K 2019

ORAHS

ORAHS 2019 CONFERENCE

Healthcare Analytics - Artificial Intelligence and Human Experience

INTERNATIONAL CONFERENCE OF THE EURO WORKING GROUP ON OPERATIONAL RESEARCH APPLIED TO HEALTH SERVICES ORGANISED BY THE KARLSRUHE SERVICE RESEARCH INSTITUTE (KSRI)

28 JULY - 02 AUGUST 2019 AT KARLSRUHE, GERMANY

Sponsors

We thank the following sponsors for their kind and generous support of the ORAHS 2019 Conference "Healthcare Analytics - Artificial Intelligence and Human Experience"
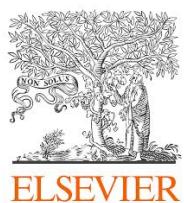
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Welcome

Dear participants, colleagues and friends,

welcome to the 45th ORAHS conference at the Karlsruhe Institute of Technology in Karlsruhe, Germany. It is the third time that ORAHS takes place in Germany after Munich in 1976 and Konstanz in 1992. The organising team of the conference is the Health Care Lab at the Karlsruhe Service Research Institute (KSRI). We especially thank Marliese Amann from the Institute for Operations Research (IOR) for her help.

As a conference motto we chose "Healthcare Analytics - Artificial Intelligence and Human Experience".

While algorithms and solution methods are improving enormously and the term artificial intelligence paves the path for an intrinsic OR integration in modern healthcare, we never should forget the focus of our research: the human and his/her experience. Therefore, we are convinced that a major challenge is to have all the algorithmic and technical progress for the benefit of humans.

For nearly two years we have been working hard on making ORAHS in Karlsruhe a success and trying not to forget too many things. Three exceptional keynotes and a packed high-quality scientific program show that it was worth the work. Nevertheless, you have to tell us after the meeting if you liked it or not. We are very much looking forward to your feedback.

Going back to the traditions we decided to offer an organised accompanying programme again, to make it more attractive for you to join the conference despite the holiday time and bring your families and loved ones with you. We hope that they will enjoy it and that we will all enjoy the social programme we have planned for Monday afternoon, Tuesday evening, Wednesday and Thursday evening.

We wish you a great conference,
Stefan Nickel and Melanie Reuter-Oppermann

Organising Committee

Melanie Reuter-Oppermann
Michael Ertel
Stefan Nickel
David Olave-Rojas
Anne Zander

Health Care Lab at KSRI

International Programme Committee

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Tuğba Çayirli (2013) (Turkey)

Evrim Didem Güneş (2013) (Turkey)

Maria Captivo (2014) (Portugal)

Inês Marques (2014) (Portugal)

Patrick Soriano (2015) (Canada)

Fermin Mallor (2016) (Spain)

Christos Vasilakis (2017) (UK)

Joe Viana (2018) (Norway)

Melanie Reuter-Oppermann (2019) (Germany)

Marion Rauner (2020) (Austria)

Katja Schimmelpfeng (Germany)

Teresa Melo (Germany)

Practical Information

Conference Venue
The conference takes place on the Campus South of KIT in the building 30.22. For the keynotes we have booked the lecture hall "Otto-Lehmann-Hörsaal". The sessions will mainly take place in the smaller lecture halls Kl. HS. A and Kl. HS. B. In some slots a third session will take place in the seminar room 229.3. In any other times, this seminar room can be used as a meeting place. The second seminar room 229.4 can also be used for meetings.

The Doctoral Consortium on Saturday and the Reception on Sunday will take place in the International Department, Schlosspl. 19, 76131 Karlsruhe.

The Practitioner Day on Tuesday takes place at the Karlsruhe Palace. The address is Schlossbezirk 10, 76131 Karlsruhe. From lunch on the conference will join the Practitioner Day in the Palace.

All three locations are within short walking distance of each other and can be reached easily with trams getting off at the station Kronenplatz for building 30.22 and Marktplatz for the International Department and the Palace.

A map showing all three locations as well as the tram stations can be found in the back.

Getting around on Campus and in Karlsruhe
The Campus of the KIT is directly located within the city centre. We recommend to walk short distances within Karlsruhe or to take public transport and to use bike sharing. Public transport in Karlsruhe is included in the conference badge. The KIT Campus South as the main location of the conference has good tram connections from the Karlsruhe main station.

To reach the Campus from the main train station you can take tram number S4, S7, S8, 4, S1, S11. Information (train/tram) schedules can be found at https://www.kvv.de/fahrt-planen/fahrplanauskunft.html. A Map about the different lines is provided in the back.
Your connections to the event locations:

- **International Department (Welcome Reception):**
  Marktplatz is the closest station to the International Department of the KIT. Bus 10 provides a direct connection between Karlsruhe main station and Marktplatz. You can walk the rest within 7 minutes.

- Ka**rlsruhe Palace (Schloss Karlsruhe):**
  Marktplatz the closest station to the Palace of Karlsruhe. Again, bus 10 provides a direct connection between Karlsruhe main station and Marktplatz. The Palace is then in a walking distance of 8 minutes.

- **Höpfner Burggarten/Schalander (Conference Dinner):**
  If you want to reach the Hoepfner Burggarten/Schalander from the conference venue, we recommend taking tram 5 from Kronenplatz until Hauptfriedhof. You can walk the rest within 3 minutes.

Trams
If you need to buy tickets before or after the conference, you can pay in cash or in some trams also by card. You can choose between single, day or group tickets. If you want a single ticket for the city centre ("1 Wabe"), the price is 2,10€. More information on tickets can be found at https://www.kvv.de/fahrkarten/fahrkarten-preise/.
KVV also offers an app for Android and iPhone that might be useful.

Taxi
You can also use a taxi to go around in Karlsruhe. Taxis should be available 24h.
Taxi companies in the region are:

Exclusive Taxi Aydin GbR Karlsruhe	+49 (0) 1577 3630164
Taxizentrale Karlsruhe	+49 (0) 721 944144
Taxi-Ruf Karlsruhe	+49 (0) 721 160200

Trains in Germany
If you want to travel by train, you can buy a ticket:
- Over the DB-App online. Payment can be done by credit card.
- At the white-red self-service ticket machines at tram stations or the main train station. Payment can be done by cash or by credit cards.
- At a service desk at a larger railway station. Payment is possible by cash or credit card. There are also service desks available.

Information about train connections and prices can be found at: https://www.bahn.de.

Registration Desk
Registration is possible during the Reception at the International Department or on Monday 8:30 – 9:30 am in building 30.22. A sign will lead you to the registration desk. Registration on a later day is possible in room 229.4 of building 30.22.

Lunches and Refreshment Breaks
On Monday, Thursday and Friday lunch and refreshments will be served in front of the lecture hall. Lunch on Tuesday will take place in the Palace.

Poster Display
The poster session will take place during the coffee break on Tuesday afternoon at the Palace.

Doctoral Consortium
The Doctoral Consortium (DC) provides an opportunity for doctoral students to explore and develop their research interests under the guidance of a panel of distinguished researchers. We invited students who feel they would benefit from this kind of feedback on their research to apply for this unique opportunity to share their work with students in a similar situation as well as with senior researchers in the field. We aimed for candidates who have a clear topic and research approach, and have made some progress, but who are not so far along that they can no longer make changes.

The DC takes place on Saturday from 10 in the International Department. 5 PhD students will present their research to the committee and receive feedback on it.

Internet Access

On campus you have access to eduroam. In many places throughout the city you have access to KA-WLAN, including the campus, the Palace and the International Department. You can log on for free without a registration.

Emergency Contact

National emergency number:	112
Local police:	+49 (0) 721 6663311
Campus security:	+49 (0) 721 608-22112

Programme at a Glance

	Saturday 27.07.19	Sunday 28.07.19	Monday 29.07.19	Tuesday 30.07.19	Wednesday 31.07.19	Thursday 01.08.19	Fri 02.08.19
9:00		Doctoral Consortium		Parallel Sessions	Day Trip	Keynote	Parallel Sessions
9:30			Opening Session Keynote				
10:00	Doctoral Consortium					Coffee	
10:30			Keynote	Coffee		Parallel Sessions	Coffee
11:00				Parallel Sessions			Parallel Sessions
11:30			Parallel Sessions				
12:00						Lunch	
12:30				Lunch			Lunch
13:00			Lunch			Parallel Sessions	Business Meeting
13:30							
14:00			Parallel Sessions	Keynote			
14:30						Coffee	
15:00				Coffee + Posters		Parallel Sessions	
15:30			Coffee				
16:00		Reception	Tours	Industry Talks			
16:30							
17:00							
17:30				GOR AG HCM Meeting			
18:00						Conference Dinner	
18:30				BBQ			
19:00							
19:30							
20:00							
20:30							

Keynote Speakers

Martin Schuster

Martin Schuster, MD, MA, is a Professor of Anesthesiology at the Ruprecht-Karls-University Heidelberg and head of the Department of Anesthesiology, Intensive Care, Emergency Medicine and Pain Therapy at the Fürst-Stirum-Hospital Bruchsal and Rechbergklinik Bretten, both academic teaching hospitals of the Ruprecht-Karls-University Heidelberg.

He studied medicine, philosophy and history in Hannover, Germany and Baltimore and New York City, USA and graduated in 1997. Afterwards he spent a year in lung immunology research on a stipend of the Studienstiftung des Deutschen Volkes and started his residency in anesthesiology at the Medical School Hannover in 1998. From 2000 to 2002 he interrupted his clinical education and worked at McKinsey & Co. in business consulting as senior associate in the healthcare sector. From 2002 to 2005 he finished his residency in anesthesiology at the university hospital Hamburg-Eppendorf and was appointed as consultant. From 2007 to 2011 he worked at the Charité University Medicine in Berlin as consultant in anesthesiology and intensive care until he obtained his current position.

His main academic interest is in Health Economics, Operations Management and Quality Improvement in hospitals. He especially focused on Process Optimization in clinical medicine, steering of clinical departments and operating room management. He leads the working group on process-, cost- and operating room management in the German Society of Anesthesiology and Intensive Care and authored over 50 peer reviewed articles and book chapters. He is section editor for quality management and economics at Der Anästhesist, the leading German journal in anesthesiology and serves as reviewer for Anesthesia and Analgesia, British Journal of Anesthesia, Anesthesiology and Anästhesie und Intensivmedizin. He is also member in the scientific advisory board of the largest German operating room benchmark program.

Martin Schuster will speak on Monday. The abstract of his talk can be found in the programme.

Matthias Reumann

Matthias Reumann studied Electronics at the University of Southampton, UK, and received the Master of Engineering First Class with Honours in 2003. He continued his studies in Biomedical Engineering at the Universität Karlsruhe (TH), Karlsruhe, Germany, and was awarded his PhD for his thesis on modelling atrial fibrillation, congestive heart failure and their non-pharmacological treatment
In 2007, he joined the IBM T. J. Watson Research Center, NY, USA, as Post Doctoral Fellow to implement multi-scalar whole heart models on the world's fastest and largest supercomputers. This expertise brought him to join the IBM Research Collaboratory for Lifesciences in Melbourne, Australia, in 2010 where he further established a research group in healthcare at the IBM Research – Australia laboratory from 2011 – 2013. During this period, he expanded his research interests into sustainable, resilient health systems research including a project in Africa. Since December 2013, he has been working at the IBM Research – Zurich Laboratory on numerous client projects aiming to get patients to the right health service provider at the right time. He was awarded a second PhD from the University of Maastricht, Maastricht, The Netherlands, in Oct. 2017 for his work on Big Data in Public Health: from Genes to Society. He holds several national and international awards and has published over 100 articles, book chapters and conference proceedings.
The rise of Big Data and the resurgence of artificial intelligence in healthcare and life science holds promises that claim to lead to a creative disruption of medicine. Several publications have demonstrated the power of AI with respect to improving diagnosis and treatment. However, most of these publications were carried out under experimental conditions. AI in healthcare has gone from a forming to a storming phase. It is essential that the next step to the norming phase will be achieved so that the power of AI and Big Data can be harnessed and perform to its expectations. To realize the potential of new technology and the fast-paced innovation in digital health, a solid foundation of quality data and methods has to be built. This talk will illustrate the vision of how big data and AI could transform healthcare giving real world examples that show the status quo of digital health bridging reality and vision from genes to society.
Matthias Reumann will speak on Tuesday. The abstract of his talk can be found in the programme.

Dolores Romero Morales

Dolores Romero Morales is a Professor in Operations Research at Copenhagen Business School. Her areas of expertise include Supply Chain Optimization, Data Mining and Revenue Management. In Supply Chain Optimization she works on environmental issues and robustness. In Data Mining she investigates interpretability and visualization. In Revenue Management she works on large-scale network models. Her work has appeared in a variety of leading scholarly journals, including European Journal of Operational Research, Management Science, Mathematical Programming and Operations Research, and has received various distinctions. Currently, she is an Associate Editor of Omega and TOP. She has worked with and advised various companies on these topics, including IBM, SAS, KLM and Radisson Edwardian Hotels, as a result of which these companies managed to improve some of their practices. SAS named her an Honorary SAS Fellow and member of the SAS Academic Advisory Board. She currently leads the EU H2020-MSCA-RISE NeEDS project, which has a total of 14 participants and a budget of more than €1.000.000 for intersectoral and international mobility, with the aim to improve the state of the art in Data Driven Decision Making.

Dolores joined Copenhagen Business School in 2014. Prior to coming to Copenhagen Business School she was a Full Professor at University of Oxford (2003-2014) and an Assistant Professor at Maastricht University (2000-2003). She has a BSc and an MSc in Mathematics from Universidad de Sevilla and a PhD in Operations Research from Erasmus University Rotterdam. Dolores Romero Morales will speak on Thursday. The abstract of her talk can be found in the schedule.

Social Programme

Beside the scientific experience, the ORAHS provides an extensive social program. Highlights, in this year´s social program are a day trip to the Palatinate region and the conference dinner at the Höpfner Burgarten/Schalander.

Monday: City Tours (16:30- 18:30)
There will be two different city tours on Monday evening. On topic is "Straße der Demokratie" (Street of democracy) and the other one "Badische Geschichte im Rundgang" (walking tour addressing history of Baden). We will meet at the Marktplatz at 16.30. Please bring your ticket!

The place of fundamental rights in Karlsruhe

Monday: Escape Game (16:00- 18:00)
As an alternative to the city tours you can participate in an escape game. This will start at the Karlsruher Palace at 16:00. Smaller groups will get a tablet, explore the city and try to solve the riddle! Please bring your ticket!

Monday: Brewery Visit (16:30- 18:30)
For those of you who want to get a peek into the brewery location for our conference dinner the Brewery Tour is the ideal option. You will learn all about the German beer making process. And at the end, there is a tasting, of course! Please bring your ticket!

Tuesday: (18:30 – end)
On Tuesday we will enjoy a barbecue dinner together. The dinner will take place on the terrace of the Karlsruhe Palace and it will start around 18:30. You can only participate if you have registered for the BBQ.

