

## Tuesday July 17th

09:30 Session 2			
<b>2A Empirical Modeling in Healthcare</b>	<b>2B Patient Flow (1)</b>	<b>2C Operating Room Planning and Scheduling (1)</b>	<b>2D Practical Challenges in Healthcare</b>
<i>Room: Carré 1A</i>	<i>Room: Carré 1B</i>	<i>Room: Carré 1D</i>	<i>Room: Carré 1C</i>
<b>Steffen Bayer (p4)</b> Length of stay for stroke patients: Statistical and simulation analysis	<b>Nelly Litvak (p6)</b> Patient flow analysis	<b>Andreas Fügener (p8)</b> Behavioral aspects of operating room planning	<b>Daniëlle Ekkel (p10)</b> Simulation based optimization of the operating theatre program
<b>Evin Uzun Jacobson (p4)</b> Causes of delays in hyper-acute stroke care	<b>Izabela Komenda (p6)</b> A model of CCU activities through queueing theory	<b>Inês Marques (p8)</b> Planning elective surgeries in a Portuguese hospital using a genetic heuristic	<b>Brecht Cardoen (p10)</b> Grouping of medical disposable items into custom packs: A mathematical programming approach
<b>Jeroen Beliën (p5)</b> Factors causing non-surgical time in a parallel surgery and anaesthesiology setting	<b>Jonathan Helm (p7)</b> Discharge planning to mitigate hospital congestion and bed block	<b>Sebastian Rachuba (p9)</b> A robust approach for scheduling in healthcare considering multiple objectives	<b>Michel Kats (p10)</b> Tactical planning in ZGT Almelo/Hengelo
<b>Hassan Baalbaki (p5)</b> Fitting multiple distributions in multiple risks situations: Impact on health economic evaluations	<b>Kiok Liang Teow (p7)</b> Systems dynamics modelling for specialist outpatient flow	<b>Fabrizio Sperandio (p9)</b> Optimization via simulation: An approach to the operating room scheduling problem	<b>Maartje Zonderland (p11)</b> Variations in the patient care process at the emergency department: Development and implications of an observational instrument
11:00 Coffee/Tea			<i>Room: Foyer Waaier</i>
11:30 Session 3			
<b>3A Healthcare Policy Modeling (1)</b>	<b>3B Patient Flow (2)</b>	<b>3C Home Care</b>	<b>3D Interaction between OR and Ward: From Theory to Practice</b>
<i>Room: Carré 1A</i>	<i>Room: Carré 1B</i>	<i>Room: Carré 1D</i>	<i>Room: Carré 1C</i>
<b>Penelope Mullen (p12)</b> Are numbers still killing people: And what is being done about it?	<b>Paolo Tubertini (p14)</b> Health planning via discrete event simulation: A breast screening case study	<b>Thierry Garaix (p16)</b> Consistent home health care service	<b>Peter Vanberkel (p18)</b> Implementing algorithms to reduce ward occupancy fluctuation through advanced planning

<p><b>Leonid Churilov (p12)</b> Can minutes really save years? Simulation modelling for understanding the effect of fast and appropriate access to stroke thrombolysis on functional outcomes and long-term stroke burden</p>	<p><b>Sylvia Elkhuizen (p14)</b> An operational model for comparison of health services for diabetes II between six countries</p>	<p><b>Ettore Lanzarone (p16)</b> A robust programming model for the assignment problem in home care services</p>	<p><b>Edgar de Groot (p18)</b> Linking the OR block plan with bed utilization: From model to implementation</p>
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<p><b>Abdur Rais (p13)</b> New insights on integer-programming models for the kidney exchange problem</p>	<p><b>Yasar Ozcan (p15)</b> Assessing the impact of organizational changes in clinical pathways</p>	<p><b>Bushra Bashir (p17)</b> The nurse-patient assignment problem in home care</p>	<p><b>Renske Visser (p18)</b> A model to reduce ward occupancy fluctuation through advanced planning: From theory to practice</p>
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<p><b>Msugh Moses Kembe (p13)</b> Combining high tech with human touch by doctors at Federal Medical Centre Makurdi</p>	<p><b>Bernadetta Addis (p15)</b> Clinical pathways: Insights from a multidisciplinary literature survey</p>	<p><b>Hanane Allaoua (p17)</b> Combining routing and rostering for the home health care problem</p>	<p><b>Bernd van den Akker (p18)</b> Using operation research in real life hospital capacity management</p>
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13:00 Lunch *Room: Foyer Waaier*

14:00 Keynote Talk 3 *Room: Waaier 2*  
**Wim van Harten (p19)** Translating operations research methods into hospital practice; evidence base and factors influencing optimal use

14:30 Discussion Session *Room: Waaier 2*  
**A panel consisting of both academics and practitioners (p19)** Applying OR models in healthcare practice: Is there need for more advanced models?

15:30 Coffee/Tea *Room: Foyer Waaier*

16:00 Session 4

<p><b>4A Healthcare Policy Modeling (2)</b></p> <p><i>Room: Carré 1A</i></p>	<p><b>4B Stochastic Modeling (1)</b></p> <p><i>Room: Carré 1B</i></p>	<p><b>4C Operating Room Planning and Scheduling (2)</b></p> <p><i>Room: Carré 1D</i></p>	<p><b>4D Implementing Scheduling Budgets: From Theory to Practice</b></p> <p><i>Room: Carré 1C</i></p>
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<p><b>Marion Rauner (p20)</b> Prevention programs for occupational injuries: Cost analysis and targeted resource allocation</p>	<p><b>Adele Marshall (p22)</b> Discrete conditional phase-type models for representing patient activity in accident and emergency</p>	<p><b>Sara Ceschia (p24)</b> Patient admission scheduling with operating room constraints</p>	<p><b>Egbert van der Veen (p26)</b> Optimal staffing under annualized hours</p>
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<b>Tracey England (p20)</b> Demonstrating the benefit of OR in maximising the use of existing health related data for the Welsh Government	<b>Dawid Kozlowski (p22)</b> Use of queue modelling in the analysis of elective patient treatment governed by a maximum waiting time policy	<b>Guoxuan Ma (p24)</b> Case mix and capacity planning: An application in a Belgian hospital	<b>Martin Woudstra (p26)</b> Controlling workforce scheduling budgets using decision support
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<b>Michael Carter (p21)</b> Crossing the OR-policy gap: System dynamics of cross-sector patient flows	<b>Greggory Schell (p23)</b> Optimal treatment policies for risk-averse patients with limited resources	<b>Manisha Rathi (p24)</b> Predicting hospital resource utilization: A fuzzy regression approach	<b>Paul Trossèl (p26)</b> Implementing workforce scheduling budgets: A case study
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<b>Teresa Cipriano Rodrigues (p21)</b> Cognitive maps in healthcare: An analysis of reported applications	<b>Shirin Geranmayeh (p23)</b> Bed allocation using a generic Markov model	<b>Luiz Guilherme Nadal Nunes (p25)</b> Analyzing the use of hospital resources: Applying mathematical programming
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18:00 Barbecue (if registered)

**1 - Length of stay for stroke patients: Statistical and simulation analysis****TUE-2A***Steffen Bayer (Imperial College Business School)**Evin Uzun Jacobson, James Barlow*

Tuesday 2A | 09:30 - 11:00 | Carré 1A

We have analysed the length of stay for stroke patients in Scotland. Based on the analysis of a large data set which covers all stroke patients in Scotland (the Scottish Stroke Care Audit - SSCA), we investigated the factors that influence length of stay and explored scenarios of different policy options using discrete event simulation.

