2021

ORAHS 2021 CONFERENCE

Applications of OR to Healthcare Adversity

INTERNATIONAL CONFERENCE OF THE EURO WORKING GROUP ON OPERATIONAL RESEARCH APPLIED TO HEALTH SERVICES

05 JULY - 09 JULY 2021 at
SOUTHAMPTON, VANCOUVER and ONLINE

Sponsors

We thank the EURO for their kind and generous support of the ORAHS 2021 Conference.

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Welcome

Dear participants, colleagues and friends,

Welcome to the 47th Annual Meeting of the European Working Group on Operational Research Applied to Health Services. Although nominally hosted by Southampton and Vancouver, we find ourselves meeting online for a second year. This past year has been a difficult one for many of us, with constant online meetings and conferences that have become webinars. We urge you not to think of ORAHS 2021 as a virtual ORAHS, but rather as a real ORAHS that is distributed across the globe.

Many people have helped organize ORAHS this year, but we would like to especially thank the team of student assistants. We also thank EURO for their ongoing support of ORAHS.

The programme contains a number of social events, such as a baking competition, pub quiz, and an Among Us game night. There will also be two Gather.town social events. Please join in the social programme, so that we can all reconnect in the spirit of ORAHS. Help us make ORAHS 2021 a real ORAHS!

We wish you a great conference,

Sandy Rutherford, Marion Penn, and Melanie Reuter-Oppermann
for the ~~virtual~~ real organizing committee.

Organising Committee

Marion Penn, University of Southampton, GB
Sandy Rutherford, Simon Fraser University, CA
Sally Brailsford, University of Southampton, GB
Roberto Aringhieri, University of Turin, IT
Melanie Reuter-Oppermann, Technical University of Darmstadt, DE
Sebastian Rachuba, University of Wuppertal, DE
Ettore Lanzarone, University of Bergamo, IT

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Patrick Sorian, CA
Fermín Mallor Giménez, ES
Christos Vasilakis, GB
Joe Viana, NO
Fredrik Dahl, NO
Melanie Reuter-Oppermann, DE
Stefan Nickel, DE

Practical Information

Zoom

There will be only one Zoom link throughout the conference. It will be emailed to all participants. The opening and closing meetings, plenary talks, panel session, and initial short talks in the discussion sessions will be held in the main Zoom room. The parallel sessions and parallel discussion talks will be held in breakout rooms.

In order to be able to move between breakout rooms, you must have version 5.3.0 or higher of Zoom installed. We encourage everyone to upgrade their Zoom client to the latest version of Zoom before the conference.

The Zoom session will start 1 hour before the first meeting on Monday and 30 minutes beforehand on all other days. This is to allow participants to ask any technical questions, or just share some coffee together.

We ask that all participants use their full name for their connection. Connections to Zoom, which are not identified among the registered participants will be asked to leave.

Any updated information on the sessions will be emailed to the participants throughout the conference.

Slack

All participants will be added to a Slack workspace. You should have received an invite to the Slack workspace by email. The two channels of most interest are:

#participants - For discussion between participants
You can use this channel to ask follow-up questions of speakers or arrange to meet privately for further discussion.

#help_desk - For questions to the student assistants or the organizers
Use this channel for technical assistance or questions about the programme. It will be monitored throughout the conference.

Gather.town

The opening and closing receptions as well as the Pub Quiz will use Gather.town, instead of Zoom. The Gather.town link will be emailed to participants.

When you first enter Gather.Town it will ask for your name, then please use your full name. You are also able to choose an avatar. In order to move around the room, use the arrow keys on your keyboard and if you want to interact with an item (eg. a whiteboard) you press 'x'. When you are close to another avatar you will see and hear the other person. If you are in one of the private spaces only the others in that space can see and hear you.

Gather.Town can be used for catch-ups in breaks and lunchtimes.

How to get Help

If you require technical assistance:

1. Go on to the #help_desk channel on Slack and post your question.
2. Send a chat message on Zoom to the host.

Programme at a Glance

	5 July 2021	6 July 2021	7 July 2021	8 July 2021	9 July 2021
13:00					
13:30		Session 1		Session 3	Session 5
14:00			PhD Competition		
14:30		BREAK		BREAK	BREAK
15:00		Session 2		Session 4	Discussion Session 4
15:30					
16:00	Opening Session	BREAK	BREAK	BREAK	BREAK
16:30		Plenary	Panel Discussion	Plenary	Business Meeting
17:00	Plenary				
17:30		Discussion Session 1	Discussion Session 2	Discussion Session 3	
18:00	Get-together in Gather.town				
18:30		BREAK	BREAK	BREAK	Get-together in Gather.town
19:00			Pub Quiz and Pizza Event		
19:30		Baking Competition		Among Us	
20:00					

Plenaries

Alec Morton: Monday, July 5th

Alec Morton has degrees from the University of Manchester and the University of Strathclyde. He has worked for Singapore Airlines, the National University of Singapore, and the London School of Economics, has held visiting positions at Carnegie Mellon University in Pittsburgh, Aalto University in Helsinki, the University of Science and Technology of China (USTC) in Hefei, and the National Audit Office and is a member of the International Decision Support Initiative. His main interests are in decision analysis and health economics. His research is funded by the European Commission, the Department of Health, the Medical Research Council and Engineering and Physical Sciences Research Council, and the Chief Scientist's Office of the Scottish NHS.

OR in the fight against Covid-19: how have we done and what can we learn?

For almost all of us, the Covid-19 pandemic has been the most disruptive global event in our lives so far. Whether the pandemic will have any positive outcomes depends on whether we are able to reflect on and learn from it. This talk aims to serve as a stimulus to such reflection. As the lead editor of the special issue of Healthcare Management Science on Management Science in the fight against Covid-19, I have been privileged to have a unique viewpoint on how our discipline has been responding. In this talk I will outline a couple of case studies of how OR academics in my own Department have engaged with the health and care system in Scotland: supporting capacity planning for ICUs during the first acute outbreak of Covid-19 in Scotland and supporting decision making about policy restrictions in care homes in the months following. Building on the case studies and on the experience of the Special Issue I will offer my personal reflections on where we in the ORAHS community should be focussing our efforts to OR can maximise its contribution in the (hopefully) late phase of the pandemic, the post pandemic period and beyond.

Christina Pagel: Tuesday, July 6th

Christina Pagel is Professor of Operational Research at University College London (UCL) and Director of the UCL Clinical Operational Research Unit. Her main research area is using OR to support delivery of health services. This includes combining statistical models, OR techniques and analysis of routinely collected national and local datasets to support service delivery and design both locally and nationally. She runs a large programme of work in understanding and communicating outcomes for people born with congenital heart disease, which has included the development and implementation of the method used nationally for 30-day survival following paediatric heart surgery. She is co-director of the new UCL CHIMERA hub where researchers will examine anonymised data from 40,000 patients at University College London Hospital (UCLH) and Great Ormond Street Hospital (GOSH), to develop a better understanding using mathematical modelling of how people's physiology changes during ill health and recovery. Since May 2020, she has been a member of Independent SAGE, a group of scientists who are working together to provide independent scientific advice to the UK government and public on how to minimise deaths and support Britain's recovery from the COVID-19 crisis.

Reflections on the intersection of OR and public communication (TBC)

SAGE, the UK Government's Scientific Advisory Group on Emergencies, has been critical in informing the UK's policy on COVID-19. SAGE does not contain any Operational Researchers. Independent SAGE is a group of scientists who are independent of government and do not answer to it. They share their work openly with the government as well as with the public. In summer 2020, Christina was invited to join Independent SAGE and since then she has been giving regular updates on the latest COVID situation in the UK during their weekly briefings. She has also been invited regularly on TV and radio, fielding questions about various aspects of the pandemic. Christina will start by discussing how her experience of working in OR applied to health care has shaped how she has understood and communicated the COVID pandemic over the past year. She will go on to reflect on the personal experience of becoming a public figure, sticking her head above the parapet on topics that have generated much heat as well as light, and maintaining both scientific and personal integrity on some of the most important issues facing us all; and identify any lessons that might help others step forward.

Vedat Verter: Thursday, July 8th

Vedat Verter joined Broad College of Business as the John McConnell Endowed Chair of Business Administration in July 2019. He also serves as Chairperson of the Supply Chain Management Department. He brings 24 years of experience at Desautels Faculty of Management, McGill University, where he was a James McGill Professor since 2013. Professor Verter specializes in the application of operations research for tackling challenges in the public sector. His areas of research are service chain design, hazardous materials logistics, sustainable operations and healthcare operations management. His work in these four areas culminated into eighty research articles in refereed journals and twenty book chapters. Professor Verter's research is well recognized through invited presentations around the globe. He is deeply invested in training scholars of the future, having supervised 15 Ph.D. students and 25 post-doctoral fellows to date.

Challenges of Delivering Healthcare in Rural Areas

Rural populations have relatively more elderly, higher unemployment rates and more poverty than urban areas. Furthermore, rural residents are known to pay less attention to a healthy lifestyle i.e., they exercise less, lack nutritional diets and smoke more. Perhaps, these explain why patients in such areas are more likely to be in poor health and have relatively more chronic diseases. Despite their greater need for healthcare services, the rural populations receive much less than their share of healthcare resources. In the United States, for example, one quarter of residents live in rural areas, but only one eighth of physicians work there.

In this plenary, I would like to highlight this relatively less studied domain as a potential avenue for contributions by operational researchers. I will discuss two examples to point out the differentiating characteristics of delivering healthcare in rural areas. The first focuses on the multiple roles specialists in rural hospitals need to assume. This requires specialists to make choices between attending the patients in their emergency department and those in the inpatient wards. I will provide a comparative analysis of the different practices in two rural hospitals. The second example involves the design of a network of dialysis centers in Atlantic Canada. The rather long travel distances that are endured by the dialysis patients constitute the primary challenge for delivering care in this context.

Panel Discussion: Wednesday, July 7th

The role of operational research in responding to the COVID-19 Pandemic

The panel will discuss the role that operational research and mathematical modelling have played in the response to the COVID-19 pandemic. The discussion will focus on lessons learned for better integration of operational research into public health and the wider healthcare system to address future crises. **Chair: Prof. Mike Carter** (University of Toronto).

