra TUA3-3: Thierry Chaussalet	TUA4 – Operating Room Scheduling II Chair – Alexander Tesch Room: Hagen 3 TUA4-1: Ashwani Kumar TUA4-2: Carla Van Riet TUA4-3: Alexander Tesch
10:30	Coffee			
11:00	TUB1 – Simulation I Chair – Sally Brailsford Room: FORUM TUB1-1: Mark Tuson TUB1-2: Eric Silverman TUB1-3: Sally Brailsford	TUB2 – Workforce Planning Chair – Monica Oliveira Room: Hagen 1 + 2 TUB2-1: Maarten Otten TUB2-2: Jan Schoenfelder TUB2-3: Monica Oliveira	TUB3 – Health Care Policy Modellng I Chair – Lesile Anne Campbell Room: VIA TUB3-1: Martin Dlouhy TUB3-2: Ravichandran Narasimahan TUB3-3: Lesile Anne Campbell	TUB4 – Scheduling I Chair – Aleida Braaksma Room: Hagen 3 TUB4-1: Yi-Hang Zhu TUB4-2: Fabian Schäfer TUB4-3: Aleida Braaksma
12:30	Lunch			
13:30	TUC1 – Clinical Modelling I Chair – Mathias Barra Room: FORUM TUC1-1: Filipe Alvelos TUC1-2: Zhichao Zheng TUC1-3: Mathias Barra	TUC2 – Mental Health Chair – Marion Rauner Room: Hagen 1 + 2 TUC2-1: Vittorio Nicoletta TUC2-2: Sean Manzi TUC2-3: Marion Rauner	TUC3 – Cardiology Chair – Thomas Schneider Room: VIA TUC3-1: Niki Matinrad TUC3-2: Mary Conlon TUC3-3. Thomas Schneider	TUC4 – Operating Room Scheduling III Chair – Francisco Ballestín Room: Hagen 3 TUC4-1: Thomas Adams TUC4-2: Derya Demirtas TUC4-3: Francisco Ballestín
15:00	Coffee			
15:30	TUD1 – Acute Care Chair – Peter Vanberkel Room: FORUM TUD1-1: Meetali Kakad TUD1-2: Daniel Gartner TUD1-3: Peter Vanberkel	TUD2 – Capacity Planning I Chair – Mario Jorge Ferreira De Oliveira Room: Hagen 1 + 2 TUD2-1: Anne Zander TUD2-2: Roberta Rossi TUD2-3: Mario Jorge Ferreira De Oliveira	TUD3 – Frameworks Chair – Jan Vissers Room: VIA TUD3-1: Syed Salleh Abdul Rahman TUD3-2: Sonya Crowe TUD3-3: Jan Vissers	TUD4 – Decision Support II Chair – Turgay Ayer Room: Hagen 3 TUD4-1: Christine Huttin TUD4-2: Namsuk Cho TUD4-3: Turgay Ayer

	Scientific Programme – Thursday 02.08.2018			
09:30	THA –IBM Chair – Meetali Kakad Room: FORUM Loek Vredenberg			
10:30	Coffee			
11:00	THB1 – Home Care Chair – Katherine Penny Room: FORUM THB1-1: Yahyaoui Asmae THB1-2: Elena Valentina Gutiérrez THB1-3: Katherine Penny	THB2 – Maternity/Obstetrics Chair – Christos Vasilakis Room: Hagen 1 + 2 THB2-1: Sylvia Elkhuizen THB2-2: Catherine Crenn Hebert THB2-3: Christos Vasilakis	THB3 – Health Care Policy Modelling II Chair – Penelope Mullen Room: VIA THB3-1: Lerzan Ormeci THB3-2: Sandy Rutherford THB3-3: Penelope Mullen	THB4 –Scheduling II Chair – Marta Cildoz Room: Hagen 3 THB4-1: Melanie Erhard THB4-2: Rimmert van der Kooij THB4-3: Marta Cildoz
12:30	Lunch			
13:30	THC1 – Emergency Medical Systems III Chair – David Stanford Room: FORUM THC1-1: Nikolaus Furian THC1-2: Adele Marshall THC1-3: David Stanford	THC2 – Capacity Planning II Chair – Sebastian Rachuba Room: Hagen 1 + 2 THC2-1: Paula Andrea Velásquez Restrepo THC2-2: Elena Tànfani THC2-3: Sebastian Rachuba	THC3 – Operating Room Scheduling IV Chair – Roberto Aringhieri Room: VIA THC3-1: Asgeir O Sigurpalsson THC3-2: Enis Kayis THC3-3: Roberto Aringhieri	THC4 – Doctor Scheduling Chair – Nadia Lahrichi Room: Hagen 3 THC4-1: Kjartan Kastet Klyve THC4-2: Julia Sophie Block THC4-3: Nadia Lahrichi
15:00	Coffee			
15:30	THD1 – Patient Flow Chair – Martin Utley Room: FORUM THD1-1: Blair Bilodeau THD1-2: Ines Verna Arnolds THD1-3: Martin Utley	THD2 – Operating Room Scheduling V Chair – Mariana Oliveira Room: Hagen 1 + 2 THD2-1: Sebastian Kohl THD2-2: Angel Ruiz THD2-3: Mariana Oliveira	THD3 – Ambulance/Vehicle Routing III Chair – Caroline Jagtenberg Room: VIA THD3-1: Krisjanis Steins THD3-2: Yannick Kergosien THD3-3: Caroline Jagtenberg	THD4 – Emergency Medical Systems IV Chair – Joe Viana Room: Hagen 3 THD4-1: Leila Keshtkar THD4-2: Khodakaram Salimifard

Scientific Programme – Friday 03.08.2018				
09:30	FA – HØKH Chair – Joe Viana Room: FORUM Kim Rand			
10:30	Coffee			
11:00 to 11:30	FB1 – Capacity Planning III Chair – Joe Viana Room: FORUM FB1-1: Mohammad Pishnamazzadeh	FB2 – Clinical Modelling II Chair – Fredrik Dahl Room: Hagen 1 + 2 FB2-1: Ibrahim Ahmed		
12:30	FC - Business Meeting and Lunch Chair – Fredrik Dahl Room: FORUM Fred Dahl, Sally Brailsford, Melanie Reuter-Oppermann			

ABSTRACTS

MA – Poster session & Coffee – 30/07/2018 – 10:00 – 11:00
Chair – Mathias Barra   Room: FORUM and outside

P01 – Siang Li Chua – 30/07/2018 – 10:00 – 11:00
Design of Outpatient Pharmacy Automation System (OPAS) for Acute Hospital using Discrete Event Simulation (DES)

Chua, SL; Chow, WL

Changi General Hospital Singapore SINGAPORE ;

Aim: Drug packing is a labour intensive process that can result in medication errors when performed manually. There is no single Automated Dispensing Machine (ADM) can complete the entire complex packing process for all drug formats (blister, loose, box, bottles, fridge items). We used Discrete Event Simulation (DES) to design a partially automated OPAS that combined a few ADM technologies. Method: A baseline DES model on current workflow was built to calibrate the service times. Patient queue data (n=60,472) in 2014 was used to derive prescription arrival rate. Prescription data (n=225,287) in 2015 and outpatient growth rate were used to project future workload. A time motion study (n=1,578) was conducted to determine service rate of registration, packing and dispensing. Models on future workflow were built to design OPAS. The models considered arrival rate, service rate, year 2017 and 2025 workload, number of ADMs, ADM operating speeds, drug format and size restrictions, drug format combinations, packing strategies, assembling solutions and constraints (floor space, cost, manpower) to generate patient wait time at 95th percentile. SIMUL8 was used to build the models. Result: 129 what-if scenarios were generated from14 DES models to derive an optimal OPAS solution comprised of 6 technologies, 4 ADM types and 2 floor layout/workflow that met the financial and layout constraints while meeting 8 minutes wait time target set by business owners. Conclusion: DES offers a cost-effective framework for the evaluation of new technologies and to-be processes where piloting future processes is challenging due to the high investment costs and the risk of disrupting current operations. Our study enabled an evidence based approach to evaluate the impact of pharmacy automation design options on key outcomes of interest prior to committing to a high cost investment.

Modelling and simulation; Process optimisation; Decision support; Capacity and network planning; Forecasting

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P02 – J-C Chen – 30/07/2018 – 10:00 – 11:00
Some findings for improving plantar pressure of flat foot people using a self-made sole with an artificial arch and different heights of textured insoles
Chen, J.C.; Wang, Y.D.
National YunLin University of Science and Technology Douliu TAIWAN ;

The pressure distribution on the soles of the feet is critical to human health. When people stand or walk, the role of the arch is to buffer the body's counterforce from the ground. When the bow of the human body is defective, such as a flat foot, it is as if the base of the human body is skewed. Not only does it affect the balance of the body, it can also cause some form of physical harm. .In this study, we used Arduino and some pressure sensing strips to create an insole that can detect the static or dynamic pressure of people's foot, and explored the distribution and body stability of flat

foot pressure through some insoles with different texture heights and an artificial arch. We first studied the difference in foot pressure between flat feet and normal feet. The results showed that people with flat feet had a tendency to lean forward when standing or walking, due to lack of an arch. The result showed that people with flat feet, when compared to people with normal feet, had a comparatively high plantar pressure on the hallux and forefoot and conversely relatively small on the heels. This result may lead to the fact that people with flat feet have toe valgus, or even injuries. By increasing the texture and height of the insole, this phenomenon can be moderately improved and the dynamic stability of people when standing can also be increased. What's more interesting is that if an artificial arch is added, this phenomenon can be better and effectively improved. In addition to the place where the artificial arch is directly stressed, there is no significant difference in foot pressure between the flat foot and the normal foot in other places.

Data analysis and risk management; Decision support; e-health; Modelling and simulation; Performance evaluation

P03 – Emily P Williams – 30/07/2018 – 10:00 – 11:00
Modelling to Support the Redesign of the Welsh Blood Service Supply Chain System
Williams, E. P.[1] ; Harper, P. R.[1] ; Gartner, D.[1] ; O'Brien, C.[2]
[1]Cardiff University Cardiff UNITED KINGDOM ;
[2]Welsh Blood Service Pontyclun UNITED KINGDOM ;

Human blood is a scarce resource and its role in healthcare is fundamental, with donated blood saving the lives of many on a daily basis. However, the availability of such an invaluable resource is ultimately attributable to the many voluntary donors. Thus, the efficiency and timelines of the collection of blood from donors is crucial to the effectiveness of the blood supply chain. Working in partnership with the Welsh Blood Service, our aim is to improve the efficiency of the collection of blood and reduce wastage in the system. Through observation, preliminary data analysis, and simulation, we have identified that the scheduling of staff and appointments at donation clinics considerably influences the success of a clinic. Presently, the majority of clinics operated by the Welsh Blood Service are mobile and take place in over 500 different locations, with staff shifts varying greatly. From our review of existing literature on Operational Research methods for the collection of blood from donors, there is a significant lack of research into the scheduling of staff for blood donation clinics, and matching location planning to supply. With the use of methods such as simulation and mathematical programming, we aim to optimise both the assignment of staff to clinics, and the scheduling of appointments based on the donor panel of the clinic location. This will enable clinics to run more efficiently and effectively, thus increasing productivity and donor satisfaction.

Modelling and simulation; Staffing and capacity planning; Workforce planning; Decision support

P04 – Emma L Aspland – 30/07/2018 – 10:00 – 11:00
Smart Simulation and Modelling for Complex Cancer Systems
Aspland, E.L.[1]; Harper, P.R.[1]; Gartner, D.[1]; Webb, P.[2]; Barrett-Lee,P.[2]
[1]Cardiff University Cardiff UNITED KINGDOM ;
[2]Velindre Cancer Centre Cardiff UNITED KINGDOM ;

Lung cancer is in the top ten causes of death, the most common cause of cancer death in men, and second most common in women, worldwide. Cancer mortality can be reduced with early treatment

and detection, and suggests that this is where the need for improvement lies. Hospital information systems are increasingly used as part of decision support tools for planning on the strategic, tactical, and operational decision levels. Clinical pathways are an effective and efficient way to standardise the progression of treatment, which in effect can reduce the pressure and problems surrounding subject areas that decision makers have to address. This research, in partnership with Velindre Cancer Centre, the largest specialist cancer centre in Wales, has the overall goal to improve patient care and outcomes by reducing time to diagnosis and treatment times for those with lung cancer. Our review of the current literature has highlighted that a view of the complete pathway, from entering to leaving the system, should incorporate patient, staff and admin activities along the way. The way in which these three types of activities are considered will produce the unique aspect of this work. Data mining and machine learning techniques will be used to discover the clinical pathways, along with observations and consultation with those who interact with the pathways day to day. The pathway will then be simulated and allow for some scenario analysis. We aim to bridge the gap between data mechanics and operational research, to produce a state-of-the-art decision support tool to allow Velindre Cancer Centre to align capacity to best match demand in an effective and efficient manner.

Care Pathways; Modelling and simulation; Clinical modelling; Decision support

P05 – Joren Marynissen – 30/07/2018 – 10:00 – 11:00
Multi-appointment scheduling in a diagnostic facility
Marynissen, Joren; Demeulemeester, Erik
KU Leuven Leuven BELGIUM ;

As shown in recent review articles, the (centralized) scheduling problem of patients who require multiple (and interrelated) appointments has gained recent attention in the healthcare literature. In this research, we try to extend this literature by studying a real-life diagnostic facility in which patients need to be scheduled on multiple diagnostic resources. The goal of this problem is to sequentially schedule all patients such that a weighted objective function is optimized. This objective function focuses on the in-hospital waiting time of patients, the number of days on which patients need to visit the hospital and provider idle time. Using a discrete-event-simulation model, we measure the effect of different scheduling methodologies on the performance of the system. These scheduling methods include heuristics as well as optimal methods.

Modelling and simulation; Patient scheduling

P06 – Mary Conlon – 30/07/2018 – 10:00 – 11:00
Profiling the patient, from a radiology perspective, for agent based simulation.
Conlon, Mary[1]; Molloy, O.[2]
[1]NUIG Galway IRELAND ;
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The aim of this work is to create a patient agents which can potentially be used in other radiology related models and disciplines.. A wide variation in patient complexity can result in staff experiencing burnout and occupational injuries and see patients receiving sub optimal care and outcomes. Quantitative data, from 2011 to 2017, was gathered from the hospital information system (HIS) and radiology information system (RIS). Six months of phone records, exam data on patient age, gender, types and numbers of radiology examinations, and scheduling/emergency

arrival patterns as well as staffing levels from 2011 to 2017 were analysed. Qualitative data was gathered through onsite observation, interviews and 62 radiographer questionnaires. This data was used to inform the parameters when the patient was included as an agent in a discrete event simulation of the radiology department. Anylogic PLE was used to develop a generic DES/ABS model for the CT (Computed Tomography) department. Infection: Infection rates are seen to be stagnant over the time period with 8.8% of patients reported as infectious. Using logistic regression it can be seen that probability of infection increases with age up to a maximum of 34% of patients by the age of 80. Exam complexity was determine based on use of IV and oral contrast. A national survey of radiographers (52 respondents) showed departments scanning on average 34.6 patients per day, with a 16% infection rate and 26% of patients reported as immobile, The sample department had a maximum, minimum and mode of 12,36,22 patients per day. The patient and radiographer agents created in this model can potentially be used in other radiology related models as parameters such as mobility and infection and patient care are common among patients. The factors affecting patient complexity should be individually assessed and minimised.

Patient flow; Workforce planning; Decision support; Data analysis and risk management

P07 – Joe Viana– 30/07/2018 – 10:00 – 11:00
Using a hybrid DES-AB simulation model to improve patient flow in an overdue pregnancy outpatient clinic

Viana, Joe[1]; Simonsen, T.B[2]; Flo, K[3]; Faraas, H.E[3] ; Schmidt, N[3]; Dahl, F.A.[4]
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[2]Health Service Research Unit, Akershus University Hospital Lørenskog NORWAY ;
[3]Department of Obstetrics, Akershus University Hospital Lørenskog NORWAY ;
[4]Health Services Research Unit, Akershus University Hospital Lørenskog NORWAY ;

Aims: This paper presents technical details of the hybrid discrete event simulation (DES), agent based model (ABM) of an overdue pregnancy outpatient clinic that was first introduced as a poster at ORAHS 2017. The clinic is subject to stochastic arrivals, due to pregnant women giving birth before their appointments, which makes scheduling of staff and appointments challenging. The current outpatient clinic operates weekday mornings, and the number of patients arriving each day can vary from 010. The number of patients scheduled to arrive can vary from 320. Appointments have increased due to an increase in the size of the catchment area the hospital serves coupled with changes to the overdue pregnancy pathway in Norway which were introduced in 2011.

Methods: The agent component is used to represent the mothers and the healthcare professionals and the discrete event component to represent the outpatient clinic, and the parallel clinics which compete for certain shared resource, waiting areas, reception staff and other staff. The model is being developed in collaboration with the obstetrics department at Akershus University Hospital.

Results: The model is designed to assess alternative: i) clinic staffing strategies, ii) changes to pathways/processes performed in the clinic, iii) changes to arrival patterns, iv) changes in opening times, and other increases to capacity. New scenarios have been proposed by members of the research team (obstetrics department and the health services research unit) which will be evaluated and presented with respect to 6 representative historical weeks of data.

Discussion: The model been updated significantly since 2017. Better data has been collected from hospital information systems; in addition an extensive data elicitation was conducted with several members of staff from the obstetrics department to enhance the model.

Patient flow; Modelling and simulation; Decision support; Care Pathways

P09 – Mohammad Jarrahi – 30/07/2018 – 10:00 – 11:00
Prioritization of lean tools in emergency departments using analytical hierarchy process (AHP)

jarrahi, mohammad; Shokouhyar, sajjad; abdoli, mohsen
shahid beheshti university tehran IRAN (ISLAMIC REP.) ;

Purpose: The purpose of this paper is determination and lean thinking tools' Prioritization in emergency departments from the physicians and nurses' viewpoints. Methodology: In the first stage, using literature review, an appropriate model was selected for finding lean tools selection criteria and indicators. In the second step, the selected criteria's accuracy was investigated and most important of them were selected using experts' opinion. In the third stage criteria and tools are compared and ranked using a questionnaire. In the fourth stage, final ranking of lean tools was done using AHP and data obtained from the third step. Finding: In this paper we find that, in physician's viewpoint, criteria such as patients' satisfaction, percentage of patients admitted within six hours, mean triage time on each level and treated patients volume were respectively prioritized. Also, they prioritized the following tools in order of importance: Theory of Constraints (TOC), Poka-yoke, 5s, Value stream mapping (VSM), Kaizen and Jidoca. The nurses also prioritized the following criteria in order of their importance: percentage of admitted patients within six hours, patient satisfaction, treated patients volume and average duration of triage on each level. The nurses also prioritized the following tools in order of their importance: 5s, TOC, Jidoca, VSM, Poka-yoke and Kaizen. Originality/Value: Offers the appropriate approach for leadership and increase productivity in emergency departments.

Emergency Medical Services; Decision support; Performance evaluation

P10 – Thierry Chaussalet – 30/07/2018 – 10:00 – 11:00
Visualising the Diabetes Population in North West London

Chaussalet, Thierry[1]; Moniz Rodriguez, D[1]; Willis, T[2]
[1]University of Westminster London UNITED KINGDOM ;
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Diabetes is a leading cause of mortality and ill health in the UK. In North West London, 6.5% (142,000) people have been diagnosed with diabetes and contribute to 22% of NHS spend, 41% of hospital admissions and 63% of inpatient bed days, with another 190,000 estimated to be in the prediabetes category.

The NW London CCGs collaborative is implementing a diabetes transformation programme across North West London to address this and is investing in digital tools to support care improvements. This includes a suite of dashboards on our Whole Systems Integrated Care record, which hosts one of Europe's largest integrated care records, combining over 2m GP and hospital records linked by NHS number.

Here we present the development of an interactive dashboard with visualisations for clinicians to improve the diabetes' patients care in North West London. This will allow clinicians to view data in a different way from their traditional ways from the traditional view of events through several visualisations including geomapping, time series analysis of improvements in care, Sankey diagrams of various factors to understand patient's care flow in the system across the North West London population and to provide patients with the best possible recommendations.

Data analysis and risk management; Healthcare Information Systems; Decision support

P12 – Kerry Pearn – 30/07/2018 – 10:00 – 11:00

Visualisation of the service use for individual clients with a Personality Disorder at Devon Partnership Trust to support clinical decision making

Pearn, Kerry[1]; Manzi, S[1]; Winterton, L[2]
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[2]Devon Partnership NHS Trust Exeter UNITED KINGDOM ;

In Devon (county in South West England) the mental health services are provided by Devon Partnership Trust (DPT). DPT are aware that clients diagnosed with a Personality Disorder (PD) utilise a large volume of their services, which comes with the associated high cost. DPT commissioned a project to help them understand the patterns and trends that PD clients access their services, to inform decisions regarding system improvements. As part of this project we developed clear visualisations of individual client's service use, based on a novel application of the Gantt Chart format. This visualisation captures and delivers the information in an easily accessible format, thus offering clinicians a visualisation tool to use both before and during a patient consultation that has the potential to save resources. (1) Time saved: A quick glance at the graphic provides information to a clinician that would otherwise require up to 20 minutes to scan pages text; (2) Appointments saved: Using the graphic during client consultations to aid the discussions regarding their previous service use, and to explore together patterns of previous service use that did not have the desired outcome (preventing repetition). In response to the clinicians enthusiasm to have access to these individual client service use graphics, DPT plan to electronically embed the service use visualisations within their existing care notes so that they can be produced automatically on demand from data already on their system. Discussions are ongoing to tailor the visualisations to embed more information (such as waiting times, number of contacts and cost of services).

Care Pathways; Patient flow; Healthcare Information Systems; Decision support; Strategic and operational planning

P13 – Sara Saadatmand – 30/07/2018 – 10:00 – 11:00

Multi-objective Scheduling in Clinics with Cancellation and Walk-In-Patients Using Genetic Algorithm and Pareto Approach

Salimifard, Khodakaram; Saadatmand, Sara
Persian Gulf University Bushehr IRAN (ISLAMIC REP.) ;

This research focuses on clinic scheduling problem where patients are assigned to a specific time slot to be visited by a doctor. The main objective of this research is to find an optimal scheduling for clinic with open access and walk-in patients. In order to satisfy the multi objective nature of the problem, an integer programming model is developed. Due to the NP-hard property of the model, it is then formulated in Genetic Algorithm, where a chromosome represents a feasible scheduling

template. In order to overcome the complexity of the calculation of different objective functions, the model is solved using the NSGAII metaheuristic algorithm. The solution procedure has efficiently produced Pareto front, where a set of non-dominant solutions is obtained. Research results show that for a single day, the obtained scheduling template assigns suitable time slots to all types of patients including those having appointments, walk-ins, and open access. The scheduling has also minimized patients waiting time, doctor overtime and ideal time. The modelling approach and the solution procedure were sufficient enough to capture the complexity of the problem and to generate optimal solution. Since the proposed model is a multi-objective optimization, it could be used to automatically generate scheduling templates to satisfy both patients and doctors.