A considerable variation between hospitals as well as a reduction in the LOS of stay for stroke patients which can be observed for stroke patients over the last 5 years, particularly in hospitals which were previously having long LOS can be observed. Our statistical analysis shows that a reduction in the pre-stroke unit length of stay (Pre-SU LOS), that is, how fast a patient is admitted to a stroke unit where he or she can receive specialized stroke care explains to a large extent the reduction in overall LOS.

The simulation analysis considers in addition to LOS of stay performance measures such as thrombolysis rates, average door to needle times, time to admission to specialized care (stroke unit), the average percentage of time spent in stroke unit in order to develop policies which improve overall performance while reducing length of stay. ARENA simulation software is used for modelling and output analysis.

**2 - Causes of delays in hyper-acute stroke care****TUE-2A***Evin Uzun Jacobson (Imperial College Business School)**Steffen Bayer, James Barlow*

Tuesday 2A | 09:30 - 11:00 | Carré 1A

Stroke care delivery is time-critical because urgent imaging of the brain is required in order to identify the patients eligible for thrombolysis which can only be given within a short period after the stroke. The analysis aims to develop a better understanding of hospital delays leading to delayed scanning and diagnosis. We examine both the factors influencing the overall tPA rate as well as the door to needle time. We have analysed the Scottish Stroke Care Audit (SSCA) data that covers all stroke patients in Scotland. A significant relationship exists between delays in the patient pathway and patient characteristics.

We perform a multilevel regression analysis on hospital admission to brain scan times that controls for the case mix and hospital effects (which includes the organisation of hyper-acute stroke care) as well as other patient and hospital level factors such as the thrombolysis rate and the stroke unit bed utilization rate of the admitting hospital and whether the patient arrives within 4 hours of the onset of stroke and within regular work hours.

Among hospitals there are significant differences. Some hospitals (admitting about a quarter of patients) scan at least 80% of those patients arriving within one hour of the onset of stroke that fast enough to be considered for thrombolysis while other hospitals (also admitting about a quarter of patients) manage to achieve this only for about 40% of patients. Hence, if the rest of hospitals perform similarly to the best performing hospitals a significant improvement would already be achieved.

### **3 - Factors causing non-surgical time in a parallel surgery and anaesthesiology setting**

**TUE-2A**

*Jeroen Beliën (Hogeschool-Universiteit Brussel)*

*Liesje de Boeck, Jan Colpaert, Michel Meulders, Annabel Sels, Jan Mulier*

Tuesday 2A | 09:30 - 11:00 | Carré 1A

Operating room efficiency can be measured in terms of non-surgical time, i.e. the time between the finishing of a surgery and the start of the incision of the next patient. The induction process often represents an important part of this non-surgical time. Even in a parallel setting, in which a succeeding patient is already induced in a separate induction room before the preceding patient has left the operating room, non-surgical time can still occur due to poor patient sequencing. By analyzing 18000 records of surgeries performed in the AZ Sint-Jan Hospital (Belgium), we identify the main factors explaining a patient to cause non-surgical time in a parallel induction surgery setting. We relate our findings to the concept of artificial variability in hospitals. The results provide interesting insights for improving the operating room schedules.

### **4 - Fitting multiple distributions in multiple risks situations: Impact on health economic evaluations**

**TUE-2A**

*Hassan Baalbaki (University of Sheffield)*

Tuesday 2A | 09:30 - 11:00 | Carré 1A

Cost effectiveness studies are used to assess different health interventions in order to provide the most efficient health care taking into consideration budget limitations.

Clinical trials and cost effectiveness analysis are complementary, as the effectiveness data extracted from the trials and then extrapolated over the lifetime of patients, in the cost effectiveness models.

In the vast majority of health economic models, fitting a single distribution into survival functions and risk events would be sufficient. However we believe that for certain complex interventions especially for patients diagnosed with chronic long term conditions, the risk function and the survivability data cannot be reduced to a single distribution. Therefore, the aim of this paper is to study the impact of such reduction on the final outcomes of cost effectiveness studies.

A practical case of patients diagnosed with heart failure and admitted to hospital after a medical event, is illustrated in this paper. In this case, we believe that the risk of death is implied by two distributions: (i) the risk due to the hospital admission and medical event (ii) risk due to the long term medical conditions i.e. the heart failure. The first risk is believed to be more pronounced but for a shorter time frame, however the second distribution is less pronounced but more consistent on the long term.

**1 - Patient flow analysis****TUE-2B**

*Nelly Litvak (University of Twente)*  
*Niek Baer, Nikky Kortbeek*

Tuesday 2B | 09:30 - 11:00 | Carré 1B

In this talk, we present a quantitative analysis for patient flows in pain rehabilitation, based on a case study in the rehabilitation center 'Het Roessingh', The Netherlands. In order to tackle its organizational challenges, such as long waiting lists and high working pressure on the practitioners, Het Roessingh is introducing the concept of 'treatment plans'. Treatment plans specify the required treatment for specific groups of patients with the same diagnosis during a period of several weeks or months. The models developed in this study will support Het Roessingh to gain insight in the behavior of their care chain, once the treatment plans are introduced. In particular, we evaluate: the number of intakes needed per week; the capacity loss as a result of cancellation of interdisciplinary meetings, during which patients can be discharged; the capacity requirements per discipline as a result of patient flows induced by treatment plans. Next, we propose a staffing policy that ensures short waiting times and balanced load across the disciplines. The methods and analyses presented in this talk are based upon Operations Research techniques. The analysis enables us to advise Het Roessingh on the optimal system configuration of the treatment plan based care chain and to derive rules of thumb that can be applied in its design and control.