Panel Members

Prof. Christine Currie is a Professor of Operational Research in Mathematical Sciences at the University of Southampton and a member of the Centre for Operational Research, Management Science and Information Systems (CORMSIS). She is Editor-in-Chief for the Journal of Simulation. Her research interests include simulation optimization, applications of simulation in health care, optimal pricing, and disaster management.

Dr. Réka Gustafson leads the integration of population and public health promotion, planning, and prevention across the clinical programs of the Provincial Health Services Authority of British Columbia. In addition, she is Deputy Provincial Health Officer and provides leadership to the British Columbia Centre for Disease Control. Réka completed her MD at the University of British Columbia and holds a fellowship in Public Health and Preventative Medicine. Before her current position, she practiced public health as a Medical Health Officer in Vancouver Coastal Health Authority for over fifteen years.

Prof. Fermin Mallor is Director of the Centre for Quantitative Methods for Uplifting the Performance of Health Systems (q-UPHS) and Professor of Statistics and Operations Research at the Public University of Navarra. He leads a team of researchers developing simulation models of critical care and hospital admissions to support the response to the COVID-19 pandemic in Spain.

Prof. Giovanni Righini is founder of the OptLab and Professor of Operations Research in the Department of Computer Science at the University of Milano. In healthcare, he worked especially in the area of the management of Emergency Medical Services in collaboration with various EMS in Lombardy. Currently, he worked with hospitals in Northern Italy to develop an optimization model for re-opening operating rooms after the first wave of the pandemic.

Social Programme

Beside the scientific experience, the ORAHS conference always provides an extensive social program. Despite the online format, we have planned several events to hopefully keep the ORAHS spirit alive.

Monday: Get-together in Gather.town (18:00 - 20:00 CEST)

Monday is the new Sunday this year. Therefore, we will meet in Gather.town and get the chance to be together, chat or share a laugh. We will also remind ourselves about the great eORAHS from Vienna last year, so make sure you will join us!

Tuesday: Baking Competition (19:30 - 20:30 CEST)

On Tuesday evening, everyone who likes cakes will meet in Zoom. The plan is for "active participants" to improve on the cake that Marion made between sessions last year and have some fun. Everyone can join, of course, no matter if you want to bake or not. You can find the recipe below together with some variations. The first is the one from the book Marion got the idea from and the second is how Marion made it a bit simpler last year. Feel free to make further adaptations – it will be interesting to see how different they all are at the end! Of course, you can also use your own favourite recipe.

PLEASE NOTE: For the timing to work the cakes will need to be made earlier in the day and decorated during the session.

The Original Recipe – Calculator

From P. Dunbar (1983), Cadbury's Novelty Cookbook, The Hamlyn Publishing Group Ltd, London, ISBN 0 600 32322 6 – a great book with some fairly simple but effective ideas for cakes for kids

Suggested tin size 28 x 18 cm or 11 x 7 inches.

Cake:

- 50g (2oz) butter, softened (left out of the fridge for a while to get soft – or use marg.)
- 125g (4oz) soft brown sugar
- 150g (5oz) self-raising flour – as this is a UK thing, substitute with 150g plain flour and 2 teaspoons baking powder
- 1.25ml (1/4 teaspoon) bicarbonate of soda
- 1 egg
- 2 ripe bananas
- 2.5ml (1/2 teaspoon) vanilla essence
- 100g (3.5oz) milk chocolate (the book says Cadbury's Dairy Milk!)
- 40-60ml (2-3 tablespoons) milk

Decorating:

- 1 Cadbury's Flake (some sort of long round chocolate to prop up the back of the cake – or something else edible – see instructions for how it is used)

- 1 packet dessert topping mix (not entirely sure what this is or if it still exists! – I made butter cream, see below)
- 125ml cold milk (for dessert topping mix if used)
- 60ml (3 tablespoons) drinking chocolate (hot chocolate powder – cocoa powder would also work)(goes in the dessert topping)
- 1 large packet chocolate buttons
- Anything else you want to add to the decorations

Cake (do this earlier in the day as it takes a while in the oven):

- With potato masher, mash butter, sugar, flour, bicarb., egg, bananas and essence together in a bowl until the mixture has no lumps and is well mixed (kids enjoy this bit!).
- Cut chocolate into small squares (4 per normal sized square). Mix into cake mixture with enough milk to make it so it will drop from a spoon when held above the bowl.
- Grease and line (with greaseproof paper) baking tin.
- Spread mixture into tin and bake in a moderate oven (180C, 350F, gas 4) for about 50 mins until cooked through (stick a skewer in the middle and if it comes out clean the cake is cooked).

Decorating:

- Remove from tin – if the cake has risen significantly you may want to level it off with a large knife, and or decorate it upside down.
- Cut 5cm (2 inches) from one of the short sides of the cake. Prop up this end with the chocolate (or something edible!) so that it stands at an angle to one of the short ends.
- Whisk the dessert topping with the milk until it holds its shape. Place two tablespoons aside for icing the numbers. Mix the drinking chocolate into the remainder – stir until evenly mixed. Spread the chocolate mixture evenly over the cake, including the sides.
- Place the buttons on to the cake (hint: start at the midline and work out). Put the remaining topping into a piping bag – I can demonstrate making one from greaseproof paper – and pipe on the figures. Add any other piping/decorations that you like.

'Quicker' Version – ORAHS Calculator

Suggested tin size 20 x 22.5 cm or 12 x 9 inches.

Cake:

- 175g (6oz) soft margarine
- 225g (8 oz) self-raising flour – substitute with 225g plain flour and 3 teaspoons baking powder
- 1 ½ teaspoons baking powder
- 175g (6oz) caster sugar
- 3 eggs
- 3 tablespoons milk

Decorating:

- 25g (1oz) cocoa powder (looks like I left out the cocoa and hot water last year!)
- 60ml (3 tablespoons) boiling water

- 175g (6oz) soft margarine (you can use butter, but it will need to have been left out to get soft)
- 250-350g (9-12oz) icing sugar
- (flavouring – if you want too!)
- 1 large packet chocolate buttons
- About 50g white chocolate – or your choice of piping substance – I think we had a special tube of white chocolate for piping on cakes in the fridge last year.
- Anything else you want to add to the decorations

Cake (do this earlier in the day as it takes a while in the oven):

- Heat oven to 180C, 350F, gas 4 and grease and line (with greaseproof paper) your tin.
- Put all cake ingredients in a large bowl and beat (electric whisk if you have one) well for about 2 mins until well blended.
- Spread into tin and smooth the top.
- Bake in the oven for 35-40 mins until the cake has shrunk from the sides of the tin and springs back when pressed in the centre with fingertips.

Decorating:

- Remove from tin – if the cake has risen significantly you may want to level it off with a large knife, and or decorate it upside down.
- Put white chocolate (if using) in a suitable (not plastic) bowl over a saucepan of just boiled water (enough water so that its level is just below the bottom of the bowl) and leave to melt.
- Cut 5cm (2 inches) from one of the short sides of the cake. Cut a smaller section off, or if the cake has risen significantly, cut the top off and use part of that (or something else edible!), so that it stands at an angle to one of the short ends.
- Mix the chocolate butter icing: Dissolve cocoa powder in the boiling water to make a paste. Cream (whisk) the marg. to soften it, then add the icing sugar and beat well – until pale in colour and light in texture, mix in the cocoa paste. Spread the chocolate mixture evenly over the cake, including the sides.
- Place the buttons on to the cake (hint: start at the midline and work out). Put the melted white chocolate into a piping bag – I can demonstrate making one from grease proof paper – and pipe on the figures. Add any other piping/decorations that you like.

Finally, find some others to help you eat it! ENJOY!

Wednesday: Pub Quiz and Pizza (19:00 - 20:30 CEST)

Join us for a fun evening of trivia! Bring your own beverages and pizza (you could even try baking pizza yourself 😀, see below for a recipe). Otherwise, take one out of your freezer or call your favourite pizza delivery. Participants will be assigned to teams of 4-6 that will work together to answer trivia questions ranging from silly to challenging, and complete a fun group challenge at the end. This social session will be hosted on Gather.town.

If you want to make your own pizza, please aim to have this prepared beforehand so that you do not need to bake while answering trivia. We've included a simple recipe, but you are welcome to find and use another recipe that can be as fancy as you'd like, or substitute store bought components to increase the speed. The following quick pizza recipe is combined from *The Stay @ Home Chef* food

blog; it should make one large pizza, and requires 12+ minutes of prep, **letting the dough sit for several hours,** and 10-20 minutes to bake:

Pizza dough:

- 1/2 teaspoons (2g) of active dry yeast
- 1/4 tablespoon (or 3 g) white sugar
- 7 tablespoons (or 104 ml) warm water (45 degrees C/110 degrees F)
- 1 ¼ -1 ½ cups (145-174 g) type 00 flour (or all purpose)
- 1 tablespoon plus 1 teaspoon(20 ml) olive oil
- 1/4 teaspoons (1.5 grams) salt

Pizza sauce:

- 1 teaspoon (4g) dried basil
- 1/2 teaspoon (2g) dried oregano
- 1/2 teaspoon minced garlic
- 1/4 teaspoon (1g) paprika
- Pince of salt

Toppings: Choose any toppings that you want! Some examples include:

- Grated cheese
- Pepperoni, ham
- Sliced green peppers, red onions, olives
- Mushrooms
- Sliced tomatoes
- Fresh basil

1. In the bowl of a stand mixer, combine yeast, sugar, salt, water, olive oil, and 1 ¼ cups of flour.
2. Knead on low until dough starts to come together. Continue kneading until the dough forms a nice, soft dough ball and the sides of the bowl are clean, adding more flour as necessary to achieve this texture.
3. Dust the dough with flour and place on a baking sheet or large tray. **Cover and let rest 4 to 5 hours.**
4. When ready to bake, preheat the oven to at least 220° C (425° F)
5. Combine all sauce ingredients in a small mixing bowl and stir into a thick sauce
6. Roll dough into a large circle. Place crust on a pizza pan or cornmeal dusted pizza peel. Top with sauce and desired toppings.
7. Bake pizza in the pre-heated oven on the pizza pan, or transfer the pizza from the pizza peel to a pizza stone. Bake until toppings are warm, bubbly, and browning.