Wednesday: Trip to the Palatine region (9:00-20:30)
We will meet at 9:00 a.m. at the Rheinhafen. The boat will leave at 9:30. After two hours of boating on the river we will reach the city of Speyer. Speyer is one of the oldest cities in Germany and directly located in the area of Reinland-Pfalz. The city is famous for its imperial cathedral. It ranks as the largest preserved romanesque church in Europe. You will have some free time to explore the city by yourself. Lunch packages will be handed out on board. During the ferry ride drinks are included.

At 14:00 the bus is taking you to the Hambacher Castle leaving from the parking lot behind the Cathedral of Speyer. The Hambacher Castle is located on the mountain Schlossberg elevation: 325m in the eastern outskirts of the Palatine Forest. In 1832 it became known as the cradle of German democracy during the Hambacher Fest. If you signed up for a round tour you will have a guided tour, there at 16:00. Afterwards, the busses will take us to Flemingen. For dinner you will enjoy a traditional 'Pfaelzer Buffet' at the winery Marienhof. At 21:00 the busses will take us back to Karlsruhe.

In case of a sunny day, bring sun glasses and sun cream! And do not forget your ticket for the day trip!

Thursday: Conference Dinner (19:00 – end)
The conference dinner will be served at the restaurant called Hoepfner Burghof/Schalander. The location is reachable within a 10 minutes tram ride or 10 minutes by walking. With public transport: take bus 125 (direction Kirrlach Hinterfeld) from Karlsruhe Durlacher Tor/Kit to Karlsruhe Hauptfriedhof or tram 5 to Hauptfriedhof. By walking for 3 minutes you will reach the destination.

Due to special requests we will have an open bar until midnight!

Accompanying Programme

As ORAHS is like a big family, we want to go back to the tradition that the conference offers an accompanying program for your loved ones! So, we set up a potential programme that is flexible and can accommodate your wishes and suggestions. We might also adapt it during the week when we know how the weather will be. We will discuss the programme during the reception. Currently, we have planned the following:

Monday: On Monday the participants will meet at 9 am at the State Museum of Natural History Karlsruhe with plenty of time to discover all the exhibitions and artefacts. For lunch the families will be reunited at the conference location. In the afternoon there is some time to relax and or play, e.g. in the Palace Garden before we go on exploring the city in different guided tours.

Tuesday: Tuesday is all about playing! We will take a train to Rühlzheim and explore the big playground. There is also the chance to visit an ostrich farm and enjoy a lake nearby. At lunchtime, the choice is between Pizza and Pasta! In the afternoon, a little train will take you through the Palace Garden before all participants end the day with a BBQ.

Are you up for a train ride?

Wednesday: On Wednesday families will be together on a boat ride and a fun day in the Palatinate region. More information can be found in the social programme.

Thursday: The theme for Thursday is up and up. The Turmbergbahn will take us up the only hill we have in Karlsruhe. If you are very sporty, you can also opt for taking the 529 steps.

Turmbergbahn Karlsruhe

The hill offers great views on Karlsruhe, a 28m high tower und a large adventure playground. After lunch, another adventure awaits at the high ropes course next to the playground. It offers many different courses, including one for little adventurers from the age of 4.

If the weather is extremely nice, we will change plans and go to a swimming pool along the river Rhine! Please bring your bathing suit, sun cream and a towel!

Friday: We saved the best for last; the Karlsruhe Zoo is always a guarantee for a fun day out. Be ready to see elephants, penguins, wallabies and many more! The gang will meet at 9 am in front of the main entrance at the train station. Lunch will be a highlight in the newly built "Exotenhaus" surrounded by cute little monkeys.

Scientific Programme

Monday July 29th

09:30	Conference Opening	Room: Otto-Lehmann-Hörsaal

10:30	Keynote Talk	Room: Otto-Lehmann-Hörsaal
	Martin Schuster	Operations Research in Operating Room Management

11:30	Parallel Sessions	

EMS Logistics I
Room: Kl. HS. A
Session Chair: Melanie Reuter-Oppermann, Peter Vanberkel

1	José Nelas	Optimal Emergency Vehicle Location with uncertainty, hierarchy and substitutability
2	Ana Sofia Carvalho	Ambulance dispatching and relocation problems: integrated optimization approaches to maximize system's preparedness
3	Davide Duma	Analysing the impact of prediction in the real-time management of ambulances
4	Peter Vanberkel	Determining Ambulance Destinations when facing Offload Delays using a Markov Decision Process

Scheduling I
Room: Kl. HS. B
Session Chair: Valérie Bélanger

1	Maddalena Nonato	On the Optimal Scheduling of Clinical Pathways
2	Emily Williams	Scheduling Blood Donation Clinics to Match Supply and Demand
3	Angel Ruiz	Managing intrahospital patients' transportation requests
4	Alexis Robbes	Minimize the total tardiness of chemotherapy drugs production and delivery

13:00	Lunch	

14:00	Parallel Sessions	

EMS Logistics II
Room: Kl. HS. A
Session Chair: Melanie Reuter-Oppermann, Marion Rauner

1	Niki Matinrad	Modeling uncertain task compliance in the dispatch of volunteers to out-of-hospital cardiac arrest patients
2	Inês Marques	Personnel scheduling in emergency medical service systems considering equity between staff members

3	Enoch Kung	Using location-allocation modelling to inform the location of specialist paediatric intensive care retrieval teams in the UK
4	Marion Rauner	Simulation-Optimizer for the New Austrian Advanced Medical Post (AMP): Investigating Different Realistic Policy Disaster Scenarios

Scheduling II
Room: Kl. HS. B
Session Chair: Anders Gullhav

1	Feray Tuncalp	MDP Model for the Preference-Based Appointment Scheduling Problem with Multi-Priority Patients
2	Dang Khoi Pham	An online approach for the chemotherapy patient scheduling problem
3	Alexander Rutherford	Transforming Community Care for Marginalized People in Inner-Cities
4	Anders Gullhav	Multi-Appointment Scheduling at a Psychiatric Outpatient Clinic

15:30   Coffee

16:00   City Tours

Keynote|Room: Otto-Lehmann-Hörsaal |Monday, 10:30-11:30

Operations Research in Operating Room Management

Martin Schuster

Operating rooms (OR) are accountable for a large share of hospital costs and OR efficiency is a major issue in hospital management. Efficient processes in the OR are not only important because of the high fix costs of operating rooms, inefficient processes also increase costs in other areas of hospital care like ward costs or costs of intensive care. Furthermore, inefficient processes lead to demotivation of the staff. However the extreme variability of surgical and anaesthesia processes, the high number of different departments, persons and professions involved in operating room processes, the high rate of emergency processes and processes running out of control and the many interfaces with almost all other departments and structures in the hospital makes it complex to ensure a smooth running of the operating rooms. Based on the drastically increased cost considerations in the DRG era a formal OR management structure has been established in most hospitals in Germany during the last 20 years. Along with this professionalization of practical OR management academic operations research in operating room management was established to provide a sound basis for management decisions: a common nomenclature of process description was established and key performance indicators to measure OR efficiency were identified and studied in detail, including turnover time and OR utilization. Detailed anaesthesia and surgery process analysis was established, and incentive structures have been studied to improve performance of the organization. Special focus has been placed on OR capacity planning and block allocation and improvement of OR list planning. A professional OR process benchmarking platform was introduced in Germany 10 years ago, which enables hospitals to compare the own processes with processes of other comparable hospitals to identify options and levers for improvement. Furthermore, process redesign approaches have been used to study further improvement opportunities, including simulation based modelling.

EMS Logistics I |Room: Kl. HS. A |Monday, 11:30-13:00

1 - Optimal Emergency Vehicle Location with uncertainty, hierarchy and substitutability

José Nelas, Joana Matos Dias

The main goal of emergency services is to guarantee that help arrives to populations where and when it is needed. Depending on the severity of the emergency episodes, it is possible to define maximum time limits that should be respected to assure a proper and timely assistance. The location of emergency vehicles is crucial for achieving this goal. In this work a new integer linear programming model for emergency vehicle location is presented, explicitly considering the relationship that exists between the different types of vehicles, in terms of the type of care they can provide and substitutability possibilities among vehicles of different types. The objective is the maximization of the expected total coverage, considering the available vehicles. The inherently uncertainty associated with emergency episodes is captured by the use of scenarios. Each scenario will have a different set of emergency episodes, that define when and where emergency vehicles have to be dispatched and for how long will these vehicles be assigned to these episodes. The time dimension is captured through the use of an incompatibility matrix. The model is applied to illustrative and real-data based problems.

2 - Ambulance dispatching and relocation problems: integrated optimization approaches to maximize system's preparedness

Ana Sofia Carvalho, Maria Eugénia Captivo, Inês Marques

In Emergency Medical Service (EMS) contexts, the decision-making process plays a decisive role to help managers in strategic, tactical and operational decisions. We focus on the operational level by solving the integrated ambulance dispatching and relocation problems for emergency requests. Dispatching decisions assign ambulances to emergencies and relocation decides to which base (re)assign available ambulances. It is crucial to have an optimized system to provide an effective and efficient EMS response. A mathematical model and a pilot-method heuristic are proposed to solve the integrated ambulance dispatching and relocation problems. The proposed strategy is to maximize system's preparedness and to provide a good service level within the maximum response time. Relocations are allowed to any base. Experiments consider Portuguese EMS data from Lisbon where solving these problems is still a handmade task. The proposed approaches are adapted to be compared with the current strategy which dispatches the closest available ambulance and relocates ambulances to their home bases. Results highlight the potential of the proposed approaches and strategy in real-time contexts.

3 - Analysing the impact of prediction in the real-time management of ambulances

Davide Duma, Roberto Aringhieri, Alessandro Druetto

The management of the Emergency Medical Service has an important role within the Emergency Care Delivery System, since it plays a vital role in saving people's lives and reducing the rate of mortality and morbidity. This problem is made more complex by the stochasticity of the rescue requests, which causes peaks in demand. On the other hand, the possibility of distributing the workload could have a significant impact on alleviating the Emergency Department overcrowding. A challenge is the definition of proper real-time dispatching, routing and redeployment policies (DRRP) in such a way to guarantee a good ambulance utilization reducing their diversion, and to maximize the number of emergency requests served within a time threshold. The contribution of this talk is an analysis of the impact that predictive models would have in the real-time management of ambulances. In the presented simulation and optimization model, an oracle interprets the role of a predictive model, giving information about the future requests with a certain precision. Such an information is then used in the decision making to define several lookahead DRRP.

4 - Determining Ambulance Destinations when facing Offload Delays using a Markov Decision Process

Peter Vanberkel, MENGYU LI, Alix Carter, Judah Goldstein, Terence Hawco, Jan Jensen

When emergency departments (ED) are crowded and cannot accept incoming ambulance patients immediately, paramedics commonly continue to provide patient care until an ED bed becomes available. This delay in transferring a patient to the ED is referred to as ambulance offload delay (AOD). AOD is a pressing problem for Emergency Medical Services as it prolongs the time before paramedics are available to respond to other calls. This can negatively affect ambulance availability and patient safety. The objective of this study is to develop an ambulance destination policy to mitigate AOD, allow patients to see physicians sooner, and return ambulances to service more quickly. We formulate a discrete time, infinite-horizon, discounted Markov Decision Process (MDP) model to determine when it is advantageous to send appropriate patients to out-of-region EDs, which have longer transport times but shorter offload times. Based on the MDP an optimal ambulance destination policy is found. is constructed using the policy iteration algorithm. A computational study is applied using 12-months of data from an EMS provider which experiences AOD regularly. We find that the optimal policies can signify.

Scheduling I | Room: Kl. HS. B | Monday, 11:30-13:00

1 - On the Optimal Scheduling of Clinical Pathways

Maddalena Nonato, Paola Cappanera, Giovanni Rondelli

Clinical Pathways (CPs) involve the organization of all care and assistance activities of patient's subject to a given pathology for a given time. CPs typically involve periodic controls or specific treatments to be delivered at the hospital. Chronical Multimorbidity is a growing phenomenon affecting large shares of the aging European population. When following multiple CPs, the same patient may have to undergo several such activities, each related to its own protocol, in a short time interval, while fulfilling several time requirements regarding time legs between successive treatments or exams, and potentially duplicating the same activity within few days. We present an optimization tool that supports a patient-centered integrated view of all the activities and schedules them so that 1) the number of times the patient has to access the care structure is minimized 2) if the same activity is present into more than one CP, these are synchronized in order to collapse into a single occurrence, to the benefit of both patient and National Health System. The proposed optimization tool solves a mathematical model based on a time-event graph, integrated within the commercial software Garsia.

2 - Scheduling Blood Donation Clinics to Match Supply and Demand

Emily Williams

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. 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 match supply and demand of blood products, whilst minimising costs and wastage in the system. We present an integer linear program model that consists of two stages. The first stage schedules mobile blood donation clinics, considering over 500 locations, with the objective to minimise the number of clinics scheduled within the planning horizon. Constraints ensure that clinics are scheduled according to their estimated supply and the daily demand for blood. The second stage assigns staff to each scheduled clinic, with the objective of minimising costs. The model is solved using PuLP - an open source Python package which utilises COIN-OR CLP to solve the linear program.

3 - Managing intrahospital patients' transportation requests

Angel Ruiz, Nathália Silva, Jose Eduardo Pecora, Cassius Scarpin, Valérie Bélanger

Given a set of transportation requests and a set of available resources (porters), managing intrahospital transportation activities consists in electing simultaneously the request to perform and the porter to perform it. Managers may pursue efficiency-oriented objectives such as minimizing the total distance travelled by porters, or patient service-oriented ones, like for example, minimizing the requests' longest waiting time. In its static version, the set of requests is given in advance, and the problem can be modeled as a parallel machines scheduling problem with sequence-dependent setup times, where the setup times represent the time required for a porter to move from the ending location of a request to the starting location of its next task. To deal with the more realistic dynamic version, where the set of requests can change with the unpredictable arrival of new requests, we reconsider, upon a new request arrival, the schedule for all the waiting requests. To this end, a Mixed Integer Linear Programming (MILP) formulation is used to minimize the makespan. The performance of this approach is assessed and compared to first-come first served heuristics on real-life instances.

4 - Minimize the total tardiness of chemotherapy drugs production and delivery

Alexis Robbes, Yannick Kergosien, Jean-Charles Billaut

The bio pharmaceutical unit of Oncology Clinic (UBCO) of the hospital Bretonneau of Tours (France) produces between 100 and 300 injections per days for the three hospitals of Tours. The production and the control can be modeling as a hybrid flow shop scheduling problem variation. Once the drugs are made, they must be delivered to the patient at a given due date thanks to delivery men. The delivery problem is a multi-trip vehicle routing problem variation. The production scheduling depends of the delivery part and the problem need to be treated in the integrated version. The production of chemotherapy drugs has some uncertainties which implies to develop an online optimization algorithm. The objective is to minimize the total tardiness to provide a quality service for the patients. A matheuristic based on clustering method and combinatorial optimization is proposed.