**2 - A model of CCU activities through queueing theory****TUE-2B**

*Izabela Komenda (Cardiff University)*  
*Jeff Griffiths, Vincent Knight*

Tuesday 2B | 09:30 - 11:00 | Carré 1B

The random behaviour of arrivals and lengths of stay within a Critical Care Unit (CCU) make for a complex system. As such, dealing with the growing constraints on the healthcare system at the acute level is difficult. In this study queueing theory is used to develop a new mathematical model of patient flow. Predictions from the model are compared to the observed performance of the Units in the real world, and the sensitivity of the model to changes in Unit size is explored. We also propose a queueing network model of two CCUs to study the effect of patient diversion. We further model the network as a non cooperative game where each CCU aims to have a utilization rate below 80% and chooses its diversion threshold based on the number of beds occupied. Four different models are considered and the effect of targets, demand and capacity are studied.

### **3 - Discharge planning to mitigate hospital congestion and bed block**

**TUE-2B**

*Jonathan Helm (Indiana University)*

*Rene Bekker, Mark van Oyen*

Tuesday 2B | 09:30 - 11:00 | Carré 1B

Bed block in hospitals leads to long waits in Emergency Department, patients being placed in the hallways on stretchers, poor quality of care, high costs and mortalities. The timing of discharges from inpatient beds significantly impacts bed block. This research models the census as a function of the controllable components of the discharge process. The purpose is to understand how the hospital can better manage the discharge process to avoid the prevalent midday congestion that leads to bed block. To do so we analyze a stochastic process of hospital census and examine the efficacy of different approaches to modifying the discharge process in terms of reduced peak occupancy levels and bed block. Some key measures we consider include the timing of discharge processing by medical professionals, the speed of exiting a bed, and the availability of hospital resources required for a successful discharge (e.g. pharmacy, rehab, etc.).

### **4 - Systems dynamics modelling for specialist outpatient flow**

**TUE-2B**

*Kiok Liang Teow (National Healthcare Group)*

*Jamie Mervyn Lim, Kannapiran Palvannan*

Tuesday 2B | 09:30 - 11:00 | Carré 1B

Patient flow is complex due to multiple flows between service points, demand and supply variability, and delay. This work studies capacity planning for Specialist Outpatient Clinics (SOC). SOC see patients referred from within hospital, including accident and emergency, inpatient discharges and inter-specialty referrals. It also receives external referrals from public and private primary care, and some walk-ins. Operational issues include: (i) first visits (FV) attendances needing one or more repeat visits (RV) before discharge; (ii) patients defaulting appointments and may be rescheduled; (iii) a triaging system allowing more acute patients to be seen earlier.

We look at two hospital measurements that track and plan SOC resources. One is total RV to FV attendances ratio. This guides clinics to plan relative number of FV and RV sessions. Many equate this ratio to an average patient pathway ratio as it measures the number of follow-up that each patient will need. Another is Appointment lead time, measuring time from FV request to appointment. This is a proxy indicator of accessibility.

We use system dynamics to map and simulate SOC flow using administrative data. We show that RV-FV ratio is useful but needs to be interpreted carefully as it does not consider capacity constraints, patient acuity, appointment lead time, or even how funding mechanisms can affect medical practice. Our simulation also suggests that feedback mechanism exists and stabilises FV lead time. When FV lead time is seen in isolation, this mechanism may mask the need for sustained capacity building.

**1 - Behavioral aspects of operating room planning****TUE-2C**

*Andreas Fügener (Technische Universität München)  
Sebastian Schiffels, Rainer Kolisch*

Tuesday 2C | 09:30 - 11:00 | Carré 1D

Planning surgeries is a critical task in operating room management. On the one hand, operating rooms are bottleneck resources which need to be utilized efficiently. On the other hand, overtime for employees caused by tight schedules should be avoided. Both, planning with too long and too short time estimates for operations, lead to additional costs. These costs are defined as operating room inefficiency in the literature. Examples for operating room inefficiency are idle time when planning with too long time estimates and overtime or rescheduling of surgeries when planning with too short time estimates. The overall objective is to minimize the expected value of operating room inefficiency due to the uncertain duration of surgeries. Most literature on operating room planning assumes rational behavior. However, behavioral studies have shown that decision makers deviate from rational behavior in real life. We set up an experimental study where surgeons were asked to schedule a set of operations with uncertain durations. We find systematic deviations from optimal decision making. We give a detailed analysis of the scheduling behavior of the surgeons and provide explanations. Even in a simplified environment the scheduling behavior of surgeons is inefficient and leads to avoidable costs.

**2 - Planning elective surgeries in a Portuguese hospital using a genetic heuristic****TUE-2C**

*Inês Marques (Universidade Lusófona de Humanidades e Tecnologias)  
Maria Eugénia Captivo, Margarida Vaz Pato*

Tuesday 2C | 09:30 - 11:00 | Carré 1D

Reduced budgets in the healthcare sector pressure health institutions to an efficient use of resources. The operating theatre is a hospital unit that represents a great proportion of the hospital budget. Furthermore, it is a central service with connections and implications in the service of many other hospital units. A more efficient use of the operating room becomes of great relevance within the hospital administration. This work provides therefore a contribution using operational research to the guideline of improving the efficient use of hospital resources by proposing a methodology for the elective surgery planning problem in a public hospital in Lisbon. The objective is to maximize the usage of the surgical suite.

A genetic heuristic is proposed and applied to real data from the studied hospital. The solution representation is a Days x Rooms chromosome. Each gene represents the surgical specialty that is assigned to each room and day. The chromosome decoder uses heuristic procedures to build a solution. An elitist chromosome is included in the initial population. The algorithm uses a multi-point crossover and replacement is generational. This approach proved to be very fast, provided good quality solutions and improved the solutions obtained with previous solution approaches to this problem.

At the talk, the genetic algorithm developed will be presented and the results of its application to real data from the hospital will be discussed and compared with results obtained with previous approaches, namely an integer linear programming methodology and simple heuristics.