Thursday: Among Us (19:30 - 20:30 CEST)

When planning the social programme this year, we thought about all the past future boat trips and all the ships we have been on and realised that so far we have not been on an airship! So we decided that this is what we want to do this year and we invite you to join us for this adventure. But wait, there are traitors among us! While most of us fulfill our duties on board, traitors try to sabotage our ship. It is on us to find these traitors and kick them out the airship to make sure we will reach our destination safely!

If you want to join us for this event, please download the game **Among Us** on your PC, laptop, tablet, Switch, Smartphone or whatever else you are using. There is a free version of the game that includes advertisements, if you want to avoid that you might want to invest a few Euros for the ad-free version. We will all meet in Zoom and then play the game in groups of up to 10 people.

In addition, we have prepared a few more games we could play, for example Scribbl.io, so we can play the whole night if we want! 😀

Friday: Get-together in Gather.town (18:30 - 20:30 CEST)

We do not want to end ORAHS and leave into the weekend without a last chance to get together and say goodbye - see you at ORAHS next year!

Scientific Programme

Monday, July 5th

16:00	Conference Opening	Zoom

17:00	Plenary	Zoom
Chair: Roberto Aringhieri		
	Alec Morton	OR in the fight against Covid-19: how have we done and what can we learn?

18:00	Get-together in Gather.town

Tuesday, July 6th

13:30	Session 1	Zoom
COVID-19 (I) **Session Chair: Jens Brunner**		
1	Christina Bartenschlager	Man vs. Machine vs. Machine: Covid-19 classification of symptomatic patients using laboratory results
2	Jan Schoenfelder	A Scalable Forecasting Framework to predict COVID-19 Hospital Bed Occupancy
3	*Mario de Oliveira*	*We keep this slot free in memory of our friend.*
Decision Support in Healthcare **Session Chair: Izabela Spernaes**		
1	Liliana Freitas	The effect of disaggregating summary statistics in Web-Delphi processes: results from a real-world Delphi experiment
2	Eline Tsai	Turnaround time prediction for clinical chemistry samples using machine learning
3	Daniel Gartner	Decision support for tactical capacity planning in vaccination centres using mathematical programming

14:30	Break

15:00	Session 2	Zoom
COVID-19 (II) **Session Chair: Marion Rauner**		
1	Fermin Mallor	The Weighted 14-day Index to monitor new cases in a pandemic: properties and application
2	Christos Vasilakis	A simulation modelling study using empirical data to help improve COVID-19 vaccination centre operation
3		

Emergency Services Session Chair: Melanie Reuter-Oppermann		
1	Robin Buter	Strategic location of Citizen Responder System defibrillators
2	Sven Watzinger	Towards a comprehensive evaluation framework of EMS logistics
3	Ana Sofia Carvalho	Optimization approaches for the multiple ambulance type dispatching and relocation problem

16:00 Break

16:30	**Plenary**	**Zoom**
Chair: Sally Brailsford		
	Christina Pagel	Reflections on the intersection of OR and public communication (TBC)

17:30	**Discussion Session 1** **Session Chair: Sandy Rutherford**	**Zoom**
1	Hakan Kılıç	The relationship between adherence to therapy and time preferences for patients with diabetes
2	Raquel Feijão	Neonatal prematurity: population risk analysis
3	Monica Oliveira	Designing and testing the IMPACT HTA socio-technical framework to assist HTA agencies in the multicriteria evaluation of new medicines on a common basis
4	Marion Rauner	Planning Hospital Resources for Mass Casualty Events: a DES-based Viennese Case Study

18:30 Break

19:30 Baking Competition Zoom

Wednesday, July 7th

14:00	PhD Competition	Zoom
Steve Gallivan Award **Chair: Sebastian Rachuba**		
1	Mansour Zarrin	Homogeneity and Best Practice Analyses in Hospital Performance Management: An Analytical Framework
2	Mariana Oliveira	Developing guidelines for extending operating room hours
3	Samantha Zimmerman	Simulation modelling for team-based staffing of a combined urgent and primary care centre in Vancouver, Canada
4	Maryam Akbari-Moghaddam	Data-driven Fair Resource Allocation For Novel Emerging Epidemics
5	Kurnia Susvitasari	Determining the Required Number of Hospital Beds to Meet Access Targets for Emergency Department Admissions Using Simulation Optimization
6	Yawo Kobara	ICU/SDU Congestion: To Premature Step-down or not to?
7	Le Khanh Ngan Nguyen	Application of hybrid simulation in the fight against Covid-19

16:00	Break

16:30	Panel Discussion	Zoom
The role of operational research in responding to the COVID-19 Pandemic **Chair: Mike Carter**		
Panel	Christine Currie Réka Gustafson Fermin Mallor Giovanni Righini	

17:30	Discussion Session 2	Zoom
Session Chair: Marion Penn		
1	Joe Viana	Defining measures, identifying, and obtaining data to conduct (cost) effectiveness analysis of medicine supply chains
2	Haifa Nouira	A cluster first-route second method for a capacitated periodic vehicle routing problem
3	Tracey England	Emergency Care for Older People: A system dynamics approach
4	Roberto Aringhieri	Novel applications of the team orienteering problem in health care logistics

18:30	Break

19:00	Pub Quiz and Pizza	Gather.town

Thursday, July 8th

13:30	Session 3	Zoom
Staff Planning **Session Chair: Erwin Hans**		
1	Marta Cildoz	A matheuristic algorithm (Iterative GRASP + LP) to solve the physician scheduling problem
2	Jens Brunner	Integrated surgery and staff scheduling in operating theatres on the operational level
3	Kimberley Morris	Improvement Potential of Flex Nurses in the Dutch Neonatal Network
Patient Management **Session Chair: Melanie Reuter-Oppermann**		
1	Anne Zander	Managing the Intake of New Patients into a Physician Panel Over Time
2	Jiun-Yu Yu	Outpatient appointment numbering model given patients' time preference and selection
3	Paolo Landa	Patient clustering comparison for modelling internal medicine department capacity: a simulation-optimisation approach

14:30	Break

15:00	Session 4	Zoom
ICU **Session Chair: Jan Schönfelder**		
1	Felipe Rodrigues	ICU-SDU Queuing Game with Length-of-stay Decisions
2	Songul Cinaroglu	Efficiency of Intensive Care Unit Services in the Age of Pandemic: A Need for Critical Care Professionals
3		
Organ Transplants and Blood Logistics **Session Chair: John Blake**		
1	Hans de Ferrante	Simulating policy changes to the Eurotransplant Kidney Allocation Scheme (ETKAS)
2	Danny Blom	A Benders-type Approach for Robust Optimization of Kidney Exchanges under Full Recourse
3	Ettore Lanzarone	A novel paradigm for blood collection from donors: home blood collection

16:00	Break

16:30	Plenary	Zoom
Chair: Roberto Aringhieri		
	Vedat Verter	Challenges of Delivering Healthcare in Rural Areas

17:30	Discussion Session 3	Zoom
Session Chair: Sandy Rutherford		
1	Mariana Mesquita-Cunha	Cyclic staff scheduling at emergency medical services
2	Christine Huttin	New developments of cost sharing research in health care
3	Dennis Horstkemper	Use cases for an integrated Simulation and Optimisation Environment for Blood Supply Chains
4	Leonidas Sakalauskas	Hybrid Modeling of Spread of Anxiety due to Virus Infection

18:30	Break

19:30	Among Us	Zoom

Friday, July 9th

13:30	Session 5	Zoom
Operating Room Planning **Session Chair: Sebastian Rachuba**		
1	Steffen Heider	Allocation Scheduling with Resource Synchronization and Uncertain Surgery Durations: A Two-Stage Stochastic Programming Approach
2	Alberto Lacort Burgos	Simulation of patient flow and surgical block optimization considering bed management in a university hospital
3	Santamaria-Acevedo Gustavo	Understanding the factors behind the Length of Stay of Non-Elective Surgical Patients: AMachine Learning approach
Hospital and care facility networks **Session Chair: Roberto Aringhieri**		
1	Rodolfo Mendoza-Gómez	Regionalization of Primary Health Care Units with Multi-Institutional Collaboration
2	Mete Ozbek	Multi-channel Chronic Patient Care in a Performance-based Reimbursement Framework
3	Davide Duma	Modelling the Regional Hospital Network using Big Data and Discrete Event Simulation

14:30	Break

15:00	**Discussion Session 4**	**Zoom**
Session Chair: Marion Penn		
1	John Blake	Estimating the impact on inventory of implementing pathogen reduced platelets in Canada
2	Catherine Crenn-Hebert	Birth practices: a website for future parents , initiated by regional health authority in Ile de France (IDF) region
3	Melanie Reuter-Oppermann	Application scenarios and optimisation approaches for first responder apps

16:00	**Break**

16:30	**Business Meeting**	**Zoom**

18:30	**Get-together in Gather.town**

Abstracts

Tuesday, July 6th

Session 1 - COVID-19 (1)

1. **Man vs. Machine vs. Machine: Covid-19 classification of symptomatic patients using laboratory results**
   Christina Bartenschlager

   For the fight against the Covid-19 pandemic, it is of particular importance to map the course of infection, in terms of the patients who have currently tested positive, as accurately as possible. In hospitals, this is even more important because resources and nursing, as well as medical staff, must be conserved. Although testing capacities have been massively expanded, they are often very time-consuming and cost-intensive and, in some cases, lack appropriate validation. In order to meet these drawbacks, many machine learning approaches have been proposed in literature in order to detect Covid-19 patients. Using data of our multicenter study, we discuss the opportunities and limitations of machine learning based Covid-19 diagnosis based on laboratory parameters. We compare the performance of machine learning algorithms for an ordinal and a cardinal scaling of the data with several physicians in different training levels.

2. **A Scalable Forecasting Framework to predict COVID-19 Hospital Bed Occupancy**
   Jan Schönfelder, Jakob Heins, Steffen Heider, Jens Brunner

   The COVID-19 pandemic has led to capacity problems in many hospitals around the world. During the peak of new infections in Germany in April 2020 and October to December 2020, most hospitals had to cancel elective patients due to capacity shortages. We present a scalable forecasting framework with a Monte Carlo simulation to forecast the short-term bed occupancy of confirmed and suspected COVID-19 patients in intensive care units and regular wards. We apply the simulation to different granularity and geographical levels. Our forecasts were a central part of the official weekly reports of the Bavarian State Ministry of Health and Care, which were sent to key decision-makers in the individual ambulance districts from May 2020 to March 2021. Our evaluation shows that the forecasting framework delivers accurate forecasts despite data availability and quality issues.