EMS Logistics II | Room: Kl. HS. A | Monday, 14:00-15:30

1 - Modeling uncertain task compliance in the dispatch of volunteers to out-of-hospital cardiac arrest patients

Niki Matinrad, Tobias Andersson Granberg, Vangelis Angelakis, Nicklas Ennab Vogel

Volunteers are an emergency response resource that has been facing rising interest in the past few years. Many projects are utilizing semi-organized volunteers for daily emergencies. Among them, there is SMS life savers who are registered volunteers contributing in out-of-hospital cardiac arrest (OHCA) cases. Although the positions of these volunteers are known, it is not trivial to decide which and how many volunteers to dispatch, or who should go directly to the patient and who should collect an AED en route to the patient. Moreover, response uncertainties, e.g. the task compliance of volunteers, complicate the dispatch problem. In this work, uncertainties associated with the volunteers' actions once assigned a task are explicitly modeled. This is done by considering the probabilities of mission abort, non-complying actions, and full compliance to instructions for each task assignment. We present a method for dispatch of volunteers in order to maximize OHCA patient's survivability. Results, based on historical data of the SMS life savers project, indicate a potential improvement in patient's survivability compared to the algorithm used in the SMS life savers project today.

2 - Personnel scheduling in emergency medical service systems considering equity between staff members

Inês Marques, Mariana Cunha, Ana Barbosa-Póvoa

Personnel scheduling is a complex and very time-consuming problem in many companies and different industries. In the health sector, due to the large variety of tasks, personnel skills and the nonstop service, the scheduling problem becomes even more hard to solve. Furthermore, besides the demand and legal constraints, a good staff schedule should consider fairness and staff satisfaction. In this work we propose an optimization approach for the personnel schedule of emergency medical system's staff. Fixed shifts are considered, and tasks are not limited to the shift's start and ending time. The primary goal is to maximize service level, by assuring that the required staff is assigned to all tasks, while considering legal constraints. Secondly, the model tries to accommodate staff satisfaction, fairness and equity perceptions, by managing overtime and undertime, as well as the shift types assigned to each person and off-work weekends. Finally, because most of the personnel scheduling models are very instance dependent, our approach is tested on a wide set of instances with varying characteristics, all inspired in a real case scenario at the Portuguese emergency medical services.

3 - Using location-allocation modelling to inform the location of specialist paediatric intensive care retrieval teams in the UK

Enoch Kung, Madeline King, Sarah Seaton, Padmanabhan Ramnarayan, Christina Pagel

Background In the UK, a network of specialist retrieval teams (PICRTs) transport critically ill children from district general hospitals (DGHs) to one of 27 Paediatric Intensive Care Units (PICUs). Could retrieval team journey times be reduced by changing the number and location of PICRTs? Objective To optimise the allocation of DGHs to PICRTs and to understand the impact of different model parameterisations on optimal allocations. Method We use location-allocation methods to find the best allocation of DGHs to PICRT locations, minimising a weighted sum of journey times between the PICRT stations, DGHs, PICUs and back. We obtain the fraction of demand reachable under various time constraints and model parameters. Results For deterministic journey times, we obtained the allocation of PICRTs to DGHs and show that time to bedside can be improved but that it will be difficult to reduce time to bedside below 90 minutes. We discuss the sensitivity of our results to the addition of important complexities within our model. Conclusion Location-allocation optimisation is a powerful and flexible tool in improving the quality of transportation in paediatric intensive care.

4 - Simulation-Optimizer for the New Austrian Advanced Medical Post (AMP): Investigating Different Realistic Policy Disaster Scenarios

Marion Rauner, Simeon Beile, Helmut Niessner

We developed a discrete event simulation-optimization policy model which has been applied by the Austrian Samaritan Organization to support planning of ambulance resources at the incident site to set up an Advanced Medical Post (AMP) for triaging, treating, and transporting patients at the incident site as well as transporting patients to hospitals. We adapted our initial policy model to account for the latest organizational changes. We provide the mean health status of severely injured patients as an additional optimization option and refined the input of the distribution for the health status of severely injured patients in the scenario setting. We investigate in detail a variety of realistic predetermined disaster policy scenarios. We illustrate that scheduling guidelines of patients at the incident site as well as to hospitals vary both among the main three optimization goals (mean total number of fatalities, mean total rescue time, mean health status of severely injured patients) and different disaster policy scenarios. These findings enable disaster policy makers to best prioritize scarce resources for certain positions and their related queues at the Austria AMP.

Scheduling II | Room: Kl. HS. B | Monday, 14:00-15:30

1 - MDP Model for the Preference-Based Appointment Scheduling Problem with Multi-Priority Patients

Feray Tuncalp, E. Lerzan Ormeci

Appointment scheduling is one of the most fundamental components of outpatient care. We study the appointment scheduling mechanism of a physician or a diagnostic resource in a healthcare facility. Each arriving patient may belong to a different priority class. The facility decides on the allocation of slots to appointment requests arriving during the day. Furthermore, we take patient preferences into account, where each type of patient prefers a day with a specific probability. We model this system with a constrained Markov Decision Process to maximize the expected average revenue subject to the constraint that the percentage of revenue generated by lower-priority patient types is more than a fixed threshold. In our model, the clinic offers the patient a set consisting of appointment days. It is also possible to offer an empty set. The scheduler may not offer a day to the patient because of two reasons: Capacity may be limited or the system may want to protect the appointment slots on that day for higher-priority patients. Patients either select one of the appointment days in this set or reject the offer. We derive analytical results about the str

2 - An online approach for the chemotherapy patient scheduling problem

Dang Khoi PHAM, Alejandra Duenas, Christine Di Martinelly

Chemotherapy is one of the most common types of treatments for patients with cancer problems, besides surgery and radiotherapy. On the treatment date, they usually go through a series of steps, including a blood test, doctor consultation, drug preparation, and drug infusion. Depending on the hospital setting, some steps can be performed before the treatment date to reduce the waiting time for patients. This study was conducted at the Outpatient Care Service (OSC) of an Oncology hospital. Our field study reveals that patient waiting times are considerable, while the utilization of resources is unbalanced throughout the day. This multistage scheduling problem has certain similarities with Hybrid Flow-Shop scheduling problem. There are some studies for the multistage appointment scheduling problem; however, most employ an offline approach which is not well suited to the current practice at this OSC. In this study, an online algorithm is proposed with the aim of reducing patient waiting time and improving resource management. A Discrete Event Simulation model is used to verify the performance of the online algorithm compared with current practices at the OSC.

3 - Transforming Community Care for Marginalized People in Inner-Cities

Alexander Rutherford, Samantha Zimmerman, Krisztina Vasarhelyi, Gabriela Sincraian, Tamon Stephen, Ronald Joe

People with complex health concerns, including mental health challenges and substance dependence, often fall through health care system gaps. Delivering community-based health care is challenging in inner-cities, where poverty and homelessness are common, and services are often uncoordinated. I will describe a collaboration to improve quality of care for marginalized people in Vancouver, Canada. We developed a nurse schedule optimization algorithm for a community care centre providing mental health, addiction, and other services. An integer linear programming and discrete event simulation approach was used to maximise nurse-patient contact hours and improve triage coverage. The optimized schedule would increase the number of patients seen per week by 10 and reduce the percentage of walk-in patients waiting over 90 minutes from 34% to 13%. We are extending this work to optimize service delivery across the network of community care centres serving marginalized people in Vancouver. Using the newly developed Vancouver Community Analytics Tool system, we are examining the potential for improved community health services to reduce emergency department visits and hospital admissions.

4 - Multi-Appointment Scheduling at a Psychiatric Outpatient Clinic

Anders N. Gullhav, Martine Helene Rønneberg, Ingrid Ødegård, Bjørn Nygreen, Henrik Andersson

We consider the problem of scheduling appointments in diagnostic pathways at a Norwegian psychiatric outpatient clinic for children and adolescents. Referred patients are assigned a diagnostic pathway consisting of a diagnostic plan of multiple activities, e.g., consults and tests. The plan might be changed or extended along the course of the pathway. Recently, the Norwegian government set a bound of 42 days on the makespan of the diagnostic pathway, which is calculated from the first diagnostic activity to the diagnosis is set. Moreover, waiting time requirements specify a deadline for when the first diagnostic activity has to be performed. The problem involves scheduling all activities in a specific diagnostic pathway for all newly referred patients, so that the waiting time and makespan are within the specified bounds, and the resource and precedence requirements of the activities are satisfied. In this work, we propose a mixed integer programming (MIP) model to perform the scheduling. To test the MIP in a stochastic and dynamic setting, we have developed a simulation model. We simulate different objectives, which gives us insights into their effect on waiting time and makespan.

Tuesday July 30th

Operating Rooms I
Room: Kl. HS. A
Session Chair: Inês Marques

1	Shiva Faeghinezhad	A system dynamics model for operating room capacity allocation
2	Nadia Lahrichi	An Integrated learning and optimization approach to reduce cancellations in the operating room
3	Oliver Buchholz	Advanced Analytics on Surgery Durations: How does the surgeon's experience influence the surgery duration?
4	Mariana Oliveira	Reallocating operating room capacity: a Portuguese case study

Primary Care
Room: Kl. HS. B
Session Chair: Christina Büsing

1	Vishal Ahuja	Maintaining Continuity in Service: An Empirical Examination of Primary Care Physicians
2	David Barrera Ferro	Predicting no-show probabilities for medical appointments among low income population in Bogotá, Colombia
3	Martin Comis	SiM-Care – A Simulation Model for Primary Care
4	Sabrina Schmitz	Controlling Patient Flow in Primary Care

10:30	Coffee

11:00	Parallel Sessions

Operating Rooms II
Room: Kl. HS. A
Session Chair: Jens Brunner

1	Seyyed Kian Farajkhah	Stochastic Scheduling of Operating Rooms and Reusable Medical Devices
2	Babak Akbarzadeh	A diving heuristic for planning and scheduling surgical cases in the operating room department with nurse re-rostering
3	Elvin Coban	Integrated Scheduling of Operating Rooms and Reusable Medical Devices
4	Steffen Heider	MSS 2.0: Master surgery scheduling for downstream workload leveling

Hospital Logistics
Room: Kl. HS. B
Session Chair: Gréanne Leeftink

1	Emma Aspland	Modelling Lung Cancer Clinical Pathways

2	Joana Matos Dias	Optimization meets Medical Physics: planning radiotherapy treatments with BAO approaches
3	Maria van Zyl	Constructing a definitive framework for waiting times in South African hospitals: A systematic literature review
4	Gréanne Leeftink	The assignment of specialties to wards: a case study

Drugs and Medical Devices
Room: 229.3
Session Chair: Mónica Oliveira

1	Steffen Rickers	Integrated procurement and reprocessing planning of perishable and reusable medical devices in hospitals
2	Edgar Mascarenhas	Hospital-based HTA meets OR: Challenges for structured and value-driven evaluations of medical devices
3	Mario Jorge Ferreira de Oliveira	3D VISUAL SIMULATION: MULTIPLE VIEWS OF MEDICINE DISTRIBUTION IN A PUBLIC HOSPITAL
4	Mónica Oliveira	A multicriteria framework to assist HTA agencies on the evaluation of new drugs on a common basis

12:30	Lunch	

14:00	Keynote	Room: Palace Gartensaal
	Matthias Reumann	Briging Vision and Reality: Big Data and AI in Healthcare

15:00	Coffee + Postersession	Room: Palace Gartensaal
1	Onur Asan	Systems Engineering Considerations in Novel Health Technologies Adoption
2	Fanwen Meng	A Mathematical Model for Optimal Personalized Anti-thyroid Drug Dosing for Patients with Graves' Disease
3	Hugo De Oliveira	Process mining for predictive analytics: a case study on NHS data to improve care for sepsis patients.
4	Daniel Gartner	The big difference of small weight losses: Creating digital solutions for patients with obesity
5	John Threlfall	Benchmarking construction and improvement heuristic algorithms for classification problems in healthcare

16:00	Industry Talks	Room: Palace Gartensaal
	Harry Kerstenbaum (Simplan)	Simulation in Healthcare
	Martin Clark & Tef Jansma (Optima)	Building a Resilient & Responsive EMS

17:30	GOR AG HCM Meeting	Room: Palace Gartensaal

18:30	BBQ	

Operating Rooms I | Room: Kl. HS. A | Tuesday, 9:00-10:30

1 - A system dynamics model for operating room capacity allocation

Shiva Faeghinezhad, Kunibert Lennerts

Operating room (OR) management and optimal distribution of its capacity between different specialty departments and surgeons are essential tasks and have remarkable impacts on the efficiency of other functions in hospitals. This issue is more highlighted when the demand for resources often overruns the amount supplied. OR capacity allocation is fundamentally dynamic and always plagued with complexities. Neglecting these characteristics makes the evaluation of long-term adequacy of specific strategic decisions somewhat unreliable. However, dynamic models for OR management have gained much less attention than static ones. Using a system dynamics approach, this paper aims to consider the OR departments as systems, comprehend interactions of different influencing parameters, and study their dynamic hypothesis. An illustrative example based on a case study from the literature is used to demonstrate the modeling process. The performance of the system during the passage of time is also investigated under different hypothetical scenarios to demonstrate the capabilities of the proposed model regarding control and productivity.

2 - An Integrated learning and optimization approach to reduce cancellations in the operating room

Nadia Lahrichi, Arnaud Augustin, Philippe Jouvet, Andrea Lodi, Louis-Martin Rousseau

In this talk, we propose a novel approach to deal with the integration of the intensive care unit to the (long term) surgical case assignment problem. The approach is based on graphical model optimization that includes the probability of canceling cases at each state. We use the practical case of the teaching hospital Sainte-Justine (CHUSJ), in Montreal and show that prioritizing patients during this process only increases the quality of the schedule without decreasing the occupancy rate of the OR.

3 - Advanced Analytics on Surgery Durations: How does the surgeon's experience influence the surgery duration?

Oliver Buchholz, Christopher Haager, Jan Schoenfelder, Jens Brunner, Katja Schimmelpfeng

Forecasting surgery durations is paramount for constructing good quality plans or planning systems in hospitals (e.g., capacity planning, case mix planning, master surgery schedules, and shift scheduling). Furthermore, the operating room belongs to a hospital's main cost drivers, thus making surgery duration a key to achieve cost effectiveness. To gain a better understanding of the respective interdependencies, we aim to investigate the influence every surgeon has on the surgery duration on a non-individual level. Since experience is a very generalizable factor across the heterogeneous group of hospitals, it is the most evident influence factor to analyze. We will particularly exploit information regarding a surgeon's level of experience and examine its correlation with the surgery duration. Due to privacy and employment law in Germany and other European countries, it is not possible to conduct this analysis on an individual base; hence our investigation focuses on groups of surgeons with a similar experience level. We conduct our analyses using real-world data of German hospitals of different sizes.

4 - Reallocating operating room capacity: a Portuguese case study

Mariana Oliveira, Inês Marques

Health care management can be a complex task due to the increasing demand and the development of new technologies. Operating rooms (ORs) are costs and revenues center of hospitals. Surgeries require expensive equipment, involve a high level of variability, and have high impact in the workload of up- and downstream units. Moreover, ORs have many conflicting stakeholders, which can influence the management process. Thus, it is important to create systematic approaches to optimize ORs' planning. This work, based in a collaboration with a Portuguese public hospital, proposes an integer linear programming model to support tactical decisions. The model aims to maximize the number of allocated slots to each specialty, comply with the dynamic demand and staff preferences, and balance workload on up- and downstream units. The model has a 1-year planning horizon that allows to consider staff availability fluctuations. The results suggest that the main bottleneck of the surgical service is the workforce. Thus, a new staff distribution and new acyclic master surgery schedules are proposed, which allow to better meet demand and achieve higher efficiency levels in the ORs.