### **3 - A robust approach for scheduling in healthcare considering multiple objectives**

**TUE-2C**

*Sebastian Rachuba (Ruhr University Bochum)  
Brigitte Werners*

Tuesday 2C | 09:30 - 11:00 | Carré 1D

The allocation of limited resources in hospitals is a challenging task as stochastic influences have a major impact on the final allocation. Therefore, uncertainties of treatment durations and of emergency arrivals have to be taken into account explicitly. Besides, we focus on different decision-makers objectives which we consider separately. A scenario-based multi-objective mixed-integer optimization model is presented in order to integrate the aforementioned aspects. We suggest a robust approach based on different scenarios to ensure that the resulting schedule is feasible. Information on stochastic parameters should be integrated into the planning model in order to avoid re-scheduling during the planning period. Thus, the final schedule can be communicated e.g. to surgeons and patients at an early stage which is beneficial for a smooth care-process. Additionally, we explicitly consider the interests of several stakeholders, e.g. patients, staff and management. These interests can be represented using different objective functions which aim at maximizing / minimizing their individual goals. As the individually optimal solutions for the different stakeholders are likely to differ we aim at identifying a good compromise solution. Thus, we focus on several concepts in order to balance the individual interests with respect to a robust solution. These concepts for a compromise schedule are evaluated in a case study using real-world data from a German hospital. We compare different compromise schedules with respect to several performance criteria according to various stakeholders preferences and evaluate the presented concepts.

### **4 - Optimization via simulation: An approach to the operating room scheduling problem**

**TUE-2C**

*Fabrcio Sperandio (Universidade do Porto)  
Bernardo Almada-Lobo, José Borges*

Tuesday 2C | 09:30 - 11:00 | Carré 1D

The Operating Room (OR) has a strong impact on key hospitals financial and social indicators. Nowadays, governments are cutting healthcare budget, while on the other hand, surgical waiting times are rising due to aging population and better access to surgical treatments. In this context, there is an urgent need for appropriate management tools to face such challenges. OR surgery planning & scheduling problems have combinatorial and stochastic features. The combination of both demands a high computational cost, leading researchers to build simplified models, often neglecting the effects of uncertainty. However, once addressing the uncertainty arising in healthcare management problems, computer simulation is considered to be the most suitable tool. Moreover, recent advances in computer power allow simulation models to be optimized. This work presents preliminary results of the development of an Optimization via Simulation (OvS) approach to the OR scheduling problem at the operational level. OvS approaches differ from deterministic optimization approaches since the objective function cannot be measured precisely, but only estimated, requiring a high estimation cost. Our approach tackles this issue with two distinct features: (1) statistical ranking & selection procedures and (2) metamodels based on neural networks. Both features are integrated into the search procedure aiming to improve efficiency, while reducing the number of replications required to estimate performance and ensure statistical validity. We aim to develop a decision support system able to proactively manage the impact of uncertainty on schedules performance measures, thus helping decision makers to reduce costs, as well as surgical waiting lists.

**1 - Simulation based optimization of the operating theatre program****TUE-2D***Daniëlle Ekkel (ZGT Almelo / Hengelo)**Martin Leferink, Jasper Quik, Michel Kats, Erwin Hans*

Tuesday 2D | 09:30 - 11:00 | Carré 1C

We present a research project of the hospitals from Ziekenhuisgroep Twente in collaboration with CHOIR/University of Twente, regarding the optimization of the operating theatre planning, using an extensive operating theatre modeling and simulation software developed by CHOIR/University of Twente. We present the software used, the outcomes of the analyses made, and resulting operating theatre planning interventions.

**2 - Grouping of medical disposable items into custom packs: A mathematical programming approach****TUE-2D***Brecht Cardoen (Vlerick Leuven Gent Management School / KU Leuven)**Jeroen Beliën, Mario Vanhoucke*

Tuesday 2D | 09:30 - 11:00 | Carré 1C

Custom packs group medical disposable items into a single sterile package that is used for surgical procedures. Although custom packs constitute a well-known concept in the hospital setting, little is known on methodologies to configure them, especially if the number of medical items, procedures and surgeons is large. We propose a mathematical programming approach to guide hospitals in developing or reconfiguring their custom packs. In particular, we optimize the configuration process so that human contact of materials, the number of configured packs and the cost of waste is optimized. We develop an intuitive integer non-linear programming model which we eventually linearize and apply to real data of a medium-sized Belgian hospital. We report on the crucial data gathering phase and the problems we encountered in retrieving accurate information. A computational experiment compares the optimized results with the performance of the current configuration settings and indicates how to improve the custom pack usage. Multiple scenarios are listed and evaluated, such as the development of surgeon-specific or discipline-wide custom packs. We point at some interesting insights that can be taken up by the hospital management to guide the configuration and accompanying negotiation processes, both internally (surgeons) and externally (vendors).

**3 - Tactical planning in ZGT Almelo/Hengelo****TUE-2D***Michel Kats (ZGT Almelo / Hengelo)**Jasper Quik, Manon Bruens*

Tuesday 2D | 09:30 - 11:00 | Carré 1C

The hospitals from Ziekenhuisgroep Twente are aligning supply and demand by an innovative tactical planning concept. This encompasses frequent gathering of information about recent capacity utilisation, access times, and demand expectations in the short term. Based on this inventory, operating theatre capacity is reallocated, and waiting lists are reduced, and under-utilisation is avoided. This presentation addresses the pitfalls and success factors for the implementation of 'tactical planning'.

**4 - Variations in the patient care process at the emergency department:  
Development and implications of an observational instrument**

**TUE-2D**

*Maartje Zonderland (University of Twente / Zonderland ZorgLogistiek)  
Daisy Koks, Christian Heringhaus*

Tuesday 2D | 09:30 - 11:00 | Carré 1C

In this talk we discuss the development and implications of an observational instrument, designed to evaluate treatment routines at an Emergency Department (ED). The instrument divides all different types of activities a doctor can perform at an ED into eight categories. In 2010, a pilot study with the instrument was carried out at the ED of Leiden University Medical Center. All physician activities were registered on a minute-to-minute base by an independent observer. Ten doctors were observed during a total of 36 hours in which 42 patients were seen. Although emergency physicians were observed for a shorter period of time than internists, they saw more patients. Emergency physicians tended to have more patient contact time than internists, but both groups dedicated most of their time to documentation and had little communication with emergency department nurses. The average LOS of internal patients was significantly higher than for the patients of emergency physicians. By protocol, patients at the Emergency Department (ED) who are seen by emergency physicians are treated one by one, resulting in a more or less serial treatment routine. Physicians from other departments tend to see more patients at the same time (parallel treatment routine), and thus occupy more treatment rooms simultaneously. We suspect that the parallel treatment routine is related to a longer patient LOS and suboptimal ED logistics. In a succeeding study we will mathematically compare the advantages and disadvantages of serial and parallel treatment routines at the ED.