Patient scheduling; Process optimisation

P14 – Angela Labberton – 30/07/2018 – 10:00 – 11:00
Access to hospital-based rehabilitation among older Norwegian stroke unit patients
Labberton, AS; Rønning, OM; Thommessen, B; Barra, M
Akershus University Hospital Lørenskog NORWAY ;

Background: Stroke survivors often have complex and persisting impairments requiring multidisciplinary rehabilitation after the acute phase. A greater understanding of which patient and disease factors are related to referral to institution-based rehabilitation will help direct planning of future health care service provision. Aims: To investigate characteristics of stroke unit patients in relation to referral to specialised neurological rehabilitation by the acute treatment team, and to construct a predictive model for referral. Methods: A cohort of stroke patients aged 60 years and over admitted to the stroke unit at a large university hospital in Greater Oslo and Akershus County, Norway, between February 2012 and March 2013, was studied to determine patient and disease factors related to referral to the hospital's neurological rehabilitation unit. Predictive models were estimated using logistic regression and Akaike inclusion criteria for model selection. Results: Four hundred and fifty patients were included in the analysis, mean age was 78.7 years and 48.7% were female. One third of patients admitted with stroke were referred to the hospital's neurological rehabilitation unit and one fifth were discharged to the unit. The independent variables positively associated with referral to rehabilitation in the final model were younger age, no history of cognitive impairment or dementia, living in the community, and requiring assistance on functional testing post-stroke. Conclusion: One third of older Norwegian stroke unit patients were referred for institution-based neurological rehabilitation. Several pre-morbid patient-related factors were important in the assessment; however the only significant disease-related factor was the outcome of functional assessment following their stroke.

Access and waiting lists; Care Pathways

P15 – Fredrik Dahl – 30/07/2018 – 10:00 – 11:00
Digital Mushroom Identification Tools - Utilizing Human Expertise and Machine Learning
Dahl, Fredrik A[1,2]; Johansen, L[3], Havre, RD.[4]; Wallin, T[4]; Jenssen, KM[5]; Karlsen, P[3]
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[2] University of Oslo, NORWAY;
[3] Norwegian Association for Mycology and Foraging, Oslo, NORWAY;
[4] Appfabrikken AS, Oslo, NORWAY;
[5] Mycoteam AS, NORWAY;

We developed a smartphone app for electronic mushroom identification in Norway. The user takes images of a mushroom in the field. The images are submitted to a human certified mushroom identification expert, who classifies the mushroom according to its edibility/toxicity. The classification is sent back to the user and also stored in a central database. The app was very popular, and users submitted a total of 22 713 mushrooms over a period of 10 weeks during the 2017-season. Based on this image database, we are training neural nets to imitate the classification of the human experts, with the ultimate goal of developing a fully automatic mushroom classification system. The preliminary results are promising, but there are still problems to be solved. In particular, it is challenging to train the neural net to recognize some of the most poisonous species, which are rare. There are obvious health benefits in preventing mushroom poisonings. The current man-in-the loop app provides a cost-efficient means of prevention, and a fully automatic system will improve this further.

Data analysis and risk management

AHO posters
A selection of posters from students of The Oslo School of Architecture and Design (AHO) will be presented.

MD1 – Operating Room Scheduling I – 30/07/2018 15:30 – 17:00
Chair – Margaret Brandeau   Room: FORUM

MD1-1: Lisa Koppka – 30/07/2018 15:30 – FORUM
Operating theater planning to maximize the probability of immediate surgery for emergencies
Koppka, Lisa
Ruhr University Bochum Bochum GERMANY ;

Hospitals need to consider elective patients as well as emergencies when scheduling the operating theater. An urgent emergency surgery can start as soon as an operating room (OR) is available. Hence, the emergency patient mostly has to wait until an elective surgery ends. Existing literature proposes a deterministic approach for scheduling elective patients that distributes the end times of surgeries evenly over the day. That way, they allow for enhanced access to an OR in case of sudden emergencies. In reality, treatment times for emergencies are not precisely predictable. Therefore, we present a stochastic extension of the existing approach: we maximize the probability of an emergency to be assigned to an operating room within reasonable time by advantageously scheduling elective patients. A simulation study is applied to verify the operational performance.

Operating room planning and scheduling; Modelling and simulation; Performance evaluation

MD1-2: Anders Gulhav – 30/07/2018 16:00 – FORUM
Master surgery scheduling under uncertainty: a stochastic modelling approach for dimensioning and allocating flexible capacity under a hybrid policy
Gullhav, Anders[1]; Bovim, TR[1]; Christiansen, M[1]; Hellemo, L[2]; Range, TM[1]
[1]Norwegian University of Science and Technology Trondheim NORWAY ;
[2]SINTEF Technology and Society, Dept. of Economics and Technology Management Oslo NORWAY ;

There are well-known trade-offs between hospital costs and patient waiting time in operating room (OR) planning due to several sources of variability, with the variability in arrivals of non-elective patients being an important one. In this study, we consider elective patients and three categories of non-elective patients with different levels of urgency: two urgent patient categories with target times 6 hours and 24 hours, respectively, and one semi-urgent patient category with target time 5 days. To tackle the trade-off between cancellation of electives and the waiting times for non-elective patients, we design a hybrid OR scheduling policy, where some ORs are dedicated for non-elective patients and others include flexible slots to handle the overflow of semi-urgent patients. This is done by addressing the problem of constructing a weekly, cyclic master surgery schedule (MSS), with the main decisions being the allocation of elective OR slots to medical specialties, and the dimensioning and allocation flexible slots. We regard the ORs, surgeons, anesthetists, and bed wards as resources. We develop a novel two-stage stochastic integer programming model (SIP) to create MSSs based on the uncertain demand for flexible slots. The scenarios reflect the uncertain weekly number of semi-urgent overflow patients, and the number of non-elective patients occupying beds at the wards. A discrete-event simulation model is used to evaluate the proposed MSS, and generate new scenarios as input to the SIP. The SIP and the simulation model are run iteratively. We provide numerical results of our approach on both constructed and real-world cases. The real-world case is from the orthopedic department at St. Olavs hospital in Trondheim, Norway. Our results show that we are able to model important trade-offs in OR planning, and show that allocating flexible slots for the overflow of non-elective patients is beneficial in certain cases.

Operating room planning and scheduling

MD1-3: Margaret Brandeau – 30/07/2018 16:30 – FORUM
Improving the Efficiency of the Operating Room Environment with a Generalizable Optimization and Machine Learning Model
Brandeau, Margaret; Brandeau, Margaret
Stanford University Stanford, California UNITED STATES ;

The operating room is a major cost and revenue center for most hospitals. Thus, more effective operating room management and scheduling can provide significant benefits. In many hospitals, the post-anesthesia care unit (PACU), where patients recover after their surgical procedures, is a bottleneck. If the PACU reaches capacity, patients must wait in the operating room until the PACU has available space, leading to delays and possible cancellations for subsequent operating room procedures. We develop a generalizable optimization and machine learning model to sequence operating room procedures so as to minimize delays caused by PACU unavailability. Specifically, we use a machine learning approach to estimate the required PACU time for each type of surgical procedure, we develop and solve two integer programming models to schedule procedures in the operating rooms so as to minimize maximum PACU occupancy, and we use discrete event simulation to compare our optimized schedule to the existing schedule. Using data from Lucile Packard Children's Hospital Stanford, we show that the scheduling system can significantly reduce operating room delays caused by PACU congestion while still keeping operating room utilization high. We are currently working on implementing the scheduling system at the hospital.

Operating room planning and scheduling; Modelling and simulation; Decision support

MD2 – Ambulance/Vehicle Routing I – 30/07/2018 15:30 – 17:00
Chair – Ettore Lanzarone   Room: Hagen 1 + 2

MD2-1: Samuel Ridler – 30/07/2018 15:30 – Hagen 1 + 2
Performance Comparison of Dynamic Ambulance Redeployment Strategies
Ridler, S.J; Mason, A.J; Raith, A
The University of Auckland Auckland NEW ZEALAND ;

Emergency Medical Services are commonly required to maintain a minimum level of service that specifies target response times for emergency medical calls. Dynamic redeployment can help in ensuring that these service levels are met. Dynamic redeployment involves reassigning available ambulances to ambulance stations or standby locations in real time, in order to cover for ambulances that are currently busy responding to emergencies. Many different dynamic redeployment strategies have been created in the literature, and the performance of most of them has been evaluated with simulation, but different simulation models have been used, so the relative performance of each dynamic redeployment strategy is not known. A comparison of performance for various dynamic redeployment strategies with a single simulation model will be presented.

Emergency Medical Services; Ambulance management; Benchmarking; Modelling and simulation

MD2-2: Ana Sofia Carvalho – 30/07/2018 16:00 – Hagen 1 + 2
Solving ambulance dispatching and relocation using a time-preparedness metric
Carvalho, Ana Sofia; Captivo, M.E.; Marques, I.
Universidade de Lisboa Lisbon PORTUGAL ;

In the Emergency Medical Service (EMS) environment, emergencies occur randomly in the area under study. In this context, an emergency is an occurrence such as an accident or a suddenly or unexpectedly health problem that needs fast medical assistance in order to avoid harmful results in the involved victims' or patients' health. This work focuses on ambulances' action to respond to urgent emergency requests. The decision-making process plays a very important role to help EMS managers in strategic, tactical and operational decisions. We focus on the operational level by solving the ambulance dispatching and relocation problems. Ambulance dispatching decisions assign ambulances to emergencies and the relocation problem decides to which base (re)assign available ambulances. An effective and efficient EMS response is needed, so it is essential to have an optimized system. We propose a mathematical model and a pilot-method heuristic with an integrated optimization approach for the dispatching and relocation problems. To evaluate the quality of the system, a time-preparedness metric is considered and calculated for a fleet of available ambulances at the current time period. The main goal is to ensure the sustainability of the system, i.e. a good system's preparedness for emergencies on the current period and on the future. It is of maximum importance not to have current uncovered emergencies and to provide a good service level within the maximum response time. Some experiments are performed to test different dispatching policies and relocation rules. EMS data from Lisbon, Portugal, where solving these problems has been a handmade task, are used to validate the effectiveness and efficiency of the proposed approaches.

Ambulance management; Emergency Medical Services; Decision support

MD2-3: Ettore Lanzarone – 30/07/2018 16:30 – Hagen 1 + 2

A Recursive Simulation-Optimization Tool to Estimate the Busy Fractions in the Ambulance Location and Dispatching Problem

Lanzarone, Ettore[1]; Galluccio, E[1]; Bélanger, V[2]; Nicoletta, V[3]; Ruiz, A[3]

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[2]HEC Montréal Montréal CANADA ;

[3]Université Laval Québec CANADA ;

Emergency Medical Services (EMS) are crucial in health care systems. They provide out-of-hospital acute medical care and transportation to an appropriate health center for injured and ill people. The Ambulance Location and Dispatching Problem (ALDP) identifies the location of the available ambulances and provides at the same time a dispatching policy, in order to minimize the expected response time to answer the calls. In particular, the ALDP considers an ordered dispatching list for each demand zone. When a call arises from a zone, the first available ambulance in its dispatching list is sent to answer the call; if no vehicles in the list are available, the closest available ambulance is sent; if no vehicles are available at all, the call is redirected to another service. However, the uncertain nature of the calls makes it impossible to know in advance if the ambulance identified by the dispatching policy will be available or not when the call arises. Thus, the probability that a vehicle is busy, denoted as busy fraction, is considered in the ALDP. While the description in terms of busy fractions is common in the literature, the corresponding probabilities that ambulances answer a call can be estimated in several manners. We propose in this work a new recursive simulation-optimization framework to fairly estimate them. In particular, we develop and compare four approaches, which are based on either the Bernoulli probability law or the queuing theory. Tests are conducted on realistic instances inspired by the city of Montréal, Québec, Canada. Results are evaluated in terms of the simulated response time and the gap between the planned response time from the optimization and the simulated one. Numerical results confirm that all approaches (especially the most complicated one) improve the performance with respect to an a priori evaluation of the busy fraction.

Ambulance management; Modelling and simulation; Decision support

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MD3 – Blood Supply Chain – 30/07/2018 15:30 – 17:00

Chair – John Blake   Room: VIA

MD3-1: Inês Marques – 30/07/2018 15:30 – VIA

Blood supply chain planning: the Portuguese case

Marques, Inês[1]; Araújo, A.M.[1]; BarbosaPóvoa, A.[1]; Marques, Inês[2]

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The blood supply chain comprises the procurement and tracking of blood and blood components from donor to recipient. For this, the blood supply chain encompasses several day-to-day activities, which include collecting, testing and processing blood and blood products prior to their distribution. Blood products are transfused to patients as part of routine medical treatments or surgical operations and in emergency situations. The availability of the right blood products at the right time in the right quantity is critical for the health provision since shortages can be fatal to patients. A

shortage in blood supply may hinder scheduled procedures or even result in a patientÂ´s untimely death, therefore potentially having a negative impact in the health status of the patients. On the other hand, surplus may be proceeded by outdates which have significant repercussions society-wise, as it is ethically wrong to waste such a valuable and scarce commodity with increasingly lower donation numbers. Besides being perishable products, matching supply and demand is particularly challenging, the supply of donor blood being irregular, while the demand for blood products is highly stochastic. Most of the literature on this topic focuses on each echelon of the supply chain, and literature focusing on the Portuguese blood supply chain is non-existing. With this work, we intend to shed some light on the Portuguese case and mitigate weaknesses and challenges of this specific system. One example is the regional imbalance of the supply chain with most of the donors being in the north and the high consumption rate in the south. The aim of this work is to characterize the Portuguese blood supply chain and to improve the main identified sources of inefficiencies by proposing a model to handle tactical and operational decisions. The overall goal is to meet demand while reducing wastage and minimize costs.

Capacity and network planning

MD3-2: Semih Yalçındağ – 30/07/2018 16:00 – VIA
Appointment Scheduling for the Blood Collection Process: A Two-Stage Framework to Balance the Production of Blood Units
Baş Güre, S.[1]; Carello, G.[2]; Lanzarone, E.[3]; Yalçındağ, S[1]
[1]Yeditepe University Istanbul TURKEY ;
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Blood is fundamental in several care treatments and surgeries, and plays a crucial role in the healthcare system. However, it is a limited resource as it can be produced only by donors and its shelf life is short. The Blood Donation (BD) system aims at providing an adequate supply of blood bags to transfusion centers and hospitals. Its main phases are blood collection, screening, storage, distribution and utilization. An effective collection of blood bags from donors, through suitable scheduling of donations, is fundamental for adequately supplying the entire BD system and optimizing blood usage. Nevertheless, despite its relevance, donor scheduling is only marginally addressed in the literature, while on the contrary a high number of papers deal with blood storage and distribution. In this work, we define the Blood Donation Appointment Scheduling (BDAS) problem, which aims at balancing the production of units among days for the different blood types, in order to provide a near constant supply of blood units to the BD system. We propose a framework for the BDAS that accounts for both booked and non-booked donors. It consists of an offline Mixed Integer Linear Programming model for preallocating time slots to the different blood types, and an online prioritization policy to assign a preallocated slot when a donor calls to make the reservation. Results from the application to one of the main blood collection centers in Italy (i.e., the AVIS Milan) show the applicability of the approach and provides good results in terms of production balancing. Finally, we also discuss two directions of improvement to include the random arrival of donors in the preallocation model: a robust approach (based on the cardinality constrained approach) and a stochastic approach (conditional value at risk).

Patient scheduling

MD3-3: John Blake – 30/07/2018 16:30 – VIA
8 Days a Week: Lessons from the Implementation of Extended Shelf Life Platelets

Blake, John
Canadian Blood Services Halifax CANADA ;

BACKGROUND: In July 2017, Canadian Blood Services adopted an enhanced bacterial detection algorithm for platelets. This allowed Health Canada to extend the shelf life for platelets from five to seven days. While enhanced bacterial detection came at a cost, savings due to reduced shelf life was anticipated to partially offset these costs. In an earlier paper we showed that wastage rate would decline by 16% with each day's extension in the usable shelf life of platelets. We also showed that a reduction in wastage of 40-50% is necessary to make the adoption of extended shelf life platelets cost neutral. Following implementation of extended shelf life, a reduction in platelet wastage was indeed. Overall wastage declined by 20%. However, when small area variations were examined, it was noted that wastage rates did not decline uniformly throughout the country. In this paper we present the experience of Canadian Blood Services with platelet wastage prior to and following the implementation of extended shelf life. We describe modelling efforts to optimize the production, delivery, and inventory parameters of a regional blood supply chain post-implementation.
STUDY DESIGN AND METHODS: We extended our earlier simulation to evaluate the systemic impact of an extended platelet shelf life within a specific region in Canada. A network model of the platelet supply chain, for a large region with a highly dispersed population was built and validated. A seven-day platelet shelf life was assumed and a series of experiments was executed with the model. Experimental parameters included changes to both supplier and consumer inventories, modifications to delivery schedules, and revisions to collection timing and mix. RESULTS: Model results suggest that changes to the collection mix, followed by optimization of consumer inventories will have the greatest impact on platelet wastage within the region.

Modelling and simulation; Strategic and operational planning; Process optimisation

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MD4 – Emergency Medical Systems I – 30/07/2018 15:30 – 17:00
Chair – Honora Smith   Room: Hagen 3

MD4-1: Davide Duma – 30/07/2018 15:30 – Hagen 3
Resource allocation in an Emergency Department: an online optimisation approach

Duma, Davide; Aringhieri, R
Department of Computer Science, University of Turin Torino ITALY ;

The Emergency Department (ED) management is highly complex due to the admissions of patients with a wide variety of diseases and different urgency, which require the timely execution of different activities involving human and medical resources. Furthermore, unpredictability and high variability of the patient arrivals make resource allocation a very challenging problem. For these reasons, overcrowding is a widespread issue affecting the performance of the ED and may affect the quality and access of health care. In this talk we deal with the overcrowding problem at the ED sited at Ospedale Sant'Antonio Abate di Cantu', Italy.

We propose an approach divided into two phases. In the first phase, to deal with the unstructured ED process we develop an ad hoc process mining algorithm to discover the patient flow. Such an

algorithm allows us to obtain a process model capable (i) to replicate properly possible patient paths, and (ii) to predict the next activities to be performed. In the second phase, we propose a Discrete Event Simulation (DES) model to represent the ED process, in which several online optimisation policies are embedded to deal with the resource allocation. Such policies exploit the prediction mined from the ED dataset in the first phase of our approach.

A quantitative analysis is provided to compare the online optimisation methods with the real case policy, focusing on performance indices that take into account the patient-centred perspective. Results prove the adequacy of online optimisation for the considered problem. Using simple online policies that exploit prediction provided by the process discovery, we are able to reduce significantly the waiting time and the duration of the whole care process, and to have a less crowded environment in which the medical staff can work better also from a qualitative point of view.

Care Pathways; Process optimisation; Modelling and simulation

MD4-2: Mario De Oliverira – 30/07/2018 16:00 – Hagen 3
Modeling and Simulation of the Intensive Care beds in the State of Rio de Janeiro
De Oliveira, Mario Jorge Ferreira; De Moraes, Raphael Soares
Federal University of Rio de Janeiro Rio de Janeiro BRAZIL ;

The accessibility and quality of health services has been a growing problem in Brazil due to the complexity of planning and the lack of adequate investments in response to the increase in demand. Among the many essential services to the wellbeing of the population, the access to Intensive Care Unit (ICU) beds is fundamental for the maintenance of life in extreme cases, when the patient often cannot wait for the availability of beds. In this context, the present study intends to provide a basis for the dimensioning of the supply of ICU beds according to regions of the State of Rio de Janeiro. The objective is to develop discrete event simulation models that represent the use of these beds, with variations in supply and demand, in several levels of comprehensiveness. The simulation models created sought to address different aspects of the problem. Five models are proposed. The goal is to evaluate the balance between supply and demand. Model 1 involves a broader scenario with all types of ICUs. Model 2 provides separated analyses for each type of ICU. Model 3 evaluates each type of ICU in each region of the State. Model 4 evaluates each region of the state including reallocation of patients between regions. Model 5 analyses each type of ICU throughout the state besides observing the number of denials of hospitalization. The scenarios created for the experiments allow us to analyze the average waiting time for a vacancy and the number of hospitalizations, among other measures of interest. One hopes that this study should contribute to the future planning of ICU beds for the State population as well as to assist in evaluating the current offer, allowing the identification of deficiencies and needs that exist today.

Access and waiting lists; Capacity and network planning; Modelling and simulation: Patient flow

MD4-3: Honora Smith – 30/07/2018 16:30 – Hagen 3
Referral propensity of out-of-hours doctors: simulation of the Oxfordshire service
Smith, Honora[1]; Lasserson, D. S.[2]; Hayward, G.[3]
[1]University of Southampton Southampton UNITED KINGDOM ;
[2]Institute of Applied Health Research, University of Birmingham Birmingham UNITED KINGDOM ;
[3]Nuffield Department of Primary Care Health Sciences, University of Oxford Oxford UNITED KINGDOM ;

The emergency departments (EDs) of UK acute hospitals are currently overloaded in terms of capacity to handle patients. This is an investigation of the effects of variations in "referral propensity" of clinicians in the out-of-hours (OOH) service. Each clinician has a different probability of referring patients to more specialised care, such as to ED or another route to acute hospital admission. Data have been analysed concerning all patient contacts with the Oxfordshire OOH service over the period December 2014 to December 2015. Several simulation models have been run to investigate the effects of different scenarios for referral propensity. Data analysis shows lower average percentages of referrals to acute hospitals when comparing regular OOH General Practitioners (GPs) from Oxfordshire GP practices with registrars (trainees), non-regular GPs, and GPs from practices outside Oxfordshire. These results hold for all types of final contact with patients, whether base visits, telephone calls or home visits. Considerable variations have been found when comparing individual clinician referral rates. Simulation models were built representing the shifts undertaken by clinicians, albeit in a simplified manner. Scenarios were run with referral probabilities capped to a fairly modest extent. Results demonstrate the possible reduction in number of contacts referred by the OOH service during the course of an average week.