Session 1 - Decision Support in Healthcare

1. **The effect of disaggregating summary statistics in Web-Delphi processes: results from a real-world Delphi experiment**
   Liliana Freitas, Ana Vieira, Monica Oliveira, Carlos Bana e Costa

   Delphi processes are participatory processes often used to collect experts and stakeholders views to inform operational research modelling. Delphi's controlled feedback feature allows individual participants to get acquainted with (eventual) new knowledge and, in sequence, revise their opinions, engaging in a knowledge construction process. Nevertheless, several studies show unexpectedly limited opinion changes occurring due to belief perseverance bias. Such bias can be avoided by recognizing expertise in the people one is interacting with, which is hindered by the aggregation of results in a Delphi environment.
   A real-world Delphi was conducted with different stakeholders within the scope of Health Technology Assessment to explore the effect of feeding back the distribution of the answers

disaggregated per groups of stakeholders on the dropout rate and opinion change. For that, as Delphi's feedback, participants were randomly allocated to see the global distribution of the answers and comments, or that information plus the distribution of answers per group of stakeholders.
Results showed that the experiment did not affect the dropout rate. No statistically significant difference between conditions was either found concerning the opinion change. Participants commenting on the disaggregation of answers considered it interesting and useful for informing their opinion. These results can impact the choice of feedback formats in future Delphi processes.

2. **Turnaround time prediction for clinical chemistry samples using machine learning**
Eline Tsai, Nick Hoogendijk, Richard Boucherie, Andrei Tintu

Turnaround time (TAT) is an essential indicator of diagnostic laboratory performance. TAT prediction is important to inform the doctor when the test results are available so that the patient's treatment may be continued. We present a model that accurately predicts the TAT of individual laboratory samples over the fully automated pre-analytical and analytical phases in the clinical chemistry laboratory of the Erasmus MC.
Logfiles from 88,000 samples over the period from January 2019 until March 2019 were used. The Python package PyCaret was used for model training and selection, using 10-fold cross validation. PyCaret contains 25 regression models, such as, Random Forests, Light Gradient Boosting, and Linear Regression. Feature selection was performed on 38 features, including workload in the different stages upon sample arrival, priority level, and number of required tests. SHAP-values were calculated to explain the behavior of the model.
The average TAT over all samples is found to be 32.1 minutes. The regression-tree-based method Extra Trees Regressor performed best with an R^2 of 0.58, a mean absolute error of 2.57 minutes, and a mean absolute percentage error of 0.08. SHAP-value analysis indicated that the TAT is mainly influenced by the number of ordered tests and the number of allocated test-modules. In future research we aim to extend our model to optimally assign samples to the different analyzer lines.

3. **Decision support for tactical capacity planning in vaccination centres using mathematical programming**
Daniel Gartner, Terrence Watkins, Izabela Spernaes

In this presentation we will illustrate the need to dovetail the demand of patients scheduled for their Covid-19 vaccinations with the capacity of different stations such as registration and resources needed for administering the actual jab. The mathematical model that we developed maximises the number of patients scheduled on the different priority categories and, when scheduled into the clinic, automatically assigns these patient numbers for the second jab. Patient type-dependent service durations within the different stations are taken into account as well as utilisation levels. A decision maker can use our decision support tool to find out whether enough capacity is available across several weeks. Furthermore, the tool can have implications on rostering decisions.

Session 2 - COVID-19 (2)

1. **The Weighted 14-day Index to monitor new cases in a pandemic: properties and application**
   Fermin Mallor, Marta Cildoz, Martín Gastón-Romeo, Daniel García de Vicuña, Laura Frías-Paredes, Cristina Azcarate

   The 14-day notification rate of new COVID-19 cases is one of the main indicator used for informing about the pandemic spread. Many national and international health agencies use it to making decisions to implement social distancing measures. However, this index is quite slow to alert of changes in the pandemic dynamics. We define an alternative index inspired in the EWMA (Exponentially Weighted Moving Average) index used in the statistical quality control. We show that it is more appropriate for monitoring the pandemic spread, we study its statistic properties and compare its performance with that of the 14-day incidence index. We have used this new index to monitor new cases in all regions of Spain whose results have been daily reported to the Center for the Control and Alert of Emergencies in Health of the Spanish Ministry of Health during 2021, who distribute them to all regional governments.

2. **A simulation modelling study using empirical data to help improve COVID-19 vaccination centre operation**
   Christos Vasilakis, Richard Wood

   Vaccinating the entire population is widely considered to offer the main route out of the COVID-19 pandemic. For many countries, dedicated vaccination centres are a key part of that effort. However, with no directly comparable historical experience there is little information to guide the operational configuration and management of these operations. In addressing this gap in knowledge, the objective of this study is to demonstrate the value of computer modelling. This is achieved through providing an account of its use in supporting management considerations and decisions at two major vaccination centres, at an early stage of the vaccination effort in the UK. We report on how modelling insight has influenced the initial setup of one site, including quantification of daily booking numbers. For the same site, we reveal how analysis has informed a significant operational shift in combining two key activities on the vaccination pathway into one. Finally, we describe how, at a second site, modelling has been used to examine pathway stability, in terms of resilience to unforeseen 'shocks' such as delayed arrivals and staff unavailability. Alongside the open-source simulation software, the modelling insights reported here can support managers in their effort to continuously improve the operation of COVID-19 vaccination centres.

Session 2 - Emergency Services

1. **Strategic location of Citizen Responder System defibrillators**
   Robin Buter, Derya Dermitas, Erwin Hans, Erik Koffijberg, Johann Huring, Arthur Nazarian

   Automated external defibrillators (AEDs) are placed in public to decrease response time and increase survival rate from out of hospital cardiac arrest (OHCA). Volunteers are alerted by a citizen responder system and are asked to retrieve a nearby AED. However, many AEDs are barely used due to poor location choices. We develop an algorithm that creates candidate AED locations and chooses near-optimal locations for new AEDs. Large instances can be solved since locations are created dynamically, keeping the problem size manageable while being able to evaluate a very granular set of locations. We apply this methodology to a case study from the Netherlands and show that coverage of OHCAs can improve by 25%.

2. **Towards a comprehensive evaluation framework of EMS logistics**
Sven Watzinger, Stefan Nickel

Emergency Medical Systems (EMS) are complex logistical systems that have to find a balance between the quality of provided care and costs. Since EMS are public, non-profit health care service providers not only the (cost) efficiency, but also aspects such as fairness should be taken into account during system design and improvement. To evaluate EMS, especially from a logistical point of view, the most commonly used indicator is the percentage of calls with a response time below some threshold. The response time measures the time between the arrival of the call and the arrival of the first vehicle on scene. The suitability of response time as the sole performance indicator however has often been questioned, since it arguably does not reflect all performance dimensions of EMS. To develop a more comprehensive evaluation system we have gathered indicators that were used in the literature and propose to structure them by efficiency, effectiveness and fairness as well as structure quality, process quality and outcome quality. The development of such a system is one goal of our joint project with the department of quality assurance in EMS in Baden-Wuerttemberg, Germany. In the future this system can be used to compare different EMS as well as to evaluate proposed changes to specific EMS, e.g. through simulation studies. In this talk we present preliminary results and discuss possible approaches for a comprehensive structure of indicators.

3. **Optimization approaches for the multiple ambulance type dispatching and relocation problem**
Ana Sofia Carvalho, Maria Eugénia Captivo

In the Emergency Medical Service (EMS) context, there are three levels of decision: strategic, tactical, and operational. We focus on the operational level by solving the ambulance dispatching and relocation problems. Dispatching decisions assign ambulances to emergencies, and the relocation problem decides to which base ambulances should be (re)assigned. Different ambulance types, which vary in the equipment and crews, should be used according to the emergency severity. Having the Portuguese EMS as a case study, several real-life features are considered, such as extra time above the maximum response time, the setup time to crews to get ready, and ambulances' working shifts.
We propose a new preparedness measure to achieve a good service level for current and future emergencies, considering different ambulance types. The proposed strategy considers the preparedness measure and allows relocations to any base. A mathematical model and a pilot-method heuristic are developed to solve these problems.
We develop a decision support system to help the EMS managers in the decision-making process. We use a Geographic Information System (GIS) to develop a GIS-based tool. The proposed strategy and the current Portuguese EMS strategy, which dispatches the closest available ambulance and relocates ambulances to their home bases, are embedded in this tool. Running simulations for all day, we highlight the proposed strategy's potential.

Discussion Session 1

1. **The relationship between adherence to therapy and time preferences for patients with diabetes**
Hakan Kılıç, Evrim Didem Gunes, Oğuzhan Deyneli, Şeyda Özcan

Diabetic patients' health suffers from non-adherence to therapy, leading to a costly burden to the healthcare system. In their decision-making process regarding adherence to therapy, patients often encounter a trade-off involving immediate costs and delayed gains. For

example, a patient might believe a physical activity to result in much-delayed health gains such that not going through the effort of physical activity is preferred. We empirically investigate such a setting by examining the relationship between patient adherence to therapy and time preferences, i.e., the patients' discounting behavior consisting of her patience, self-control, and self-awareness about her self-control in line with the behavioral economics literature. We aim to determine 1) which dimension of adherence to therapy (glucose management, dietary control, physical activity, healthcare use) is mainly influenced by time preferences, 2) how self-awareness affects adherence, 3) which feature of the time preferences has the most significant impact on the health status, 4) can number of physician visits and continuity of care diminish the possible adverse effects stemming from the time preferences. To that end, we are conducting a survey targeting patients with type 1 or type 2 diabetes aged 18 or older. Preliminary results of the ongoing study will be shared.