**1 - Are numbers still killing people: And what is being done about it?****TUE-3A***Penelope Mullen*

Tuesday 3A | 11:30 - 13:00 | Carré 1A

A paper presented earlier at ORAHS - Killing by numbers: Can it be ethical for quantitative analysis to result in avoidable death? - argued that pursuit of the superficially-attractive and apparently-scientific objective of health-gain maximisation had resulted in potentially life-saving or life-prolonging treatment being denied because it is deemed to cost too much per QALY (ie exceeds a pre-determined cost/QALY threshold). It then asked whether this could lead to compulsory euthanasia for those whose cost-per-QALY is deemed too high? None of the ethical arguments explored demonstrated convincingly that this could not happen. Ensuing papers questioned the appropriateness of adopting health-gain maximisation as a principal objective of health care systems as advocated by many health economists and also implicitly or explicitly by many policy makers in the UK. Those papers also explored what might be appropriate health-system objectives.

Recently some proponents of health-gain maximisation, whilst arguing that providing treatments above the cost/QALY threshold would unfairly deprive others of more efficient health care and so reduce aggregate health gain, have recognised the potential for inequity and adverse headlines resulting from its pursuit. This has led to a number of proposals and policies to attempt to address the concerns.

This paper reviews the debates on the risk of compulsory euthanasia and appropriate health-service objectives, examines the extent to which recent UK (England and Wales) policies and proposals address the various concerns and re-considers the role and dangers of quantification in health care policy and priority setting.

**2 - Can minutes really save years? Simulation modelling for understanding the effect of fast and appropriate access to stroke thrombolysis on functional outcomes and long-term stroke burden****TUE-3A***Leonid Churilov (Melbourne Brain Centre)**Mahsa Keshtkaran, Andrew Flitman, Helen Dewey, Geoffrey Donnan*

Tuesday 3A | 11:30 - 13:00 | Carré 1A

Stroke is the third most common cause of death and the sixth most common cause of disability worldwide. Treating acute ischemic stroke with thrombolysis within 4.5 hours from symptom onset is effective in improving patient outcomes. A need for simultaneous systemic evaluation of multi-factorial interventions in acute stroke care systems, aimed at improving patients outcomes through increasing their eligibility for stroke thrombolysis, is well recognized both in the clinical literature and by stroke services operations managers. To support such evaluation, we earlier developed a simulation model that provides clear measure of the relative benefit of alternative potential interventions in pre-hospital stroke care operations. In this study we improve this model by explicitly linking availability of stroke thrombolysis services, time from stroke onset to arrival to hospital, patients age, gender, and stroke severity, to functional outcomes at 3 months post-stroke and, subsequently, stroke burden measured as disability-adjusted life years. The new model extends across the whole acute stroke care chain and provides a valuable tool for systematic investigation into the relationship between various components of the acute stroke care system. In particular, we use this model to address an important question of whether, given a certain availability of thrombolysis services, fast and appropriate actions immediately after the stroke event results in tangible improvement in disability-adjusted years

of life in the long term. The strengths of the model include its novel across-the-whole-acute-stroke-care-chain nature, as well as firm grounding in contemporary empirical findings in the area of clinical stroke and stroke burden assessment.

### **3 - New insights on integer-programming models for the kidney exchange problem**

**TUE-3A**

*Abdur Rais (University of Minho)*

*Miguel Constantino, Ana Viana, Xenia Klimentova, Filipe Alvelos, Joao Pedro Pedroso*

Tuesday 3A | 11:30 - 13:00 | Carré 1A

In recent years, several countries have set up programs that allow exchange of kidneys between two or more incompatible patient-donor pairs. These programs are commonly known as Kidney Exchange Programs, and the underlying optimization problems are typically modeled as integer programs. However, these previously proposed models have exponential number of constraints or variables, which makes them fairly difficult to solve when the problem instances are large. In this work, we have developed compact models for the problem that have certain advantages over the previous models. We present systematic comparison between our models and the two previous ones via thorough computational analysis. We also highlight advantages and disadvantages of each model and provide results on dominance of some models over others.

### **4 - Combining high tech with human touch by doctors at Federal Medical Centre Makurdi**

**TUE-3A**

*Msugh Moses Kembe (Benue State University)*

Tuesday 3A | 11:30 - 13:00 | Carré 1A

This paper studies the application of diagnosis using high tech at the same time bringing human touch to bear in the process at the Federal Medical Centre Makurdi. The problem of epileptic power supply and the attendant high cost of running generating sets to power the equipment at the medical center have slowed down the use of high tech at the health facility. The technical expertise of many of the doctors at the health facility is inadequate especially that many of these technologies are new inventions alien to them and need to update. It was established that patients are more comfortable with the blending of physical examination with high tech than solely depending on high tech for medical examination and the need for human touch is a matter connected with the psychology of human nature.

**1 - Health planning via discrete event simulation: A breast screening case study****TUE-3B***Paolo Tubertini (Università di Bologna)**Alberto Caprara, Andrea Lodi, Francesca Senese, Roberto Grilli*

Tuesday 3B | 11:30 - 13:00 | Carré 1B

Agenzia Sanitaria e Sociale Regionale of Emilia Romagna, a regional center for innovation and improvement, is trying to understand how OR and DES can be incorporated as new tools for planning decisions, complementary to others already in use. Most of decision support systems used by regional and local health planners face problems from the epidemiological point of view and few studies are focused on dynamic capacity planning. The aim of this work is to study how two different DES software packages can be effectively applied to support tactical and operative decision making processes. In order to show the potential of DES modelling we built a breast screening pathway and we show how this model can predict lead time performance with different capacity settings. We focus our work in 45-49 and 70-74 women age bands inclusion that took place in 2010 showing how simulation can help in understanding how many resources the screening program needs in order to face an increased demand of services. We analyze the screening program with two DES software packages in order to show how different tools can help stakeholders that operate at different decision levels (local vs. regional). We compare our results with the observed performance in order to validate the model with health managers and we discuss if and how simulation tools can be included as organizational tools for their future planning processes.

**2 - An operational model for comparison of health services for diabetes II between six countries****TUE-3B***Sylvia Elkhuisen (Erasmus University Rotterdam)**Mahdi Mahdavi, Tom Bowen*

Tuesday 3B | 11:30 - 13:00 | Carré 1B

The Managed Outcomes project explores the assumption that healthcare outcomes and costs are affected by the efficiency of service production, the time/location constrained regional structure of healthcare delivery, and the degree to which people are empowered to participate in the co-production of their care. The project uses three different complementary research strands to explore the assumption: case instance research, literature review and survey research. The survey and case instance research are performed for four different patient groups in six countries. In the case instance research, we developed a general operational model for comparing demand, health services, resources and costs.