Primary Care| Room: Kl. HS. B | Tuesday, 9:00-10:30

1 - Maintaining Continuity in Service: An Empirical Examination of Primary Care Physicians

Vishal Ahuja

In many settings, customers have repeated interactions with service providers. This creates two important questions for service design: (i) How important is it to maintain the continuity of service for individuals? (ii) Since maintaining continuity is costly and, at times, operationally impractical, should certain customer types be prioritized for continuity? These questions are particularly important in healthcare where patients with chronic conditions visit primary care offices repeatedly. We explore these questions using a detailed dataset from the Veterans Health Administration, the largest integrated healthcare delivery system in the U.S. which permits us to control for potential sources of heterogeneity. We analyze over 300,000 patients that suffer from both diabetes and chronic kidney disease over an 11-yr span. We find that continuity of care is related to improvements in three important health outcomes: inpatient visits, length of stay, and readmission rate. Further, this relationship is curvilinear, suggesting that there may be value in having multiple providers. We also find that care continuity is even more important for patients suffering from more complex conditions.

2 - Predicting no-show probabilities for medical appointments among low income population in Bogotá, Colombia

David Barrera Ferro, Sally Brailsford, Honora Smith, Cristian Bravo

Currently, 15% of the population of Bogotá does not have the capacity to pay for private health. With a model of competition in insurance, such as the one in Colombia, income inequality decreases access to health services. Consequently, the District Secretary of Health designed a program to eliminate barriers to access health system affecting the low-income population. In order to achieve it, a group of health workers assesses the risk level of each patient and schedule him an appointment with a physician, ideally, within the next two weeks. After this appointment, patient continues his treatment with the providers of his insurance company. For the last two years, due the increasing coverage, the planning process of the program has become more challenging. In particular, high no shows rates have led to long indirect waiting times for the patients and idle times from the physicians. Hence, the use of machine learning is proposed in order to predict no-show probabilities. The classification algorithm uses information from both the patient and the appointment. Preliminary results, using historical data, shows accuracy of the method and will be used to inform scheduling practices.

3 - SiM-Care – A Simulation Model for Primary Care

Martin Comis, Christina Büsing, Catherine Cleophas

Today's health care systems are facing great challenges: Ageing populations have a record demand for health care services and are increasingly immobile. Simultaneously, available workforce decreases and health care providers cluster in the densely populated urban areas. To predict and counter the resulting implications to our health care systems, new methods analyzing and optimizing system performance are required. To support this endeavor for primary care, we developed SiM-Care - a Simulation Model for primary Care. SiM-Care models the interactions of patients and primary care physicians on an individual level. By tracking agent interactions, SiM-Care enables modelers to assess key indicators such as access time, waiting time, and capacity utilization. Analyzing these indicators allows for an assessment and comparison of primary care systems and an evaluation of changes in infrastructure, patient behavior, and service design. Next to the presentation of the simulation model itself, we exemplify the process of generating an input instance for SiM-Care which is an essential part in the production of meaningful results.

4 - Controlling Patient Flow in Primary Care

Sabrina Schmitz, Christina Büsing, Martin Comis

In Germany, general practitioners (GPs) are generally the first point of contact for patients requesting medical care. Subsequently, GPs are responsible for ensuring continuing care either by themselves or by referrals to specialists. Accordingly, GPs play a crucial role in the German health care system by managing patients' access to medical care. In order to fulfill this important role, a GP must work efficiently which requires a smooth workflow. Unfortunately, the GP's planning process is complicated as patients often forgo an appointment and seek immediate care as walk-in patients. Moreover, a GP's planning has to take patient satisfaction into account by avoiding long access times to an appointment and long waiting times in the practice. To aid the GP's planning process, we develop an appointment system based on a minimum cost flow model that accounts for unforeseen patients and ensures a balanced workload to improve the GP's efficiency. Furthermore, we introduce an advanced appointment system that can be easily adjusted to cover fluctuating demand. Finally, we evaluate the presented methods by an agent-based simulation.

Operating Rooms II | Room: Kl. HS. A | Tuesday, 11:00-12:30

1 - Stochastic Scheduling of Operating Rooms and Reusable Medical Devices

Seyyed Kian Farajkhah, Enis Kayis, Elvin Coban

Health care expenditures are expected to grow every year, and more than 40% of a hospital's total expenses and revenues are generated by surgical operations. One of the major resources required during surgeries are reusable medical devices (RMDs). RMDs are surgical instruments utilized during surgeries which have to be reprocessed by thorough cleaning followed by sterilization after each use. RMDs have to be planned with operating rooms (ORs) concurrently since insufficient RMDs may cause delays in operation starting times. However, management of RMD sterilization stage is nontrivial. First, RMDs are sent to sterilization service at different times due to different finishing times of operations. Second, the decision of how to load the sterilization machines, i.e., how to batch RMDs, is a complicated one. Lastly, time spent during sterilization must be considered during scheduling of ORs. In this paper, we study the integrated scheduling of ORs and sterilization of RMDs under stochastic surgery durations. We propose a simulation optimization approach to tackle with this problem, and through numerical studies show that our approach could lead to significant savings for a hospital.

2 - A diving heuristic for planning and scheduling surgical cases in the operating room department with nurse re-rostering

Babak Akbarzadeh, Broos Maenhout

The decisions in the operating room scheduling process related to the case mix planning, the master surgery schedule and the nurse roster are based on the expected demand, predicted by historical data. However, in the operational level, when surgical cases need to be planned and scheduled the actual patient demand may differ from the expected demand and may lead to a mismatch between the nurse roster and the nurse demand. To tackle this problem, we include the nurse re-rostering decision and nurse-patient assignment in the surgical case planning and scheduling problem to utilise the operating room department as efficiently as possible and maximise the operating room profit. We propose a two-phase heuristic that uses the LP solution generated via column generation to construct a high-quality feasible solution. Computational experiments have been conducted on a diverse artificial dataset generated in a controlled and structured manner and real-life data from the Sina hospital (Tehran, Iran). We show that the presented approach is able to produce (near-)optimal solutions and benchmark the procedure with other optimisation strategies and solution methodologies.

3 - Integrated Scheduling of Operating Rooms and Reusable Medical Devices

Elvin Coban

Reusable medical devices (RMDs) are surgical instruments that are reprocessed by high-level sterilization. We study integrated scheduling of operating rooms(ORs) and sterilization of RMDs since solving only OR scheduling problem via ignoring RMDs' sterilization may result in inadequate number of clean RMDs. Hence, there may be surgery cancellations, thus, ORs may be underutilized. First, we model this integrated scheduling problem by an integer linear programming model minimizing the total cost of RMDs' sterilization, OR usage, and surgery cancellations. Then, real life practice of disaggregating the problem, first, solving the OR planning problem, and afterward solving the sterilization schedule given the OR schedule, is modeled. We also propose heuristics based on availability of ORs and RMDs. Our computational results show that disaggregating the scheduling performs the worst over all proposed methods for a single day schedule. Our results demonstrate the usefulness of integrating OR scheduling problem and sterilization of RMDs, and hospital administrations can not only decrease their total costs but also prevent cancellations due to inadequate number of required RMDs.

4 - MSS 2.0: Master surgery scheduling for downstream workload leveling

Steffen Heider, Jan Schoenfelder, Thomas Koperna, Jens Brunner

Scheduling surgeries in the operating theatre is a challenging task. Resources within the operating theatre, as well as resources of downstream units, e.g., the intensive care unit, and the regular bed wards of each medical specialty, are limited and have to be considered for surgery scheduling. We highlight the advantages and disadvantages of a commonly used planning instrument, the master surgery schedule. We especially focus on one disadvantage, the workload variability on downstream units specifically on the intensive care unit. We introduce two kind of block types to have better control over the patient flow through the hospital after surgery is completed. We present a mixed integer problem to create an MSS 2.0 and use a simulation model to evaluate our results with seven years of data from Universitätsklinikum Augsburg. We show that workload variability can be drastically reduced, even when the current MSS is not changed, and that MSS 2.0 outperforms the state-of-the-art approach.

Hospital Logistics | Room: Kl. HS. B | Tuesday, 11:00-12:30

1 - Modelling Lung Cancer Clinical Pathways

Emma Aspland, Paul Harper, Daniel Gartner

Clinical pathways are an effective and efficient approach in standardising the progression of treatment to support patient care and facilitate clinical decision making. Our review of the related literature highlighted a need to better integrate data engineering and OR techniques with expert/domain knowledge to assist with clinical pathway discovery and formation. Consequently, we have produced a decision support tool that facilitates expert interaction with data mining, through the application of clustering. This has involved the development of a new distance metric, modified from the Needleman-Wunsch algorithm, that considers weightings and groupings of activities as specified by an expert user. The resulting set of pathways are then automatically translated into the basis of a discrete event simulation to model patient flows through the captured clinical pathways. Our research is in partnership with Velindre Cancer Centre, the largest specialist cancer centre in Wales, and has the overall goal to improve patient care and outcomes by reducing time to diagnosis and treatment for those with lung cancer.

2 - Optimization meets Medical Physics: planning radiotherapy treatments with BAO approaches

Joana Matos Dias, Humberto Rocha, Tiago Ventura, Brígida da Costa Ferreira, Maria do Carmo Lopes

Radiotherapy is a very effective technology driven approach for cancer treatment. There are different treatment modalities that share one thing in common: they require a computer-assisted trial-and-error Radiotherapy Treatment Planning Process that presents severe limitations: it is expensive in terms of workload; the quality of the plan is highly dependent on the planner's skills, past experience and time availability; there is no way of knowing if it would be possible to achieve a better treatment plan for each patient. The use of optimization models and techniques gives an important contribute to the automation of treatment plans, producing better plans in less time, and releasing the human planner for other very important tasks. An important problem is the beam angle optimization (BAO) problem, a highly nonconvex optimization problem whose objective function value is very expensive in terms of computational time. The importance of the fluence map optimization for BAO will be discussed. Alternative optimization approaches will be presented (namely a quadratic model and a fuzzy inference based approach embedded in evolutionary strategies).Results will be presented and compared.

3 - Constructing a definitive framework for waiting times in South African hospitals: A systematic literature review

Maria Van Zyl

A preliminary overview of literature related to process problems experienced in hospitals in South Africa has indicated that waiting time is one of the most critical problems. Academic literature that address waiting times in healthcare in South Africa is extremely limited and only refer to the introduction of basic triage systems to reduce waiting times. Furthermore, the way in which waiting times in hospitals in international literature is defined seems problematic. Examples of different waiting time definitions include elements related to access times to theatres and care, triage waiting times and in-process waiting times. Definitions are not necessarily relevant to the South African healthcare context. In order to understand patients' and other stakeholders' value perception related to waiting times in South Africa, a definitive framework on waiting times in hospitals needs to be established. This research makes use of a systematic literature review according to the PRISMA methodology to establish a framework of waiting times hospitals in South Africa.

4 - The assignment of specialties to wards: a case study

Gréanne Leeftink

This work presents a case study of the strategic/tactical decision of assigning specialties to wards. With the planned reallocation of our partnering hospital, major burdens for reassigning specialties to wards are overcome. To include intelligence in the assignment of specialties to the wards, we strive for an assignment that ensures a low blocking probability, given the demand characteristics of all specialties and capacity restrictions in each of the available ward locations, as well as satisfying a number of hard and soft constraints. These constraints include for example (un)preferred specialty combinations, location preferences, and nursing capabilities. Furthermore, we assess the logistical consequences of the introduction of an acute medical unit (AMU), given the reallocation of the wards. Our results provided our partnering hospital with a new specialty to ward allocation, which was favored over the current assignment and their initial reassignment plans, with lower blocking probabilities while introducing the AMU, given the same number of beds.

Drugs and Medical Devices | Room: 229.3 | Tuesday, 11:00-12:30

1 - Integrated procurement and reprocessing planning of perishable and reusable medical devices in hospitals

Steffen Rickers, Florian Sahling

We present a new model formulation for a multi-product dynamic order quantity problem with product returns and a reprocessing option. The optimization includes the limited shelf life of sterile medical devices as well as capacity constraints of reprocessing and sterilization resources. The time-varying demand is known in advance and must be satisfied by procuring new medical devices and/or by reprocessing used and expired ones. The objective is to determine a feasible procurement and reprocessing schedule that minimizes the incurred costs. As even small problem instances are not solvable in reasonable time, a new heuristical approach is presented.

2 - Hospital-based HTA meets OR: Challenges for structured and value-driven evaluations of medical devices

Edgar Mascarenhas, Mónica Oliveira, Ricardo Fernandes

The widespread introduction of innovative medical devices (MDs) across health systems has contributed to an improvement of patients' health outcomes but is also key driver of health expenditures growth in most developed countries, forcing governments to reconcile access with economic sustainability of health systems. In this context, Health Technology Assessment (HTA) activities have been spreading to many hospitals that, due to limited resources and increasing demands, are required to assess MDs on multiple dimensions and on a common basis. Yet, oftentimes evaluation of MDs is based on scarce evidence, particularly for MDs in pediatric use, due to ethical, legal and safety reasons, making this appraisal highly dependent stakeholders' opinions. In this first study, departing from a systematic review on the literature evaluating MDs in pediatrics, we will map the challenges concerning multicriteria evaluation and stakeholder involvement that can be addressed by the Operational Research Community, so that new tools can be developed to assist hospital decision-makers in performing structured and value-driven assessments of MDs.

3 - 3D VISUAL SIMULATION: MULTIPLE VIEWS OF MEDICINE DISTRIBUTION IN A PUBLIC HOSPITAL

Mario Jorge Ferreira de Oliveira

The visualization of the results of a simulation model is a recent progress that has been applied to the hospital context. The new approach leads to the direction of study the different visions of the agents involved in the simulation process. The method has theoretical interest and leads us to the elaboration of a complex model. An innovative multiple and parallel simulation model is now under research. The interactive virtual aspect of the platform contributes to reduce the gap between theory and practice. This instrument should be extensively used in learning and training programs. The objective of this paper is to describe a 3D visual simulation of the medicine distribution system at pharmacy of a public hospital. The model is based upon the integration, at the same level of importance, of the viewpoint of three of the most important entities involved in the medicine distribution process: The patient, the attendants and the medication logistics. It is argued that the synchronization of the life cycle of these important entities could contribute to improve the performance of the hospital system.