2. **Neonatal prematurity: Population risk analysis**
Raquel Feijão, Jose Eduardo Pecora, Taisa Gonçalves de Resende, Marcos Vinicius Kaminski

The concept of prematurity includes every live newborn (NB) with less than 37 complete weeks of gestation. Prematurity is one of the most critical determinants of infant mortality, besides being a source of associated complications, ranking first among the causes of death in the first five years of a newborn's life. This paper's research question is: 'Which factors related to the previous healthcare events of the patient may be used to identify increased risk for infant prematurity?' The population is postpartum woman of a health insurance company with a gestational outcome associated with prematurity and full-term delivery during 2017-2020. A quantitative and retrospective analysis was conducted into the health insurance database, using information of beneficiaries who had a premature gestational result in the year 2020. Was considered data compliance with clinical protocols used by medical societies. We identified 3401 pregnant women with outcomes of delivery, miscarriage, and fetal death in the year 2020; of these, 8.1% had a premature outcome. The financial impact in average cost is approximately 142.70% over on-term births considering the delivery procedure and 650.74% during the first year of the baby's life. As a future analysis, a total of 798,609 rows will be mined using process mining algorithms. It is expected to develop an early identification protocol of possible pregnant women with increased risk for premature birth to be applied within the operator's databases.

3. **Designing and testing the IMPACT HTA socio-technical framework to assist HTA agencies in the multicriteria evaluation of new medicines on a common basis**
Monica Oliveira, Teresa Cipriano Rodrigues, Liliana Freitas, Ana Vieira, Klára Dimitrovová, João Bana e Costa, Aris Angelis, Panos Kanavos, Carlos Bana e Costa

When evaluating medicines, Health Technology Assessment (HTA) committees consider multiple value dimensions, variable quantity and quality of evidence, as well as make use of their qualitative knowledge regarding medicines' impacts; and at the top level, HTA agencies face the challenges of promoting consistency in medicines evaluations across committees and of finding a balance in the involvement of HTA stakeholders and experts in evaluations. In this study we describe the development and testing of the IMPACT HTA socio-technical framework to assist HTA agencies in valuing medicines in multiple dimensions across diseases on a common basis. Technically, the framework combines MACBETH with concepts of the swing weighting matrix so that a common value frame is set by the HTA agency for groups of therapeutic indications, and committees evaluate medicines on a structured basis and departing from the value set defined by the agency. Socially, the framework is developed through a collaborative modelling approach in which key HTA stakeholders and members of evaluation committees are involved in a sequence of Delphi and decision conferencing

processes so as to develop both the value frame for each therapeutic indication, and MACBETH value models for specific medicines' evaluations. Results from testing the HTA framework in case studies developed in two HTA agencies from Belgium and Sweden are presented, and feedback and insights from participants about the framework are provided.

4. **Planning Hospital Resources for Mass Casuality Events: a DES-based Viennese Case Study**
   Marion Rauner, Daniel Staribacher, Helmut Niessner

   This paper presents a simulation-based policy analysis of the available resources for a major Viennese hospital in the case of a disaster with a mass casualty event. Using a Discrete Event Simulation (DES) model, the current disaster plan is simulated and then compared to an adapted version with additional changes in personnel and equipment. The results show that with the current resources of the hospital severely injured patients may have to wait up to 168.4 minutes until a life-saving operation can be performed. Assuming that the death from blood loss of severely injured patients has a peak at 2 to 2.5 hours after arrival in a hospital, this waiting time of nearly 3 hours is clearly not acceptable. A theoretical increase in staff or equipment did not lead to a sufficient reduction of this timespan. Therefore, in the short term, it is recommended that the current hospital disaster plan reduces the number of severely injured patients that can be successfully accepted and treated. In the long term, this analysis recommends expanding structural resources and improving regional disaster planning.

Wednesday, July 7th

PhD Competition

1. **Homogeneity and Best Practice Analyses in Hospital Performance Management: An Analytical Framework**
   Mansour Zarrin, Jan Schoenfelder, Jens Brunner

   In the traditional DEA framework, it is assumed that the decision-making units (here hospitals) are functionally similar and therefore homogenous. Consequently, any identified inefficiency of hospitals is supposedly due to their inefficient usage of inputs in producing the outputs. However, the difference in efficiency scores might be caused by the non-homogeneity of hospitals that can be defined in two forms: semantic non-homogeneity and scale non-homogeneity. Another issue of the traditional DEA framework is its lack of predictive capabilities, despite it being frequently used as a benchmarking tool. This study aims to develop and evaluate a framework for analyzing hospital performance by combining two complementary modeling techniques. Specifically, we employ artificial neural networks to perform heterogeneity and best practice analyses on a large dataset containing more than 1,200 hospitals in Germany. The framework enables a decision-maker not only to predict the best performance but also to explore whether the differences in relative efficiency scores are ascribable to the heterogeneity of inputs and outputs.

2. **Developing guidelines for extending operating room hours**
   Mariana Oliveira, Valérie Bélanger, Angel Ruiz, Daniel Santos, Inês Marques

   Backlogs of elective surgical patients may arise due to poor planning or a mismatch between demand and supply. When resuming elective surgeries after COVID-19 pandemic-related suspension, operating room managers will face complex challenges, namely due to high levels of demand. Therefore, strategies to increase existing response capacity must be developed.

Extending operating room hours may allow increasing throughput and reduce waiting times. This strategy is already used in practice to face surges in demand, but it is not formalized in the literature. Thus, this work intends to explore this concept and propose guidelines for its implementation in different contexts. Moreover, it aims to stimulate a discussion among researchers, operating room managers and policymakers to promote sustainable management and capacity allocation decisions.

3. **Simulation modelling for team-based staffing of a combined urgent and primary care centre in Vancouver, Canada**
   Samantha Zimmerman, Alexander Rutherford, Ana Fernandes, Andy Day

   Urgent and primary care centres (UPCC's) provide walk-in services for conditions requiring prompt attention, but not emergency level care – for example sprains or minor burns. Additionally, some UPCC's combine this with longitudinal care by building a patient panel and offering continuing care through booked appointments. Members of our research team spent a day shadowing staff at a new UPCC in Vancouver, Canada. A multi-disciplinary team of healthcare professionals at the centre work together to provide client care and efficiently meet the holistic needs of clients. The team includes physicians, nurse practitioners, registered nurses, social workers, medical office assistants and other allied health professionals. We built a discrete event simulation model of client flow for both urgent and longitudinal care at the centre. This simulation model is guiding our development of new staffing formulas, which use queueing theory approximations to determine the team size and composition required to meet access targets for growing client demand. Our interactive discussion session will describe client flow at the centre, introduce our simulation model, and then compare different team-based staffing approximations with simulation results.

4. **Data-driven Fair Resource Allocation For Novel Emerging Epidemics**
   Maryam Akbari-Moghaddam

   During emerging epidemics, there are usually limited resources that have the ability to mitigate the effects of the disease, making it challenging to make resource allocation decisions. Furthermore, several other key reasons are of concern for decision-makers, including not having sufficient prior information about the disease, and dealing with a periodically changing and location-specific disease behaviour that can arise naturally or as a result of government policies. We first discuss a model that can make reasonable short-term real-time supply and demand forecasts without relying on demographic information. Second, a data-driven mixed-integer programming (MIP) model is proposed for allocating resources while maximizing a notion of fairness. Numerical results obtained from a COVID-19 Convalescent Plasma (CCP) case study suggest that our approach can help minimize the unmet CCP demand ratios and lead to a balanced and fair CCP supply and demand between the entities.

5. **Determining the Required Number of Hospital Beds to Meet Access Targets for Emergency Department Admissions Using Simulation Optimization**
   Kurnia Susvitasari, Jasdeep Dhahan, Alexa van der Waall, Alexander Rutherford

   Increasing demand for acute care service has put hospitals under immense pressure. Admitted acute patients may wait a significant amount of time in an emergency department until they transfer to a ward. This leads to emergency department overcrowding, service delay, and early discharge of patients. We develop a discrete event simulation model of hospitals and use simulation optimization to compute the minimum number of beds required in each hospital department to meet access targets. These targets take the form of at least x

percent of patients admitted through the emergency department must be in a ward bed within y hours. Our model, implemented in AnyLogic, is a non-preemptive multi-server priority queue network, which consists of connected and stand-alone departments. Patients arrive as emergency, elective or transfer admissions. A patient's priority of receiving a bed depends on their arrival stream. We choose the initial values for the optimization from an asymptotic approximation of queuing theory.
The simulation model is a useful tool for resource planning and identifying bottlenecks for timely access to care. It also provides hospital management with guidelines for average occupancy standards to meet access targets. This project is being conducted in collaboration with the Ministry of Health in British Columbia, Canada.

6. **ICU/SDU Congestion: To Premature Step-down or not to?**
Yawo Kobara, David Stanford, Felipe Rodrigues

A Step-Down Unit (SDU) provides an intermediate Level of Care for patients from the intensive Care Unit (ICU) as their acuity lessens. SDU congestion, as well as upstream patient arrivals, force ICU administrators to incur in Alternate Level of Care (ALC), either in the form of overstays or premature step-downs. Basing on a proxy for patient acuity level called `Nine Equivalents of Nursing Manpower Score (NEMS)', we develop, solve computationally and simulate a Markov Decision Process (MDP) using approximate linear programming (ALP) that selects actions to optimize the patient net survivability with and without premature step-downs. Our results show that the policy without premature step-down's net survivability significantly exceeds that of the policy with the premature step-down and contributes to congestion downstream. We then conclude that in the advent of increasing demand, ICU's may need to avoid excessive premature step-downs to prevent patient loss as well as downstream congestion.

7. **Application of hybrid simulation in the fight against Covid-19**
Le Khanh Ngan Nguyen, Itamar Megiddo, Susan Howick

Hybrid simulation which combines different simulation modelling methods has become more crucial in supporting decision makers at all levels as part of the effort of tackling the spread of Covid-19 and saving overwhelmed healthcare systems while trying to minimize the economic and social impact of interventions such as lock-downs. In the fight against the Covid-19 pandemic, we have developed an integrated hybrid system dynamics and agent-based model that studies the transmission dynamics and control measures of Covid-19 outbreak across care homes in a network via staff sharing to support decision makers from the Health and Social Care Partnership Lanarkshire and the Department of Health and Social Care in the UK. In the modelling process, we have been working closely with our clients and other care home stakeholders to ensure that the model sufficiently represents the investigated system and is useful for its purpose. Our model results show that sharing staff across care homes increases the risk of SAR-CoV-2 infection for residents and the risk of outbreaks and, therefore, should be limited. Creating smaller bubbles of care homes within which staff movement is restricted has a small impact in reducing the risk of transmission across care homes in most cases. Sharing staff impacts care homes in a network differently depending on their characteristics.