This presentation focusses on the case instance research of the Diabetes Mellitus type II (DM II) care processes. For this patient group a stage model was developed which represents three different stages in the care for DM II patients: life style advice, oral medication and insulin injections. For each of the stages the health services are modelled, using health service elements as building blocks. Resources and costs are linked to these health service elements. The model also includes clinical outcome measures. The model is applied in different regions in the Netherlands, Finland, Spain, and Greece and partly in Germany. A different model with comparable data is applied in the United Kingdom.

### **3 - Assessing the impact of organizational changes in clinical pathways**

**TUE-3B**

*Yasar Ozcan (Virginia Commonwealth University)*

*Elena Tànfani, Angela Testi*

Tuesday 3B | 11:30 - 13:00 | Carré 1B

In this work we focus our attention on the analysis and management of Clinical Pathways (CPs), from an operational point of view, where the CP is "the path" followed by a patient with a given pathology through the health-care system. The study objective is to develop a modeling framework aimed at analyzing the pathway of patients with common acute diseases, and highlighting not only variability but also critical points, bottlenecks, identifying the best organizational model of care and the proper sizing, as well as optimal management of resources. This framework has been applied to a case study for the thyroid surgical treatment using the data collected at a Department of Surgery of a public hospital sited in Genova (Italy).

The model identifies the fundamental activities that make up the CP as an integrated project with many tasks to be executed. Next, the CP has been modeled with a discrete event simulation model in order to discover the critical activities and scarce resources that represent the process bottlenecks both from a patient-centered and facility-centered point of view. The simulation model has been designed to analyze the three main operative areas which the flow of surgical patients within the hospital is decomposed: waiting list management, operating theatre planning and bed ward organization. These operative areas also correspond to the main resources that impact on the CP duration and patient waiting time. Finally, the Optimizer, an optimization module, integrated with Witness simulation environment has been used to identify the best scenario, i.e. to find the configuration of the resources that minimizes the patient waiting time.

### **4 - Clinical pathways: Insights from a multidisciplinary literature survey**

**TUE-3B**

*Bernadetta Addis (Università degli Studi di Torino)*

*Roberto Aringhieri, Elena Tànfani, Angela Testi*

Tuesday 3B | 11:30 - 13:00 | Carré 1B

The Clinical Pathways (CPs), also known as Integrated Care Pathways (ICP), Multidisciplinary pathways of care, Pathways of Care, Care Maps, Collaborative Care Pathways, can be defined as "health-care structured multidisciplinary plans that describe spatial and temporal sequences of activities to be performed, based on the scientific and technical knowledge and the organizational, professional and technological available resources".

The medical literature is very rich and a plethora of papers have been put forward to develop CPs for specific diseases and pathologies. Many studies show that, appropriately implemented, CPs have potential to reduce patient length of stay and limit variability in care, thereby yielding cost savings.

On the contrary, the OR&MS literature focused on giving modelling insights to make CPs operative in the current health service delivery system and improve their impact on the organization, is particularly poor. It seems that no consolidated agreement exists to fine tune clinical CP requirements with the optimal management of resources.

The aim of our work is twofold. Firstly, we analyse the relevant literature on CPs and propose a classification scheme to be used for researchers on this topic that covers the medical, economical and OR&MS area. Secondly, we discuss a general quantitative model to globally approach the analysis of a clinical pathway in such a way to make the clinical point of view, implicit in the CP approach, compatible with economic and managerial requirements and to account the improvements gained by subsystem optimisation.

**1 - Consistent home health care service****TUE-3C***Thierry Garaix (École des Mines de Saint-Étienne)**Dominique Feillet, Fabien Lehuédé, Olivier Péton, Dominique Quadri*

Tuesday 3C | 11:30 - 13:00 | Carré 1D

Last years, assignment and routing optimization of nurses visiting patients have been extensively studied in the context of Home Health Care Services. Such problems are often modeled as rich vehicle routing problems, involving side constraints as time windows. Periodicity of care has also to be considered since patients are to be visited repeatedly along a given time horizon. In this work, we guarantee a consistent service in terms of times of service and nurses. Time-consistency ensures close visiting times on each day for each patient. Such constraints couple days and give a special structure of the underlying optimization problem. We propose an exact solution approach based on column generation and branch-and-price for this problem that we named Time-Consistent Vehicle Routing Problem (TCVRP). We also propose a set of valid inequalities dedicated to the TCVRP. Results demonstrate the interest of this approach compared to using a solver on a compact formulation.

**2 - A robust programming model for the assignment problem in home care services****TUE-3C***Ettore Lanzarone (Consiglio Nazionale delle Ricerche)**Giuliana Carello, Andrea Matta*

Tuesday 3C | 11:30 - 13:00 | Carré 1D

Home Care (HC) includes medical, paramedical and social services which are delivered to patients at their domicile rather than in hospital. Managing human and material resources is a difficult task, because the HC provider has to synchronize the use of resources, to deal with peculiar constraints (e.g., the continuity of care) and to manage the high variability of patients demands.

Under continuity of care, one of the main issues encountered in the planning is the nurse-to-patient assignment. Despite the importance of this topic, the problem is only marginally addressed in the literature, where it is solved adopting the stochastic programming or analytical policies. However, both these approaches proved to be limited, even if they improved the quality of the assignments with respect to those actually provided by HC providers in practice.

In this paper, we develop a robust assignment problem, which allows exploiting the potentialities of a programming model rather than an analytical approach, without the necessity of generating scenarios.

The developed model is finally applied to a relevant HC provider operating in Italy, in order to evaluate its capability of reducing the variable costs related to nurses overtimes, and to compare the results with both the real practice of the analyzed HC provider and the previously developed approaches.

### 3 - The nurse-patient assignment problem in home care

TUE-3C

*Bushra Bashir (Université Blaise Pascal)  
Christophe Caux, Michelle Chabrol*

Tuesday 3C | 11:30 - 13:00 | Carré 1D

Home health care, i.e. visiting and nursing patients in their homes, is a growing sector in the medical service business. In this type of treatment, the care is provided to patients while living at their homes. The care providers e.g. nurses, doctors travel to patients homes. The patients and care providers can be at different geographical positions. Therefore minimizing the travelled distance is one of the important objectives of home care sector in order to save the resources. In this paper, we have solved the problem of assigning patients to nurses in order to reduce the travelled distance (i.e. cost). The new feature that we added to this problem is to consider their geographical positions while doing assignments. The required qualification of nurses is guaranteed via compatibility constraints. A binary integer programming model is formulated to assign the nurses in different periods. This model is solved by LINGO 6.0. Computational tests are performed for different scenarios in order to analyze the tradeoffs among different performance measures.