Modelling and simulation; Capacity and network planning; Data analysis and risk management

TUA1 – Emergency Medical Systems II – 31/07/2018 09:00 – 10:30
Chair – Melanie Reuter-Opperman   Room: FORUM

TUA1-1: Dandan Shi – 31/07/2018 09:00 – FORUM
Effective Provisions of Critical Care Services

Shi, Dandan; Smith, H.K; Currie, C.S.M
University of Southampton Southampton UNITED KINGDOM ;

Demand for critical care services is increasing and there is pressure on hospitals to improve the efficiency of delivering the service. A UK Intensive Care Unit (ICU) provides a case study for this research. Of particular interest here is the impact of 'late admissions', which account for 13.8% of all first-time admissions to this ICU. Patients admitted to the ICU more than a day after entering the hospital are shown to have higher mortality rates and to stay longer in the ICU. The overall performance of the prediction models developed in this project is better than using established scoring systems directly. Including late admission as a predictor can significantly enhance the performance of both mortality and Length of stay (LoS) prediction models. A new method for modelling LoS has been tested and applied. LoS was split into three subparts, admission hour, nights spent in the ICU and discharge hour. Empirical distribution functions were used to model these subparts for different admission groups. We describe a Discrete Event Simulation (DES) model, populated and validated using data from the ICU, to investigate the impact of the late admission group and strategies for improving efficiency. Key findings of scenario tests are as follows. 1. Stress tests show that the number of ICU beds rather than nurses are more critical resources to the ICU. 2. With everything else kept unchanged, bringing in patients earlier can save lives and resources. 3. Controlling the discharge time of patients to be within four hours of discharge decisions does not have a significant impact on ICU throughput. We also consider an epidemic scenario for contagious diseases, designed to simulate possible critical situations.

Staffing and capacity planning; Patient flow; Statistical modelling; Modelling and simulation

TUA1-2: Marion Penn – 31/07/2018 09:30 – FORUM
A mixed methods study of the impact of consultant overnight working in an English Emergency Department: Should Emergency Department consultants work more night shifts?

Penn, Marion[1]; Monks, T.[1]; Pope, C.[1]; Clancy, M.[2]
[1]National Institute for Health Research Collaborations for Leadership in Health Research Applied Research and Care Wessex, Univ Southampton UNITED KINGDOM ;
[2]Accident and Emergency Services, University Hospital Southampton National Health Service Foundation Trust Southampton UNITED KINGDOM ;

In the United Kingdom Emergency Departments (EDs) are facing increasing pressures, with the extent of breaches of the national target for 95% of patients to be through ED within 4 hours regularly discussed in the national press. One of the suggested solutions to this is to have consultant level doctors working overnight in EDs. A local hospital had had consultants working nights Monday to Thursday for over a year and asked us to analyse the impact of this and model the expected impact of extending consultant overnight working to Friday-Sunday. This talk will cover the variety of quantitative and qualitative methods, including interrupted time series analysis, which we used to explore the impact of existing consultant night working. Outcome measures included total time in ED, time to be first seen, time to allocate a bed and admit patients where needed and proportion admitted. We also considered the opinions of a variety of ED medical staff through semi-

structured interviews. We were unable to identify an impact of consultant working on the quantitative metrics chosen, and our recommendations are that if this is considered then further evidence is needed to justify it. This talk will also explore potential patient flow issues identified in the course of our analysis and suggested further work.

Emergency Medical Services; Staffing and capacity planning; Workforce planning; Performance evaluation; Statistical modelling

TUA1-3: Melanie Reuter-Opperman – 31/07/2018 10:00 –FORUM
Towards a decision support tool for EMS management in Germany
Reuter-Oppermann, Melanie[1]; Rachuba, S.[2]; Manzi, S.[3]; Morana, S.[1]; Hottum, P.[1]
[1]Karlsruhe Institute of Technology Karlsruhe GERMANY ;
[2]University of Wuppertal Wuppertal GERMANY ;
[3]University of Exeter Exteter UNITED KINGDOM ;

This research project aims at studying necessary aspects for designing a decision support tool for Emergency Medical Services (EMS) management in Germany. It combines knowledge from different disciplines like (Behavioural) Operations Research (BOR/OR), Information Systems (IS) and Service Science. The aim is to support dispatchers and EMS managers with various backgrounds to make decisions on various planning problems on different levels for varying time horizons. The research also intends to bridge the gap between academic OR and the use of OR in practice. User assistance systems investigated in IS research can help decision makers in practice, especially by offering potential solutions to these planning problems and explaining the options and solution processes. For example, it can assist dispatchers by proposing which ambulance to assign to an emergency or patient transport. Our goal is to investigate possible representations of solutions to logistical planning problems. In particular, we assess the relevance of available information and the usefulness of certain factors of the underlying problem in order to provide useful support to decision makers. We intend to contrast the decision makers' preferences and requirements with what has already been proposed in the literature. The idea is to see whether the parameters used in published planning models and approaches actually reflect the need of practitioners. As a first step, we contacted decision makers in an empirical study by means of web-based questionnaires. The results of the questionnaires show that decision makers have indeed different and often multiple objectives that need to be included in a decision support tool. Therefore, we aim to focus on multi-criteria approaches and will investigate in future work how many alternative solutions can be presented to a decision maker and how to display them. Initially, we focus on planning support for ambulance location and patient transport problems.

Emergency Medical Services; Ambulance management; Decision support; Healthcare Information Systems; Strategic and operational planning

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TUA2 – Ambulance/Vehicle Routing II – 31/07/2018 09:00 – 10:30
Chair – Valérie Belanger   Room: Hagen 1 + 2

TUA2-1: David Barrera -Ferro – 31/07/2018 09:00 –Hagen 1 + 2
A simulation optimization approach to the clinical specimen's collection and transport problem
Barrera -Ferro, David; Arango, L; Barrios, M; Noguera, M; Montoya, C

Pontificia Universidad Javeriana Bogota COLOMBIA ;

The proper collection and transport of clinical specimens plays a key role in the diagnosis of diseases and the quality of service. The delay in transport can, for example, lead to anaerobic infection or make it difficult to identify the pathogens present in a specimen. Furthermore, the lack of a logistical and operational structure for the storage and transportation of clinical specimens can put the health of the communities at risk. As in other complex problems of resource allocation, the use of formal techniques to support the decision-making process can positively affect the quality and sustainability of services. In this context, the development of models and tools for the design of collection routes and delivery of specimens has a high potential impact on the management of clinical laboratories. This work studies logistics processes of a health service provider company (EPS for its name in Spanish, Empresa Prestadora de Servicios de Salud) in Bogotá, Colombia. The EPS offers a service of collection and study of specimens for medical diagnosis collected in 178 laboratories. The samples are collected at the laboratories and transported to their corresponding processing center. Given that stochastic travel times are considered, a simulation optimization approach is proposed in order to solve the resulting vehicle routing problem. Particularly, a simheuristic structure was implemented using Tabu search for the optimization phase. The algorithm was tested using random instances generated from the historical records of the EPS. The results show a satisfactory performance of the metaheuristic in the deterministic version of the problem. Additionally, preliminary results shows costs saving by including variability in the optimization process.

Process optimisation; Modelling and simulation

TUA2-2: Pieter van den Berg – 31/07/2018 09:30 –Hagen 1 + 2
Exploring air ambulance base locations in Norway

van den Berg, Pieter[1]; Røislien, J.[2]; Lindner, T.[3]; Zakariassen, E.[3]; Aardal, K.[4]; van Essen, J.T.[4]
[1]Rotterdam School of Management Rotterdam NETHERLANDS ;
[2]University of Stavanger Stavanger NORWAY ;
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[4]Delft University of Technology Delft NETHERLANDS ;

Norway has a nationwide physician manned air ambulance service with 12 bases, established through historical local engagement from the 1970s. Government requirements state that 90% of the population should be reached within 45 minutes. Even though this target is met by the current set of bases, a wide political debate arose in Norway concerning the air ambulance coverage. Part of the debate was the question whether the 45 minute response time target should be reduced. Inspired by this debate, we initiated a project with the Norwegian air ambulance service to evaluate the current base structure. Using the Maximal Covering Location Problem (MCLP) facility location optimization model, we find the optimal helicopter base locations in different scenarios. In order to support the political decision making, we conduct three experiments to show the impact of certain political decisions. First, we quantify the impact of reducing the response time target to a stricter 30 minutes. The results show the financial implications of such a political decision. Second, we evaluate the impact of replacing the current population-based response time target to an incident-based target. Here, we find that a different set of bases would be selected if the covered incidents are maximized rather than the covered population. This shows that using population data as a proxy for the expected number of incidents leads to suboptimal decisions. Finally, we evaluate the impact of using fine grid data (1 km x 1 km squares) compared to the commonly used municipality data. Reducing the number of demand points from 55 213 (fine grid) to 423 (municipalities) does not lead

to a drastic change in the optimal base configuration. The results of these studies have been included in official studies by the Norwegian government on prehospital care.

Ambulance management; Emergency Medical Services; Strategic and operational planning; Modelling and simulation

TUA2-3: Valérie Bélanger – 31/07/2018 10:00 –Hagen 1 + 2
A multi-criteria districting approach for ambulance fleet management
Bélanger, Valérie[1]; Regis-Hernandez,F.[2]; Lanzarone, E.[2]; Ruiz, A.[3]
[1]HEC Montréal Montréal CANADA ;
[2]Consiglio Nazionale delle Ricerche (CNR) Milan ITALY ;
[3]Université Laval Québec CANADA ;

Emergency Medical Services (EMS) play an important role in modern healthcare systems. They provide fast response to any person requiring medical assistance in case of emergency, and ensure a safe transportation to the selected healthcare facility. The performance of an EMS, generally defined in terms of the response time, is strongly impacted by the many decisions related to the ambulance fleet management, which involve all decision levels, i.e., strategic, tactical and operational. At the strategic level, some organizations divide their territory into districts. A given number of vehicles is assigned to a district, and each district is managed independently. Such decentralized management aims at easing fleet management, but it can also result in poorer performance if districts are not carefully designed. However, in the practice, districts are often defined a priori, without considering the dynamics of the system. This may lead to undesirable consequences during operations, e.g. ambulances may be sent to serve out-of-district calls to compensate local criticalities and keep a good service level. In this work, we propose a solution framework to deal with the districting problem in EMS, with the goals of minimizing out-of-district assignments and balancing the workload among the districts. The approach consists of an iterative matheuristic in which, at each iteration, the ambulance location and dispatching problem is solved given a layout of districts, to determine locations and assignments of ambulances. Then, redistricting decisions are performed based on the solution found at the operational level. The proposed approach is applied to a set of realistic instances representative of the city of Montréal, Canada, in order to validate its potential. Results show that the layout of districts strongly affects the quality of the solution and that our approach improves the solution with respect to an a priori districting.

Ambulance management; Emergency Medical Services; Capacity and network planning; Decision support

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TUA3 – Decision Support I – 31/07/2018 09:00 – 10:30
Chair – Thierry Chaussalet   Room: VIA

TUA3-1: Maria Eugenia Captivo – 30/07/2018 – 09:00 – VIA
Scheduling elective surgeries in a Public hospital –Heuristic Approaches
Captivo, Maria Eugénia[1]; Martins, Carolina[2]; Sousa, Raquel[2]; Moura, Pedro[2]
[1]Faculdade de Ciências da Universidade de Lisboa and CMAFcIO Lisboa PORTUGAL ;
[2]Faculdade de Ciências da Universidade de Lisboa Lisboa PORTUGAL ;

We study the elective surgeries scheduling problem in a Portuguese public hospital. The operating room represents a large part of the expenses and profits of any hospital, so the efficiency in its use is fundamental. Also, as a consequence of the inability of the hospital units to respond to the increase in the demand for surgeries, the waiting lists for surgery are very large. So, their reduction is one of the main objectives of the National Health Service. The administration of the hospital aims to achieve the targets set by the Portuguese Ministry of Health for surgical production and to ensure a surgical service with a high level of efficiency. However, hospitals do not have an elective surgery scheduling system, so surgeries are scheduled in a non-systematical manner and without respecting equity criteria. Heuristics to find quickly good solutions for the problem are developed, considering different criteria. The heuristics select patients from a long waiting list for surgery to be scheduled in each week, and define a room and a day for each selected surgery according to one of the criteria. This problem was used as the theme of a Project in Operational Research during the last semester of the graduations in Applied Mathematics and Applied Statistics in the current academic year, at our Department in the University of Lisbon. It was one of the years when it was possible to feel that the students were really motivated to develop something whose usefulness they could recognize immediately. Tests with real instances are presented and analyzed. A user-friendly interface for the hospital is under development.

Operating room planning and scheduling; Teaching

TUA3-2: Mathias Barra – 31/07/2018 09:30 – VIA
Length of Stay on the stroke Ward early warning of overcrowding.

Barra, Mathias; Dahl, FA; Viana, J; Rand, K
HØKH, Akershus University Hospital Lørenskog NORWAY ;

Introduction: Understanding the dynamics of Length of Stay (LOS) is crucial to the expedient running of a hospital wards. It is of great value to hospital managment to be able to predict the LOS of admitted patients, so as to enable early warning of possible overcrowding. Stroke units have relatively long LOS, following fairly unimodal distributions, when restricting the analysis to the actual stroke patients. However, often a large fractions of the admitted patients do not have a stroke, but suffers instead from so-called stroke mimics: conditions that initially mimic stroke symptomes. Methods: In this study we develope regression models, based on patient characterisitics available at the time of admittance, with the aim of better predicting remanining total LOS for a stroke unit's patients. Results: We find that this is very difficult. Tradtional meanbased estimates appears to be the best one can accheive based on variables available at admission. We further explore approches based on timedependent covariates that are updated with as the LOS extends.

Statistical modelling; Patient flow; Staffing and capacity planning

TUA3-3: Thierry Chaussalet – 31/07/2018 10:00 –VIA
Developing a Predictive Risk Modelling for Integrated Care
Chaussalet, Thierry; Worrall, P
University of Westminster London UNITED KINGDOM ;

If patients at risk of admission or readmission to hospital or other forms of care could be identified and offered suitable early interventions then their lives and long term health may be improved by reducing the chances of future admission or readmission to care, and hopefully their cost of care reduced.

Considerable work has been carried out in this subject area especially in the USA and the UK. This has lead for instance to the development of tools such as PARR, PARR++, and the Combined Model for prediction of emergency readmission or admission to acute care.
Here we present the development of a new model for predicting the risk of admission based on routinely collected local data. Despite being based on much smaller datasets than other studies (hundreds of thousands as opposed to millions of records), our results show some improvements on the performance of previous models by deriving new variables.

Forecasting; Screening and prevention; Healthcare Information Systems

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TUA4 – Operating Room Scheduling II – 31/07/2018 09:00 – 10:30
Chair – Alexander Tesch   Room: Hagen 3

TUA4-1: Ashwani Kumar – 31/07/2018 09:00 –Hagen 3
A Sequential Stochastic Mixed Integer Programming Model For Tactical Master Surgery Scheduling
Kumar, Ashwani; Coata, AM; Fackrell, M; Taylor, PG
The University of Melbourne Melbourne AUSTRALIA ;

Healthcare delivery is a complex process with multiple sources of uncertainty. The uncertainty in the care delivery process makes the system less efficient, and it becomes difficult to ensure smooth patient flow. A robust tactical master surgery schedule (MSS) is required to optimise the patient flow process amid uncertainty and to minimise the risk of flow failures. In this talk, we present a stochastic mixed integer programming model to optimise the tactical MSS in order to achieve a better patient flow under downstream capacity constraints. We optimise the process over several scheduling periods and we use various length of stay scenario realisations to model the uncertainty in the process. This model has the particularity that it uses the scenarios in chronologically sequential manner, not parallel. We position patients randomly in a queue, and we constrain the model to schedule patients in their queuing order. This simple approach enhances the non-anticipative feature of the model, and we empirically demonstrate that our approach is useful in achieving the desired objective. We use simulation to show that the most frequently optimal schedule is the robust schedule. Finally, we develop a robust MSS to maximise the utilisation level while keeping the number of cancellations within acceptable limits, and we evaluate them by using simulation. The simulation results indicate that the robust schedules obtained are rather effective and promising.

Operating room planning and scheduling; Strategic and operational planning; Patient scheduling; Patient flow; Process optimisation; Modelling and simulation

TUA4-2: Carla Van Riet – 31/07/2018 09:30 –Hagen 3
The impact of introducing pediatric operating room sessions
Van Riet, Carla; Demeulemeester, E.
KU Leuven Leuven BELGIUM ;

The need for specialized anesthesia equipment for pediatric patients and the preference for audio-visual separation of pediatric and adult patients can be addressed by separating pediatric surgeries in one or more fully equipped operating rooms (ORs). Although the benefits of this separation are clear with regards to equipment (e.g., less investment and/or less movement), its impact on patient scheduling has barely been studied. The aim of this study is to assess the feasibility of allocating OR sessions to pediatric patients with regards to keeping the access times of both adult and pediatric patients within acceptable limits and with regards to the change in several operational performance measures. Introducing these separate pediatric sessions obviously decreases the scheduling flexibility. The question is whether this decrease is acceptable compared to the benefits the separation offers. We assess several scenarios using a data-driven simulation model. The results show that the percentage of patients that are served within their due time is only slightly affected when looking at adult and pediatric patients together, but this percentage for the pediatric patients separately drops from 86% to 73%. This decrease for some disciplines can be as large as 69 percentage points. Therefore, from a planning point of view, it is advised to only organize pediatric sessions for the disciplines whose performance drop is acceptable. Alternatively, for future research, the capacity allocation could be optimized for each discipline individually to account for the discipline's characteristics.

Operating room planning and scheduling; Patient scheduling

TUA4-3: Alexander Tesch – 31/07/2018 10:00 –Hagen 3
Operating Room Planning by Stochastic Constraint Programming
Tesch, Alexander
Zuse Institute Berlin Berlin GERMANY ;

We consider the common problem of scheduling operations with stochastic durations to operating rooms and staff subject to difficult side constraints such as assignment restrictions, (non-) availability periods and robustness guarantees. Driven by the success of constraint programming for deterministic scheduling problems, we propose an extension to stochastic scheduling to optimize the daily operational schedule of the Charite Berlin, one of largest university hospitals in Europe, on a real-time basis. We discuss several problem-relevant modeling issues and propose a complete solution procedure that combines aspects of constraint programming, stochastic programming and stochastic scheduling. Our approach is tested on real-world instances from years of historical data.

Operating room planning and scheduling; Process optimisation; Staffing and capacity planning; Workforce planning; Patient scheduling

TUB1 – Simulation I – 31/07/2018 11:00 – 12:30
Chair – Sally Brailsford   Room: FORUM

TUB1-1: Mark Tuson – 31/07/2018 11:00 –FORUM
Social Network Formation and Dynamics: The Case of Obesity
Tuson, Mark[1]; Harper, P[1]; Gartner, D[2]; Behrens, D[2]
[1]Cardiff University Cardiff UNITED KINGDOM ;
[2]Cardif University, Aneurin Bevan University Health Board Cardiff UNITED KINGDOM ;

Evidence from social network analysis suggests that an individual's immediate social network can significantly affect the probability of that individual becoming overweight or obese. Our research uses five avenues of enquiry to investigate this paradigm: First, exploring the nature of the interaction between social networks and obesity. Second, identifying how this interaction varies for different subgroups of the population. Third, assessing which intervention strategies would be effective in modifying this interaction. Fourth, we would like to identify which subgroups might have the most impact on resources in the future. Finally, quantifying the future impact of current childhood obesity issues on the adult population. To tackle the problem, we use a hybrid simulation modelling approach: An agent-based model of social networks is used to model individual stochastic behaviour and at the same time deliver a topologically stable network consistent with real world social networks. Embedded within each of the agents is a Systems Dynamics model simulating individual decision-making behaviour using input from the network and constructs from the Theory of Planned Behaviour, and the subsequent impact of that decision-making on calorie intake and that individuals body mass. The simulation is calibrated using a vectorised implementation of a gradient descent function, modified to allow for the stochastic nature of the simulation output. Our results demonstrate that the approach can be used by local health service networks strategically to set policy, specifically prioritisation and resource allocation for obesity. Tactically it provides a means for a more detailed review of resource allocation within the area, and a mechanism for testing and 'tuning' the social elements of existing or proposed implementations. The presentation includes initial forecasts using data from a local health authority, and a description/discussion of the implementation methodology, trialling and validating sub-models with AnyLogic, and then combining and programming them in Java.

Modelling and simulation; Epidemiology and disease modelling; Healthcare policy modelling; Strategic and operational planning; Forecasting

TUB1-2: Eric Silverman – 31/07/2018 11:30 –FORUM
Agent-Based Modelling of Formal and Informal Social Care
Silverman, Eric; Gostoli, Umberto
University of Glasgow Glasgow UNITED KINGDOM ;

The UK, like many other nations, is facing a demographic challenge. The elderly population is growing faster than any other group, stretching social care resources to their limit. Carers UK estimates that the demand is rising to such a degree that the population of carers will need to increase 40% by 2037. In order to meet this challenge, policymakers must find ways to support and encourage informal carers in an effort to alleviate the spiralling costs of state-provided formal care. We present an agent-based model of care provision in the UK which models the supply and demand of social care, and the multiple economic and social processes driving care decision-making in families. Agents live in a simplified UK geography, and live complex lives during which they age, form

partnerships, have children, participate in the labour market, get educated, move between socioeconomic status groups, and provide informal care or pay for private formal care. Informal care provision is modelled as a complex negotiation between family members that takes place over kinship networks. Providing care has substantial effects on carers, including loss of salary and reduction of the time available for education. Early results indicate that the simulation can reproduce the population dynamics and economic indicators of the UK. Real-world inequalities, including the gender pay gap and gender gap in care provision, emerge from agent interactions. Simulation outputs show that despite the theoretical care supply being far in excess of total demand, unmet care need gradually rises steadily over time. Future work will investigate possible policy-change scenarios and perform detailed sensitivity analyses of model parameters. We propose that this model can help policy-makers discover the most effective ways to increase informal care provision and support carers in the economic and social challenges they face.

Modelling and simulation; Home care and Long Term Care; Healthcare policy modelling

TUB1-3: Sally Brailsford – 31/07/2018 12:00 –FORUM
Hybrid simulation in health a review
Brailsford, Sally
University of Southampton Southampton UNITED KINGDOM ;

Healthcare is the largest single application area for hybrid simulation, i.e. models that combine more than one simulation approach. Most healthcare problems are highly complex, with many different features, and it is rarely possible to capture all of them using only one approach. For example, population level aspects are better modelled using system dynamics, to account for feedback effects and the flows of patients over time, whereas the operational aspects of healthcare delivery systems to manage these patients are better represented using the detailed stochastic approach of discrete-event simulation, due to the existence of queues, resource allocation issues and individual variability. In this talk we describe some examples from the literature, and discuss other reasons for the popularity of healthcare in this rapidly growing area.