4 - A multicriteria framework to assist HTA agencies on the evaluation of new drugs on a common basis

Monica Oliveira, Ana Vieira, Aris Angelis, Panos Kanavos, Carlos Bana e Costa

Multicriteria decision analysis (MCDA) is being increasingly explored to inform Health Technology Assessment (HTA). Nevertheless, literature in the area has not delivered MCDA modelling approaches that enable the evaluation of drugs across disease areas on a common basis, that help evaluation committees to perform structured evaluations while considering qualitative knowledge, and that are informed by the views of a large number of HTA stakeholders. Within the scope of the IMPACT HTA H2020 project, in this study we describe the development of a multicriteria value framework to assist HTA agencies on the evaluation of drugs on a common basis and that addresses these challenges. Technically, the framework is based upon adaptable and flexible multi-criteria models that make use of novel features, including equivalent across-areas attribute-references and interval-weights. Socially, the framework is developed through a collaborative modelling approach in which a large number of HTA stakeholders are involved in a sequence of Delphi and decision conferencing processes and provide insights to build a framework with potential to be used in practical settings.

Keynote | Room: Palace Gartensaal | Tuesday, 14:00-15:00

Briging Vision and Reality: Big Data and AI in Healthcare

Matthias Reumann

The rise of Big Data and the resurgence of artificial intelligence in healthcare and lifescience holds promises that claim to lead to a creative disruption of medicine. Several publications have demonstrated the power of AI with respect to improving diagnosis and treatment. However, most of these publications were carried out under experimental conditions. AI in healthcare has gone from a forming to a storming phase. It is essential that the next step to the norming phase will be achieved so that the power of AI and Big Data can be harnessed and perform to its expectations. To realize the potential of new technology and the fast-paced innovation in digital health, a solid foundation of quality data and methods has to be built. This talk will illustrate the vision of how big data and AI could transform healthcare giving real world examples that show the status quo of digital health bridging reality and vision from genes to society.

Poster session|Room: Palace Gartensaal | Tuesday, 15:00-16:00

1 - Systems Engineering Considerations in Novel Health Technologies Adoption

Onur Asan

With the recent developments in artificial intelligent applications, we have started seeing emerging new technologies in healthcare which uses adaptive AI algorithms. In addition to AI driven technologies, there has been increased rate of adoption in novel consumer and clinical technologies. The initial purpose of these technologies is to improve efficiency, quality, decision making as well as patient centered care in health practice. However, the value of health information technology ultimately depends on end users accepting and appropriately using it for patient care. Technology Acceptance model strongly shows that two main parameters "perceived usefulness and perceived ease of use" predict the actual use. We will report several studies focusing on novel Health Information Technology implementations in inpatient and outpatient settings using technology acceptance model. The findings have implications for research, design, implementation, and policies for novel informatics. Several changes are recommended to improve the design and implementation of the studied IT.

2 - A Mathematical Model for Optimal Personalized Anti-thyroid Drug Dosing for Patients with Graves' Disease

Fanwen Meng, Enlin Li, Paul Michael Yen, Melvin Khee Shing Leow

The current practice of titration of anti-thyroid drug (ATD) treatment for Graves' disease based on thyroid function trend is arbitrary and time-consuming, requiring multiple clinic monitoring visits before an optimal dose is found. This study seeks to develop a personalized medicine model that facilitates optimal drug dosing via the titration regimen. We analyzed patient data consisting of drug dosage, time period and serum free thyroxine (FT4). Ordinary differential equation (ODE) modeling was applied to describe the dynamic behavior of FT4 concentration. With each patient's data, an optimization model was developed to determine parameters of synthesis rate, decay rate and IC50. We derived the closed form solution to estimate personalized predicted FT4. Compared against actual FT4 data within a tolerance, we demonstrated the feasibility of predicting the FT4 subsequent to any prescribed dose of ATD with favorable accuracy using the initial 3 to 5 patient-visits' data respectively. The proposed model may assist clinicians in rapid determination of optimal ATD doses to achieve a desired FT4 within a specified treatment period to accelerate the attainment of euthyroid targets.

3 - Process mining for predictive analytics: a case study on NHS data to improve care for sepsis patients

Hugo De Oliveira, Martin Prodel, Ludovic Lamarsalle, Andi Orlowski

Clinical pathway management is challenging, but knowledge extraction from real-life data is a lever for improvement. Recorded in event logs, pathways data are hard to analyze with classic statistics or machine learning. Although predictive analytics is useful to detect high-risk patients' pattern, understandable results are a key for acceptability and practical deployment. It requires transparency and explicitness. A new Process Mining algorithm is introduced to perform binary classification, specifically designed for event-log data. Its transparency results from the production of a graphical process model representing the learning process and pattern predictions. It was applied on data extracted from NHS data. Patients with a sepsis episode in 2016 were included and followed 2 years before and 1 year after. Data contained about 580 000 events for 72 000 patients. Based on patients' medical history, sepsis relapse was to be predicted. Results show encouraging performance of the algorithm. Moreover, a graphical "bowtie" graph provided explaining predictions and interesting patterns to practitioners and decision makers.

4 - The big difference of small weight losses: Creating digital solutions for patients with obesity

Daniel Gartner, Doris Behrens, Enzo DiBattista, Anita Lynam

In many industrial nations, the proportion of adults and children who are not maintaining a healthy body weight is increasing and an estimated 70,000 premature deaths a year related to obesity could be avoided in the United Kingdom (Public Health England 2016). Losing and maintaining a healthy body weight may decrease the risk for obesity-related conditions such as diabetes - one of the major causes for premature deaths. In this project, we develop a motivational tool to reduce the risk of obesity-related diabetes. We developed a Monte Carlo Simulation which is used to predict the inter-temporal progression of diabetes risk as a consequence of obesity. The simulation is implemented in a mobile application and Java desktop application to serve patients' and dietitians' needs as stakeholders of the tool. Testing the m-health solution using the Think Aloud Protocol with patients as stakeholders, we evaluated the usability and acceptability of the platform. Our study suggests useful insights that we incorporated into a tailored improvement process of our innovative technology.

5 - Benchmarking construction and improvement heuristic algorithms for classification problems in healthcare

John Threlfall, Daniel Gartner, Paul Harper, Rema Padman

Datasets with many discrete variables and relatively few observations are generated in domains such as health care and electronic commerce. Learning which variables are relevant and non-redundant effectively and efficiently is a difficult task. Moreover, achieving high accuracies for making predictions is challenging. In this poster, we implement and evaluate a Java-based approach that combines a construction heuristic with a scatter search-based improvement heuristic to learn a graphical Markov Blanket-based classifier from the data. Results from the Scatter Search generated Markov Blanket are compared against Computational results from different benchmark data sets. These different dataset in different domains indicate which method can lead to competitive classification results. The graphical models which are generated can be interpreted by practitioners such as physicians. In addition, our results reveal that the graphical models learned from the data have substantially less predictor variables than in the full data set. Results of the approaches are analyzed and broken down by computation times, size of the graphs, classification accuracy.

Thursday August 1st

09:00	Keynote	Room: Otto-Lehmann-Hörsaal
	Dolores Romero Morales	Learning and Interpreting with Mathematical Optimization

10:00	Coffee	Room: Otto-Lehmann-Hörsaal

10:30	Parallel Sessions	

Healthcare Logistics
Room: Kl. HS. A
Session Chair: Honora Smith

1	Ana Maria Anaya-Arenas	From Local To Regional Healthcare Logistics Network: Challenges, Opportunities and Lessons Learned
2	Nitin Ahuja	Location Analysis and Mobility for Modern Health Care Use Cases
3	Tommaso Giovannelli	A Simulation-based Optimization approach for reducing the hospital Emergency Department overcrowding through the improvement of low-complexity patient flow
4	Honora Smith	Planning a paediatric neuro-rehabilitation outreach service: location of centres in a region of the UK

ICU and ED
Room: Kl. HS. B
Session Chair: David Stanford

1	Daniel García de Vicuña	Learning decision-making of an Intensive Care Unit using a Management Flight Simulator
2	Felipe Rodrigues	ICU Length of Stay: Individual predictions and short-term capacity planning using a Parametric Accelerated Failure Time Model
3	Sebastian Rachuba	Using Discrete-Event Simulation to evaluate strategies for joint OR and ICU planning
4	David Stanford	The Average Waiting Time for Both Classes in a Delayed Accumulating Priority Queue

Healthcare Analytics I
Room: 229.3
Session Chair: Christos Vasilakis

1	Liliana Freitas	Embedding behavioural OR within Delphi knowledge construction processes in health settings
2	Fredrik Dahl	Classifying Norwegian radiology reports with deep neural net learning
3	Oguzhan Alagoz	An agent-based simulation modeling approach to evaluate hospital-acquired Clostridioides difficile infection control interventions
4	Christos Vasilakis	Supporting national planning through improved forecasting of demand for health services

12:00   Lunch

13:00   Parallel Sessions

Emergency Department
Room: Kl. HS. A
Session Chair: Maartje van de Vrugt

1	Evgueniia Doudareva	The Development of a Generic Emergency Department (ED) Discrete Event Simulation Model
2	Sofia João	Simulation of an Emergency Department to assess resources capacity to attend future demands
3	Marta Cildoz	Improving the patient flow in an emergency department: report of a success story
4	Maartje van de Vrugt	Assigning and prioritizing patients at the Emergency department

Mental Health
Room: Kl. HS. B
Session Chair: Sally Brailsford

1	Sean Manzi	A comparison of mental health service use for people with severe and complex disorders using a network based approach
2	Leslie Anne Campbell	Identifying novel mental health service use cohorts in a maternal administrative health database
3	Valérie Bélanger	A new insight in the factors of diagnostic changes in major psychiatric disorders through an organizational standpoint
4	Sally Brailsford	A hybrid simulation model for dementia

Healthcare Analytics II
Room: 229.3
Session Chair: Roberto Aringhieri

1	Penelope Mullen	What can OR do to reduce the burden of being a patient?
2	Catherine Crenn-Hebert	Delivery practices heterogeneity, appropriateness and efficiency in Ile de France (IDF) region
3	Jules Le Lay	Organizational challenges to support multimorbid patients in Saint-Étienne's area.
4	Martin Dlouhy	An Assessment of Regional Variations: Expert Knowledge and Quantitative Analysis

14:30   Coffee

15:00	**Parallel Sessions**	
Bed Management in Hospitals		
Room: Kl. HS. A		
Session Chair: Theresia van Essen		
1	Michael Grütz	An integer linear model for hospital bed planning/operating theatre scheduling
2	Fabian Schäfer	Hybrid Heuristic for the Patient-Bed Allocation Problem in Large Hospitals
3	Tabea Krabs	Online Patient-to-Room Assignment in Hospital Wards
4	Theresia van Essen	Reducing the number of required beds at the holding and recovery department
Healthcare Policies and Systems		
Room: Kl. HS. B		
Session Chair: Joe Viana		
1	Roberto Aringhieri	Modelling Health Care Systems using Big Data and Discrete Event Simulation
2	Paula Andrea Velasquez Restrepo	Methodology to implement risk management in health for a population of patients assigned under a prospective global payment model
3	Neda Pourreza	An acute patient journey: the role of the system factors affecting timeliness and quality of care
4	Joe Viana	Research governance and ethical challenges for simulation studies: Should we develop guidelines?

18:00	**Conference Dinner**	**Hoepfner Burggarten**

Keynote | Room: Otto-Lehmann-Hörsaal | Thursday, 9:00-10:00

Learning and Interpreting with Mathematical Optimization

Dolores Romero Morales

Data Science aims to develop models that extract knowledge from complex data and represent it to aid Data Driven Decision Making. Mathematical Optimization has played a crucial role across the three main pillars of Data Science, namely Supervised Learning, Unsupervised Learning and Information Visualization. Data Science models should strike a balance between accuracy and interpretability. Interpretability is desirable for by non-experts; it is required by regulators for models aiding, for instance, credit scoring; and since 2018 the EU extends this requirement by imposing the so-called right-to-explanation. In this lecture, we show the important role that Mathematical Optimization plays to model the trade-off between learning accuracy and interpretability.

Healthcare Logistics | Room: Kl. HS. A | Thursday, 10:30-12:00

1 - From Local To Regional Healthcare Logistics Network: Challenges, Opportunities and Lessons Learned

Ana Maria Anaya-Arenas, Valérie Bélanger, Angel Ruiz

This study is inspired by the context of the Integrated Centre of Healthcare and Social Services – Chaudière-Appalaches (CISSS-CA) in Quebec (CA), which serves 422 000 people on a 17 500 km2 area, and where several types of material need to be transported between different healthcare facilities to serve to the patients. Currently, the Ministry of Health and Social Services of Quebec is creating regional clusters to optimise healthcare operations and service's quality, hence the CISSS-CA needs to review its network. We study three structures, including the required routing schedule to deliver and collect the materials, considering its various frequencies and time frames. 1) The decentralised structure of the CISSS-CA will give a descriptive analysis of the current network and its needs. 2) A full centralisation with a single management location will seek to standardise and control the logistics' operations, and we will examine the cost related to it. 3) We analyse a case where managers will select from a set of potential facilities some consolidation points, defining a two-echelon distribution network. The advantages and challenges of these structures will be discussed.

2 - Location Analysis and Mobility for Modern Health Care Use Cases

Nitin Ahuja

Traditional OR methods for solving various location as well as clustering problems are being used since ages to design efficient and reliable health care services. With the increase in computing power it is now possible to solve larger and more complex instances of these problems. This enables the creation of better and more involved health care services on a strategic level. With the advent of Mobility as a Service (MaaS), service providers now have new tools and decision support systems at their disposal. These tools can not only help them improve traditional services at tactical and operative levels, but also empower them to provide new and innovative services. In this talk we provide insights into how new and old OR methods, together with some of the latest technologies, can be used to efficiently tackle modern health care use cases. In addition to presenting some results we will also demonstrate the workings of a subset of the aforementioned tools.

3 - A Simulation-based Optimization approach for reducing the hospital Emergency Department overcrowding through the improvement of low-complexity patient flow

Tommaso Giovannelli, Stefano Lucidi, Mauro Messedaglia, Massimo Roma

People arriving to an Emergency Department need to receive medical care in a short time according to their urgency. This task is endangered by the well-studied and increasing problem of the overcrowding, which tends to enlarge the waiting times, threatening the life of critical patients. Since the majority of the waiting patients are low-complexity, using minor injuries units for discharging these patients earlier allows to reduce the ED overcrowding, improving the service quality for all patients. In this work a Simulation-based Optimization approach is adopted for determining the resource allocation and the settings of the ED minor injuries unit in order to minimize the patient waiting time with acceptable costs. To this aim, first we build a Discrete Event Simulation model reproducing the patient flow within the ED of a big Italian hospital. As a second step, we determine the optimal settings combining the DES model with a Derivative-Free Optimization method. This approach provides a reliable decision support system which enables to improve the healthcare service performance.

4 - Planning a paediatric neuro-rehabilitation outreach service: location of centres in a region of the UK

Honora Smith

Small numbers of children receive neuro-rehabilitation as in-patients at a tertiary hospital in the south of England after, for example, brain injuries. It could be beneficial for more children to have rehabilitation from a centre closer to home; an outreach service from the hospital is in the planning stages. Sites throughout the region will be chosen for outreach centres, where hospital staff will supervise rehabilitation carried out by locally-based therapy specialists. Travel time is an important consideration in the planning of this outreach service. Location analysis has been used to support decisions on where to locate such outreach centres. A range of maximum travel times has been considered, using the Maximal Cover Location Model. Results are presented using both data on patient residences and census data on the under-18 population in the region. Findings are that the optimal numbers of outreach locations are robust for both patient and population data. However, the set of locations recommended varies with the different data sources, because of the relatively small numbers of patients that are treated.