### 4 - Combining routing and rostering for the home health care problem

TUE-3C

*Hanane Allaoua (Université Paris)  
Sylvie Borne, Lucas Létocart, Roberto Wolfler Calvo*

Tuesday 3C | 11:30 - 13:00 | Carré 1D

Home health care (HHC), i.e., visiting and nursing patients at home, is a growing sector in the medical care system, therefore the problem of how to schedule the health care staffs arises. The objective of this problem is to construct routes and rosters for the staffs by optimizing costs. The patients to be treated may require (possibly) several cares and each one is characterized by a required skill, a treatment duration and an earliest and a latest starting time. Each health care staff is characterized by a skill and by a time window within which the health care staff must leave and return to its home (office). In our problem we also assign health care staffs to a set of shifts. A shift is characterized by a time window and a skill.

Initially we propose an integer linear programming formulation (ILP) and we tested this model on small instances. To deal with larger instances we are developing a matheuristic in which we decompose the ILP formulation into two problems. The first one solves the rostering part of our problem which represents the set partitioning problem. We will solve it with a heuristic approach. The second problem solves the routing part which is equivalent to a shortest path problem with time windows (SPPTW), we will solve the SPPTW using an exact method and the result will be used as data for the set partitioning problem. Some computational results obtained on instances coming from the literature will be presented.

**1 - Implementing algorithms to reduce ward occupancy fluctuation through advanced planning** **TUE-3D***Peter Vanberkel (Dalhousie University)**Richard Boucherie, Erwin Hans, Johann Hurink, Wineke van Lent, Wim van Harten*

Tuesday 3D | 11:30 - 13:00 | Carré 1C

Well-designed surgical schedules which take into account inpatient ward resources lead to reduced cancellations and higher and balanced utilization. A model was developed in conjunction with NKI-AVL to redesign their master surgical schedule which, through better use of ward capacity, allowed an additional operating room to be built without ward expansion. The success of this project served as proof-of-concept for our model which has been applied in several Dutch hospitals. To further disseminate our model, we partnered with Information Builders and developed a commercial version of it. Our model is currently being offered to Dutch hospitals and marketed worldwide.

**2 - Linking the OR block plan with bed utilization: From model to implementation** **TUE-3D***Edgar de Groot (Information Builders / iWay Software)*

Tuesday 3D | 11:30 - 13:00 | Carré 1C

In this talk, Information Builders will show how its Information Management product, Web-FOCUS, can be used to fit in advanced models and algorithms within a ready-to-use system for the operational user. One example of a successful implementation using the software of Information Builders is a model to optimize the relation between the OR block plan and the bed utilization. This work is done in collaboration with the NKI-AVL (Netherlands Cancer Institute - Antoni van Leeuwenhoek Ziekenhuis) and the Centre for Healthcare Operations Improvement & Research (CHOIR) of the University of Twente.

**3 - A model to reduce ward occupancy fluctuation through advanced planning: From theory to practice** **TUE-3D***Renske Visser (The Netherlands Cancer Institute - Antoni van Leeuwenhoek Hospital)*

Tuesday 3D | 11:30 - 13:00 | Carré 1C

In this presentation the NKI-AVL will show how WebFOCUS, the Information Management product of Information Builders, was implemented to improve the bed utilization by alternating the master surgery schedule. To make implementation possible several iterations have been performed in which the model outcomes were validated by comparing them to hospital data and the model was adapted to increase the reliability of the results. Subsequently WEBFOCUS was used to find a surgery schedule that balances the bed utilization on the wards.

**4 - Using operation research in real life hospital capacity management** **TUE-3D***Bernd van den Akker (Isala klinieken)*

Tuesday 3D | 11:30 - 13:00 | Carré 1C

Is there an analogy between weather forecasting and a hospital? How do we translate strategic decisions into daily operation? In this presentation we will discuss the use of academic operation

research results into daily practice. How we support planners, doctors and nurses to create an effective and efficient hospital. The Isala klinieken in Zwolle, is one of the largest non academic hospitals in the Netherlands. We work closely together with the University of Twente and accommodate students in their master project.

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**Keynote Talk 3****Room: Waaier 2****Translating operations research methods into hospital practice; Evidence base and factors influencing optimal use TUE-K3**

*Wim van Harten (The Netherlands Cancer Institute - Antoni van Leeuwenhoek Hospital / University of Twente)*

Tuesday K3 | 14:00 - 14:30 | Waaier 2

In recent years, health care institutions and especially hospitals are challenged by governments and insurance agencies to improve efficiency especially out of concern for the financial sustainability of health care spending. In combination with a growing emphasis on patient centeredness, there is a need for logistic improvement. We increasingly see a tendency to emphasize process improvement, whereas this was so far 'just' an element of quality management, and especially techniques from Operations Research (OR) are explored and used in this field.

However, there seems to be a chasm between the OR field and hospital practice. Groups active on the OR side seldom have direct links to hospitals to experiment with their algorithms or simulations and creating an evidence base, as is often done for costly new technologies, is only at its start. Hospitals have limited access to the relevant knowledge, which is mostly presented to them in relatively easy accessible ways by commercial firms, and knowledge is lacking among hospital leadership on operations management and -research.

In this presentation we will present results from a survey among 17 hospitals in the Netherlands, present our experiences from a number of relevant OR projects in the NKI-AVL in Amsterdam and identify a number of critical factors for both the OR field and hospital leadership to improve the implementation success of OR interventions.

Lastly we will explore the evidence base and suggest actions to improve the evidence in order to more easily convince hospital leadership and clinicians to adopt these techniques.

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**Discussion Session****Room: Waaier 2****Applying OR models in healthcare practice: Is there need for more advanced models?****TUE-DS**

*A panel consisting of both academics and practitioners*

Tuesday DS | 14:30 - 15:30 | Waaier 2

During this plenary discussion session academics and practitioners can discuss the applicability of OR models in healthcare practice. Participants from both ORAHS 2012 as from the symposium 'Operations Research Applied to Health Service: from theory to implementation' take part in the discussion. A panel group will open the discussion, but the audience is welcome to share their opinion.