Topics 17 Modelling and simulation

TUB2 – Workforce Planning – 31/07/2018 11:00 – 12:30
Chair – Monica Oliveira   Room: Hagen 1 + 2

TUB2-1: Maarten Otten – 31/07/2018 11:00 –Hagen 1 + 2
Robust scheduling for bed cleaning at wards.
Otten, Maarten; Bos, J; Braaksma, A; Boucherie, R J
University of Twente Enschede NETHERLANDS ;

Beds at nursing wards are cleaned between the moments one patient is discharged and the next patient is admitted. High patient turnover and lack of buffer capacity to store clean beds may result in small time windows to clean beds. In order to avoid bed shortages, it is therefore important that bed-cleaning staff is at the right ward at the right time. We investigate how to allocate bed-cleaning staff in order to clean the beds at the wards before they are needed for the next patient. Based on historical data of patient-discharges and admissions we predict at which moments beds become

available for cleaning at the wards. Allocation of bed-cleaning staff can then be modelled as a scheduling problem with family-dependent setup times. We extend this scheduling problem to incorporate the randomness in the time windows. The performance of our approach is demonstrated for a case study at two Dutch hospitals.

Workforce planning; Staffing and capacity planning; Strategic and operational planning

TUB2-2: Jan Schoenfelder – 31/07/2018 11:30 –Hagen 1 + 2
Analysis and optimization of personnel scheduling planning for medical radiation technicians
Heins, J; Schoenfelder, Jan; Kraul, S; Brunner, JO
University of Augsburg Augsburg GERMANY ;

The ongoing workforce shortage and the increasing expenditures in hospitals lead to difficult tasks for hospital management. Especially in personnel scheduling, it is crucial to utilize advanced approaches supported by operations research methodology, because an optimal schedule can increase service quality and reduce overtime as well as wage costs. In this study, we develop a combined shift design and workplace assignment problem that handles workstation rotation requirements. The goal is to find the optimal plan to minimize over- and understaffing for a given workforce. Due to the complexity of the program, we solve the problem with a column generation heuristic. We use real-world data from a radiology department and provide insights into the potential benefits of our approach in a setting with predefined shifts. Furthermore, the effects of allowing or requiring workstation switchovers are discussed and evaluated.

Staffing and capacity planning; Workforce planning

TUB2-3: Monica Oliveira – 31/07/2018 12:00 –Hagen 1 + 2
Enhancing optimization planning models for health human resources management through scenario planning
Oliveira, Monica[1]; Barbas, Marta[1]; Barbosa-Povoa, Ana[1]; Raposo, Mariana[1]; Alvarenga, Antonio[2]; Alves, Marco[3]; Lopes, Mario[4]
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To ensure a balanced health workforce it is critical for health policymakers to plan the supply of health human resources (HHR). Mathematical programming models have been widely used to assist such planning, but sensitivity analysis typically shows that solutions are highly sensitive to changes in uncertain parameters and stochastic solutions are difficult to interpret. This study proposes a new methodology that makes use of foresight and scenario planning concepts to enhance HHR management and planning through optimization models. The methodology embeds a transparent process for scenario building within an optimization model. Departing from the input parameters of the planning model, health decision-makers or experts are invited to engage into a scenario building process in which: they provide potential drivers for input parameters future variation in a web-platform; cognitive maps are used to cluster the drivers into key variables; morphological analysis is used to create contrasted and meaningful scenarios; semi-structured interviews are used to adjust and validate scenarios; and finally a workshop is used to quantify future variations in input

parameters, which are then used to run the HHR planning model for each scenario. The proposed methodology has been fully applied to inform HHR planning in Portugal.

Workforce planning; Modelling and simulation; Forecasting; Decision support

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TUB3 – Health Care Policy Modelling I – 31/07/2018 11:00 – 12:30
Chair – Lesile Anne Campbell   Room: VIA

TUB3-1: Martin Dlouhy – 31/07/2018 11:00 –VIA
An Evaluation of Capacities and Regional Distribution of Health System Inputs
Dlouhy, Martin
University of Economics Prague Prague CZECH REPUBLIC ;

Background: Inequalities in the regional distribution of health system inputs represent an important health policy problem. The existence of significant regional inequalities in health system inputs, health expenditures, and the utilization of health services have been documented by many research studies from various countries. Aim: The objective of this study is to measure and evaluate development of the capacities of multiple health system inputs and the inequality in their regional distribution by one method. The traditional inequality measures (e.g., Gini Coefficient, Robin Hood Index) evaluate inequality separately for each health system input, so the possibility of substitution is ignored. For example, doctors and nurses are, at least to some extent, substitutes. Hence the region with fewer doctors may compensate such disadvantage by larger number of nurses. In order to cope with cases with multiple inputs, one can use multiple criteria decision making and set the nationwide resource weights. More flexible approaches to estimate input substitution are based on estimation of production frontier (e.g., frontier analysis, data envelopment analysis). Results: The new method is proposed that is able to transform multiple health system inputs into a single virtual resource. The method is based on the data envelopment analysis. The capacities are compared by the ratio of total virtual resources and the regional inequality is measured by the application of the Robin Hood Index to the regional distribution of virtual resource. The illustrative example based is presented.

Capacity and network planning; Healthcare policy modelling; Staffing and capacity planning

TUB3-2: Ravichandran Narasimahan – 31/07/2018 11:30 –VIA
Health Care policy option In India
Narasimahan, Ravichandran
Indian Institue of management Ahmedabad INDIA ;

In this paper we provide a macro view of Indian health care system and explore some approaches to improve the same.The Indian health care system is complex in terms of provider mix, patient mix and range of health conditions to be addressed.The diminishing role of state in heath care delivery,the emerging trends in health insurance,revised role of regulatory authority,actions related to capacity expansion,talent pool are discussed to get a broad picture to suggest areas of improvement.

Healthcare policy modelling

TUB3-3: Lesile Anne Campbell – 31/07/2018 12:00 –VIA

Transforming Care in Nova Scotia: Implementation of Health System Change in Child and Adolescent Mental Health and Addictions

Campbell, Leslie Anne[1]; Kephart, G.[1]; Chorney, J.[2]; Clark, S.[2]; Emberly, D.[2]; Bishop, A.[2]; Wozney, L.[2]; MacDonald, J.[3]; MacKenzie, A.[4]; Marsh, D.[5]; York, A.[6]

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[6]Independent London UNITED KINGDOM ;

The creation of an accountable, recovery-oriented mental health and addictions (MHA) care system is a leading priority for health system transformation in Nova Scotia, Canada. This requires a major shift in the philosophy and organization of health care to replace a traditional system that is largely "clinician as the expert, patient as the help seeker", with little ability to measure patient-centred outcomes, tailor care, or actively engage patients and families in the care process. Selected to guide transformation of child and adolescent MHA services, the Choice and Partnership Approach (CAPA) combines collaborative and participatory practice with Lean principles to enhance effectiveness, leadership, skills modelling, and demand and capacity management. While CAPA has been implemented to varying degrees across Nova Scotia, progress has been slower than desired, and achieving 'scaleup' has proven problematic. Efforts to achieve the transformational change needed to improve patient and system outcomes are challenged by the highly complex nature of health care systems. Even when a new technology or model of care delivery is well supported by evidence and has been locally pilot tested, full implementation is a challenge due to important differences in context within and across health care systems. Emerging research methods that examine components of successful interventions within a complex systems framework can be used to better inform the implementation of innovations. We propose to use Realist Evaluation methods to describe "To what degree does CAPA work in Nova Scotia, for whom, and under what circumstances?", engaging patients and families, clinicians, administrators, and decision makers to identify outcomes, mechanisms, and contexts that inform our understanding of facilitators and barriers to the implementation of CAPA. This work will support a broader program of research aimed at informing transformational systemic change for other areas of health care in Nova Scotia and in other jurisdictions.

Clinical modelling; Healthcare policy modelling; Access and waiting lists; Staffing and capacity planning

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TUB4 – Scheduling I – 31/07/2018 11:00 – 12:30
Chair – Aleida Braaksma   Room: Hagen 3

TUB4-1: Yi-Hang Zhu – 31/07/2018 11:00 –Hagen 3
An idle-resource-based short-term strategy for dynamic patient admission scheduling
Zhu, Yi-Hang[1]; Toffolo, T. A. M.[2]; Vancroonenburg, W.[1]; Vanden Berghe, G.[1]
[1]CODeS, Computer Science Department, KU Leuven Gent BELGIUM ;

[2]Federal University of Ouro Preto Ouro Preto BRAZIL ;

When registering patients at a hospital for treatment, they must be assigned both an admission date and room, in addition to an operating room and surgery date if the patient requires surgery. These decisions are categorised within the field of dynamic patient admission scheduling where new patients register every day. This work focuses on its most realistic variant: the Dynamic Patient Admission Scheduling Problem (DPAS). Patient schedules are updated on a daily basis in the DPAS. The admission scheduling problems solved each day are referred to as short-term problems. After all these short-term problems during the respective scheduling period are solved, a long-term solution is obtained and evaluated using the DPAS' long-term objective. It is extremely challenging to design a short-term objective that is consistent with the long-term objective given that it is possible for optimal short-term problem solutions to lead to low quality or even infeasible long-term solutions. While several studies have been conducted on dynamic patient admission scheduling, research concerning this particular issue is noticeably absent. In this study, a short-term strategy is introduced. It includes idle resource penalties and anticipatory information in short-term objectives. This new strategy is incorporated into a mixed integer programming formulation, which is applied to solve short-term DPAS problems. Additionally, due to the fact that gender related patient-to-room assignment constraints significantly impact the problem's computational complexity, a new formulation for those constraints is proposed to reduce the time required for solving the model. The experimental study concludes that (1) this new formulation requires considerably shorter computational times than existing formulations and (2) employing the proposed short-term strategy results in significantly better optimality gaps on the existing DPAS benchmark with respect to new lower bounds.

Patient scheduling; Operating room planning and scheduling; Performance evaluation

TUB4-2: Fabian Schäfer – 31/07/2018 11:30 –Hagen 3
Advanced heuristics for the patient-bed allocation problem
Schäfer, F.[1]; Hübner, A.[2]; Kuhn, H.[1]
[1]Catholic University of EichstättIngolstadt Ingolstadt GERMANY ;
[2]Technical University of Munich Straubing GERMANY ;

Managing patient to bed allocations is an everyday task in hospitals. In recent years it has moved into focus due to a general rise in occupancy levels and the resulting need to efficiently manage tight hospital bed-capacities. This holds true especially for large maximum-care hospitals, which are by definition obliged to treat any incoming patient. Hence, maximum-care hospitals exhibit a high ratio of emergency patients as well as a high volatility and uncertainty regarding patient arrivals and lengths of stay. The patient-bed allocation problem (PBA) decision support model refined the patient admission scheduling problem (PAS) by means of a real-world situation in a large maximum-care hospital. The PBA identifies three main stakeholders, namely patients, nursing staff, and doctors, whose individual objectives and constraints lead to a potential trade-off situation. Due to the combinatorial complexity of the PBA, there is a need for a heuristic that intelligently assists the bed manager in taking fast decisions and is able to deal with uncertain situations through quick recalculations. Based on the PBA decision support model we conducted a survey on different sophisticated heuristics to solve the PBA, focusing in detail on the trade-off between runtime and solution quality.

Decision support; Capacity and network planning; Patient scheduling; Decision support; Process optimisation

TUB4-3: Aleida Braaksma – 31/07/2018 12:00 –Hagen 3
Real-time assignment of inpatients to beds

Braaksma, Aleida[1]; Ugarph, E.[2]; Levi, R.[2]; Zenteno, A.C.[3]; Daily, B.J.[3]; Orcutt, B.[3]; Dunn, P.F.[3]
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[2]Massachusetts Institute of Technology Cambridge UNITED STATES ;
[3]Massachusetts General Hospital Boston UNITED STATES ;

Assigning newly admitted patients to beds involves multiple constraints. Suboptimal patient-to-bed assignment may cause excessive patient wait times, crowding in upstream areas, and prolonged length-of-stays. We develop algorithms for real-time assignment of patients to beds, aiming at shortening patient wait times and decreasing upstream congestion. Through data-driven simulation, we quantify the benefits of the developed algorithms. Implementation of our results at Massachusetts General Hospital (Boston, United States) has resulted in significant decreases in patient wait times for beds, in addition to multiple other benefits.

Patient flow; Modelling and simulation

TUC1 – Clinical Modelling I – 31/07/2018 13:30 – 15:00
Chair – Mathias Barra   Room: FORUM

TUC1-1: Filipe Alvelos – 31/07/2018 13:30 – FORUM
Optimization for kidney exchange problems with probing

Alvelos, Filipe[1]; Viana, Ana[2]; Klimentova, Xenia[3]
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Kidney exchange programs rely on the exchange of donors between patients having an incompatible willing donor. Those incompatible donor-recipient pairs are joined in a pool and the compatibility between all donors and all patients are assessed via blood types and virtual crossmatches. The decision problem of which transplants to conduct can be modelled by a network where each node corresponds to an incompatible donor-recipient and each arc indicates compatibility between the donor of a pair and the recipient of another pair. Integer programming allows obtaining optimal solutions with respect to appropriate objectives as for, for example, the maximization of the number of transplants. After a transplants plan is decided, more precise crossmatch tests are made in the pairs belonging to the plan. These additional tests may reveal new incompatibilities and result in the cancellation of some of the planned transplants. In this work, we address the impact on the expected number of transplants of conducting crossmatch tests before the definition of a final transplants plan. Assuming known probabilities for positive crossmatches for all potential transplants, an integer programming model for maximizing the expected number of transplants is used to decide the (set of) potential transplants to test. We consider that the number of tests that can be made is fixed and two variants: in the first, tests are performed sequentially (the potential transplant to be tested is decided after the result of the previous test is known) and, in the second,

simultaneously (a set of tests is decided without the knowledge of any results). Different policies to decide the set of tests are described, evaluated and compared through computational experiments.

Decision support; Modelling and simulation; Strategic and operational planning

TUC1-2: Zhichao Zheng – 31/07/2018 14:00 – FORUM

Optimizing Colorectal Cancer Screening Policies Using A Combination Of Fecal Occult Blood Test And Colonoscopy

Li, Jing[1]; Zheng, Zhichao[2]; Chou, Mabel[3]; Dong, Ming[4]
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Over the years, various countries have adopted a combination of fecal occult blood test (FOBT) and colonoscopy as the preferred protocol for colorectal cancer (CRC) screening and surveillance. Current guidelines recommend three consecutive FOBTs annually after age 50 and immediate colonoscopy if there is at least one positive outcome from the three FOBTs regardless of other factors or screening history. It is unclear from literature about the values of having the FOBT as a pre-screening method before colonoscopy, and there is still related debate going on in practice. We propose a finite-horizon, partially observable Markov decision process model to optimize the CRC screening policy that combines FOBT and colonoscopy. Compared to the screening protocol that uses colonoscopy alone, we demonstrate that when FOBT sensitivity is not too low, adding annual FOBTs can help identify CRC in a timely manner and increase expected total quality-adjusted life years, while at the same time significantly reduce the number of colonoscopies required.

Screening and prevention; Healthcare policy modelling; Modelling and simulation

TUC1-3: Mathias Barra – 31/07/2018 14:30 – FORUM

Investigating Temporal Trends in Childhood Stroke and Stroke in the Young Incidence

Barra, Mathias[1]; Labberton, AS[1]; Faiz, KW[1]; Lindstrøm, JC[1]; Rønning, OM[2]; Viana, J[1]; Dahl, FA[1]; Rand, K[1]
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Introduction: Recently, concern has been voiced that although overall stroke incidence is declining in the developed world,it may be the case that the sharp decline in the older cohorts is masking an increase in stroke incidence amongst the youg (1554). Methods: Using a large data set spanning 20102015, containing all cerebrovascular events (including fatalitites) in Norway (TIA, ischemic and haemmoragic strokes), we have fitted various negative binomial regression models trying to identify any discernible temporal trends. This approach contrasts the recently presented studies, which use less appropriate methods. Furthermore, we consider all strokes, not only hospitalised cases, and thus are in a position to control for possible shifts in the health systems senstivity for midler strokes, or trends in diagnostics (e.g. from TIA to infarction). Results and Conlusion: From a Norwegian perspective, it seems there is little reason to fear that the young are experiencing increased exposure to stroke risk, with stroke incidences and fatality rates remaining stable, or declining, for both sexes, and for all age (sub)categories. Incidence rates are comparable to those found in the literature.

Statistical modelling

TUC2 – Mental Health – 31/07/2018 13:30 – 15:00
Chair – Marion Rauner   Room: Hagen 1 + 2

TUC2-1: Vittorio Nicoletta – 31/07/2018 13:30 – Hagen 1 + 2
Regression models to identify changing diagnosis for mental diseases: a preliminary work

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Major Depressive Disorder, Bipolar Disorder and Schizophrenia are chronic diseases without curative treatments. Individuals affected by these illnesses experience a diminished quality of life, especially if they are not diagnosed in a timely fashion. Furthermore, misdiagnoses risk exists: clinicians may confuse depression and bipolar disorder, leading to an ineffective treatment, which further worsens the outcome. From an economic point of view, direct and indirect costs incurred by individuals with suffering from depression, including major depressive disorder (MDD) and bipolar disorder, totalled $77.5 billion in 2005, rising to $98.9 billion in 2010, just in the United States. For these reasons, early detection can be a major asset in order to improve quality of life of affected individuals and reduce social costs. However, as opposed to many diseases, such as cancer, the evolution of mental diseases cannot be easily observed. Consequently, ad hoc approaches that take into account the particularity of mental diseases need to be developed to help better understand the illnesses' dynamics and support the diagnosis process. The main objective of this project is thus to find new ways to help clinicians correctly diagnose a mental disease. We propose two regression models in order to understand the reason leading to a change of diagnosis, switching from one of the three considered disease to another. A comparison with other diseases is performed, underlining the peculiarity of mental diseases. Our results enable us to suggest certain guidelines to clinicians, with the aim of improving the diagnostic process.

Statistical modelling; Decision support; Clinical modelling

TUC2-2: Sean Manzi – 31/07/2018 14:00 – Hagen 1 + 2
A network analysis of Personality Disorder client service use at Devon Partnership Trust

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[2]Devon Partnership NHS Trust Exeter UNITED KINGDOM ;

This project was undertaken in collaboration with Devon Partnership Trust (DPT) the main National Health Service (NHS) provider of mental health services in Devon. DPT approached us having identified that clients diagnosed with a personality disorder (PD) (care clusters 7 & 8, ICD10 codes 60 to 61) were using a large number of services, costing the trust a lot of money and not having optimal care outcomes. The question posed in this study was "What are the current trends in the provision of care for personality disorder clients within services provided by or commissioned by Devon Partnership Trust". A network analysis approach was used to derive data driven maps of PD client service use. In addition to this, individual client service use timelines were produced as a way of

assessing individual patient service use behaviour. The rates of escalation from community to acute psychiatric care services were also calculated as part of the analysis. The findings from the project showed that PD clients were most likely to access the psychiatric liason services in emergency departments, Crisis Resolution and Home Treatment Teams (CRHT's) and Mental Health Assessment Teams (MHAT's). Accessing these services was also likely to resulted in PD clients being escalated to inpatient services which have a greater financial cost than community based services. The collaborating organisation, DPT, identified that there was the need to better manage the care of PD clients and provide alternative services which would avoid clients attending liason psychiatry in the Emergency Department. DPT are now seeking to adapt the service use time line method that we used in this project to support clinical decision making and are using the project findings to design a new care pathway for PD clients with the aim of reducing client service use and improving care quality.

Capacity and network planning; Care Pathways; Strategic and operational planning; Healthcare Information Systems; Decision support

TUC2-3: Marion Rauner – 31/07/2018 14:30 – Hagen 1 + 2

Ambulant psychiatric rehabilitation in Vienna, Austria: A cost-effectiveness analysis

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The cost-effectiveness study presented includes all patients treated in the context of a standardized 6weeks multimodal ambulant rehabilitation programme (WHO phase 2) in Vienna (Zentrum für seelische Gesundheit WienLeopoldau) from January 2014 to December 2016, that is in total 2,486 patients (63.4% females). Patients with missing data and rehabilitation dropouts were excluded from further analyses, resulting in a final sample size of 1,952 patients. Treatment was performed as a standardized 6weeks rehabilitation programme (142 treatment units), composed of the following treatments: 1) group and individual psychotherapy (cognitive behavioural therapy), 2) occupational therapy, 3) physiotherapy, 4) social work, and 5) weekly psychiatrist consultations. Questionnaire-based surveys (e.g., BSI, BDI, WHODAS) were performed at the time of pre-contact, at the time of admission, at the time of discharge, as well as 6 months and 12 months after discharge. In the cost-effectiveness analysis, data were compared for the period of 12 months before admission to the rehabilitation programme and the period of 12 months after the end of the rehabilitation programme. The results significantly demonstrated that the psychological effectiveness measures highly improved during the 6weeks rehabilitation programme and have not dramatically dropped 12 months after discharge of the patients. Furthermore, the employment status of the patients included significantly improved from the start of the six week rehabilitation programme compared to 12 months after the rehabilitation programme. However, this effect was not stable when including only the sample of 481 rehabilitation patients that has completely returned catamnesis questionnaires. A similar trend was found for the productivity loss. We could also illustrate interesting differences among rehabilitation patients depending on their particular characteristics.

Cost effectiveness and health economics; Performance evaluation; Data analysis and risk management

TUC3 – Cardiology – 31/07/2018 13:30 – 15:00
Chair – Thomas Shcneider   Room: VIA

TUC3-1: Niki Matinrad – 31/07/2018 13:30 – VIA
Optimal dispatch of volunteers to out-of-hospital cardiac arrest patients

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Emergency response resources, such as ambulances and fire trucks, are utilized to help victims of accidents or acute medical illness. One type of resource that has been facing a rising interest in the past few years is volunteers. The number of projects with the initiative of utilizing volunteers for daily emergencies is growing, and civilians show interest by signing up for providing help if needed. One such project is "SMS life savers" (https://www.smslivraddare.se/), which started in 2010 as a research project in Stockholm, Sweden. It is now an integrated part of the emergency response system, utilizing volunteers in both Stockholm and Gothenburg. SMS life savers are volunteers registered for contributing in out-of-hospital cardiac arrest (OHCA) cases. They get an alarm on their mobile phone, and if they can, they will respond. Their tasks can be categorized into two main activities: (1) finding an automated external defibrillator (AED), taking it, and delivering it to the incident site, or (2) going directly to the patient and performing cardiopulmonary resuscitation (CPR) on him/her. In this work, we propose a mixed-integer optimization model, maximizing the patient's chance of survival. The model suggests how many and which volunteers to send directly to an OHCA patient, and who should first pick up an AED, and which AED. The computational results show that the model can be used for optimal dispatching of volunteers.

Emergency Medical Services; Decision support; Strategic and operational planning

TUC3-2: Mary Conlon – 31/07/2018 14:00 – VIA
Patient complexity and radiographer workload – Using agents and DES to create a picture of "Busyness".