Discussion Session 2

1. **Defining measures, identifying, and obtaining data to conduct (cost) effectiveness analysis of medicine supply chains**
   Joe Viana, Marianne Jahre, Christine Årdal, Kim van Oorschot

   Due to increasing shortages prior to and exacerbated during Covid, ensuring availability of medicines and vaccines is a key societal challenge. Complex and vulnerable global supply chains, manufacturing problems, product recalls, short product shelve life, new digital technology, a few suppliers dominating markets, funding limitations, and high demand volatility are among the causes of this worldwide problem. In response, countries are developing strategies to safeguard against smaller (e.g., price increase) and larger disruptions of supply (e.g., health system breakdowns) and/or demand (e.g., pandemics). Strategies to mitigate against disruptions include but are not limited to strategic stocks (stockpiling), emergency ordering, reshoring production, maintaining a flexible supply base and, joint procurement.
   We are currently developing a hybrid (ABM-SD-DES) simulation model of Norwegian paracetamol MSCs to investigate the effects of MSC disruptions and mitigation strategies. The purpose of the model is to help key stakeholders make evidence-based decisions that sustainably reduce shortages ensuring future health and care services.
   We will discuss:
   Selecting and defining outcome/output measure and other KPIs
   Defining disruption events, risks
   Incorporating resilience (time for system to recover to pre-disruption level) into cost effectiveness analysis
   Suitable time frames
   Availability of data and estimation processes
   Scenario experimentation vs. optimisation

2. **A cluster first-route second method for a capacitated periodic vehicle routing problem**
   Haifa Nouira, Imen Ben Ida, Sondes Hammami, Adnen el Amraoui, Hanen Bouchriha, Gilles Goncalves

   In this paper, we present a method to solve the problem of delivering consumables to hemodialysis patients which is NP-hard. The problem is a Periodic vehicle Routing Problem (PVRP), it consists of finding the optimal visit frequency to patients and constructing vehicle tours simultaneously, subject to constraints as the patient's limited holding capacity and vehicle capacity. The objective is to get the best compromise between the patient’s inventory holding and traveling costs. Our method is a two-phase method (i.e., cluster-first route-second method) based on the Variable Neighborhood Search metaheuristic (VNS). Firstly, we cluster patients using a clustering algorithm. Next, we affect patients to visit days using Mixed Integer Programming and build routes for vehicles. Finally, we use a VNS variant to get optimal or near-optimal solutions to our model. The proposed solution strategy has been tested on a set of PVRP Benchmarks. Results of the numerical investigation were presented to illustrate the effectiveness of the algorithms.

3. **Emergency Care for Older People: A system dynamics approach**
   Tracey England, Sally Brailsford, Simon Conroy

   Emergency and Urgent Care is a major international issue. Demand is rising annually in the UK, especially in older people. Strategies are needed to manage older people in Emergency Departments, improving patient outcomes for them and others.

A system dynamics computer simulation model has been developed to represent the patient flow of patients aged 75 and over through the entire process from the point of an ambulance being called through to admission, and/or transfer out from hospital. The model has been parameterised using Emergency care data for the Yorkshire and Humber (Y&H) region of the United Kingdom (extracted from the CUREd Research Database) and represents 397,969 people aged 75+ who attended an ED in Y&H at any point between April 2011 and March 2017.
The model has been designed to evaluate different interventions in different hospital settings on patient outcomes such as mortality, readmission and length of stay. The intervention strategies considered include: proactive care (including hospital at home), consultant-led comprehensive geriatric assessments, and front-door frailty policies.
The system dynamics model and the associated user interface (developed in AnyLogic) will be presented along with initial comparison runs of the intervention strategies.

4. **Novel applications of the team orienteering problem in health care logistics**
Roberto Aringhieri, Sara Bigharaz, Davide Duma, Alberto Guastalla

The Team Orienteering Problem (TOP) is a routing problem belonging to the class of the Vehicle Routing Problems with Profits (VRPPs). The VRPP is characterised by the fact that set of customers to serve is not given. This implies the need to consider two different decisions as reported in Archetti et al. (2014), that is (i) which customers to serve, and (ii) how to cluster the customers to be served in different routes (if more than one), and order the visits in each route. The customer selection is driven by a profit associated with each customer that makes such a customer more or less attractive. To the best of our knowledge (Vansteenwegen & Gunawan (2019)), the TOP framework is never applied to the modelling and to the solution of health care logistics problems.
In this talk, we present two routing problems arising in the health care logistics. The former is a problem arising in the digital contact tracing system as a measure for the containment of the Covid-19 pandemic, that is the daily swab test collection problem (DSTCP). The latter is a problem arising in post-disaster management, that is the Ambulance Routing Problem (ARP) to transport the injured to hospitals. We discuss the novelty of some of their features with respect to the current TOP literature. We present and discuss the mathematical formulation of a new variant of the team orienteering problem that includes such new features.

Thursday, July 8th

Session 3 - Staff Planning

1. **A matheuristic algorithm (Iterative GRASP + LP) to solve the physician scheduling problem**
Marta Cildoz, Fermin Mallor, Pedro Mateo

In this work, a constructive heuristic algorithm that mimics the human scheduling process followed by the manager at the hospital is developed to solve the physician scheduling problem in an Emergency Room (ER). Shifts vary in type: day and night, workday and holidays, short and long shifts, etc. Even within these categories, there are differences in terms of the task requirement. In addition, there is also variation in the availability and annual working time of the physicians, such that they are not all able to work all types of shifts. The algorithm sequentially fixes, first, the days the physicians work, then, the period of the day, and, finally, the type of shift. In this way, characteristics that are considered more important in the solution quality assessment are fixed first, when more freedom degrees are available.

The heuristic combines the use of a constructive phase of a Greedy Randomized Adaptive Search Procedure (GRASP) with sequences of small mixed-integer linear programming problems. A local improvement is done by using network flow optimization. The application of the algorithm has been tested in a real case in which it is necessary to schedule the 43 physicians of a Public Hospital ER in Spain and is now being used.

2. **Integrated surgery and staff scheduling in operating theatres on the operational level**
   Jens Brunner, Stefanie Ebel

   Two of the most important, costly and scarce resources in hospitals are physicians and operating rooms. Consequently, efficient and effective scheduling of both of these resources is one of the most relevant planning tasks within hospitals. As a result, efficient scheduling directly affects operating costs as well as patient and staff satisfaction and thus the quality of care. The decisions on the operational planning level regard the sequencing of patients' treatment as well as the assignment of appropriate staff to surgeries subject to qualification and experience. Additionally, there are several interdependencies between surgery schedules and physician rosters. Therefore, it is a meaningful approach to consider both planning problems within one integrated optimization problem. We present a mixed integer programming model for the simultaneous scheduling of treatments and staff. To solve the model, we apply a Dantzig-Wolfe decomposition and apply column generation approach. We show preliminary results based on real-data provided by our cooperation partner. The project is funded by the German Research Foundation.

3. **Improvement Potential of Flex Nurses in the Dutch Neonatal Network**
   Kimberley Morris, Erwin Hans, Tim Antonius, Willem de Vries

   The Dutch neonatal intensive care (NIC) network has nine NIC units, for which nursing capacity is scarce. As a result, patient arrivals are often rejected and are transferred to other centers or even abroad. This places a heavy burden on patients, their family, and involved caregivers. Given the limited distances between the centers in the Netherlands, the idea arose to not move patients but instead share nurses between NIC centers. At present, this is not done due to organisational and financial barriers. Therefore, this study aims to demonstrate the improvement potential in order to start a discussion. To optimise patient transfers and nurse allocations we use an ILP formulation. It determines, before every nurse shift change, the nurse allocations and newly arrived patient transfers for the upcoming shift. The model minimises transfers and distances travelled by patients and nurses. We test this ILP formulation in a discrete event simulation environment. This study is performed in close collaboration with the Wilhelmina Children's Hospital and uses real life data obtained from the neonatal network in the Netherlands, and particularly its capacity dashboard tool BabyZoektBed. The computational results show great improvement potential in terms of reducing the transfers of newly arrived patients, even for a low number of flex nurses. The model can be easily adjusted to make all kinds of what-if analyses. Examples of these will be discussed in the presentation.

Session 3 - Patient Management

4. **Managing the Intake of New Patients into a Physician Panel Over Time**
   Anne Zander, Stefan Nickel, Peter Vanberkel

   We focus on balancing supply and demand for physicians and panel patients on a tactical level to ensure a manageable workload for the physicians and access to care for patients.

Patients are part of the physician's panel if they visit the physician somewhat regularly. We propose deterministic integer linear programs that decide on the intake of new patients into panels over time, taking into account the future panel development. The main objective is to minimize the deviation between the expected panel workload and the physician's capacity over time. We classify panel patients where we use at least the two patient attributes: age and the number of visits in a period. We use transition probabilities between classes from one period to the next. The programs work with aggregation levels for the new patients' demand concerning the patient attributes. We conduct experiments with parameters based on real-world data. We consider the transition between classes and the new patients' demand to be stochastic in a discrete-event simulation. We define upper bounds on the number of patients in a patient class to be accepted in a period through solving the programs several times with different demand inputs. Even in this uncertain environment, we can significantly reduce the expected differences between workload and capacity over time, taking into account several future periods instead of one. Using a detailed classification of new patients decreases the expected differences further.

5. **Outpatient appointment numbering model given patients' time preference and selection**
Yiun-Yu Yu

In the current practice, patients who would like to make an appointment with a doctor can only unwillingly accept the queue number usually generated by the first-come-first-serve principle. However, such a queue number tells little information about the most appropriate time for the patient to arrive at the hospital or clinic, making the patient spend huge amount of time waiting.
We propose a model based on historical data analysis so that the patients will have some time-slot options to choose from. The model will then provide a corresponding queue number and suggest a proper arrival time for the patient. Simulation studies show that this proposed model significantly reduces the expected waiting time of the patients.