ICU and ED | Room: Kl. HS. B | Thursday, 10:30-12:00

1 - Learning decision-making of an Intensive Care Unit using a Management Flight Simulator

Daniel García de Vicuña, Laida Esparza Artanga, Fermin Mallor

Management Flight Simulators (MFS) supply a simulated environment in which managers can learn from experience in a controlled setting. MFS also allow researchers to study decision-making in real time by requesting input from participants. Although its use is usual in other areas, no such type of simulation has been developed to learn about the complexity of the Intensive Care Unit (ICU) management. This paper introduces a web-based MFS of ICUs which enables us to induce decision-making processes, test theories about physicians' decision-making, analyze triage processes and detect biases. The mathematical model is a discrete event simulation model in which patient arrivals occur according to a known schedule for those coming from surgeries or randomly for emergency patients. Through the change of some settings, interesting scenarios can be created which generate conflicts among physicians regarding discharge, admission or diversion of patients. The MFS provides a computer interface which imitates the real ICU environment (reports, computer screens…) and puts physicians in control of a realistic environment where they must make key decisions like those they face in their work.

2 - ICU Length of Stay: Individual predictions and short term capacity planning using a Parametric Accelerated Failure Time Model

Felipe Rodrigues, Lori Murray, John Wilson, Greg Zaric

Prediction of a patient's length of stay (LOS) may help Intensive Care Units (ICU) to plan future resource allocation. Present-day ICUs collect a number of patient data and aggregate it in the form of severity scores, which have been used in the literature for individual patient LOS predictions and LOS benchmarking. In Canada, patient severity is often measured by the "Multi-Organ Dysfunction Syndrome" (MODS) score and nursing workloads by the "Nine Equivalents of Nursing Manpower Use Score" (NEMS). Using MODS and NEMS as covariates, we developed a parametric Accelerated Failure Time model serving two purposes. First, we assess LOS prediction performance considering ICU arrival measures. Second, we use each patient's individual survival function to generate individual survival probabilities and pool the patient cohort probabilities to form expected short-term bed needs. Using data from a large Canadian university hospital, we show that, although individual LOS prediction is prone to significant error, aggregate occupancy is more predictable and can be used reliably for short-term resource capacity planning purposes.

3 - Using Discrete-Event Simulation to evaluate strategies for joint OR and ICU planning

Sebastian Rachuba, Lisa Imhoff, Khairun Bapumia, Brigitte Werners

Operating rooms (ORs) are an important cost and revenue centre in hospitals. Besides the OR's own utilisation, planning surgeries also affects downstream resources such as Intensive Care Units (ICUs) or inpatient wards. In order to simultaneously plan the use of ORs and ICUs, we consider different planning policies on a tactical level which we derive from a linear optimisation model. Those planning rules provide decision makers with the number of surgeries to be planned while considering the scarce resources OR time and ICU beds. In order to evaluate these tactical decisions, we develop a discrete event simulation (DES) model that replicates the activities during typical weeks in both OR and ICU. The DES model captures the process of selecting and scheduling patients for surgery and especially stochastic resource requirements in both OR and ICU. We demonstrate the beneficial effects of simultaneous planning of OR and ICU utilisation on both bed occupancy and OR time utilisation. These effects are illustrated using a series of computational experiments. We conclude with critical reflections and managerial implications which can be drawn from this planning approach.

4 - The Average Waiting Time for Both Classes in a Delayed Accumulating Priority Queue

David Stanford, Blair Bilodeau

Mojalal et al (2019) presents the waiting time distribution for the lowest class in the Delayed Accumulating Priority Queue (APQ), in which lower priority class patients wait for a fixed period of time before starting to accumulate priority. Certain simplifying assumptions which apply in the analysis of this case do not extend to the higher-priority classes, which is why analytical expressions for the waiting time distributions for these classes have not yet been found. However, in order to identify the optimal period of delay `d' before a low priority patient can accumulate priority credit, some quantification of benefit gained by the higher-priority class patients is needed. In the absence of the high-priority waiting time distribution, we focus instead on the exact average waiting times before service for both classes of patients a 2-class Delayed APQ, by making use of a conservation law for average waiting times. We exploit a theorem in Mojalal et al (2019) to quantify the impact upon the average waiting times seen by both classes of patients as a function of the value of the initial delay period `d'. Numerical investigations in the context of selected KPIs will be presented.

Healthcare Analytics I | Room: 229.3 | Thursday, 10:30-12:00

1 - Embedding behavioural OR within Delphi knowledge construction processes in health settings

Liliana Freitas, Ana Vieira, Monica Oliveira, Carlos Bana e Costa

Stakeholder involvement is crucial for developing operational research tools to assist health policy- and decision-makers. The Delphi process is widely used for involving large and geographically dispersed groups, with its recent use being enhanced by new web platforms. However, stakeholders' interaction within Delphi processes may be influenced by their characteristics and advice-taking attitude. Such aspects are critical for interpretation and use of the information generated. This study designs features to be embedded within web platforms enabling behavioral research within Delphi. Namely, we build an experimental design to be included in a Delphi to explore if health stakeholders' willingness to take advice is influenced by their knowledge about the stakeholder group who gives the advice, with social network analysis used to draw the stakeholders' advice network; and we use metrics to understand if the Delphi knowledge construction process is influenced by group characteristics and cognitive diversity search. This will be tested within the MEDI-VALUE research project, in which a Delphi process will be used to gather consensual dimensions for Medical Devices evaluation.

2 - Classifying Norwegian radiology reports with deep neural net learning

Fredrik A. Dahl, Haldor Husby, Petter Hurlen, Pål Brekke, Øystein Nytrø, Taraka Rama Kasicheyanula, Tore Gundersen

Hospital journal systems contain large amounts of unused information, in the form of unstructured text, which could potentially be used for improved decision making and patient treatment. Natural language processing is a hot research topic internationally, and deep learning with neural nets is currently the most promising approach. However, most research focuses on English language, and the Norwegian language presents different problems, relating to more complicated inflection patterns and compound words. Also, medical journal text tends to give specific challenges relating to abbreviated syntax and inclusion of Latin words. In the present project, we analyse the text body of 15.000 radiology reports, in order to classify them as "normal" or "abnormal". The ground truth is given by a radiologist in the project, who interprets the main text body. We develop word vector embeddings and utilize these as input to deep neural net language models, for the classification task.

3 - An agent-based simulation modeling approach to evaluate hospital-acquired Clostridioides difficile infection control interventions

Oguzhan Alagoz, Elizabeth Scaria, Anna Barker, Nasia Safdar

Clostridioides difficile (C. difficile) infection (CDI) is the leading cause of health care-associated diarrhea. CDI causes approximately 500,000 infections and 15,000 deaths in the US year annually. We developed an agent-based simulation model (ABM) of CDI at an acute care hospital that uses a discrete-time Markov chain to represent the status and progression of C. difficile in a patient that is estimated using calibration. We validated the ABM by comparing the CDI rates obtained by the model to those reported by the literature. We then used the ABM to evaluate the comparative effectiveness of nine infection control interventions at reducing hospital-acquired CDI and asymptomatic C. difficile colonization. Our ABM generated CDI rates that are consistent with those reported by the literature. We found that the most effective interventions to reduce CDI were daily cleaning of patient rooms and common areas with sporicidal disinfectant and asymptomatic C. difficile screening of admitted patients. Our ABM can be used to evaluate core and emerging CDI control interventions. Our ABM can easily be tailored to evaluate infection control interventions in different hospital settings.

4 - Supporting national planning through improved forecasting of demand for health services

Christos Vasilakis, Fotios Petropoulos, Vicki Cruze

Planning in the National Health Service (NHS) in England is supported by forecasting demand for health services. The forecasts for variables such as emergency department visits, hospital admissions and outpatient appointments, form the basis on which activity and progress against plans are monitored. Currently, these forecasts are generated at an organisation (Trusts) level and hierarchically aggregated to geographical regions and national levels. In this study, we empirically compare the performance of the status quo (bottom-up approach) with a state-of-the-art combination approach, where forecasts are produced independently at all nodes of the hierarchy (England, 5 geographical regions and 150 organisations) and optimally reconciled. Our analysis is based on a rolling evaluation of the up to 12-months-ahead forecasts at all levels of the hierarchy. The results suggest significant accuracy improvements, especially for the national and region levels. The approach offers aligned decision making, as forecasts across the hierarchical levels are coherent. Finally, we estimate the cost of forecast error associated with the improved forecast accuracy.

Emergency Department | Room: Kl. HS. A | Thursday, 13:00-14:30

1 - The Development of a Generic Emergency Department (ED) Discrete Event Simulation Model

Evgueniia Doudareva, Megan Chan, Michael Carter

Problems in the ED, such as prolonged length of stay (LOS) and staff allocation, are associated with increased patient morbidity and mortality. Our research focuses on creating a generic discrete event simulation (DES) model for an ED that aims to examine common problems, their potential causes, and propose levers that can effectively address the challenges. While DES is an established approach for modelling EDs, there exists a limited amount of literature on the development and use of generic ED DES models. We aim to develop a model that will represent the flow of patients from the point of entry (walk-in or ambulance), through the ED's key action and decision-points, such as triage, physician assessment, ordering of tests and consult, until the patient is either discharged or admitted. It will include resource constraints related to staffing, stretchers and chairs. It will be designed as a generic model that can be tailored to specific hospitals through inputs. We will describe current progress based on the outcomes and learnings from single-site DES models for two Toronto EDs and initial analysis at a third hospital and how the work feeds into the creation of a generic ED model.

2 - Simulation of an Emergency Department to assess resources capacity to attend future demands

Sofia João, Fermin Mallor, Marta Cildoz, Inês Marques

Senior population is increasing worldwide through the past years as well as the Emergency Department (ED) demand. Consequently, resources consumption in ED is also increasing. This research aims to forecast the future ED patients according to the future demographic evolution, to understand the resources consumption in future. For that, a population evolution projection is performed by a system dynamics simulation model. In the other hand, the current ED patients are evaluated according to the demographic characteristics (age and gender) and the needs in ED, i.e. priority level and resources consumption. Future ED patients' needs are achieved by projecting the current ED demand characteristics in the future population projection. Thus, future ED visits by priority and resources consumption are reached and are used as inputs in a discrete event simulation model to evaluate the daily performance of the ED. The method is tested in the context of the Hospital of Navarra. The results show an increase of patients with higher priority levels, leading to a higher consumption of resources. Furthermore, an additional physician should be scheduled in each working shift to meet future demand.

3 - Improving the patient flow in an emergency department: report of a success story

Marta Cildoz, Amaia Ibarra, Fermin Mallor

This study is part of a broad project which aims to enhance the performance of Emergency Departments (EDs) in Public Hospitals. One of the main objectives is the improvement of patient flow, which is usually managed after triage by nurses-who assign patients to physicians-, and then by physicians-who manage their own portfolio of pending patients. Particularly, in this presentation we outline the research carried out to improve the distribution of patients among physicians, from idea generation to implementation. It aims to optimize not only patient waiting time but also working conditions. First, patient-physician assignment policies were theoretically studied and tested with a simulation model. Second, the results were shown to the hospital managers, who approved to implement one of them. Third, a new easy to use computer tool was developed to support the decision making on managing the physicians' workload at triage and the triage nurses were provided with training sessions. Finally, a pilot test was carried out for a month. The analysis of the data recorded during the test period led the ED director to request the government computer department to implement the new method.

4 - Assigning and prioritizing patients at the Emergency department

Maartje van de Vrugt, Ilze Ziedins

Medical doctors at emergency departments (EDs) relatively often treat severely ill patients, and logistical inefficiencies at EDs may result in life-threatening situations quicker than at other hospital departments. At EDs, one doctor typically occupies multiple rooms in parallel; when patients are awaiting diagnostic test results, the doctor treats other patients in other rooms. We investigate several patient prioritization rules and patient-doctor assignment policies. Both prioritizing patients and assigning patients to doctors significantly affect patients' length of stay (LoS) and are currently performed by nurses or doctors. By using a rolling-horizon approach, we are able to incorporate all relevant realistic assumption, such as time-varying arrival rates, in Integer Linear Programming model. We compare the optimized policy to simple heuristics using a discrete event simulation.

Mental Health | Room: Kl. HS. B | Thursday, 13:00-14:30

1 - A comparison of mental health service use for people with severe and complex disorders using a network based approach

Sean Manzi, Susan Mizen, Kerry Pearn, Martin Pitt

In the United Kingdom there is considerable pressure on mental health services which are often operating at or over 100% capacity. People with severe and complex disorders (such as personality disorders) have been identified as high service users. In a previous project we sought to understand the service use of this cohort of patients in Devon. It revealed a small sub-population of persistently high service users whose consumption of resources was disproportionately large in comparison to the rest of this patient cohort. In the current project we have compared the service use of patients with complex personality related disorders in the area of West London and the county Devon. The network analysis to be presented demonstrates the similarities and differences in service use of this patient cohort between the two geographic regions. As well as providing a data driven map of service provision the respective rates of service use for patients in the two geographic regions are compared. Explorative work in the application of machine learning to determine service use patterns and to predict future service requirements will also be presented.

2 - Identifying novel mental health service use cohorts in a maternal administrative health database

Leslie Anne Campbell, Stefan Kuhle, Samuel Stewart, Rudolf Uher, Jillian Filliter, George Kephart

Background: Mental illnesses are highly prevalent among youth and are increasing. Early intervention is key to optimal outcomes; planning adequate services is essential. There is a well-established predictive relationship between maternal and offspring mental illness. However, common measures of maternal mental illness in administrative data have insufficient accuracy for prediction and planning. Objectives: To improve the identification of mental illness in routine data sources. Methods: A population-based virtual retrospective cohort of women and offspring was derived from administrative data sources. Latent growth modelling incorporated frequency and type of health service use to identify cases and to compare to traditional case definitions for predicting outcomes in offspring. Machine learning methods may improve identification of meaningful clusters of mothers based on patterns in diagnostic codes, health service use, and demographic variables. Outcomes: To provide meaningful insight into patterns of mental health service use among mothers, and how they relate to patterns of service use in their offspring, offering an improved means of measuring mental health care needs.

3 - A new insight in the factors of diagnostic changes in major psychiatric disorders through an organizational standpoint

Valérie Bélanger, Vittorio Nicoletta, Michel Maziade, Thomas Paccalet, Angel Ruiz

Major Depressive Disorder (MDD), Bipolar Disorder (BP) and Schizophrenia (SZ) are major psychiatric disorders presenting several diagnostic challenges. In particular, each patient displays his own set of symptoms, which may vary over the disease course. In addition, the evolution of these disorders cannot be easily measured by objective means. Finally, MDD, BP, and SZ share several symptoms, which complicates the diagnostic process. In this paper, the diagnostic trajectories of patients affected by SZ, BD and MDD are investigated. The goal is to assess whether such patients change diagnoses over time, which kind of trajectories may be associated with such changes and what are the factors related to these trajectories. Our statistical analysis is performed on data from the Régie de l'assurance maladie du Québec. Different patterns of longitudinal trajectories in terms of diagnostic change have been observed, and two models were applied to predict if the diagnostics would be changed at any given visit. Our analysis shows that demographic and comorbidity factors could explain diagnostic change, but also suggests that organizational factors play an important role for such changes.