Conlon, Mary[1]; Molloy, O.[2]
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Background: Quite often optimisation models fail to demonstrate the relationship between patient complexity and radiographer workload. A wide variation in patient complexity can result in staff experiencing burnout and occupational injuries and see patients receiving sub optimal care and outcomes. Methods: Quantitative data, from 2011 to 2017, was gathered from the hospital information system (HIS) and radiology information system (RIS). Six months of phone records, exam data on patient age, gender, types and numbers of radiology examinations, and scheduling/emergency arrival patterns as well as staffing levels from 2011 to 2017 were analysed. Qualitative data was gathered through onsite observation, interviews and 62 radiographer questionnaires. This data was used to inform the parameters when the patient and radiographer were included as an agent in a discrete event simulation of the radiology department. Anylogic PLE was used to develop a generic DES/ABS model for the CT (Computed Tomography) department. Patient complexity is ascertained using a patient weighting matrix, which includes mobility, infection status, type of exam and patient care needs. Departmental factors described as "noise" include

interruptions, information system support, department layout and ergonomics. Radiographer workload is calculated as a function of patient complexity, departmental factors and the number of patients scanned. Simulations were used to experiment how increasing patient complexity affects the radiographer workload. Results: The workload for 1 patient, as perceived by radiographers, can vary by a factor of 15 when patient complexity is simulated from low to high and as such the productivity of departments cannot be compared in crude units of patient numbers. Conclusions: The patient and radiographer agents created in this model can potentially be used in other radiology related models as parameters such as mobility and infection and patient care are common amongst patients. Patient complexity and departmental factors have a direct effect on radiographer workload.

Data analysis and risk management; Healthcare Information Systems; Decision support; Process optimisation; Workforce planning

TUC3-3. Thomas Schneider – 31/07/2018 14:30 – VIA
Implementation of an Online Multi-Appointment Scheduling Algorithm for Care Pathways at the Cardiology Outpatient Department: A MDP approach
Schneider, A.J. (Thomas)[1]; Zonderland, M.E.[2]; Boucherie, R.J.[2]; Schalij, M.J.[3]
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[2]Center for Healthcare Operations Improvement and Research (CHOIR), University of Twente Enschede NETHERLANDS ;
[3]Department of Cardiology Leiden University Medical Center NETHERLANDS ;

Value is the newest paradigm in healthcare worldwide. To operationalize the concept of value based healthcare care, pathways and integrated practice units should be formed. This means that the corresponding physical and human resources should be optimally aligned. Furthermore, medical and technological innovations require more specialized staff and thus more healthcare providers are involved in the treatment of an individual patient. As a result, care pathways are more complex. The Cardiology outpatient department at Leiden University Medical Center in the Netherlands is pre-eminently a department with many different care pathways. The department consists of two units: the heart laboratory for performing heart function tests and the outpatient clinic for the Cardiologist consultations. Patients have on average more than two appointments on the same day. The department struggles with increased waiting times and an overcrowded waiting room. The offline scheduling of both patients and staff is performed fairly good, though the online scheduling process is lacking. In the setting of care pathways, the delay of a single appointment affects all other subsequent appointments and patients. We therefore propose an online multi-appointment scheduling algorithm that eliminates the offline scheduling process and allocates patients to their next appointment based on actual waiting times for each queue (type of test or cardiologist). We analyze this problem as a finite-horizon MDP with a waiting costs reward function. This algorithm is fully implemented via a check-in system, using self-service kiosks. We measured pre- and post-implementation random samples; the results show significant improvements in sojourn time, namely a 20 minutes reduction (average the pre- implementation sojourn time was 90 minutes), and in the number of waiting patients. We are currently extending the algorithm for multi-departmental scheduling and are developing an app for appointments, online check-in and notifications.

Care Pathways; Patient flow; Patient scheduling; Healthcare Information Systems; Process optimisation

TUC4 – Operating Room Scheduling III – 31/07/2018 13:30 – 15:00
Chair – Francisco Ballestín   Room: Hagen 3

TUC4-1: Thomas Adams – 31/07/2018 13:30 – Hagen 3
Surgical Session Planning A New Zealand Case Study
Adams, Thomas; O'Sullivan, M; Walker, C
University of Auckland Auckland NEW ZEALAND ;

Counties Manukau District Health Board operates two facilities that perform surgical procedures in Auckland, New Zealand. The District Health Board has targets for the number of elective procedures that they should perform for several different surgical specialties, which they are struggling to meet. The District Health Board was interested in determining whether their current allocation of sessions to specialties was appropriate for their goal of meeting their targets. Two tools were created to assist them with this problem. The first is an Excel spreadsheet which includes a mixed integer program that distributes a number of sessions between specialties to maximise the mean percentage target performed. The second is a command line program which takes into account the theatres that the sessions are in, and can therefore take into account more complex scheduling rules. Both of these tools and the results of their use will be presented.

Operating room planning and scheduling

TUC4-2: Derya Demirtas – 31/07/2018 14:00 – Hagen 3
Improving timeliness in radiotherapy using discrete-event simulation modeling
Demirtas, Derya[1]; Vieira, B.[2]; Hans, E. W.[1]; van de Kamer, J. B.[2]; van Harten, W.[1]
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In radiotherapy (RT), the minimization of the time between referral and start of treatment (waiting time) is increasingly important to mitigate tumor growth and avoid psychological distress in cancer patients. However, the RT process, involving a chain of preparation steps before the treatment can start, is subject to uncertainties (e.g. due to patient inflow) that hamper the design of a simple workflow control system. RT pre-treatment workflow is driven by the scheduling of the first irradiation session, which is usually set right after consultation (pull strategy), but can alternatively be set after (some of) the pre-treatment operations have been completed (push strategy). In this work, we use discrete-event simulation to test several configurations of workflow control and assess the optimal allocation of the doctors' activities (consultation and contouring) in each configuration. A case study using data from a large RT department of a Dutch hospital has been undertaken, in which fluctuations in patient inflow and resource availability are considered. By comparing both strategies for lung cancer patients, preliminary results show that a push strategy leads to a 22% reduction in the average waiting times and 25% fewer appointment cancellations, whilst a pull strategy leads to 5% less patients breaching the waiting time targets and, unlike push, avoids the need for overtime work. These findings help us identify the optimal balance between the push and pull strategies.

Patient flow; Access and waiting lists; Modelling and simulation; Patient scheduling; Staffing and capacity planning

TUC4-3: Francisco Ballestín – 31/07/2018 14:30 – Hagen 3

Comparison of different models to maximise the satisfaction of patients in the surgical case assignment problem

Francisco Ballestín ; Ramon-Baviera, A. RB.
Universidad de Valencia Valencia SPAIN ;

This work studies the surgical case assignment problem. The decision maker should decide which patients to operate on each week and each session, selecting the patients from a waiting list that receives new patients every week. The durations of the surgeries are deterministic. In the problem patients express their preferences in a range from 1 to 5 about being operated on each session. The satisfaction of a patient is calculated as the preference in the assigned session if the patient is operated on before a month in the waiting list. After a month, the satisfaction decreases linearly with the days in the waiting list (even reaching a negative satisfaction). The goal of the hospital is to maximise the total satisfaction of the patients. We study different models to maximise this goal. One of them selects the patients to be operated on the following week, using different objective functions trying to capture the long term goal. Another model selects the patients for the following two weeks, although only one week is implemented (rolling horizon approach). A two-phase model which solves two different integer linear problems to choose the patients for one week is also presented. These models are compared in the long term regarding the goal of the hospital, using instances randomly generated with a generator from the literature. These instances try to cover a wide range of possible hospitals. One of the important results of the work is that the best model depends on the types of the durations of the surgeries if the arrival rate is the same.

Operating room planning and scheduling; Modelling and simulation

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TUD1 – Acute Care – 31/07/2018 15:30 – 17:00
Chair – Peter Vanberkel   Room: FORUM

TUD1-1: Meetali Kakad – 31/07/2018 15:30 – FORUM
Occupancy and discharge in municipal acute units in Norway

Kakad, Meetali; Dahl, F.A
Akershus University Hospital NHS trust LØRENSKOG NORWAY ;

PLACEHOLDER ABSTRACT Over recent years, hospital admissions in Norway have continued to rise and bed occupancy levels have regularly reached dangerous levels during winter months. Shifting care away from hospitals towards less resource-intensive, municipal health care services, nearer the patient's home has been a political priority, culminating in the 2012 Coordination reform.
The Reform used legislative, organizational and financial policy instruments to expand the scope of municipal health care services. One such example was the introduction of municipal acute care facilities (MAUs) which would admit low acuity patients who would previously have been admitted to hospital. MAUs have been established nationwide to. Funding was diverted from acute hospital trusts to municipal budgets in order to finance these new units and some attempt was made to define the types of patients suitable for admission to MAUs. Initially MAUS were underutilized, in part due to skepticism amongst GPs and in part due to overly strict admissions criteria, limiting the number of patients suitable for admission. Occupancy rates have improved over time with the

majority of units being at an occupancy rate between 6070%. Whilst MAUs were originally only allowed to admit patients for a maximum of 3 days, this practice was abandoned medical grounds, resulting in an average length of stay of slightly more than 3 days, for the majority of units. MAUs are not supposed to be used for step down purposes, nor as a substitute for nursing home care though this occasionally happens if bed capacity is available. In this presentation we will look at the relationship between bed occupancy and discharge rates in order to determine whether length of stay in MAUs is driven by exogenous or endogenous factors. We will use logistic regression techniques to analyse patient stay data from MAUs.

Patient flow; Staffing and capacity planning; Strategic and operational planning

TUD1-2: Daniel Gartner – 31/07/2018 16:00 – FORUM
Multi-Site Demand and Capacity Modelling within the National Health Service
Gartner, Daniel[1]; Behrens, Doris[2]; Boulton, John[2]; England, Tracey[3]; Harper, Paul[3]; Spernaes, Izabela[2]
[1]School of Mathematics Cardiff UNITED KINGDOM ;
[2]Aneurin Bevan University Health Board Newport UNITED KINGDOM ;
[3]Cardiff University Cardiff UNITED KINGDOM ;

In 2012, the Aneurin Bevan University Health Board in Wales, U.K. submitted a business case for a new Specialist and Critical Care Centre. The application was based on Microsoft Excel models which considered the number of beds and operating theatres needed. In October 2017, the embedded Mathematical Modelling Unit within the health board were commissioned to significantly extend the modelling in terms of uncertainty and future case mix modelling. In a first step, more than 600 000 data records were analysed using different clustering and forecasting methods to develop a demand prediction model for operating theatre, diagnostics, and bed resources. In a second step, a Discrete Event Simulation (DES) model was developed and represents the whole health board as a system from arrival at A&E through to a ward bed. The simulation model has been used to estimate the number of beds needed across the Health Board, by specialty, ahead of the new hospital (in 2021), and further beyond (in 2035). The model also considers the relationship between bed utilisation and compliance with the national 4-hour target for A&E. The scenario analysis showed that the population projection estimated a higher bed utilisation and a worsening 4-hour target if all else remains the same. However, these performance metrics could be improved by targeting specific specialties. The diagnostics and subspecialty-level planning of theatres provides a detailed future allocation of demand while the specialties can be either fixed (based on the business case) or optimized using a discrete-optimisation model. As a conclusion, the models can evaluate and communicate the relationship between demand, capacity, and performance targets at chief executive level down to the individual consultant level working on subspecialty cases. The tools are also used in a taught modelling programme to increase NHS managers' capability for mathematical modelling.

Modelling and simulation; Capacity and network planning; Forecasting 09 Decision support

TUD1-3: Peter Vanberkel – 31/07/2018 16:30 – FORUM
Mixing scheduled patients with walk-in patients: A simulation optimization approach
Vanberkel, Peter; Wing, J. R.
Dalhousie University Halifax CANADA ;

This paper is motivated by the Collaborative Emergency Centre (CEC) care model used in rural Nova Scotia, Canada. The daytime CEC is staffed by a physician and guarantees same-day appointments to walk-in patients. These patients alone often do not constitute a full day's work for the physician. As such, booked patients are scheduled to fill the clinic. Knowing how many booked patients to schedule to ensure same-day access to walk-in patients is a complicated decision. The objective of this study is to design patient scheduling methods to ensure that, sufficient space is reserved for walk-in patients, while at the same time appropriately utilizing the daytime CEC resources. This is accomplished by developing an appointment scheduling system to determine the suitable volume of booked patients to schedule in addition to the clinic's walk-in demand and when throughout the day to schedule these booked patients. The primary goal of this study is to balance three conflicting objectives: 1) volume of booked patients scheduled, 2) the waiting times of patients, and 3) the overtime scheduling of the care provider(s).

Clinical modelling; Emergency Medical Services; Patient scheduling

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TUD2 – Capacity Planning I – 31/07/2018 15:30 – 17:00
Chair – Mario Jorge Ferreira De Oliveira   Room: Hagen 1 + 2

TUD2-1: Anne Zander – 31/07/2018 15:30 – Hagen 1 + 2
Using simulation to solve capacity planning problems in hospitals: Deciding on the number of patient transfer rooms and the number of beds

Zander, Anne[1]; Messer, C.[1]; Arnolds, I.[2]; Reuter-Oppermann, M.[1]; Krumholz, L.[1]; Landes, P.[1]; Nickel, S.[1]; Schuster, M.[2]
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[2]FürstStirumKlinik Bruchsal Bruchsal GERMANY ;

In most hospitals, transfer rooms separate the operating rooms (OR) from the rest of the hospital. Patients have to pass through those rooms for reasons of hygiene. They are placed on the OR table before surgery and returned to the hospital bed after surgery. As a result, the OR transfer rooms may become a bottleneck and patients may have to wait what, in turn, may lead to delays in the OR schedule. In this study, we make use of a discrete event simulation to analyze the necessary number of patient transfer rooms such that they do not become a bottleneck. We investigate two main influence factors: The average surgery duration and the number of available ORs in a hospital. We determine the number of needed transfer rooms for a wide range of parameters so that hospitals can easily find their specific case using a lookup table. It is important for hospitals to provide the right number of beds on each ward such that the demand can be satisfied while ensuring a high utilization at the same time. In Germany, if every bed in a ward is occupied, the ward checks out, meaning that new patients, both elective and emergency, cannot be admitted. During checkout, the hospital loses revenue due to rejecting incoming demand. In Germany, a DRG (Diagnosis related group) is assigned to each patient. In principle, hospitals are paid a fixed amount per DRG independently of the hospitals' real costs to treat a specific patient. Using a simulation model the DRG revenue loss in relation to the number of beds can be quantified. Together with further investigations on costs for hospital beds, this could help to make an economically sound decision on the number of beds.

Staffing and capacity planning; Modelling and simulation; Decision support; Performance evaluation

TUD2-2: Roberta Rossi – 31/07/2018 16:00 – Hagen 1 + 2
Cooperative optimization-simulation policies for drug replenishment at Intensive Care Units

Rossi, Roberta[1]; Cappanera, P.[1]; Nonato, M.[2]; Visintin, F.[3]
[1]Dipartimento di Ingegneria dell'Informazione, University of Florence, Florence, ITALY ;
[2]Dipartimento di Ingegneria, University of Ferrara, Ferrara, ITALY ;
[3]Dipartimento di Ingegneria Industriale, University of Florence, Florence, ITALY ;

This study proposes a cooperative optimization model which supports nurses in drugs order management at point of use in a real case study involving two Intensive Care Units. Specifically, this study investigates the effects of lateral transshipment as an alternative to the classic urgent order made to the entity of a higher level of the supply chain. The related integer linear programming model decides for each drug when and the quantity to order, minimizes order occurrences while ensuring service regularity under capacity and budget constraints. Orders are based on a forecasted demand for the incoming W weeks (W=2 or 3), the so-called planning period. The effectiveness of the proposed optimization model is tested using a combined optimization-simulation approach over a rolling time horizon. Specifically, the simulation model mimics the actual operations working in parallel at the two wards. For each ward it reproduces the patients' arrivals, therapy definitions, drugs consumptions and dismissals. The actual drug demand can thus be different from the forecasted one. Then, during the scheduling period, which is defined as a sub-period of the planning one, the simulation model places orders according to the agenda suggested by the optimization model. In case of stock-outs, different strategies can be implemented according to the two wards' inclination to cooperate. Every W weeks, for each ward, the simulation model collects information about the current drugs stock level, the current patients at the wards, predicts a demand accordingly, and returns the information to the optimization model. The potential advantage coming from cooperation is an increase of service quality, since (i) drugs borrowed by a neighbouring ward can cover shortages and be promptly available for patient care; (ii) orders occurrences may be decreased; and (iii) drugs potentially stocked in excess at wards can be used more efficiently.

Decision support; Strategic and operational planning; Healthcare policy modelling

TUD2-3: Mario Jorge Ferreira De Oliveira – 31/07/2018 16:30 – Hagen 1 + 2
Care pathways and capacity planning in unities of emergency care in Brazil

De Oliveira, Mario Jorge Ferreira[1]; Almeida, Luana S.[2]; Sabbadini, F. S.[3]; Gonçalves, A. A.[4]
[1]Federal University of Rio de Janeiro Resende BRAZIL ;
[2]Rio de Janeiro State University Resende BRAZIL ;
[3]Rio de Janeiro State University/Estácio de Sá University Resende BRAZIL ;
[4]Universidade Estácio de Sá Rio de Janeiro BRAZIL ;

In 2008, the Brazilian government started to lauch the Unities of Emergency Care (UPU) in order to relieve the Emergencies Centers. In thesis, with the lunch of the UPA, the emergency center start to be responsible just for the critical cases while the low and intermediate cases are treated at UPAs. The path coverd by the patient starts at the UPA where he passes through a classification of risk. Depending on the diagnosis, the patient is transferred to the emergency center with an ambulance provided by UPA. Even with the criation of UPAs, the hospitals continue to be congested. The presente work aims to study the rate of occupation of the practices at the UPA in order to verify if it is saturated (occupation equal or bigger than 100%), the impact on the patient´s pathway and if it need to be improved in order to be effective.

Care Pathways; Capacity and network planning; Modelling and simulation; Patient flow; Performance evaluation

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TUD3 – Frameworks – 31/07/2018 15:30 – 17:00
Chair – Jan Vissers   Room: VIA

TUD3-1: Syed Salleh Abdul Rahman – 31/07/2018 15:30 – VIA
Guidelines for conducting discrete-event simulation based resource modelling in health technology assessment
Abdul Rahman, Syed Salleh
University of Sheffield Sheffield UNITED KINGDOM ;

Discrete-event simulation (DES) is one of the techniques typically found in the field of healthcare operational research (OR) and can help with resource modelling (RM). The termed RM involves understanding the constraints and estimating resource requirements within the service pathway for each intervention (e.g. number of cardiologist required for administering angioplasty treatment).

Health technology assessment (HTA) involves estimation of the costs and effects of all relevant technologies to estimate whether the new technology is cost-effective. Such analyses typically take the long-term perspective, where all inputs are assumed to be unconstrained, i.e. the resources (e.g. doctors, beds) required by the new technology are immediately available and deployed optimally. Therefore, there is a need for issues of implementation and feasibility to be captured in HTA studies.

Whilst DES-based RM is very common in the OR community, it is still quite new in the HTA field. We have consolidated the practices from both OR and HTA fields to understand the key issues and establish good practice when estimating long-term outcomes taking resource constraints into account.

This presentation will outline the findings from a recent systematic literature review on how DES-based RM has been used in HTA and briefcases studies of implementation of these methods will be outlined. Guidelines on applying DES-based RM in HTA, developed using the knowledge from the systematic review and experiences from the case studies, will be presented. The presentation will conclude with an open discussion allowing the audience to interact in a Q&A and collaborative discussion with the presenter on ideas for improving the guidelines.

Cost effectiveness and health economics; Staffing and capacity planning; Modelling and simulation

TUD3-2: Sonya Crowe – 31/07/2018 16:00 – VIA
Effective Operational Research in healthcare
Crowe, Sonya; Utley, Martin
University College London Clinical Operational Research Unit London UNITED KINGDOM ;

Background
Academic OR often fails to influence decision-making in healthcare and the sustained adoption of OR solutions remains disappointingly low, despite some excellent counter examples. Research in related

fields such as implementation science has shown that a broad range of context-specific factors strongly influence change and adoption of research findings in healthcare organisations. Yet operational researchers often lack the skills, support or tools to 'tailor' their approach to take into account these context-specific factors. Our aim was to develop resources for operational researchers that could help them influence or adapt to context so as to enhance the uptake of beneficial OR in healthcare.

Methods
Semi-structured interviews were conducted with n=24 operational researchers working in healthcare. Using an interview topic guide, participants' experiences in relation to OR in healthcare were explored, including challenges they encounter and strategies they find helpful in overcoming these, and their views on suitable resources to support them were sought. Interviews were digitally recorded, transcribed in full and analysed thematically using an abductive approach. A development group was convened to review the interview findings and co-develop the resources, which included a structured selection process in a facilitated workshop.

Findings
5 domains of barriers and enablers were identified: project 'process'; project 'people and relationships'; project 'client organisation and decision processes'; OR person; OR group. 31 potential resources, or ideas that could be incorporated in resources, were also identified and mapped to the 5 domains. From these, the development group selected 10 that they considered to be: within the sphere of influence of the development group; containable/ tractable within the finite timeline of the project; and within the capabilities of the research team to develop. These included a 'taster' series highlighting insights from other disciplines that might support more effective OR in healthcare.

Modelling and simulation

TUD3-3: Jan Vissers – 31/07/2018 16:30 – VIA
Healthcare logistics and beyond. A survey based perspective on the future of hospital operations management.
Vissers, J.M.H.; Elkhuizen, Sylvia; Van de Klundert, J.J.
Erasmus University Rotterdam / Erasmus School of Health Policy and Management Rotterdam NETHERLANDS ;

The logistics/operations management function of hospitals is concerned with organizing services for patients and optimizing the use of resources. Patients expect good quality of care, short waiting times, well-organized patient journeys. Hospital management expects that scarce resources are well used. In short, this is what hospital logistics/operations management is currently about. But will this also be the focus in the future? As organizing patient processes in a patient centred way and with added value for the patient are nowadays priorities in hospital management policies, what will be the implications for the operations management function? We performed a survey under Dutch hospitals to assess the state of the art of hospital operations management and to ask for their views on the development of the operations management function in the future. The survey was sent to all general hospitals (83) and all university hospitals (8). About 50% of the hospitals participated in the study. The results of the study provided insight in the importance of topics such as admission planning, bed planning and operating theatre planning in the future and the emergence of new topics such as care pathway planning and chain management. Moreover, it provided support for a

scenario of the development of health care operations management that is built up with three layers of operations management efforts: (1) the classical operations management with its focus on optimal use of scarce hospital resources, (2) the quality improvement approaches (lean, theory of constraints, six sigma) with its focus on the process, (3) the value based approach on optimizing patient processes from a customer value perspective.