6. **Patient clustering comparison for modelling internal medicine department capacity: a simulation-optimisation approach**
Paolo Landa, Elena Tanfani, Angela Testi

Recently the increase of elder population with multiple morbidities affected the number of hospital admission in internal medicine wards. The increase of patient needs is an important issue for healthcare systems, with a burden of activities, risks and costs, mining both patient care and hospital performances. The larger patient clinical complexity requires organizational changes to address their health needs appropriately. A new reorganisation of medical wards from specialty-based to a new setting, where separation among internal medicine specialties - e.g. cardiology, respiratory, geriatrics, infectious diseases - disappears to merge into a single general department, where clinicians work in multidisciplinary teams. To evaluate the impact of the new organisational model, we firstly develop a simulation model to describe the pathways of complex patients through medical hospital wards. The patient complexity requires a clustering analysis to classify patients in the simulation model, considering several characteristics such as administrative, clinical and demographics data. An unsupervised learning clustering method is proposed and compared to the current clinician-led classification. Finally, an optimization component embedded in the simulation model is used to provide the optimal beds capacity of the department able to adequately treat all the patients needing hospital care. The model has been applied a case study, and the preliminary results are presented and analysed.

Session 4 - ICU

1. **ICU-SDU Queuing Game with Length-of-stay Decisions**
   Felipe Rodrigues, Yawo Kobara, Camila Pedroso, David Stanford

   We consider a queue with two (2) servers in tandem, the first is the Intensive Care unit (ICU) followed by a Step-down unit (SDU). Due to congestion at and possible costs of rejection of patients arriving into the ICU, the utility if intensive care is concave. On the other hand, the second server (SDU) faces the costs of overstay upstream (ICU) depending on its own LOS decisions.
   As such we characterize the ICU-SDU care pathway as a queuing game. We consider the length of stay (LOS) decisions these two units play, both independently, as leaders and as well as in centralized cooperation. In our analysis, we determine the characteristics and optimality conditions of their LOS and treatment intensity decisions in multiple game scenarios.
   While it has been shown that for the particular case of a tandem network of two servers with Jackson characteristics, cooperation tends to be beneficial, for the peculiar non-Jackson network that describes the ICU-SDU, this question remains to be addressed.

2. **Efficiency of Intensive Care Unit Services in the Age of Pandemic: A Need for Critical Care Professionals**
   Songul Cinaroglu

   Shortage of critical care professionals has been a challenge during pandemic. The objective of this study is to examine the efficiencies of intensive care unit (ICU) services in Turkey in the age of Covid-19 pandemic. Data were gathered from the Public Hospital Statistical Year Book for the year 2017. Analysis are presented at hospital level by comparing teaching and non-teaching hospitals. Bootstrapped data envelopment analysis procedure was used to gather more precise efficiency scores. Three analysis levels are incorporated into the study such as, all public hospitals (N=100), teaching (N=53), non-teaching hospitals (N=47) and provinces that are providing high density of ICU services through the country (N=54). Study results reveal that average efficiency scores of ICU services obtained from teaching hospitals (eff=0.65) is higher than non-teaching (eff=0.54) hospitals. After applying the bootstrapping techniques, efficiency scores are significantly improved and the difference between before and after bootstrapping results are statistically significant ($p<0.05$). Province based analysis indicates that, ICU services efficiencies are high for provinces located in southeast part of the country and highly populated places, such as İstanbul. Evidence-based operational design that considers the spatial distribution of health resources and effective planning of critical care professionals are critical for efficient management of intensive care.

Session 4 - Organ Transplants and Blood Logistics

1. **Simulating policy changes to the Eurotransplant Kidney Allocation Scheme (ETKAS)**
   Hans de Ferrante, Marie Baratto, Bart Smeulders, Frits Sieksma

   Eurotransplant (ET) executes the allocation of deceased donor organs for 8 European countries. For the kidney, a points-based system (ETKAS) is used which allots points for accrued waiting time, transplant candidate-donor match quality, and expected future mismatches. Consensus that ETKAS currently overemphasizes waiting time has led to a policy proposal emphasizing candidate-donor match quality (“ETKAS2016”). Questions remained on how ETKAS2016 would affect match quality, patient waiting time, and the number of transnational transplantations.

To answer these questions, we developed a simulation framework tailored to unique challenges faced by ET like the required balancing of transnational flows of organs. Using historic data from ET between 2004, we confirm simulated match quality is close to observed match quality under current ETKAS. As expected, we find that ETKAS2016 leads to greater match quality compared to simulations under current ETKAS. However, ETKAS2016 also leads to a substantially more transnational transfers, greater patient waiting times, and is disadvantageous to patients with already accumulated waiting time.
Results have been discussed with the ET Kidney Advisory Committee (ETKAC), and informed refinements to ETKAS2016. Modular implementation of the framework permits evaluation of these refinements and other policies. We are expanding the framework to better capture organ acceptance behavior by centers, as turndown of offers remains high.

2. **A Benders-type Approach for Robust Optimization of Kidney Exchanges under Full Recourse**
Danny Blom, Bart Smeulders, Christopher Hojny

The goal of kidney exchange programs is to match recipients having a willing, incompatible donor with another compatible donor, so as to maximize total (weighted) transplants.
Planned exchanges might not proceed to transplant for a variety of reasons.
It is therefore crucial to consider failures and recourse options when planning exchanges.
We reconsider a robust optimization model with recourse proposed in Carvalho et al. (2020) in which a fixed number of donors might leave the KEP.
After these donors have left the program, a new set of exchanges is identified (the recourse decision) with the aim to realize transplants for as many of the originally planned recipients.
Current algorithms do not allow to solve the robust optimization model to optimality for realistically sized kidney exchanges with a reasonable time frame.
Following the iterative framework in Carvalho et al. (2020) for solving a large mixed-integer program, we propose a new variable and constraint generation method based on a cutting plane approach.
We provide MIP formulations for this method based on two widely used IP models for kidney exchanges.
Furthermore, a lifting technique is proposed to obtain stronger cuts to speed up computation. Computational results show that our algorithm is very competitive, improving on the running time of the state-of-the-art method by one order of magnitude.
Our methods are able to solve a large number of previously unsolved instances within the same time limit.

3. **A novel paradigm for blood collection from donors: home blood collection**
Ettore Lanzarone, Martina Doneda, Semih Yalçındağ

Blood Donation Supply Chain is a key component of any health care system. According to a recent study, the global need for blood was estimated to be 300 million units in 2017, while only 270 million units were collected.
The COVID-19 pandemic has worsened the issue, and shortages have dramatically increased. For example, in Italy, the production of red blood cells in April 2020 was reduced by 36.4%, compared to that of 2019.
Moreover, COVID-19 has stressed the need for delocalization of health services.
In this light, we propose a novel paradigm for blood collection, which consists of collecting blood at donors' homes rather than in donation centers, and it more comfortable and safe for patients, even in pandemic times.
To manage home blood collection systems, we propose a decision support framework characterized by the integration between a Blood Donation Appointment Scheduling (BDAS) and a Multi-Trip Vehicle Routing Problem with Time Windows (MTVRP-TW). It consists of 3

planning phases: 1) possible time slots for donor appointments are created while balancing the production of the different blood types; 2) planned slots are turned into actual appointments based on the booking requests from donors; 3) a fleet of vehicles is organized to collect blood from donors' homes at predefined donation day and time.
The proposed framework has been tested and validated with the data of an Italian blood collection center.

Discussion Session 3

1. **Cyclic staff scheduling at emergency medical services**
   Mariana Mesquita-Cunha, Ana Paula Barbosa-Póvoa

   Staff scheduling is a complex and time-consuming task required by many industries. In the health care sector, due to the 24h service, large variety of skills and scarce personnel, problems can be even harder to solve. Particularizing to the staff scheduling at emergency medical services the aforementioned aspects are combined with a pool of personnel shared between disperse locations. To address this problem, an integer programming model that assigns staff to tasks and shifts of each day in the planning horizon in a cyclic manner is presented. This model aims to maximize the quality of the final schedule (in terms of coverage and team changes), maximize the overall fairness (by balancing personnel working hours and incomplete weekends), and also minimize the total cost (considering the total amount of extra hours and incomplete weekends). These objectives are combined in a weighted sum objective function. Apart from contractual constraints, the training hours in each service are considered. To lower the solution time, an heuristic generated initial solution is provided to the model. This methodology is applied to the Portuguese emergency medical service case and tested both in real instances and instances inspired by the real case.

2. **New developments of cost sharing research in health care**
   Christine Huttin

   The talk presents the development of a model on economics of medical decision making;it uses the milestone on impact of cognitive cost cues on judgement and choices (Huttin,2017). The domain mainly comes from behavioral economics, is used in policy for nudges (Thaler&Sunstein,2008). Applications in Cost sharing research may be used by behavioral insight teams for payers in health policies. This presentation continues methodological steps in several ways. It explores how recent advances of economic axioms (Csato,2019) can contribute to consistency of physicians' choice models (Huttin,2018), it provides random experiments on prices for mixed logit models and results with control of heterogeneity of preferences using the specification tests from Han,Hausman&Lustig(2020). Some usercases include patients and physicians' judgments. The conceptual framework also starts to incorporate elements of Strand II of behavioral economics (Hoff&Stiglitz,2016). It enlarges the research domain from psychology to sociology and anthropology and from the "quasi-rational" decision maker to the "enculturated actor". This step uses previous qualitative focus groups on physicians and patients in the EU, USA and Canada, some studies on narratives networks (Smith,2008), especially applied to medical judgment and World Bank reports. The incorporation of sociological and cognitive knowledge into the economic model can contribute to better capture heterogeneity of choices in different contexts.

3. **Use cases for an integrated Simulation and Optimisation Environment for Blood Supply Chains**
   Dennis Horstkemper, Adam Widera, Melanie Reuter-Oppermann, Michael Middelhoff

   Blood supply chains are complex networks of independent actors comprising the collection, separation, testing and transfusion of blood products. A limited availability of blood donors and a mismatch of the available and required blood products combined with the complexity of the network make planning and controlling a blood supply chain difficult. These issues are further emphasised in times of crisis, like epidemics or natural hazards, which impose further challenges during the collection and distribution of blood products. We propose a simulation-based optimisation environment to provide decision support for blood supply chains emphasising crisis management. Unlike previous research, we hereby make use of a hybrid discrete-event and agent-based simulation to enable a better representation of the independent actors with their own planning processes and to model the emergent effects caused by a crisis. In this talk, we want to discuss several use cases based on a case-study for the South-African blood supply chain, including the dynamic demand dependent positioning of mobile donation centres and the usage as well as location of smart fridges.