4 - A hybrid simulation model for dementia

Sally Brailsford, Dave Evenden, Paul Roderick, Bronagh Walsh

The term dementia covers a wide range of neurological diseases associated with loss of cognitive and functional ability. It is mainly associated with older people, and hence planning services for dementia patients is a challenging issue in an ageing society. This paper describes a hybrid simulation model, developed for the Wessex region of southern England, that provides information for service planners about the future demand for different types of care. System Dynamics simulation is used to capture the ageing process and the onset of dementia, whereas Agent-Based simulation is used to model disease progression, the impact of any interventions, and mortality, all of which vary considerably from person to person. By using this hybrid approach, the model can handle very large populations while simultaneously taking account of individual variability. The model calculates the total numbers of patients in different disease severity states over time, the costs of providing appropriate care, and the numbers of deaths over time. Results are presented for three scenarios, a baseline and two interventions: medication and the promotion of a healthier lifestyle.

Healthcare Analytics II | Room: 229.3 | Thursday, 13:00-14:30

1 - What can OR do to reduce the burden of being a patient?

Penelope Mullen

Barriers to, and burdens of, being a patient can arise in a number of ways. As argued in an earlier paper, health care systems inadvertently and unthinkingly (but possibly sometimes deliberately?) place many obstacles in the way of accessing and using health care services. It is also widely acknowledged that distance and service distribution can affect equity and accessibility. Further, as argued earlier in earlier papers exploring the objectives of health care systems, users seek security and assurance that services will be available when needed – denial of access whether on financial grounds or absence of appropriate provision impacts adversely on such security and assurance. In addition, whilst ill health itself places burdens on people, the provision of healthcare and choice of treatment and pathways can place possibly unnecessary additional burdens on being a patient. Whilst some of the barriers and burdens are unavoidable, many can be mitigated by careful planning, thoughtfulness and awareness. Drawing on research and using a range of examples, this paper explores how OR can help reduce some of the burdens and in doing so help promote equitable access to health care

2 - Delivery practices heterogeneity, appropriateness and efficiency in Ile de France (IDF) region

Catherine Crenn-Hebert, Elodie Lebreton, Claudie Menguy, Marina Martinowsky, Lucas Anzelin, Matthieu Hanf

IDF has wider variations and higher rates of operative delivery than other regions of France. Method: Identification of cesarean section (CS), maternity level (I, IIA, IIB, III according to neonatal care availability) in hospital summaries. CS mean values and 1.5 standard deviation (STD) values for each level in France. IDF maternities with CS rates out of their level 1,5 STD values, are selected for a quality contract. Results: France and IDF maternities registered 721 092 and 176 141 delivery stays in 2017. French CS rate mean value was 20,2%. In the 83 IDF maternities, CS rate mean value was 22,5%, from 13,8% to 46,8%; 15 were above +1,5 STD of their level, none was -1,5. Discussion-Conclusion: Distribution of the CS rate doesn't follow a gaussian bell curve in IDF. Median and percentiles would have been used in IDF maternities only as mothers differ from metropolitan France. However, variations are really wide. We hope that our approach (mainly analysis of their practices and patient information) with selected maternities will help to understand and reduce practices heterogeneity.

3 - Organizational challenges to support multimorbid patients in Saint-Étienne's area

Jules Le Lay

Multimorbidity, defined as the co-occurrence of two or more chronic diseases for a given patient, is a growing concern for hospitals as a care management challenge. Indeed, the complex interactions between the diseases and the treatments need to be addressed through a global and coordinate care. Our research, focusing on a case study in Saint-Etienne's area (France), aimed to provide guidelines for the care of such patients. We quantified the population impacted by multimorbidity, as well as the prevailing chronic diseases. A mathematical representation of patients' trajectories, combined with a simulation model, have been produced. Several possible improvements have been identified, to reduce patients' length of stay and improve quality of care at a large temporal scale (reduced number of readmissions among hospitals of the region). As-if scenarios have also been tested, traducing the intended improvements made to each studied hospital. After integration in our simulation model, expected changes in term of length of stay and readmission have been quantified. The results obtained with this method demonstrate how simulation can help improve care management of multimorbidity.

4 - An Assessment of Regional Variations: Expert Knowledge and Quantitative Analysis

Martin Dlouhy

To minimize regional variations in access to health care is a major goal of health policy. Surprisingly, the regional variations in health resources are frequently observed in many European health systems that are publicly funded and highly regulated. The objective of this contribution is to show alternative methods for a comparison of regional resource capacities that take into account the possibility of resource substitution. A comparison of resource capacities can be seen as a problem of multiple criteria decision making in which the main issue is setting of resource weights. There are two main approaches to obtain such weights: (a) a survey among experts that give us their subjective views; (b) a calculation of weights objectively by a model. Both the expert knowledge and quantitative approaches were used and applied to the distribution of doctors and nurses in the Czech Republic. The methods that take into account the possibility of substitution calculated lower regional differences than the separate assessment of resources. Therefore, both researchers and policy makers should consider the possibility of resource substitution.

Management in Hospitals | Room: Kl. HS. A | Thursday, 15:00-16:30

1 - An integer linear model for hospital bed planning/operating theatre scheduling

Michael Grütz

Similar to industrial "Job shop scheduling" (where jobs are planned to minimize the number of machines required), the nursing process of a hospital is based on bed scheduling. A new philosophy is proposed: The fewer the number of schedule gaps, the more efficient is the nursing process. The more the number of required beds is decreased, the more nursing and manpower needs decline. Acute patients can be dedicated to unused beds with on-call duties ("stand by for emergencies"). For optimal bed scheduling an algorithm is presented, addressing the high complexity of patient assignment by using high performance solvers like IBM ILOG CPLEX to achieve acceptable computing times. Based on real data the found optimum is used for exploring further improvement options: goal programming with defined punishment costs allowing relaxations, yielding further savings in required beds. Unavoidable gaps in a schedule provide a good chance for the case manager to shift admissions, based on suggestions from the system. Further options exist for using the developed model; such as operating theatre scheduling, based on real data, with the optimum indicating possible savings in capacity.

2 - Hybrid Heuristic for the Patient-Bed Allocation Problem in Large Hospitals

Fabian Schäfer, Alexander Hübner, Dominik G Grimm

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. 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 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 assists the bed manager in taking fast decisions and is able to deal with uncertain situations through quick recalculations. Therefore, we developed a hybrid heuristic based on a preferred iterative look ahead technique and a genetic algorithm. Furthermore, to deal with the high volatility and uncertainty of emergency admissions, we trained a deep neural network to forecast emergency occupations based on features related to time designation, weather, fairs, and holidays.

3 - Online Patient-to-Room Assignment in Hospital Wards

Tabea Krabs, Christina Büsing, Clemens Thielen

Every day, emergency patients arrive at hospitals and are in need of immediate treatment and a bed to recover. After the treatment, a central office assigns the patients to different wards where they are assigned to a room by the medical staff. The assignment of patients to rooms is an important task in hospitals and has a high impact on the provided care quality and on the hospital's degree of capacity utilisation. In some wards, up to 80 percent of all patients arrive unannounced which increases the difficulty of determining an efficient patient-to-room assignment significantly. In this talk, we focus on the online version of the patient-to-room assignment problem restricted to a single ward. We analyze this setting and present competitive online algorithm as well as lower bounds on the competitive ratio.

4 - Reducing the number of required beds at the holding and recovery department

Theresia van Essen

Several papers in existing literature discuss the effect of the operating room (OR) planning on the bed capacity needed in the wards. However, to our knowledge, the effect of the OR planning on the bed capacity needed in the holding and recovery department has not been studied yet. In the case of the holding and recovery department, the number of required beds depends on the order in which the surgeries are performed during the day. In this presentation, we discuss several integer linear programming (ILP) models which are used to determine the order in which the surgeries should be performed in their pre-assigned OR such that the number of required beds at the holding and recovery department is reduced. The ILP models differ in the way that stochasticity is considered. All solutions are evaluated by the same approach that considers the probability distribution of the length of stay at both the holding and recovery department and the probability distribution of the surgery duration.

Healthcare Policies and Systems | Room: Kl. HS. B | Thursday, 15:00-16:30

1 - Modelling Health Care Systems using Big Data and Discrete Event Simulation

Roberto Aringhieri, Davide Duma, Michele Sonnessa

A defining characteristic of today's data-rich society is the collection, storage, processing and analysis of immense amounts of data. This characteristic is cross-sectoral and applies also to healthcare. Big Data is generated from a plurality of sources and offers possibilities for new insights, for understanding human systems at the systemic level to develop personalised medicine, prevent diseases and support healthy life. From the Health Care Management perspective, Big Data are a key enabling technologies to support detailed health system analysis. We argue that the Health Care Big Data (HCBD) can power a detailed health system analysis using Discrete Event Simulation (DES) methodology: exploiting the HCBD, one can replicate the behaviour of the health system modelling how each single patient flows within her/his care pathway. The novelty of the proposed approach is therefore the use of the DES methodology for the health system analysis exploiting the Big Data in order to better represent the variety of the patients accessing the health system. We illustrate this approach modelling two health systems at the regional level exploiting the available HCBD of Piedmont Region.

2 - Methodology to implement risk management in health for a population of patients assigned under a prospective global payment model

Paula Andrea Velasquez Restrepo, Edwin Alonso Alvarez Tobon

The current Colombian health system is immersed in a context of demographic and epidemiological transition, 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. The present research work exposes a new model of differential attention based on risk co-management. 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 and develop differential attention. 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 model. Finally; by means of an analytical, the demand of resource is projected.

3 - An acute patient journey: the role of the system factors affecting timeliness and quality of care

Neda Pourreza

This study concerns with identifying the effective strategies to cope with ED boarding under tight capacity constraints. The Middlemore Hospital where the study is taking place is not only the largest in New Zealand but, perhaps, also the most constrained. The population in the region has been growing notably faster than across the country and the hospital capacity is not matching the growth. Currently, for example, the ratio of the daily patient presentations at the ED to the number of the ED staff is the highest in the country. Excessive boarding at ED occurs almost daily, typically triggered by surges, when 2x the average number of regular patients or even 3-5 high-acuity patients present within an hour. Despite active flow improvement efforts, no effective solution has been yet. The search has been complicated by a high variability of the exogenous factors and a high degree of endogeneity. Our study focuses on three broad questions: evaluation of the bed blocking on the ED performance, detecting (unintended) changes in the patient flow management under high utilization conditions, and finding the optimal staffing levels and skill set for each stage of the patient journey.

4 - Research governance and ethical challenges for simulation studies: Should we develop guidelines?

Joe Viana

This talk focuses on the Research Ethics Committee (REC), and Data Privacy and Governance (data access) challenges researchers face who apply Operational Research (OR) techniques, such as simulation, to better understand and improve Health and Social care systems. It is not uncommon for a REC to judge OR research as service improvement, quality assurance, or other research outside their mandate. Protection of data, privacy and exemption from consent are the main concerns that need to be carefully considered by researchers and Data Privacy and Governance specialists. A selection of guidelines and review papers including those from the health care economic guidelines that can support the application process will be presented and assessed e.g. ISPOR-SMDM (International Society for Pharmacoeconomics and Outcomes Research-Society for Medical Decision Making) and STRESS (Strengthening the reporting of empirical simulation studies). The author will reflect on experiences from the UK and Norway. It is hoped that the session will prompt a discussion between colleagues from different sectors in different countries about application strategies, to share guidelines, literature, and advice.

Friday August 2nd

09:00	**Parallel Sessions**	
Clinical Decision Making		
Room: Kl. HS. A		
Session Chair: Margaret Brandeau		
1	Evrim Didem Gunes	Empirical analysis of the impact of operational factors on clinical decision making in a chronic care clinic
2	Babak Farhang Moghaddam	Future prospects of optimal hierarchical organ allocation: A trade off between efficiency and equity
3	Reza Mahjoub	Evaluating the Cost-effectiveness of Repeated Monitoring Tests
4	Margaret Brandeau	Optimizing interventions across the HIV continuum of care: Process improvement analysis
Workforce Planning I		
Room: Kl. HS. B		
Session Chair: Jan Schoenfelder		
1	Ana Dias	Is planning human resources in healthcare a priority?
2	Yi-Hang Zhu	Balancing nurse workload by scheduling patient admissions
3	Timo Gersing	Equitable Planning of Out-of-Hours Services for Pharmacies
4	Jan Schoenfelder	Emergency Department Nurse Scheduling and Shift Design to Achieve Balanced Workloads

10:30	**Coffee**

11:00	**Parallel Sessions**	
Stroke		
Room: Kl. HS. A		
Session Chair: Leonid Churilov		
1	Qi Li	Ensemble and rule-based decision models for paediatric stroke diagnosis
2	Hannah Johns	Simulation for Planning and Communicating Adaptive Clinical Trials: a Case in Stroke Rehabilitation
3	Mathias Barra	Stroke Mimics at a large Norwegian hospital
4	Leonid Churilov	Decision support for the operation of the First Mobile Stroke Unit in the southern hemisphere: an overview
Workforce Planning II		
Room: Kl. HS. B		
Session Chair: Clemens Thielen		
1	Marelise Hattingh	A prototype decision support system for scheduling orthopedic surgeons
2	Diana Lopes	Health workforce demand modelling: a systematic review
3	Sebastian Velten	Collaborative Duty Rostering in Healthcare Professions

4	Clemens Thielen	
		A Web-Based Duty Rostering System for Physicians and its Application in Two German Hospitals

13:00   Bussiness Meeting   Room: Otto-Lehmann-Hörsaal

Clinical Decision Making| Room: Kl. HS. A | Friday, 9:00-10:30

1 - Empirical analysis of the impact of operational factors on clinical decision making in a chronic care clinic

Evrim Didem Gunes, Zehra Onen, Tolga Tezcan, Raj Sengupta

The rising prevalence of chronic conditions (for which there is currently no cure, and which are managed with drugs and other treatment) is one of the main challenges facing health-care systems globally. We investigate how non-clinical operational factors affect clinical decisions of health professionals using 75,702 patient visit data from a rheumatology outpatient clinic in Bath, UK. We focus particularly on the decision to follow-up or discharge a patient and re-attendance of discharged patients. We show that increasing workload and patient waitlist size decrease discharges and increase re-attendances. By contrast, continuity of care improves the system by increasing discharges and decreasing re-attendances.