Patient flow;Patient scheduling; Process optimisation; Access and waiting lists

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TUD4 – Decision Support II – 31/07/2018 15:30 – 17:00
Chair – Turgay Ayer   Room: Hagen 3

TUD4 -1: Christine Huttin – 31/07/2018 15:30 –Hagen 3
Consistency issues and conjoint models in healthcare
Huttin, Christine
Aix Marseille UNiversity and endepusresearch Inc Bruxelles UNITED STATES ;

this paper aims to discuss the consistency of conjoint estimation for a special approach called reversed conjoint approach, for economic questions in medical decision making. The reason why this approach was chosen was to change the conventional conjoint design where only product attributes are compared in the study design, usually with a paired comparison approach. In this approach, the objective is to analyze the effects of economic questions on physicians' preferences. The use of conjoint estimation is then an elicitation method of physicians' preferences; it aims to deal with a value judgment on patients, more than product comparisons. The full profile approach is then preferred to the pairwise comparison; since such pairwise comparisons do not represent the decision making process. The cost studies on physicians from the endep/biomed project confirmed that pair wise comparisons were irrelevant in the case of patients' economics cues. The representation of the mathematical structure of the axiomatic system used and discussed in the case of conjoint estimations for product attributes may therefore not apply in such cases, and this working paper starts a discussion on the relevance of such axiomatic system and its limitation for testing sets of cost cognitive cues in modules possibly in use for medical software.

Decision support; Statistical modelling; Modelling and simulation

TUD4 -2: Namsuk Cho – 31/07/2018 16:00 –Hagen 3
A Study on Critical Parameters for Military Medical Support Planning Using Discrete-Event Simulation
Cho, Namsuk[1]; Moon, H[1]; Kwon, O[2]
[1]Korea National Defense University NonsanSi SOUTH KOREA ;
[2]Korea Advanced Institute of Science and Technology Daejeon SOUTH KOREA ;

Military Medical Support Planning is essential to the success of military operations. There are various parameters that can be used for anticipating medical needs and managing medical resources during wartime. For example, such parameters include evacuation rate, discharge rate, died of wounds rate, evacuation policy, and so on. Currently, we use historical war data for estimating these parameters. However, the character of war is changing, so should these parameters. In this research we develop discrete-event simulation model which is the imitation of the military medical system.

We select expected length of stay (LOS) of patient as a critical parameter of the simulation model because LOS is a flexible factor that can be modified to represent the characteristics of modern warfare. It is also useful to reflect the characteristics of atypical warfare such as CBRN (Chemical, Biological, Radiological, and Nuclear) warfare. We mainly discuss techniques for implementing simulation model as well as statistical methodology for reasonably estimating parameters.

Decision support; Modelling and simulation; Strategic and operational planning

TUD4 -3: Turgay Ayer – 31/07/2018 16:30 – Hagen 3
Analytics in Prioritizing Access to Hepatitis C Treatment in Prisons

Ayer, Turgay[1]; Spaulding, Anne[2]; Chhatwal, Jagpreet[3]
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HCV prevalence in prison systems is significantly higher than the general population, and hence prison systems offer a unique opportunity to control the HCV epidemic. New HCV treatment drugs are very effective, but providing treatment to all inmates is prohibitively expensive, which precludes universal HCV treatment in prison systems. As such, current practice recommends prioritizing treatment based on clinical and incarceration-related factors, including disease staging, remaining sentence length, and injection drug use (IDU) status. However, there is controversy about how these factors should be incorporated because of the complicated trade-offs. In this study, we propose a restless bandit modeling framework to support hepatitis C treatment prioritization decisions in prison systems. We first prove indexability for our problem and derive several structural properties of the well-known Whittle's index, based on which, we derive a closed-form expression of the Whittle's index for patients with advanced liver disease. From the interpretation of this closed-form expression, we anticipate that the performance of the Whittle's index would degrade as the treatment capacity increases; and to address this limitation, we propose a capacity-adjusted Closed-form index policy. We parameterize and validate our model using real-world data from Georgia state prison system and published studies. We test the performance of our proposed policy using a detailed, clinically-realistic simulation model and show that our proposed policy can significantly improve the overall effectiveness of the hepatitis C treatment programs in prisons compared with the current practice and other benchmark policies, including the commonly used Whittle's index policy. Our results also shed light on several controversial health policy issues in hepatitis C treatment prioritization in the prison settings. Lastly, we have developed a decision support tool for practical use, which is currently being piloted in two state prison systems.

Healthcare policy modelling; Cost effectiveness and health economics; Modelling and simulation; Clinical modelling; Decision support

THB1 – Home Care – 02/08/2018 11:00 – 12:30
Chair – Katherine Penny   Room: FORUM

THB1-1: Yahyaoui Asmae – 02/08/2018 11:00 – FORUM
Admission policies in home care facilities study through simulation

Asmae, Yahyaoui[1]; Thierry, Garaix[2]; Xie, Xiaolan[2]
[1]CIS SAINT ETIENNE FRANCE ;
[2]CIS Saint Etienne FRANCE ;

In this work we developed a discrete time simulation of home care systems, (HCS) in order to evaluate admission policies to these services. Many researches have been conducted to optimize planning activities of HCS. Very few studies considered, patient casemix and admission rules. However these rules impact significantly the efficiency of HCS. The key performance indicators are the balance between capacity and demand, the equity among patients, the access time to service and the financial cost. Classes of patients are defined according to their dependency level, their age and their geographical location. The care process is simulated from the initial demand of a patient to access to the system until his exit of the system. At the beginning of each week, some patient are picked from the waiting queue and added to the patient panel. The weekly patient workload is then compared against the nurses and caregiver workload capacities at the half day a period level. The patient workload is determined by his care plan which gives the set of task to perform at each period. The task duration is correlated to the patient dependency level. Routing times between patients are roughly approximated by average travel times. At the end of the week some patients may leave the system according to some statistics.The design of experiments applied to this system evaluates the efficiency of current rules used in our case study HCSs: a maximum panel size and first come first served admission policy. We also propose other rules that aim to minimize workload and capacity mismatch by considering the patient panel casemix. Numerical experiments have been conducted with the parameter settings we obtained from several HCSs of the Eovi Mcd group.

Modelling and simulation; Performance evaluation; Patient flow

THB1-2: Elena Valentina Gutiérrez – 02/08/2018 11:30 – FORUM
Home Health Care Districting Decisions: Modeling and solving the problem for a health care provider in Latin America

Gutiérrez, E.V.[1]; Cortés, S.[2]; Villegas, J.G.[2]; Palacio, J.D.[3]
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[3]Universidad EAFIT MEDELLIN COLOMBIA ;

Population increase and aging, among other social and economic factors, have led to a substantial increase in demand for home health care (HHC) services. In HHC settings, patients receive coordinated medical care at their homes, while meeting medical prescriptions. Geographical dispersion of patients and medical staff generate complexity when health providers face districting decisions. The districting problem (DP) consists of defining districts made up of several territorial basic units BUs (i.e., city quarters) to ensure that the service is delivered to the patients' location at the prescribed time, and to assign balanced workloads to medical staff. In this work we propose a modeling and solving approach to support districting decisions in the HHC context. First, we present a mixed integer-programming model that uses a flow formulation to ensure the contiguity of the resulting districts. Using this formulation, we solve small DP instances with up to 44 BUs. To solve

largescale instances with more than 50 BUs, we propose a greedy randomized adaptive search procedure (GRASP). In this metaheuristic, the greedy randomized phase expands in parallel a set of districts initialized from random seed BUs, and the improvement phase relies on a variable neighbourhood descend with two neighborhoods. Using the proposed GRASP, we solve a largescale DP instance with 484 BUs faced by a real HHC provider in a rapid-growing city in Latin America. The provider takes care of acute and chronic patients, mostly subsidized by the public health system, and we consider a set of 55 medical procedures, which involves five types of medical professionals. The comparison of the GRASP solution with the districting currently used by the service provider revealed a 54% reduction in the workload imbalance.

Home care and Long Term Care; Modelling and simulation; Capacity and network planning

THB1-3: Katherine Penny – 02/08/2018 12:00 – FORUM
The Use of Telecare to Support People with Dementia to Remain Living within their own Homes
Penny, Katherine
University of Southampton Southampton UNITED KINGDOM ;

There are currently 820,000 people in the United Kingdom living with dementia and around 670,000 partners, family members, and friends providing them with support. The behavioural disturbances and memory loss, that typify dementia, can make the role of caregiver incredibly challenging. The consequent burden that many of these carers experience is closely associated with admission to institutional care. Due to the UK's ageing population, the number of people with dementia is set to rise to over one million by 2021. Consequently, the UK government is keen to explore different options to support carers and to meet the increasing demand on care services. One such option is telecare, which uses information and communication technology to help manage the risks of community living for people with dementia and support care delivery. In order to explore telecare's influence on the number of people with dementia able to remain living at home, this research uses a hybrid modelling approach. The success of discrete event simulation (DES) for modelling multifaceted care systems has been well documented. Using this trusted OR tool to model the care pathway in combination with statecharts, enhances its capability for capturing the complexity of this human centric system. Statecharts, a common component of agent based simulation (ABS), are used to convert the passive entities associated with traditional DES, into autonomous beings that exert control over the system. These transformed entities are better equipped to reflect the people they represent; capturing disease progression, level of dependency, and carer burden. These factors then govern the person's movement through the social care system. The TeleDem Simulation models the potential experiences of thousands of hypothetical telecare service users. This enables the testing of different scenarios to inform planning decisions for the provision of telecare services for people with dementia.

Home care and Long Term Care

THB2 – Maternity/Obstetrics – 02/08/2018 11:00 – 12:30
Chair – Christos Vasilakis   Room: Hagen 1 + 2

THB2-1: Sylvia Elkhuizen – 02/08/2018 11:00 – Hagen 1 + 2
Modelling service concepts for obstetric services in a regional hospital in The Netherlands

Elkhuizen, S.G.[1]; van der Sman, G.[2]; van Vliet, E.J.[2]
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[2]Franciscus Gasthuis & Vlietland Rotterdam NETHERLANDS ;

In The Netherlands, there is a long tradition of giving birth at home. However, due to several developments, there is a trend towards increasing numbers of pregnant women opting for hospital care settings. In Rotterdam, a multi-location hospital is planning to concentrate their obstetric services aiming for better accessibility and efficiency. Two service concepts with different architectural elements for hospital obstetric care are employed: a traditional birth setting and a single-room maternity concept. Within restrictions of physical and financial capacities to redesign the concentration-accommodation, the hospital has to choose the 'best' service concept. To facilitate this decision, we applied a service operations management framework to systematically compare the concepts. Subsequently, we used patient flow data measuring each activity between admission and discharge to analyse the use of resources. One of the main challenges was to create realistic scenarios for patient growth, based on different developments in different patient groups. We used a demand segmentation approach, in which we combined historical data with demographic data and expert data to create three different scenarios. We compared the service concepts with respect to the outcome parameters 'utilization' and 'accessibility', for each of the scenarios.

Strategic and operational planning; Healthcare policy modelling; Decision support

THB2-2: Catherine Crenn Hebert – 02/08/2018 11:30 – Hagen 1 + 2

Perinatal health and territorial analysis in the Ile de France (IDF) region

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Background: The IledeFrance (IDF) region has higher infant and perinatal mortality than the rest of metropolitan France. In 2012, the Regional Health Authority initiated a project aimed at Reducing Infant and Perinatal Mortality (RÃƒÂ©MI). It focused first on the SeineSaintDenis (SSD) district with an audit of all perinatal deaths: 33% of them were judged potentially avoidable by improving adherence to good practice guidelines and better management of risk factors, such as obesity. Objectives: To identify territories with an excess of perinatal mortality throughout the IDF region and assess risk factor availability. Method: We used routine data from the Perinatal health Information System which combines hospital discharge summaries, vital statistics, census data and data on hospital structural characteristics. The human development index (IDH2) combining life expectancy at birth, education and income level was measured at the level of the 27 subdistricts of the region, considered to be an appropriate geographic scale for evaluating social inequalities. Risk factors, including obesity and diabetes were analysed using delivery discharge summaries. Results: Among about 12 million inhabitants, nearly 3 million women from 15 to 49 years old lived in the IDF region in 2016. During the period 20142016, 545 502 total births were recorded; IDF perinatal mortality was 11.5 per one thousand total births and varied from 8.9 to 15.3 per 1000 across the subdistricts with a significant excess in 4, including 2 in SSD. Perinatal mortality increased when subdistrict level income or educational level decreased. Risk factors monitoring showed large variation in recording of risk factors between maternities even in a same subdistrict. Discussion- Conclusion:
Other areas of the region face higher risks and would benefit from specific actions aimed at reducing perinatal mortality. The quality of risk factors coding in delivery stays has to be improved.

Healthcare Information Systems; Epidemiology and disease modelling; Data analysis and risk management; Healthcare policy modelling

THB2-3: Christos Vasilakis – 02/08/2018 12:00 – Hagen 1 + 2

Supporting decisions around the provision and allocation of regional maternity services with operational research

Vasilakis, Christos; Erdogan, Gunes; Stylianou, Neophytos
University of Bath Bath UNITED KINGDOM ;

Decisions around the provision and allocation of care services within a regional health economy are multifaceted and often require a delicate balancing act across a number of trade-offs. Operational research is thus very suitable in providing insights and quantitative support to those tasked with making such decisions. The support can take different shapes, from providing a practical quantitative analysis of the problem, to deciding on the metrics the decisions should be based upon, to the development and use of more advanced techniques such as optimisation. In this case study, we were commissioned to look into the provision and allocation of maternity services within a region in the UK. Having recently acquired a number of relevant facilities, the collaborating organisation asked us to evaluate the model of service provision currently in use and to support, through quantitative and geographic analysis, decisions around the strategic reconfiguration of the service. The objectives, parameters and scenarios of the location analysis were discussed between the modelling team and the commissioners of the study. As part of this discussion, we articulated 12 scenarios to form the basis of the location analysis. We used a specialised software tool developed by researchers in the University of Bath to help with identifying the optimal locations of maternity service facilities. We did so by calculating the minimum distances travelled between a geographic central point of aggregate demand, as defined by the Middle Layer Super Output Area (MSOA), to the closest maternity facility (for the quickest route). Aggregate demand, used as input in the tool, was estimated based on historical data of demand adjusted for the index of deprivation associated with the relevant MSOA. The experimental results, which we will present during the talk, have been fed back to planners and are currently used to inform the reconfiguration process.

Strategic and operational planning

THB3 – Health Care Policy Modelling II – 02/08/2018 11:00 – 12:30
Chair – Penelope Mullen   Room: VIA

THB3-1: Lerzan Ormeci – 02/08/2018 11:00 – VIA

Modelling Care for Patients with Multiple Chronic Conditions and Varying Patient Activation Levels

Ormeci, Lerzan[1]; Gunes, ED[1]; Kanavetas, O[1]; Vasilakis, C[2]
[1]Koc University Istanbul TURKEY ;
[2]University of Bath Bath UNITED KINGDOM ;

We develop a Markov Decision Process framework to manage care for patients with multiple chronic conditions through a complex care hub. Patients are further grouped according to their activation levels which can be measure by Patient Activation Measure (PAM). The type of care provided, either normal or complex care, affects the evolution of both the health state and activation levels of

patients. We investigate the structure of optimal policies, and numerically explore the performance of alternative heuristic policies under different settings.

Care Pathways; Healthcare policy modelling; Screening and prevention

THB3-2: Sandy Rutherford – 02/08/2018 11:30 – VIA
The Continuum of HIV Care for Men Who Have Sex with Men in Vancouver, Canada
Rutherford, Alexander[1]; Wai, B[1]; Zimmerman, S[1]; Kok, S[1]; Barrios, R[2]; Gustafson, R[3]; Vasarhelyi, K[1]
[1]Simon Fraser University Burnaby CANADA ;
[2]BC Centre for Excellence in HIV/AIDS Vancouver CANADA ;
[3]Vancouver Coastal Health Vancouver CANADA ;

Strategies for health service delivery to achieve optimal control or prevention of infectious diseases can be analysed by marrying operational research with epidemiological models. We present a long-term project with Vancouver Coastal Health authority and the BC Centre for Excellence in HIV/AIDS to model the continuum of HIV care for the Men who have Sex with Men (MSM) community in Vancouver. A system dynamics (differential equation) approach is used to model HIV testing, engagement in care, and retention programs. It is coupled to a compartmental epidemiological model of the HIV epidemic, which captures the impact of improvements in testing and treatment on HIV incidence, morbidity and mortality. The model was first applied to optimizing public health testing resources across targeted testing, routine testing in high prevalence settings, and routine testing in general health care settings. It was found that for the MSM community, the optimal strategy for reducing HIV incidence is a combination of routine testing in high prevalence settings with routine testing in general health care settings. More expensive targeted testing programs, such as contact tracing, remain essential, but should be streamlined and reserved for situations when they are most needed. An extended model has been applied to the optimization of treatment, treatment support, and retention programs for minimizing HIV incidence, morbidity, and mortality. Additional investment in treatment support for the MSM community should be focused in improving engagement in care and general treatment support services, rather than intensive case management. Recently, there has been a focus on reducing HIV infections by combining multiple strategies, such as Treatment as Prevention (TasP) with Pre-exposure prophylaxis (PrEP). We present results on the potential of targeted PrEP combined with TasP for reducing HIV incidence in the MSM community.

Epidemiology and disease modelling; Process optimisation; Modelling and simulation; Healthcare policy modelling; Strategic and operational planning

THB3-3: Penelope Mullen – 02/08/2018 12:00 – VIA
A STARring Role for OR
Mullen, Penelope
Independent Birmingham UNITED KINGDOM ;

Earlier it has been argued that, whilst promoting health and preventing ill-health are important objectives of health care and healthcare systems, a major objective of healthcare systems is to promote trust and security – to provide assurance that health care will be available when needed. To security, trust and assurance, we can add resilience – hence STAR. There has recently been considerable interest in the concept of resilience in a number of sectors. Whilst individual resilience defined by Jo Wolff as "people's ability to "bounce back" after an adverse health event" has been

identified as an important aspect of individual health security, healthcare-system resilience would appear essential in assuring both the security of the system and assurance and security for individuals. However, health-gain maximisation has been widely promoted and adopted as the primary or even sole objective in healthcare priority-setting, explicit policymaking and, most prominently, in the evaluation of new drugs and other interventions. However, the pursuit of health-gain maximisation (QALY [Quality Adjusted Life Year] maximisation) can have a number of consequences which run counter to security and assuring the availability of needed health care counter to STAR. They include reinforcing inequalities, discrimination against those with rare diseases, against those with pre-existing disabilities and against those needing more costly interventions. Further, analysis of reality in the organisation and provision of health care suggests that, implicitly, policymaking practice pursues STAR rather than pure health gain maximization. Nevertheless, in priority-setting and explicit policymaking, the difficulty arises of expressing STAR in terms of operationalisable objectives to challenge the undoubted attraction of pursuing the single objective of QALY maximisation. This paper will elaborate on these points and explore the implications for policymaking and analysis, including an examination of the contribution of OR.

Strategic and operational planning; Cost effectiveness and health economics; Healthcare policy modelling

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THB4 – Scheduling II – 02/08/2018 11:00 – 12:30
Chair – Marta Cildoz   Room: Hagen 3

THB4-1: Melanie Erhard – 02/08/2018 11:00 – Hagen 3
Flexible staffing of physicians with column generation
Erhard, Melanie
University of Augsburg Augsburg GERMANY ;

In Germany, around 40% of the hospitals do not generate an annual surplus. This leads to an increasing pressure on hospitals' management to reorganize and restructure their processes and resources to decrease the upcoming costs and become profitable. Since personnel, especially physicians, generates a major part of the arising costs, assigning staff in an efficient way provides an opportunity to decrease associated costs. Up to now, experienced physicians create rosters manually which is cost and time intense due to the complexity of the problem and especially the fluctuation in demand. To circumvent this difficulty, it is our main aim to create a new mathematical modeling approach to implement additional flexibility in the rostering process to better match supply and demand. Therefore, we formulate the problem as mixed-integer programming model with the objective to minimize the total size of the workforce subject to coverage of demand. In our approach, full flexibility in terms of patterns of working days, shift types and the placement of the break is provided. To solve the problem under consideration, a column generation heuristic is presented. In our experimental study, the performance of the provided solution approach as well as the effect of additional flexibility in the rostering process are evaluated using real-life data. Results indicate the significant impact of implementing flexibility in the scheduling process on the total number of required physicians and evidence the superior quality of our solution approach.

Staffing and capacity planning; Strategic and operational planning; Workforce planning

THB4-2: Rimmert van der Kooij – 02/08/2018 11:30 – Hagen 3
Adapting Integral Capacity Management from the Netherlands to Norway, the first steps
van der Kooij, Rimmert[1]; Hans, E.W.[2]; Landsem, E.[1]; Toussaint, P.J.[3]; Thorvik, K.[4]; de Man, J.C.[3]
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[3]NTNU Trondheim NORWAY ;
[4]HEMIT Trondheim NORWAY ;

Background: The aging society in Norway poses increased demand on the health care system. However, the demand is not countered by an adequate increase in available staff and money. If the health care system is supposed be able to cope with the demographic development, productivity and cost-effectiveness has to increase substantially. One possible strategy is applying advanced Operations Research techniques to enable better Operations Management. To create an environment in which we can apply OR techniques a number of requirements have to be met.

Methods and Results: Planning within hospitals can be divided in three levels: strategic, tactical and operational. A research group in the Netherlands developed a planning approach that focusses on the tactical level, the strategic and operational level are often covered, where the tactical level is often completely missing. The approach is referred to as Integral Capacity Management (ICM).
Using the managerial problem-solving method, we found that also in Nord Trøndelag only strategical and operational planning is done, causing big variations in both waiting lists, overtime and resource usage. To convince both leadership and healthcare workers that the lack of proper tactical planning was one of the main causes for the problems encountered, a problem tree was drawn, going from root causes to identified problems, and which root causes could be solved by applying ICM.

Conclusion: To implement ICM, the following requirements need to be met: *) there should be urgency (problem), *) leaders on the different levels need to support the change, *) doctors must be willing to adopt ICM, *) ability to change the ICT systems where required, *) organizations require a tactical planning unit which has cross-department autonomies regarding tactical planning decisions that integrally analyze and optimize patient flows.
A good start to accomplish these requirements is creating insight by drawing a problem tree.