4. **Hybrid Modeling of Spread of Anxiety due to Virus Infection**
   Leonidas Sakalauskas

   The research aims to develop a hybrid model of pandemic anxiety dynamics, calibrated through indirect social anxiety indicators, and to apply it to the analysis, forecasting and management of anxiety and related panic scenarios.
   The developed model combines agent modeling, dynamic systems modeling with differential equations and machine learning methods. The spread of anxiety and panic associated with fear of contracting a viral disease is a characteristic feature of pandemics. From the point of view of cognitive anxiety theory, an important part of the anxiety mechanism is the stimuli that trigger it, which become negative information that spreads in the social space. Because direct investigation of the prevalence and spread of anxiety and related panic is a complex task, coronavirus morbidity data and data on indirect anxiety indicators are used to calibrate and verify the developed model, which will be processed by machine learning algorithms.
   One of the possible reflections of public anxiety is the comments of Internet users' daily newspaper articles, social network posts, the dynamics of creating user groups. Sentence analysis will identify and extract subjective information about anxiety from the media and personal text entries and comments published in electronic sources.
   In this way, the application of machine learning methods would help to identify additional variables and their properties in the development of a hybrid model.

Friday, July 9th

Session 5 - Operating Room Planning

1. **Allocation Scheduling with Resource Synchronization and Uncertain Surgery Durations: A Two-Stage Stochastic Programming Approach**
   Steffen Heider, Daniel Santos, Inês Marques, Jens Brunner

   Scheduling surgeries in a hospital is a challenging task for operating theater managers and surgeons. Many resources, e.g., rooms, surgeons, nurses, anesthetists as well as machines need to be scheduled simultaneously and need to be available at defined times of each surgery. Uncertain time of surgical sub procedures only increases the complexity. In practice,

this problem is usually split in smaller subproblems where specialties are assigned to rooms and necessary resources are attached to a room, allowing specialties to schedule and sequence their surgeries independently. We present a two-stage stochastic programming model using a Benders decomposition approach to minimize idle time, overtime, and cancelled surgeries. We determine the surgery sequence and starting time for each resource including breaks and resource dependent available times, allowing for an individual patient sequence for each resource. We show that we can solve small and medium size instances to optimality.

2. **Simulation of patient flow and surgical block optimization considering bed management in a university hospital**
   Alberto Lacort Burgos, Nadia Lahrichi, Adam Lebrigui

   The project aims to generate an overview of bed utilization in a university hospital based on the hypothesis that patient flow in the emergency department and the operating room are key factors for its management. The objective of the project is to provide tools to ensure efficient scheduling of the operating room and proper bed management. To this end, this project offers two solutions that help decision making: a simulation DES model, which aims to analyze the flow of incoming patients, as well as an optimization model, which generates Surgical Master Schedules accounting for the availability of beds.

3. **Understanding the factors behind the Length of Stay of Non-Elective Surgical Patients: AMachine Learning approach**
   Gustavo Santamaria-Acevedo

   The Length of Stay (LOS), which represents the interval of time between the moment a patient is admitted to the hospital and the moment that the patient is discharged from the hospital, is one of the most widely used indicators in the evaluation of the performance of hospitals and healthcare systems. This indicator is used by medical organizations and healthcare systems as a potential target for quality improvement activities and programs, and the average LOS at a hospital is considered one of the most important quality measures for hospitals and healthcare systems in general.
   The objective of this paper is to develop modelS using methods from Predictive Analytics and Machine Learning to predict the LOS of non-elective surgical patients in the hospital. Random Forest, Support Vector Machines, and Neural Network models, as well as several regression models have been implemented and compared.
   This prediction is deemed as highly important by hospitals and the healthcare agencies (such as the Parisian AP-HP) due to the fact that it will allow for an optimal planning of the patient flow, and a better management and synchronization of the human resources. We use historical data provided by the hospital to build supervised learning models. The development of these models can be quite useful for the decision makers, since currently the hospital does not make a prediction on the patients' LOS.

Session 5 - Hospital and care facility networks

1. **Regionalization of Primary Health Care Units with Multi-Institutional Collaboration**
   Rodolfo Mendoza-Gómez, Roger Z. Rios-Mercado

   We address the problem of locating and upgrading primary health care units (HCU) within a multi-institutional public system. The problem is motivated by a real-world application in the Mexican Health Care System. Decisions also involve allocating customer demand to HCUs with the goal of minimizing the total travel distance in a capacitated facility location problem.

The capacity is measured in units named basic kernels composed by a group of medical staff for outpatient services. A mixed-integer linear programming model is proposed. A computational study based on a real-world case in the State of Mexico is carried out. Test instances are successfully solved by the branch and bound. The distribution of patient-to-health care unit distances and the variation of the capacity utilization rate of HCUs are analyzed. Among the results, we found that the total travel distance had an average improvement of up to 32% when the capacity is shared between institutions. Some parameters such as the kernel capacity and the minimum allocated demand at each facility could help to balance the workload between HCUs, but this outcome has a negative impact on the total travel distance. On average, 91% of demand travels less than 10 kilometers to its HCU and 99% less than 20 kilometers in the computed solutions. These results open the opportunity of using OR tools in the planning of health care resources in developing countries to face the challenges of the next decade in health care matters.

2. **Multi-channel Chronic Patient Care in a Performance-based Reimbursement Framework**
Mete Ozbek, Hessam Bavafa, Evrim Didem Gunes, E. Lerzan Ormeci

We model and analyze the Comprehensive Primary Care Plus (CPC+) reimbursement system that was recently introduced by the Centers for Medicare & Medicaid Services. Our model includes a primary care practice (PCP) as a profit-oriented service provider with limited capacity. PCP employs multiple channels of care in handling demand of patients with chronic conditions to maximize its revenue in the existence of additional financial incentives. We analyze the operational decisions of the PCP, in particular the panel size and time allocated to different channels, under CPC+ and investigate conditions under which CPC+ could encourage the PCP to improve the quality of care for chronic patients.

3. **Modelling the Regional Hospital Network using Big Data and Discrete Event Simulation**
Davide Duma, Roberto Aringhieri

Awareness of the usefulness of data collection has recently increased in health care organisation, making available large amounts of detailed information that allow the exploration of new methodologies in the field of operations research and management science.
The availability of homogeneous data on hospital stays at regional level leads to perfectly identify the patient flow within the hospital network. This allows us to model the entire health care system with a discrete event simulation (DES) model, replicating the patient path at a fine-grained level. The use of such a methodology is motivated by several advantages over the adoption of a more common system dynamic model, such as avoiding high-level assumptions to address the lack of information and evaluating fairness criteria that capture the discomfort of the single patient.
We present a DES model that exploits the health care big data collected by Regione Piemonte in Italy, about more than one million (and a half) of accesses in the hospital network, including the involved facility and specialty, the period of the stay, and her/his city of residence. Such a model is used to analyse the impact of different policies for the re-addressing of patients following the closure of several facilities, taking into account efficiency and fairness objectives and observing different performance indices.

Discussion Session 4

1. **Estimating the impact on inventory of implementing pathogen reduced platelets in Canada**
   John Blake

   Pathogen reduction (PRT) is a technology for improving the safety of blood products. In this study, we focus on running a dual product inventory for pooled PRT platelets and non-PRT treated apheresis platelets, each having different shelf lives.
   A simulation model was built to evaluate the impact of applying PRT to pooled platelets. Experiments were conducted to determine the impact on collection, production, and distribution of both pooled platelets and apheresis platelets following the implementing of PRT.
   Pooled platelet waste and shortages increase as pooled shelf-life decreases. Shortages of apheresis platelets increase as the shelf life of pooled units decreases, but apheresis waste declines as pooled shelf-life decreases, since apheresis units can be substituted for pooled demand.
   To sustain patient service levels, an experiment was conducted using increased levels pooled and apheresis platelet collections. These results suggest it is necessary to collect 15% more platelet units (either pooled or apheresis or both) to maintain customer service levels.
   The implementation of PRT technology will result in a decrease in the shelf-life for pooled platelets. Simulated experiments reflecting the implementation of PRT in the Ottawa region show that collections must increase by 15% above nominal demand to preserve product availability. System wide wastage of platelets following PRT implementation is estimated at 18%.

2. **Birth practices: a website for future parents , initiated by regional health authority in Ile de France (IDF) region**
   Catherine Crenn-Hebert, Claudie Menguy, Lucas Anzelin, Joana Da Costa, Matthieu Hanf , Marina Martinowsky, France Artzner

   IDF regional information system in perinatal health was mainly used for professionals practices evaluation. The aim is now to provide data easier to read and to understand, taking into account patient centricity. Method: A working group of perinatal professionals, data scientists and patient representative association conducted by a UX - Design Agency, selected childbirth indicators and explained them with the help of an illustrator during virtual meetings over a 9 months period in 2020-2021. The regional health digital agency team already producing the data , has developed the website for smartphone. Results: Five main birth practices are explained (spontaneous or assisted vaginal delivery, caesarean section, episiotomy, epidural analgesia), as well as median value in IDF maternity units and metropolitan France. Indicators are practices rates among identified populations of women: with first pregnancy or following births, simple or multiple pregnancy, breech or vertex presentation. Maternity units are geolocated. Other criterias for selection are their neonatal care level or for-profit private/public status. Discussion-Conclusion: Maternity units benchmarking was considered as not appropriate by some professionals when we showed them the web-site. The information is shared to satisfy transparency demands, to promote women empowerment and to facilitate discussion with their perinatal care providers. The communication campaign for women will begin soon.

3. Application scenarios and optimisation approaches for first responder apps
Melanie Reuter-Oppermann

The recently started research project SPELL, funded by the German Ministry for Economic Affairs and Energy, aims at developing and initiating a platform that provides decision support to coordination centres in case of a crisis or (natural) disaster. The platform will offer different types of AI-based services including intelligent dashboards, chatbots as well as forecasting, optimisation and simulation approaches for addressing planning problems on all three planning levels.
Within this project, we will also integrate an open source first responder app into the platform. Worldwide, already many different apps exist that send first responders to out-of-hospital cardiac arrests, for example. When a mass casualty incident occurs, many resources from the emergency medical service (EMS) system are deployed, potentially leading uncovered areas. Then, first responders or other pre-EMS services can be especially important to provide first aid to patients in case of a medical emergency.
In this talk, we want to discuss application scenarios for first responder apps as well as optimisation and machine learning approaches that could be integrated, for example to predict emergencies, efficiently dispatch first responders to incidents or locate AEDs, transported for example in taxis, busses or drones.

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