2 - Future prospects of optimal hierarchical organ allocation: A trade off between efficiency and equity

Babak Farhang Moghaddam, Mahmood delgoshaei, Zahra Saedi

Currently, Iran has no transplant geographical region configuration for all 52 organ procurement organizations (OPOs). Region size affects organ travel time and organ viability at transplant. Largest region size means more chance to receive an organ but each transplant has lower viability chance, and a smaller region size means lower chance to receive an organ but each transplant has more viability chance. Our purpose is to develop a methodological framework for determining optimal configurations of regions maximizing transplant allocation efficiency and geographic equity for futuristic periods of time. A Multi-objective integer Mathematical programming was designed to optimize a weighted combination of 2 objectives: 1) maximizing intraregional transplants, 2) geographic equity —minimizing the maximum number of patients who have not received any organ at the end of each period of time across all OPOs.

3 - Evaluating the Cost-effectiveness of Repeated Monitoring Tests

Reza Mahjoub

We consider a chronic disease affecting a population of individuals where spontaneous disease regression is possible without treatment but is more likely with treatment. The health state of individuals is not perfectly observable, but a costly and imperfect test based on a single continuous bio-marker is available. The decision maker seeks to maximize net health benefits. At any time, the decisions available to the decision maker are to wait, to treat, or to use the disease monitoring test. We consider scenarios in which the testing interval and test cut-off are fixed, and where both are decisions in each period. Then the results show that simultaneously optimizing the time to next test and the cut-off to use at that time improves utility over fixed testing intervals or optimized testing intervals with a single testing cut-off.

4 - Optimizing interventions across the HIV continuum of care: Process improvement analysis

Margaret L. Brandeau

To achieve UNAIDS' ambitious 90-90-90 goals, effective care delivery programs are needed. We show how HIV care can be improved by viewing the patient care process as a production process and applying methods of process improvement analysis. We examine the HIV care continuum at a hospital-based HIV clinic in Kingston, Jamaica. We perform qualitative analysis to identify key programmatic, personnel, and clinical areas for process improvement. We then perform quantitative analysis: We develop a stochastic model of the care process which we use to evaluate the effects of potential process improvements on the number of patients who receive ART and the number who achieve viral suppression. We also develop a model for optimal investment of a fixed budget among interventions aimed at improving the care cascade and we use the model to determine the optimal investment among three interventions the clinic could invest in. By viewing the patient care process as a production process and applying qualitative and quantitative process improvement analysis and an innovative optimization methodology, our approach can help patient care clinics identify the best ways to maximize clinical outcomes.

Workforce Planning I | Room: Kl. HS. B | Friday, 9:00-10:30

1 - **Is planning human resources in healthcare a priority?**

Ana Dias, Diana F. Lopes, Gonçalo Santinha, Jorge Simões, Eduardo Castro

A lot of efforts have been devoted to the human health resources (HHR) planning, with an exhaustive description of all planning systems, such as: objectives; the forecast model; the data model; the link between planning and policy action and the organization of the planning system. Within this context, a literature review was carried out to assess if HHR planning is faced as a priority in European countries. Interesting practices have emerged across different countries within the scope of research projects. For instance, in Portugal we can highlight the HEALTH_2040 project-Future Needs of Human Resources for Health. However, there is no validated and explicit strategy in this field. Much more research is needed, in order to tackle more strategic aspects, such as talent-related management and redefinition of professional boundaries, which impact both in the design of workflows and in the resource allocation for the various activities. The tasks of coordinating care (e.g. global needs assessment, assistance in patient navigation, monitoring of the quality of care provided and connection with the patient and informal carers) have been neglected and are particularly relevant today.

2 - **Balancing nurse workload by scheduling patient admissions**

Yi-Hang Zhu, Wim Vancroonenburg, Greet Vanden Berghe

Patients admitted to a hospital are assigned to a ward and will need care from the nurses working in that ward. It is common that the availability of nurses in a given ward does not perfectly match the demand of its patients. As a result, nurses might receive considerably different workloads. One of the reasons for this mismatch is that nurse rosters are fixed weeks in advance, while the number of patients admitted to hospital wards is uncertain and varies from day to day. Furthermore, the required nursing care also varies from patient to patient. Although many papers in the literature focus on rescheduling nurse rosters to meet the demand, there is little research on further balancing nurse workload with nurse rosters as an input. The patient admission schedule determines when and where each patient stays in the hospital. An improper schedule is likely to result in poorly balanced nurse workload. We define workload imbalance based on each nurse's relative workload and quantify it in a manner similar to the Gini coefficient. The aim of this research is to reduce the imbalance by better scheduling patient admissions.

3 - Equitable Planning of Out-of-Hours Services for Pharmacies

Timo Gersing, Christina Büsing, Arie Koster

The supply of pharmaceuticals is an integral part of a functioning health care system. In the German health care system, the chambers of pharmacists are legally obliged to ensure that every citizen can reach an open pharmacy at any day and night time within an appropriate distance. To that end, the chambers of pharmacists create an out-of-hours plan for a whole year in which every pharmacy is assigned some 24-hours shifts. These shifts are important for a reliable supply of pharmaceuticals in the case of an emergency but also unprofitable and stressful for the pharmacists. Therefore, we are interested in an efficient planning that meets the citizens' needs, reduces the load of the shifts and distributes them in a fair manner. In this talk, we focus on an equitable distribution of the 24h shifts on the pharmacies. While an equitable distribution is mandatory, we do not have to assign an equal number of shifts to all pharmacies due to geographical and structural differences. We show how the differences complicate the definition of an equitable planning and present approaches to overcome these obstacles. Finally, we evaluate our approaches on the basis of a real-world instance.

4 - Emergency Department Nurse Scheduling and Shift Design to Achieve Balanced Workloads

Jan Schoenfelder, Sebastian Kraul, Steffen Netzband

The ongoing nursing shortage coupled with a growing number of patients necessitates efficient and effective staffing and scheduling of nurses. From a medical perspective, staffing levels should be sufficiently high to assure adequate treatment. From a provider perspective, budget concerns and employee satisfaction need to be considered as well. In a large emergency department that faces highly volatile patient demand levels both in quantity and quality, matching supply and demand by means of scheduling becomes an especially challenging problem. Our modeling approach introduces an adjusted nurse-to-patient ratio (ANPR) to capture expected hourly nurse utilization rates. Incorporating work time, qualification, and shift request constraints allows us to significantly improve on existing, manually generated schedules in one of Germany's largest emergency departments with respect to balanced nurse utilization rates, granted shift requests, and higher expected ANPR minima. We also quantify the potential improvements that result from redesigning the currently used shift structure and highlight trade-offs between employee flexibility and the aforementioned performance measures.

Stroke | Room: Kl. HS. A | Friday, 11:00-12:30

1 - Ensemble and rule-based decision models for paediatric stroke diagnosis

Qi Li, John Hearne, Mark Mackay, Leonid Churilov

Acute stroke is a highly time-sensitive condition. Correct and timely identification of stroke patients and separating stroke mimics is of crucial importance. Decision modelling in this domain has not been undertaken. Using the data from Royal Children's Hospital in Melbourne, Australia, we have implemented multiple models for paediatric stroke diagnosis, using decision trees, Random Forest, Naïve Bayes, and Neural Networks. Best candidate models were incorporated into the ensemble and rule-based modelling with subsequent implementation as a mobile App to be used as a part of the patient care process. The implemented models exhibited excellent accuracy, sensitivity, and adequate specificity for identifying stroke mimics in both training and testing samples. Classification of both ischaemic and haemorrhagic stroke patients can be achieved with high accuracy and specificity. Ensemble and rule-based models demonstrated better performance compared to individual classification models. In-hospital prospective validation of the decision-making tool is under way.

2 - Simulation for Planning and Communicating Adaptive Clinical Trials: a Case in Stroke Rehabilitation

Hannah Johns, Leonid Churilov, John Hearne, Julie Bernhardt

Large-scale clinical trials are often associated with high costs due to the number of participants involved. Such trials also pose an ethical dilemma as one experimental treatment may be clearly inferior, but will still be assigned to patients to preserve experimental validity. Adaptive Trial Designs address this by dynamically adjusting the randomisation process according to prespecified rules, encouraging patients to be assigned to effective treatments while maintaining covariate balance. This can reduce costs by using smaller sample sizes and address ethical concerns while maintaining trial integrity. However, the dynamic behaviour of these designs can be difficult to communicate to clinicians, and can lead to inflated type-I error and unintuitive relationships between effect size, sample size and statistical power. This presentation demonstrates how discrete-event simulation can be used to communicate and plan adaptive clinical trials in the context of stroke rehabilitation. Two models are presented, the first built for explaining the dynamics of the trial design to clinical investigators to promote trust and support, and the second to select the optimal rules for the trial.

3 - Stroke Mimics at a large Norwegian hospital

Mathias Barra, Kashif W. Faiz, Halvor Næss

Introduction: Admissions to specialized stroke units (SUs) are costly, but significantly benefits patients. So-called stroke mimics (SMs) – symptoms that are mistaken for acute stroke – are less studied: a few studies on the share of SMs at SUs, and none on temporal trends. We analysed a data set of SU admissions at Haukeland University Hospital between 2008—2017. Data, Methods & Analysis: We used a data set of N = 11241 admissions (patient age ≥ 15 years), coupled with population data on the catchment area. Our main outcome is SMs' relative share of SU admissions, and we estimated incidences of various SMs. Shares were estimated with linear- and incidences by negative Binomial regression. Results: The share of SMs at the SU rose from ~40% to ~50% between 2008—2017; but we cannot say if this increase will continue or level out. The increase is fueled by younger patients, and dominated by 'softer' diagnoses (e.g. headaches, vertigo and numbness). Discussion: The surge in SMs at the SU suggests that finding SU triage criterion which can better distinguish between SMs and strokes provides an urgent and efficient way for improving patient flow and containing costs.

4 - Decision support for the operation of the First Mobile Stroke Unit in the southern hemisphere: an overview

Leonid Churilov

First Melbourne Mobile Stroke Unit (MSU), designed to deliver expert stroke care to the patient at first response, started its operations in 2017. It has the built-in CT scanner, telemedicine equipment and mobile laboratory. The MSU enables a specialist stroke-trained team to quickly evaluate a patient and immediately start treatment. In addition to providing clinical care and delivering thrombolysis medication in the field rather than waiting for a patient to arrive at a hospital for this treatment to be administered, the MSU serves as a base for a number of important research projects. These focus on studying how faster treatment in the MSU improves long-term patient outcomes compared to standard ambulance hospital admissions and on testing new treatments for stroke that are more effective when delivered early. Decision analytics and modelling contributed to the successful operation of Melbourne MSU in the areas of clinical decision making, location and routing, and service evaluation. In this talk we provide a brief overview of Melbourne MSU activities and related decision modelling projects, specifically focusing on clinical decision support and service evaluatio

Workforce Planning II | Room: Kl. HS. B | Friday, 11:00-12:30

1 - A prototype decision support system for scheduling orthopedic surgeons

Marelise Hattingh, Richard Boucherie, Rob Vromans

On a two weekly basis planners at the orthopedic department of a hospital in The Netherlands draw up a roster to schedule activities for the orthopedic surgeons. There are various activities to be planned at different locations, of which the main two activities are surgery and outpatient sessions. The number of surgery and outpatient sessions to be scheduled per surgeon is based on requirements regarding the waiting time for patients and the utilisation of operating rooms. Making this daypart roster is time consuming and an iterative process. To support the planners in this decision making process the problem was modelled as an integer linear program followed by developing it into a prototype decision support system with a user interface. Additional to scheduling activities, the model aims to evenly distribute the expected utilisation at the downstream departments (e.g. beds utilisation arising from surgeries and x-rays arising from outpatient sessions). This prototype was validated with actual planning rules and is regarded successful in optimising the effects at downstream departments whilst creating a feasible schedule subject to various constraints, within a few minutes.

2 - Health workforce demand modelling: a systematic review

Diana F. Lopes, Gonçalo Santinha, Ana Luísa Ramos, Eduardo Castro

Objectives: This study presents a systematic review of the literature surrounding health workforce demand modelling. Methods: This systematic review was performed by following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyses) statement. Relevant keywords were used for the search through the PubMed/MEDLINE, SCOPUS and Web of Science databases, such as healthcare demand modelling; estimating the demand (requirements or needs) for human health resources. Within the inclusion criteria, we have considered all the studies published up to the end of 2018, in English and Portuguese languages, of any size or design that handle the process of modelling the healthcare demand for health workers (e.g. physicians, nurses among others). Studies only focusing on epidemiological studies or services were excluded. Results: About 2 599 papers were found in the search results, being then evaluated according to their title and abstract. The full text of 402 papers were analysed, of which 137 met the inclusion criteria. Conclusion: The findings offer a guidance for modelling the health workforce demand and highlight opportunities and orientations for further research.

3 - Collaborative Duty Rostering in Healthcare Professions

Sebastian Velten, Sandy Heydrich, Rasmus Schroeder

For shift workers, in particular in healthcare, the duty roster and its reliability has a large impact on the compatibility of family and work. Therefore, it is important to take preferences of employees into account and solve potential conflicts as early as possible. In the BMBF and ESF funded research project GamOR (Game of Roster) ergonomists, designers and mathematicians cooperate with application partners to address these issues and develop a collaborative process for designing duty rosters, which depends on model based decision support. In this talk, we discuss the basic ideas of GamOR and the collaborative planning process. The focus lies on the model based decision support. We introduce a Constraint Programming model containing legal regulations and staff requirements as well as different objectives, like balanced time accounts and alternating free weekends. In addition, we show how we use this model in the collaborative planning process to resolve conflicts and generate alternative rosters. The talk ends with a short presentation of the prototype software implemented in the project.

4 - A Web-Based Duty Rostering System for Physicians and its Application in Two German Hospitals

Clemens Thielen, Florian Schuler

Duty rostering for nurses and physicians is an important task within personnel planning in hospitals. Good rosters should not only satisfy many complex constraints resulting, e.g., from minimum rest times or required staffing levels, but at the same time achieve a fair distribution of the workload and adhere to the preferences of the planned personnel. This talk presents a web-based duty rostering system for physicians that is used in practice in two different departments of two German hospitals. The system consists of integer-programming-based optimization models for duty roster generation and a web interface that is used to collect all necessary input data such as each physician's preferences concerning each possible duty assignment on each day of the planning period. Besides the structure of the duty rostering problems faced in the two departments, we present how fairness and physician preferences are incorporated in the optimization models used for duty roster generation and demonstrate how the physicians' preferences are elicited via the web interface. Moreover, we present and compare two approaches for dealing with unpredictable disruptions of the generated duty rosters.

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Maps

Maps on KIT Campus

From registration on Sunday to the end of day Friday the conference badge will work as a public transport ticket for the city of Karlsruhe. You can use it to get to the conference location, the Palace on Tuesday, the dinner location on Thursday and the starting point for the boat trip on Wednesday. For more info on the network, please see the LINK.
https://www.kvv.de/fileadmin/user_upload/kvv/Dateien/Fahrplaene_Netzplaene/KVV-Wabenplan.PDF

Due to construction works in the city center, there will be a changed tram network in place. Please see the LINK for details.
https://www.kvv.de/fileadmin/user_upload/kvv/Dateien/Pressemitteilungen/Umleitungsplan_Sommerferien_Phase_1.pdf

Updated tram network during construction