Strategic and operational planning; Care Pathways; Patient flow; Patient scheduling; Operating room planning and scheduling; Staffing and capacity planning

THB4-3: Marta Cildoz – 02/08/2018 12:00 – Hagen 3
A heuristic approach to solve the ED physician scheduling problem
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[1]PUBLIC UNIVERSITY OF NAVARRE PAMPLONA SPAIN ;
[2]UNIVERSITY OF ZARAGOZA ZARAGOZA SPAIN ;

An Emergency Department (ED) is the department of a hospital responsible for the provision of medical and surgical care to patients arriving at the hospital in need of immediate care. Therefore, an ED is usually open 24 h per day and 7 days a week. This work addresses the physician scheduling problem with long planning horizon (one year). All shifts in the planning horizon have to be distributed among the staff. Shifts differ in length and characteristics related with their associated tasks. In addition, different numbers and types of shifts are scheduled for different types of days.

Not all physicians can work any shift, some of them are exempt from doing night shifts for reasons of age while others are not full time workers. The main goal of the scheduling is to get feasible assignments with a balanced distribution of all types of shifts among the physicians. This is a very difficult practical problem that has to consider many different types of constraints (demand, workload, ergonomic, fairness, equitability, etc.) and for large instances cannot be solved effectively by using exact solution methods. We address this problem by designing a heuristic algorithm based on a greedy randomized adaptive search procedure (GRASP) which is guide by the solution of a general demand covering problem (solved by linear programming). A local search optimization improves the initial GRASP solutions. This methodology is applied to an existing emergency department of a hospital that has to schedule 43 physicians with a planning horizon of one year, whose results show the superiority of our algorithm over the use of an integer linear programming approach and a human scheduling approach.

Staffing and capacity planning; Emergency Medical Services; Workforce planning

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THC1 – Emergency Medical Systems III – 02/08/2018 13:30 – 15:00
Chair – David Stanford   Room: FORUM

THC1-1: Nikolaus Furian – 02/08/2018 13:30 – FORUM
GEDMod – Towards a Generic Toolkit for Emergency Department Modeling

Furian, Nikolaus[1]; Neubacher, D.[2]; O'Sullivan, M.[3]; Walker, C.[3]
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The design of generic models, or generic building blocks, for health care operations has been discussed in depth and identified as one of the grand challenges for researchers in the field of Modeling and Simulation with corresponding research questions being raised. In this paper we provide an investigative basis for answering recently raised research questions for a specific subdomain of health care facilities and a specific Modeling and Simulation paradigm, i.e. Discrete Event Simulation Models of Emergency Departments. Therefore, we perform a detailed analysis of a large set of published Emergency Department models. This analysis is executed following a structured conceptual modeling framework to ensure the coverage of all conceptual modeling aspects: objectives; input scenarios; output definitions, i.e. commonly used performance indicators; structural components such as physical resources and human resources (including expertise and skill levels); patient classifications (arrival modes, triage grades, complaint categories); patient pathways including triage, treatment and admission phases; and organizational structures including control policies. The resulting collection and classification of modeling archetypes are used as the basis for an initial generic modeling toolkit for Emergency Department operations. Thereby, the modeler is guided through the main steps of conceptual modeling of Emergency Departments and generic building blocks for each step are provided. The paper concludes with a discussion on the applicability and benefits of the resulting framework along with the potential to combine the toolkit into a single generic Emergency Department model.

Emergency Medical Services; Modelling and simulation

THC1-2: Adele Marshall – 02/08/2018 14:00 – FORUM
Generalisable discrete event simulation modelling of hospital emergency departments
Marshall, A.H.[1]; Boyle, L.M.[1]; Mackay, M.[2]
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[2]Flinders University Adelaide AUSTRALIA ;

Emergency departments (EDs) internationally form the main point of contact for patients requiring urgent medical treatment, and therefore it is essential that they operate in a safe and efficient manner. EDs have become severely overcrowded due to increased demand, and issues with 'boarding' patients (those awaiting beds for inpatient admission). This has contributed to a reduced ability of EDs to treat patients within government performance targets. It was recently reported that only 67.3% of patients in South Australian EDs were treated within the four-hour National Emergency Access Target (NEAT).
Discrete event simulation (DES) has been used widely to model EDs, however the existing literature has mainly focused on unit-specific studies. There is a growing need for generalisable approaches, which promote model reuse, and allow direct comparison between EDs. It is proposed that a generalisable model can provide the first step for understanding the key issues surrounding patient flow within EDs, and be utilised for testing improvement strategies.

This research introduces a conceptual modelling framework for developing generalisable emergency department DES models. The framework discusses what is possible to achieve by using generalisable models in terms of scope, level of detail, assumptions, and simplifications. The generalisable framework operates by embedding survival regression models into a DES, so that length of stay estimates depend on influential patient and system attributes (including overcrowding level, and interdependencies with inpatient units). Therefore, considerable flexibility exists for including varying levels of detail in the model. This procedure additionally provides a method of identifying patient-types who are likely to have a longer stay within the ED, and consequently permits more informed allocation of resources. The methodology is illustrated with application to an ED in Adelaide, South Australia.

Modelling and simulation; Patient flow; Emergency Medical Services

THC1-3: David Stanford – 02/08/2018 14:30 – FORUM
An updated approach to Emergency Department prioritization in light of empirical data
Stanford, David[1]; Bilodeau, BL[1]; Ziedins, IB[2]; Taylor, PG[3]; Mojalal, M[1]; Li, N[4]; Sharif, AB[1]; Caron, RJ[5]; Pardhan MD, A[4]
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[4]McMaster University Hamilton CANADA ;
[5]University of Windsor Windsor CANADA ;

In recent years, several ORAHS presentations have addressed the utility of the Accumulating Priority Queue (APQ) discipline, to respond to the stated limits of Key Performance Indicators for the waiting times, such as the Canadian Triage and Acuity Score (CTAS) and the Australasian Triage Score (ATS). Recently, we have been working with a two-year Emergency Department dataset from a hospital in Southern Ontario, which profiles the demand for emergency care by CTAS category. This profile

reveals that this hospital, and others like it in Ontario, are highly dominated by the middle acuity class, CTAS 3 (Urgent cases). This reality changes significantly the appropriateness of an APQ approach, which now needs to entail an element of delay for some classes before priority starts to accumulate. This presentation will explain the rationale behind this conclusion, and present numerical results for the lower acuity class of interest: CTAS 4 (Less Urgent) cases. It is hoped at time of writing that numerical waiting time results for the higher priority classes will be available analytically; it not, simulation results will be reported. It is also hoped that a lively discussion of opinions will follow the presentation.

Access and waiting lists; Patient flow; Statistical modelling

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THC2 – Capacity Planning II – 02/08/2018 13:30 – 15:00
Chair – Sebastian Rachuba   Room: Hagen 1 + 2

THC2-1: Paula Andrea Velásquez Restrepo – 02/08/2018 13:30 – Hagen 1 + 2
Estimation of the number of beds per month required by a hospital of high level of complexity in the city of Medellin Colombia, for the care of an assigned population, under a model of risk co-management between the institution providing health services (hospital) and the health insurance company

Velásquez Restrepo, Paula Andrea[1]; Edwin Alonso Alvarez Tobon, Msc[2]
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[2]IPS Universitaria, Clínica León XIII Medellín COLOMBIA ;

The current Colombian health system is immersed in a context of demographic and epidemiological transition; drastic climate changes; unhealthy lifestyles, which have generated an increase in chronic diseases and the comorbidity of the population. This, added to the economic crisis of the sector, requires that hospitals work for a reorientation of attention, and a planning, and management more successful of resources, which are increasingly scarce, for patient care. The present research work exposes a new model of differential attention based on risk co-management, which considers it necessary to differentiate and prioritize the assigned population by risk groups, in order to develop differential care strategies. The model based on risk co-management has the premise that the company providing health services (hospital) also has responsibility for managing the health risk of the population, together with the health insurance company. In this context, it is also the responsibility of the hospital, to know its assigned population, its epidemiological profile and its health risk, and on this basis to project the demand for resources for health care. The present investigation developed a case study, where a geographical, demographic and epidemiological characterization is carried out; a population segmentation by life cycle and comorbidity level; as well as a stratification and prioritization of risk groups by level of chronicity, hospital stay and frequency of consultation, of the population assigned to the hospital, by an insurance company in health, through statistical analysis and descriptive models. Finally; by means of an analytical and simulation model (systems dynamics), the demand per month of the hospital bed resource is projected during the care process of said assigned population, according to the hospital demand of the identified risk groups, under a horizon of simulation of one year.

Capacity and network planning; Data analysis and risk management; Strategic and operational planning

THC2-2: Elena Tànfani – 02/08/2018 14:00 – Hagen 1 + 2

Modelling hospital internal medicine departments organization to address patient complexity

Tànfani, Elena[1]; Landa, P.[2]; Testi, A.[1]; La Regina, M.[3]; Murialdo, G.[4]; Orlandini, F.[5]
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[5]ASL 4 Chiavarese, Direzione Sanitaria Chiavari ITALY ;

In this paper we focus on patient flows inside hospital Internal Medicine departments, with the aim of supporting new organizational models taking into account the patient relevant characteristics such as complexity and frailty. The main contribution of this paper is to develop a Discrete Event Simulation model that describes the pathways of complex patients through medical hospital wards. The model has been applied to reproduce a case study of an medium sized Italian hospital of 800 beds and which has about 30 000 elective admissions per year. The first objective of our study is to quantify the impact of alternative organizational models (e.g. longitudinal, transversal, intensity of care based) using a set of performance indicators. The reorganization is mainly based on changing the available bed and staff assignment inside the wards to better address the complexity of care of patients with comorbidity. Following a patient-centred approach, patients are clustered considering the clinical characteristics (i.e. the pathology, proxy of Diagnoses Related Groups classification) and sub-grouped considering other characteristics such as complexity and age. Then, an optimization component embedded into the model is used to choose the best pooling strategy to reorganize medical wards, determining the corresponding number of beds able to improve some process indicators, such as throughput and length of stay. The simulation model developed is presented and preliminary results are analysed and discussed.

Care Pathways; Patient flow; Modelling and simulation; Staffing and capacity planning; Process optimisation

THC2-3: Sebastian Rachuba – 02/08/2018 14:30 – Hagen 1 + 2

Modelling capacity requirements of a recovery room at a large public hospital

Rachuba, Sebastian[1]; Wytrieckus, Thomas[2]
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Hospital recovery rooms are a typical bottleneck within the flow of surgical patients as beds are limited. Typically, the vast majority of patients is admitted to a recovery room following surgery. Depending on the number of planned surgeries and the expected time a patient will spend in the recovery room, the demand for beds can vary significantly. Ensuring efficient utilisation of such units while taking into account variable patient inflow and staff availability a key concern for the management. Our case study at a large public hospital investigates the process of merging two spatially separated recovery rooms into a new, larger unit. Together with an already existing recovery room, the new unit will then serve 15 operating rooms in total which are shared by six surgical departments. In those operating rooms, the hospital currently performs approximately 14,000 surgeries for both inpatients and day cases per year. We model current activities within the

recovery room and respective patient flows through the using discrete event simulation. Planned structural changes are captured in distinct what-if scenarios to assess the resulting utilisation of the recovery rooms in comparison to the status quo. In a subsequent analysis we contrast the respective workloads with availabilities of nursing staff in the recovery rooms. Finally, results from a sensitivity analysis demonstrate the impact of operating room schedules on the performance of the recovery room.

Modelling and simulation; Patient flow; Performance evaluation

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THC3 – Operating Room Scheduling IV – 02/08/2018 13:30 – 15:00
Chair – Roberto Aringhieri   Room: VIA

THC3-1: Asgeir O Sigurpalsson – 02/08/2018 13:30 – VIA
Practical General Surgery Scheduling
Sigurpalsson, Asgeir O. ; Runarsson, T.P ; Saemundsson, R.J ; Moller, P.H ; Hallgrimsdottir, V.
University of Iceland Reykjavik ICELAND ;
National University Hospital of Iceland Reykjavik ICELAND ;

In practice, surgery scheduling can be challenging due to various sources of uncertainty. Both surgery times and which surgeries will be performed are inherently uncertain. Prior to a surgery, a plan is made for several types of procedures likely to be performed. Different scenarios for surgery times are realized based on historical data for both plans and surgeons. Additionally, knowledge of whether a patient will require ward time or placed in an Intensive Care Unit (ICU) may be known with some degree of certainty, however the length of stay is uncertain. In this study, we propose a stochastic programming model that follows normal practices for general surgery at Landspitali University Hospital. Due to resource limitations, not all patients can be accommodated during the planning horizon. Therefore in the first phase of the model, a subset of patients is selected based on their priority status and registration date on the waiting list. The list is dynamic with patients entering and leaving it. In the second phase, the selected patients are assigned to days so that the expected number of patients in the ward and the ICU at any given day is minimized. Furthermore, the probability of an operating room going into overtime is constrained. Today, the general surgery uses two operating rooms out of eight during the week. Once the day shift is over two surgical teams remain to serve acute surgeries, thus it is feasible for two surgeries to overrun. However, if the program director recognizes that more than two surgeries will go over, one of the surgeries must be postponed. We will present a comparison between a stochastic programming model that considering the practical challenges met today to manually created plans. The comparison addresses the practical implications and challenges in implementing optimization models for practical general surgery scheduling.

Operating room planning and scheduling; Modelling and simulation; Decision support; Patient flow

THC3-2: Enis Kayis – 02/08/2018 14:00 – VIA
Next-Day Operating Room Scheduling With Time-Dependent Stochastic Surgery Durations
Karatas, Tugce[1]; Kayis, Enis[2]; Gullu, Refik[3]
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[2]Ozyegin University Istanbul TURKEY ;

[3]Bogazici University Istanbul TURKEY ;

Operating rooms are the most critical units of the hospitals responsible for 40% of the revenues and costs. We consider the next-day operating room scheduling problem for a given list of elective surgeries. It is assumed that surgeries have uncertain durations and unlike existing works distributions of surgery durations are assumed to be time-dependent as suggested by recent empirical work on surgery duration estimation. We aim to find the optimal OR sequence and schedule when surgery durations are time-dependent to minimizes the weighted sum of expected waiting time of patients, idle time of operating rooms, and overtime of the hospital staff. We formulate the problem and use sample average approximation to solve the resulting stochastic optimization model. Using these results, we quantify the penalty of ignoring time-dependent surgery durations. Furthermore, we study how the penalty is affected if commonly used heuristics are used in OR scheduling and sequencing.

Operating room planning and scheduling; Patient scheduling; Strategic and operational planning

THC3-3: Roberto Aringhieri – 02/08/2018 14:30 – VIA
Combining workload balance and patient priority maximisation in operating room planning through hierarchical multi-objective optimisation

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Several performance criteria have been reported to lead and to evaluate the Operating Room (OR) planning decisions: usually, patient priority and OR utilisation maximisation are the most used, but also the maximisation of patient satisfaction and the minimisation of delays, cancellation and fixed patient and societal costs. Further, the workload balance leads to a smooth without peaks bed occupancy determining a smooth workload in the ward and, by consequence, an improved quality of care provided to the patients.

Taking into account a patient-centred perspective, a preliminary comparison between two criteria patient priority maximisation and workload balance has been reported. Such a comparison confirmed the ability of ensuring a high level of OR utilisation dealing with long waiting lists, which is a common situation in many hospitals belonging to publicly funded health systems. The patient priority maximisation is a fairness criterion among patients that allowed us to have an OR utilisation close to 100% in all cases. Conversely, the workload balance is a criterion to have a smooth workload along the week, which has been able to schedule a high number of patients in most cases.

The aim of this work is to develop a methodology for OR planning and scheduling capable to take into account such different performance criteria. We propose a hierarchical multi-objective optimisation model for workload balance and patient priority maximisation for the combined Master Surgical Scheduling and Surgical Cases Assignment problems. To solve the problem we propose a MultiNeighborhood Local Search based Matheuristic in which several large neighbourhoods are sequentially addressed by means of Integer Programming models capable to exhaustively explore large neighbourhoods in small computational times. Computational results on realistic instances prove the effectiveness of the proposed approach providing high quality solutions regarding the two criteria considered.

Operating room planning and scheduling; Performance evaluation; Strategic and operational planning; Patient scheduling

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THC4 – Doctor Scheduling – 02/08/2018 13:30 – 15:00
Chair – Nadia Lahrichi   Room: Hagen 3

THC4-1: Kjartan Kastet Klyve – 02/08/2018 13:30 – Hagen 3
Semicyclic-physician rostering
Klyve, Kjartan Kastet
NTNU Trondheim NORWAY ;

In this work, a physician rostering problem with semi-cyclic structures for different subgroups of employees is presented. It is a real-life problem occurring at the Clinic of Surgery at St. Olavs Hospital in Trondheim, Norway, that has proven very hard to solve using manual techniques. Resident surgeons of three different experience levels must cover a minimum demand for staff at an emergency room for patients who are in need of surgery. These shifts must be covered round the clock at all days, and according to regulations they must be scheduled cyclically. The resident surgeons must also cover the need for staff at different sections, where each resident surgeon belongs to one section, such as the endocrine section, the pediatric section etc. As well as minimum demand for staff constraining the planning problem, there are regulations related to finding sufficient time off for the resident surgeons and regulations that ensure a maximum total workload. For schedules to be considered high-quality, they should be robust, i.e. resilient to absence among employees, and overtime costs should be low. Therefore, even staff levels and spreading excess staffing resources is considered a good quality in schedules. In this work a mixed integer program is created, and using a rolling horizon heuristic the problem is solved, finding solutions that far outperforms the schedules currently in use. The schedules produced by the model far outperforms the previously used manual methods in both cost reduction, ensuring even staff levels and robustness to absence among employees. The robustness is ensured both through even distribution of extra capacity at the different sections and through ensuring that at least one employee can step in to cover a night shift, while respecting regulations.

Staffing and capacity planning; Workforce planning

THC4-2: Julia Sophie Block – 02/08/2018 14:00 – Hagen 3
Multi-criteria evaluation of appointment scheduling for multiple general practitioners
Block, Julia Sophie; Koppka, L.; Schacht, M.; Werners, B.
Ruhr University Bochum, Faculty of Management and Economics Bochum GERMANY ;

In Europe, general practitioners have a key role in primary health care. They are responsible for diagnostic and curative services, often combined with disease prevention. Frequently, they are the first point of contact in case of illness. If necessary, they refer patients to specialists, and they are the main contact person for their patients. Their available scarce capacity has to be well utilized to fulfill the requirements of several stakeholders, mainly patients of different types and different practitioners. When scheduling appointments for their patients, sufficient capacity should remain to treat as much short-term demand as possible on the day of request. Other patients prefer to take an

appointment on a following day to avoid long waiting times in practice. By adequately offering prescheduled appointment slots, patient demand can be channeled to a certain extent; this applies for group practices in particular as demand can be channeled between weekdays and additionally between practitioners. We propose a generally applicable mixed integer linear optimization models with different goal functions. It tactically optimizes weekly appointment schedules for practices with multiple general practitioners. Dependent on different structural characteristics of a practice concerning patient type and patient preferences, typical appointment schedules are determined and compared regarding multiple criteria. In a series of stochastic simulations, we further analyze the obtained solutions according to different evaluation criteria, when patient arrival, their willingness to wait and treatment duration are uncertain. Results allow recommendations for practices dependent on their respective structure and patient panel.

Patient scheduling; Strategic and operational planning; Performance evaluation; Modelling and simulation

THC4-3: Nadia Lahrichi – 02/08/2018 14:30 – Hagen 3
Productivity-driven physician scheduling in emergency departments

Lahrichi, Nadia[1]; Camiat, Fanny[1]; Chauny, Jean-Marc[2]; Restrepo, Maria Isabel[1]; Rousseau, Louis-Martin[1]
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The overcrowding of emergencies in Quebec is often in the news headlines. In fact, the province has the reputation for having the worst wait times in emergencies. This has many consequences such as dissatisfaction of patients and physicians, prolonged suffering for patients, or an increase in the number of patients who leave the emergency without being seen. Reducing this congestion is a major challenge for improving access to care. Our approach to deal with this problem is to offer an innovative approach to scheduling emergency physicians. Currently, departments define a covering constraint that determines the number of required physicians per shift and day. The constraint may also be specific to sections of the emergency department if applicable. This number is usually fixed. We observe two main issues. First, the variation in demand in terms of number of patients is not considered when designing the schedule. Second, all physicians are considered equivalent in terms of their productivity, i.e. the number of patients that can be seen in a shift. These two aspects lead to a mismatch between offer and demand on a day to day basis. In this project, we will address these two issues to better align the schedule of physicians to patients demand in emergency departments (ED). We will collaborate with the ED department of the Sacré Coeur Hospital in Montreal (HSCM). We will have access to data covering the period 2008 2017. Although we use a specific case to address the problem, our scheduling model is generic and our approach applicable to different contexts.

Staffing and capacity planning

THD1 – Patient Flow – 02/08/2018 15:30 – 17:00
Chair – Martin Utley   Room: FORUM

THD1-1: Blair Bilodeau – 02/08/2018 15:30 – FORUM
Simulated geographical colocation of patients admitted to an inpatient internal medicine teaching unit: Potential impacts on efficiency and physician-nurse collaboration

Bilodeau, Blair[1]; Stanford, D.A.[1]; Goldszmidt, M.[2]; Appleton, A.[2]
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This presentation reports the results of a study to increase physician-to-patient time in the internal medicine (IM) ward at University Hospital in London, Canada, by reducing the incidence of two sources of inefficiency. Currently, three medicine teams operate on the IM floor, with each team's patients spread over the entire floor. The project proposed changes to the bed assignment method to geographically co-locate each team's patients in a contiguous area. This thrust would also reduce inefficiency in the number of nurses a physician collaborates with for the same patient load, as nurses are generally assigned to patients in adjacent rooms. This improved efficiency during physician-nurse interactions will lead to better patient care.

The other novel aspect to the project was the hybrid assignment of patients to teams. Each patient will be assigned to the first available bed, and the initial proxy for this upon patient admission is the team with the lowest census level. Occasionally, the first available bed will belong to another team, in which case a change of medicine team will occur. A simulation model of the ward was developed specifically to test these changes, and the results presented suggest an implementation will achieve these goals without impacting patient waiting time or occupancy levels. Two new metrics defined to quantify the impacts of the new assignment method were a) the relative number of nurses each medicine team has assigned to their patients, as well as b) the variation between the total number of patients assigned to each team. Simulation results show that the hybrid assignment minimized this variation, while the number of nurses a team has to interact with is significantly reduced.

Modelling and simulation; Access and waiting lists; Care Pathways; Strategic and operational planning; Patient flow; Performance evaluation

THD1-2: Ines Verna Arnolds – 02/08/2018 16:00 – FORUM
An Iterative Simulation-Optimization Approach for Hospital Layout Planning

Arnolds, Ines Verena; Nickel, S
Institute of Operations Research: Discrete Optimization and Logistics, Karlsruhe Institute of Technology Karlsruhe GERMANY ;

Layout planning for hospitals is a strategic long-term decision. Nevertheless, it influences operational processes such as patient flows during their hospital stays and personnel flows over their working day. Furthermore, organizational factors and patient flows change over time. In this paper, we consider the planning of a hospital-wide layout taking into account the impact of strategic layout decisions on the operational performance with uncertain process flows.
In order to incorporate process uncertainties in the layout planning phase, optimization is combined with discrete event simulation (DES). While solving a mathematical model results in an optimal layout under deterministic data, simulation scenarios help to find a robust layout which will show a

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good performance even when patient, personnel and material flows are uncertain. In the first step, an adapted Quadratic Assignment Problem (QAP) is formulated to solve the layout problem assuming deterministic patient flows and numbers. The solution, i.e. the layout assignment, is then evaluated using a DES model with stochastic patient flows and numbers. It then feeds back the results and other parameter values to the QAP. The models interact multiple times until the stopping criterion is met. This iterative simulation-optimization approach is implemented in AnyLogic using the callable CPLEX library.

Computational results reveal a good performance of our approach as compared to an optimization-only approach. Beyond incorporating uncertainty, there are further advantages, for example: The possibility to define different scenarios by changing both input data (extrinsic configuration like capacity and number of elevators) and factors which are revealed during the simulation run (stochastic influences like uncertainty of clinical pathways). Furthermore, the performance of the hospital layout can be evaluated separately for different patient types. Thus, a fairness factor can be established. Patient types can be defined, for example, by severity of illness or level of mobility.

Modelling and simulation; Strategic and operational planning; Patient flow; Performance evaluation

THD1-3: Martin Utley – 02/08/2018 16:30 – FORUM
Patient flow in non-Markovian systems
Utley, Martin[1]; Kung, E[1]; Worthington, D[2]
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Analytical compartmental models of patient flow based on the concepts and results of queueing theory are often underpinned by assumptions that a patient's future movement from a given state does not depend on the path taken by the patient to enter that state or the time that the patient has resided in that state. In many health care contexts, such assumptions do not have clinical face validity or are not supported by empirical observations. The analyst then has to weigh this lack of verisimilitude against the insights on offer from the analytical model. Infinite server queueing systems allow relaxation of these Markov assumptions and are becoming more widely used in health care applications, particularly in models of flow used to forecast demand for services. As part of a programme of work exploring the potential uses and limitations of infinite server systems in health care, we assess the value of relaxing the Markov assumptions in a model forecasting short-term demand in a multistate flow system. Using extensive data on patient pathways from our partner hospital (a large tertiary paediatric hospital), we explore the extent to which the Markov assumptions are violated within the data and the impact that this has on the accuracy of forecasts made using the model. The dependence of this impact on the forecasting horizon is also studied.

Patient flow; Forecasting

THD2 – Operating Room Scheduling V – 02/08/2018 15:30 – 17:00
Chair – Mariana Oliveira   Room: Hagen 1 + 2

THD2-1: Sebastian Kohl – 02/08/2018 15:30 – Hagen 1+2
Simulation based evaluation of operating room management policies
Kohl, Sebastian; Brunner, J.O.

University of Augsburg Augsburg GERMANY ;

Since operating rooms are a major bottleneck resource and an important revenue driver in hospitals, it is important to use these resources efficiently. Studies estimate that between 60% and 70% of the hospital admissions are due to surgeries. Furthermore, staffing cannot be changed on a daily basis to respond to a changing demand. The resulting high complexity in surgery scheduling necessitates perpetual process evaluation and the use of managerial decision support tools. In this study, we evaluate several management policies and their consequences for the operating theater of a large German hospital. For the evaluation, a detailed simulation model is built to capture the complete workflow in the operating theater. On the basis of a data set with over 10 000 patients, we create random daily schedules that are additionally interfered by the arrival of patients with different acuity levels. With our simulation, we are able to evaluate management options as the parallel induction of anesthesia, the use of buffer times in the patient scheduling process or the use of a dedicated emergency room. The system performance is measured by indicators as the patients waiting time, OR idle time, staff overtime or the amount of postponed surgeries.

Modelling and simulation; Operating room planning and scheduling; Decision support

THD2-2: Angel Ruiz – 02/08/2018 16:00 – Hagen 1+2
A multicriteria prioritization framework to improve patients' access to healthcare services
Ruiz, Angel
Université Laval Quebec CANADA ;

The imbalance between the demand and availability of access to specialized social and healthcare services causes long waiting times. Consequently, some patients wait longer and, in some cases, even longer than what is clinically recommended. In many medical procedures, these long waiting times directly affect the patients' health and quality of care, so waiting lists management and appropriate patients' prioritization can play an important role in diminishing undesirable outcomes, such as patients' injury or mortality. Patients' prioritization on waiting lists has become one of the major issues in public systems and several researchers have stressed the need for an interdisciplinary and collaborative research to explore systematic and precise prioritization frameworks. We propose a general and integrated framework able to prioritize patients in complex dynamic systems, taking into account multiple decisional criteria, considering both medical staff and patients' opinions, risks, uncertainties and incomplete information. The framework encompasses a three-step decision system which includes (1) a multi criteria decision-making tool to structure and define the stakeholders' goals and objectives, (2) a patients' evaluation phase where the situation of each patient is assessed with respect to each criterion by a group of experts to obtain an individual score, and (3) an optimization model to schedule the patients' access to services in such a way that the global system utility is maximized. This presentation will review the foundations of this framework and will explain how it is currently adapted and applied to several social and healthcare's services contexts. It will also discuss the next steps and the challenges towards a largescale deployment of such prioritization systems.

Access and waiting lists; Decision support; Patient scheduling

THD2-3: Mariana Oliveira – 02/08/2018 16:30 – Hagen 1+2
Using patients' prioritization to improve operating room scheduling
Oliveira, M[1]; Bélanger, V[2]; Marques, I[1]; Ruiz, Angel[3]

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Waiting time is an important concern both for patients in need of a surgery and for the organizations providing the service to the patient. Serious consequences can arise due to higher than recommended waiting times. In particular, long waiting times can directly impact the patient's health and well being. Various approaches have been used to determine the priority of a patient, and several tools have been developed to build operating rooms schedules. Despite their strong relationship, these two problems are commonly treated as separated issues. The main objective of this research is to establish a connection between the prioritization system of elective patients and the planning of the operating rooms. A new scoring method is created to calculate the utility value for each patient on the waiting list. The score is computed according to the prioritization criteria, the strategic value of the surgery and the clinical and social situation of the patient. This result is then used as an input to the scheduling system with a given planning horizon. A mixed integer linear programming model is proposed to optimize the operating room planning. It is designed in a patient centered way, respecting their priority levels. Some other restrictions are taken into account, namely the availability and workload balance between surgeons and capacity constraints of the hospital under study. Using data provided by a hospital center in Québec (Canada), several scenarios are tested. Results are then analyzed and compared with the current approach.

Operating room planning and scheduling

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THD3 – Ambulance/Vehicle Routing III – 02/08/2018 15:30 – 17:00
Chair – Caroline Jagtenberg   Room: VIA

THD3-1: Krisjanis Steins – 02/08/2018 15:30 – VIA
Predicting volume of ambulance calls using zero-inflated Poisson regression
Steins, Krisjanis; Matinrad, N.; Andersson Granberg, T.
Department of Science and Technology, Linköping University Norrköping SWEDEN ;

Accurate forecasts of expected demand for ambulances can provide useful input to both the longterm planning and the daily management of emergency medical services. The current forecasting model used by SOS Alarm Sweden (Swedish Public Safety Answering Point; the company also manages ambulance dispatch for most of the country) generates a forecast for each hour of the week in a particular geographical grid zone. This model is based on a historical total volume of calls per county and a population distribution in grid zones. The aim of this study is to investigate if including more population and zone characteristics can improve the accuracy of the forecasts. Data from ambulance call records in three counties in Sweden from years 2013 and 2014 were used for modelling and analysis in this study. After removing low priority calls and cancelled ambulances, the rest of the call data was aggregated into grid zones used by the current forecasting model. The resulting dataset was then complemented with additional population and grid zone characteristics. The selection of these additional characteristics was based on a study of previous research and interviews with emergency call centre operators. Due to the large number of zeros in the data describing the hourly volume of ambulance calls in each of the geographical grid zones, zero-inflated

Poisson regression was chosen for the statistical modelling of the call data. Independent variables tested in the model included number of people in different age groups, place of birth, income and unemployment rate, along with number of nightlife spots and length of the road network. The resulting model performs slightly better than the existing one in terms of prediction accuracy but further research is needed into incorporating additional factors and real time data in the model.

Ambulance management; Emergency Medical Services; Forecasting; Statistical modelling

THD3-2: Yannick Kergosien – 02/08/2018 16:00 – VIA
A pool-based approach to manage transportation and urgent request by EMS organizations

Kergosien, Yannick[1]; Bélanger, Valérie[2]; Ruiz, Angel[3]
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Emergency medical services (EMS) are dedicated to provide urgent medical care to any person requiring it and to ensure their transport to a hospital or care facility, if required. In many cases, EMS also provide transportation services for patients needing to go from one hospital to another, or between their home and medical facilities. Since both missions are carried out by the same vehicles, one might think that these two missions should be managed together. However, doing so involves solving simultaneously two difficult vehicle routing problems, an ambulance relocation problem and a dial-a-ride problem, which address the particularities and requirements of each type of mission. This is why, in practice, EMS organizations often split the overall fleet into two subfleets, one assigned to emergency calls and the other to transfer demands. This study proposes a new management strategy based on a partial pooling of ambulances. Although it assumes two fleets that are managed separately, the strategy allows modifying the size of the two fleets dynamically by considering that a limited number of ambulances can change their mission during the day to better adapt to the system state. This strategy offers an incomplete integration of the fleets but has the advantage of being simple to implement in an EMS organization. Preliminary computational experiments on realistic data have been conducted to assess the potential of the proposed strategy using a discrete event simulation tool.

Emergency Medical Services; Ambulance management

THD3-3: Caroline Jagtenberg – 02/08/2018 16:30 – VIA
Fairness in the ambulance location problem

Jagtenberg, Caroline; Mason, A
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We discuss how to position ambulances across an EMS region in a 'fair' way. Ambulance literature often focuses on maximizing the number of people served, regardless of where they live. This is equivalent with optimizing a utilitarian Social Welfare Function (SWF). It is well known that such an approach benefits people living in cities, at the cost of people living in remote areas. An often mentioned alternative is equity: providing the same service to people at every location. However, this gives so much focus on helping people in remote locations, that it usually leads to poor overall performance. Instead, we propose to use the so-called BernoulliNash SWF. This may be viewed as an appealing compromise between the two solutions above. We formulate and solve models that maximize the BernoulliNash social welfare. The most straightforward model maximizes coverage,

but we also use more complex measures such as survival functions. We juxtapose the BernoulliNash optimal solution with the Utilitarian optimum, and show how the results differ depending on the load of the system. Calculations are done for a realistic EMS region in the Netherlands.

Ambulance management; Capacity and network planning; Emergency Medical Services

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THD4 – Emergency Medical System IV – 02/08/2018 15:30 – 17:00
Chair – Joe Viana   Room: Hagen 3

THD4-1: Leila Keshtkar – 02/08/2018 15:30 – Hagen 3
Investigating patient flow variations across emergency departments: a process-mining and simulation approach

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Overcrowding in emergency departments (EDs) has become a significant international crisis that negatively affects patient safety, quality of care, and patient satisfaction. In response, managerial interventions and clinical guidelines keep evolving to improve care processes and the quality of care delivery. However, the consequences of these interventions are not tested prior to their introduction and ultimately guidelines are implemented differently across hospitals. In turn, more deviations from the normative process are created and patient outcomes are at risk in terms of lower patient throughput, increased length of stay, and higher treatment costs. Therefore, it is essential to obtain an accurate view of patient flow in order to address these challenges. Aim: The objective of this paper is to analyse and quantify the differences in patient pathways across acute hospitals and to assess the effectiveness of any proposed changes before their implementation. Methodology: To achieve this objective, a three-phase methodology is proposed: process mining for patient pathways discovery and analysis; comparative analysis to identify similarities and differences; and simulation modelling for capturing uncertainty and testing 'what-if' scenarios. The proposed methodology is demonstrated on a case study of three emergency departments with data logs of 500,000 records collectively. Process mining techniques are applied to exploit patient- and Process-related data captured by Hospital Information Systems. Patient flow in each hospital is analysed from two perspectives: the control-flow perspective and the performance perspective. Control-flow explores the execution order of process activities and automatically discovers the underlying process structure while the performance perspective analyses the execution timing of activities and process bottlenecks. Findings from the comparative analysis are used to identify common practices across hospitals as well as inefficiencies in process variations. Best practices adopted by high-performance EDs are identified while simulation models are developed to evaluate the introduction of these changes to struggling EDs.

Patient flow; Emergency Medical Services; Patient flow; Modelling and simulation; Decision support; Healthcare Information Systems

THD4-2: Khodakaram Salimifard – 02/08/2018 16:00 – Hagen 3
Integrated Operating Rooms and Recovery Beds Scheduling, Considering the Preferences of Surgeons and Emergency Operations
Salimifard, Khodakaram; Zarei, Elaheh
Persian Gulf University Bushehr IRAN (ISLAMIC REP.) ;

This paper studies the problem of scheduling surgeries in the Persian Gulf General Hospital in Iran. Both operating rooms and recovery beds are considered. Also, the satisfaction of surgeons with regard to their preferences, and emergency surgeries have been considered. The mathematical model of this research is formulated as a mixed integer programming problem. An innovative method is proposed to construct the initial solution. Two NSGAII and MOPSO algorithms with the Pareto approach have been used to solve the problem. The findings of this study indicated the effectiveness of the proposed metaheuristic methods in solving the problem. The proposed metaheuristic algorithms are compared with each other and, finally, one of them is presented for better performance. Optimized scheduling, in addition to increasing the use of the operating room, takes into account the preferences of surgeons and the priorities of surgical procedures.

Operating room planning and scheduling; Patient scheduling; Modelling and simulation

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FB1 – Capacity Planning III – 03/08/2018 11:00 – 11:30
Chair – Joe Viana　　　Room: FORUM

FB1-1: Mohammad Pishnamazzadeh – 03/08/2018 11:00 – FORUM
Reallocation of unoccupied beds among requesting wards
Pishnamazzadeh, Mohammad; Sepehri, Mohammad Mehdi; Panahi, Atefeh; Moodi, Parisa
Tarbiat Modares University Tehran IRAN (ISLAMIC REP.) ;

Hospitals are complex system which should serve patients with healthcare services continuously even in time of disruptions. Disruptions can make demand fluctuation which could cause overcrowding at hospital wards, make the waiting list of patient longer and decrease the performance of hospitals. In one hand, Bed management at hospitals is one of the solutions to deal with overcrowding at hospital wards. On the other hand, resilience engineering is an approach that can help organizations to bounce back to their desired performance state after a disruption. In this paper, the concept of resiliency engineering has been used to improve bed management of hospitals during and after disruption. More precisely, investigating the impact of bed sharing among hospital wards as a collaboration strategy on the length of patients' waiting list as the major performance index of hospitals is the main goal of this paper. Hospital comprises several wards and each wards consist of several rooms. Each room has a limited number of beds. Relationships priority between different wards, patients' gender, patient's length of stay and the number of rooms in every ward are the major points considered in our modeling. A mixed integer linear programming optimization model with the objective of minimizing the length of patients' waiting time of a hospital has been proposed for the real world problem. The main contribution of the present paper is proposing a resiliency-based modeling of patients' bed management in hospitals. Results show that applying resilience strategy has a great impact on improving the performance index of the hospital.

Capacity and network planning; Access and waiting lists; Modelling and simulation; Patient flow; Strategic and operational planning

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FB2 – Clinical Modelling II – 03/08/2018 11:00 – 11:30
Chair – Fredrik Dahl　　Room: Hagen 1 + 2

FB2-1: Ibrahim Ahmed – 03/08/2018 11:00 – Hagen 1 + 2
Doses venous thromboembolism risk assessment and prophylaxis work among cardiac patients
Ahmed, Ibrahim
Prince Sultan Cardiac CenterAlhassa Hofuf/Alahassa SAUDI ARABIA ;

Venous thrombosis is a major problem worldwide, and is often preventable in the hospitalized setting. It is estimated that approximately 1 per 1000 persons has a 1st time VTE event per year. Actually, the incidence of VTE is identical to cardiovascular incidence for patients at moderate risk as shown by the recent studies. Most hospitalized patients have at least one risk factor for venous thromboembolism (VTE), such as pulmonary embolism or deep venous thrombosis. It is recommended that any patient admitted to the hospital has to be assessed for VTE risk. VTE risks assessment and prophylaxis, is widely practiced but is often undermined by many practitioners. VTE Risk assessment and prophylaxis is also an important quality of care measure. In this study examined VTE risk assessment, management and outcome of 180 cardiac patients admitted at tertiary cardiac

centre during the period of Jan to March 2018. The study will discuss patients characteristics, VTE risk identification, risk stratification, risk scoring and summarize pharmacological and mechanical methods used in VTE prophylaxis and outcome. Keywords: Venous thromboembolism; assessment; risk; prophylaxis

Data analysis and risk management

LIST OF PARTICIPANTS

Name	Organisation	Session
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Syed Salleh Abdul Rahman	University of Sheffield	TUD3-1
Thomas Adams	University of Auckland	TUC4-1
Ibrahim Ahmed	Prince Sultan Cardiac Center- Alhassa	FB2-1
Filipe Alvelos	University of Minho	TUC1-1
Roberto Aringhieri	University of Turin	THC3-3
Ines Arnolds	Karlsruhe Institute of Technology	THD1-2
Yahyaoui Asmae	CIS	THB1-1
Emma Aspland	Cardiff University	MA
Turgay Ayer	Georgia Tech	TUD4-3
Francisco Ballestín	University of València	TUC4-3
David Barrera-Ferro	Pontificia Universidad Javeriana	TUA2-1
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Valérie Bélanger	HEC Montréal	TUA2-3
Blair Bilodeau	Western University	THD1-1
John Blake	Dalhousie University	MD3-3
Julia Sophie Block	Ruhr University Bochum	THC4-2
Laura Boyle	Queen's University Belfast	-
Jasper Bos	University of Twente	-
Richard Boucherie	University of Twente	-
Aleida Braaksma	University of Twente	TUB4-3
Sally Brailsford	University of Southampton	TUB1-3
Margaret Brandeau	Stanford University	MD1-3
Jens Brunner	University of Augsburg	-
Leslie Anne Campbell	Dalhousie University	TUB3-3

Name	Organisation	Session
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Martin Dlouhy	University of Economics Prague	TUB3-1
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Sylvia Elkhuizen	Erasmus University Rotterdam	THB2-1
Melanie Erhard	University of Augsburg	THB4-1
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Glenn Flandorfer	HSØ RHF	-
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Erwin Hans	University of Twente	-
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Name	Organisation	Session
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Marit Kise	Akershus University Hospital	-
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Fermin Mallor	Public University of Navarre	-
Sean Manzi	University of Exeter	TUC2-2
Inês Marques	University of Lisboa	MD3-1
Joren Marynissen	KU Leuven	MA
Niki Matinrad	Linköping University	TUC3-1
Taqee Ansari Mohammed	Mak College Of Pharmacy	-

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Ravichandran Narasimahan	Indian Institue of management	TUB3-2
Stefan Nickel	KIT	-
Vittorio Nicoletta	Université Laval	TUC2-1
Bjørn Nygreen	NTNU	-
Mariana Oliveira	University of Lisboa	THD2-3
Monica Oliveira	IST Universidade de Lisboa	TUB2-3
Lerzan Ormeci	Koc University	THB3-1
Jan Willem Maarten Otten	University of Twente	TUB2-1
Kalyan Pasupathy	Mayo Clinic	-
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Marion Penn	Southampton University	TUA1-2
Katherine Penny	University of Southampton	THB1-3
Sebastian Rachuba	University of Wuppertal	THC2-3
Kim Rand	HØKH Health Services Research Unit Akershus Univerity Hospital	MC
Marion Rauner	University of Vienna	TUC2-3
Melanie Reuter-Oppermann	Karlsruhe Institute of Technology	TUA1-3
Julian Oppermann	Accompanying Melanie Reuter-Oppermann	-
Samuel Ridler	The University of Auckland	MD2-1
Jo Roislien	University of Stavanger	-
Roberta Rossi	University of Florence	TUD2-2
Angel Ruiz	Université Laval	THD2-2
Alexander Rutherford	Simon Fraser University	THB3-2
Karianne Rygh	Oslo School of Architecture and Design	MB
Sara Saadatmand	Persian Gulf University	MA
Khodakaram Salimifard	Persian Gulf University	THD4-2
A.J. (Thomas) Schneider	Leiden University Medical Center	TUC3-3

Name	Organisation	Session
Jan Schoenfelder	University of Augsburg	TUB2-2
Fabian Schäfer	Catholic University of Eichstätt-Ingolstadt	TUB4-2
Mohammad Mehdi Sepehri	Tarbiat Modares University	FB1-1
Birger Sevaldson	Oslo School of Architecture and Design	MB
Dandan Shi	University of Southampton	TUA1-1
Asgeir Orn Sigurpalsson	University of Iceland	THC3-1
Eric Silverman	University of Glasgow	TUB1-2
Tone Breines Simonsen	HØKH Health Services Research Unit Akershus Univerity Hospital	-
Honora Smith	University of Southampton	MD4-3
David Stanford	University of Western Ontario	THC1-3
Krisjanis Steins	Linköping University	THD3-1
Thomas Stidsen	Technical University of Denmark	-
Elena Tanfani	University of Genova	THC2-2
Alexander Tesch	Zuse Institute Berlin (ZIB)	-
Mark Tuson	Cardiff University	TUB1-1
Martin Utley	University College London CORU	THD1-3
Noëlle van de Vrugt	University of Twente	-
Pieter van den Berg	Rotterdam School of Management	TUA2-2
Rimmert van der Kooij	SINTEF	THB4-2
Gaby van der Sman	Franciscus Gasthuis & Vlietland	-
Carla Van Riet	KU Leuven	TUA4-2
Peter Vanberkel	Dalhousie University	TUD1-3
Krisztina Vasarhelyi	Simon Fraser University	-
Christos Vasilakis	University of Bath	THB2-3
Paula Andrea Velásquez Restrepo	University of Antioquia	THC2-1
Joe Viana	HØKH Health Services Research Unit Akershus Univerity Hospital	MA
Jan Vissers	Erasmus University Rotterdam	TUD3-3

Name	Organisation	Session
Loek Vredenberg	IBM	THA
Cameron Walker	University of Auckland	-
Brigitte Werners	Ruhr University Bochum	-
Emily Williams	Cardiff University	MA
Semih Yalçındağ	Yeditepe University	MD3-2
Anne Zander	Karlsruhe Institute of Technology	TUD2-1
Zhichao Zheng	Singapore Management University	TUC1-2
Yi-Hang Zhu	KU Leuven	TUB4-1