**1 - Prevention programs for occupational injuries: Cost analysis and targeted resource allocation TUE-4A**

*Marion Rauner (University of Vienna)*

*Michaela Schaffhauser-Linzatti, Johannes Bauerstätter*

Tuesday 4A | 16:00 - 17:30 | Carré 1A

Occupational injuries are a great burden on health care costs worldwide. We develop a detailed decision for support system called cost calculation tool for the main Austrian occupational insurance company (AUVA) that investigates the total direct and main indirect costs of individual injury claims from the time of the incident of all injured individuals up to their death. For example, in the first two years, treatment costs account for about 66%, pension costs for about 12%, and co-payments for sick leave for about 10% of the total AUVA costs. For example, a costly case of the 2010 data is a middle-aged male who had a car accident at work in 2008 and injured his back with costs over 313,000 Euro (pension, treatment, rehabilitation, prosthesis, transportation) for the years 2010 and 2011. However, pension costs are the main cost driver with nearly 50% of total AUVA costs for a lifelong cost-perspective, while treatment costs then only account for less than 15%. We also approximate main costs for the employers and the economy. These calculated costs for the data of the year 2010 are included in the data warehouse of the AUVA and help clustering patients into risk groups according to criteria that most influenced related total costs. AUVA decision makers can now optimally target prevention strategies and better plan for prevention budgets. Based on these insights and former research projects, the AUVA highly focus their prevention strategies on injuries at construction sites, in the forest, and on the road to/from/at workplace.

**2 - Demonstrating the benefit of OR in maximising the use of existing health related data for the Welsh Government TUE-4A**

*Tracey England (Cardiff University)*

*Sarah Lowe, Paul Harper*

Tuesday 4A | 16:00 - 17:30 | Carré 1A

In October 2011, the Welsh Government recruited four Knowledge Transfer Partnerships Research Fellows to investigate how existing administrative and survey data could be used more effectively. The role of the Operational Research fellow was to identify areas within the Welsh Government where OR techniques such as computer modelling and simulation could be used to make use of existing data, highlight data that would be useful in providing policy with evidence, or develop models in a relatively data-free context to aid decision making. Progress with two specific case studies will be discussed:

Case Study 1: Using OR to assess the benefits of using Teledermatology across Wales

Teledermatology is the use of technology (e.g. videoconferencing, store and forward image transfer) in the diagnosis and triage of dermatology patients. The project considers the benefit of using Teledermatology from both the patients and clinicians perspective. A simulation model is developed to represent the clinicians working schedule. A cost-benefit analysis is undertaken to assess the benefit of reduced patient travel distances and costs.

Case Study 2: Using OR to assess the benefits of introducing a Direct Access to a Midwife approach to maternity care throughout Wales

Direct Access to a Midwife is an approach where a pregnant woman goes direct to her midwife (on realising shes pregnant) rather than going to the GP or other health professional.

The project considers the initial pathway of the woman and the effect that Direct Access to a Midwife has on her subsequent pregnancy path and associated outcomes.

### **3 - Crossing the OR-policy gap: System dynamics of cross-sector patient flows TUE-4A**

*Michael Carter (University of Toronto)*

*Ali Esensoy*

Tuesday 4A | 16:00 - 17:30 | Carré 1A

This research is motivated by the desire to incorporate system-modelling tools in the policy-making process at the Ontario Ministry of Health and Long-Term Care (MOHLTC) to facilitate a better understanding of the system-wide effects of decisions, and the sources for policy resistance. The specific objective for the Cross-Sector Patient Flow Model (the model) is to develop a system dynamics simulation of the patient flows between the health system sectors in a Local Health Integration Network (LHIN), with a focus on seniors as the main cohort. In the model, similar providers are aggregated into clusters such as acute care and rehabilitation. The linkages are conceptualized to be between these clusters and not the individual providers of the LHIN. As such, this simulation can be characterized as macro-level patient flow model of a LHIN.

### **4 - Cognitive maps in healthcare: An analysis of reported applications TUE-4A**

*Teresa Cipriano Rodrigues (Technical University of Lisbon)*

Tuesday 4A | 16:00 - 17:30 | Carré 1A

Across the literature, several authors emphasize the role of Problem Structuring Methods (PSM) in healthcare, as they allow to: clarify the nature of the complexities surrounding health systems, identify key agents of change within health systems, support these agents in giving meaningful contributions and thereby plan and implement effective interventions. One of the most well-known PSM is Cognitive Maps (CM), consisting of a network whereby each node represents a concept and each link between two nodes represents causality/influence/implication. CM allow to model, in a transparent way, significant factors, knowledge and conditions that influence decision-makers. Therefore, in recent years, there has been a growing interest in their use and related methods have emerged in order to enhance the capabilities of CM. This is the case of Fuzzy Cognitive Maps (FCM), Reasoning Maps and Bayesian Causal Maps. Hence, in order to understand how CM and related methods may help healthcare decision-makers in structuring complex problems we carried out a literature review about their applications in healthcare. The results of our research showed that the application of these methods in healthcare decision-making problems is still quite limited, as only FCM have been widely applied in this context, mainly for diagnosis and/or prediction of diseases. Therefore, although literature states that CM and related methods may help healthcare decision-makers in structuring complex problems involving multiple stakeholders, data scarcity and multiple sources of uncertainty, it is still crucial to apply these methods in healthcare real-world setting in order to validate their potential benefits to healthcare decision-making.

**1 - Discrete conditional phase-type models for representing patient activity in accident and emergency TUE-4B**

*Adele Marshall (Queen's University Belfast)*

Tuesday 4B | 16:00 - 17:30 | Carré 1B

This paper introduces a special type of Discrete Conditional phase-type model (DC-Ph) for representing patient length of stay in hospital. The DC-Ph model consists of two components (Marshall et al., 2007). The first component is a representation of the inter-relationships between the predictor variables which are conditioned on the second component that models survival time. The Coxian phase-type distribution is used to represent the second component, the survival time to absorption of a finite Markov chain in continuous time, when there is a single absorbing state and the stochastic process starts in the first transient state (Neuts, 1981, Latouche, 1999). The DC-Ph model has previously been used to represent patient length of stay within hospital by using a Bayesian network to categorise patients into cohorts with similar length of stay using patient characteristics and then based upon this classification, employ the Coxian phase-type distribution to represent patient length of stay.

This paper wishes to extend the current form of the discrete conditional phase-type models to include more recent developments in the use of alternative approaches of classification for the first component. The work is illustrated using data reported for patients arriving to the Accident and Emergency unit of a local hospital. Based on patient information available on arrival to hospital, the model can predict the patients likely to experience trolley waits and plan ahead to prevent such cases happening.

**2 - Use of queue modelling in the analysis of elective patient treatment governed by a maximum waiting time policy TUE-4B**

*Dawid Kozłowski (University of Southern Denmark)*

*Dave Worthington*

Tuesday 4B | 16:00 - 17:30 | Carré 1B

Many public healthcare systems struggle with excessive waiting lists for elective patient treatment. Different countries address this problem in different ways, and one interesting method entails a maximum waiting time guarantee. Introduced in Denmark in 2002, it entitles patients to treatment at a private hospital in Denmark or at a hospital abroad if the public healthcare system is unable to provide treatment within the stated maximum waiting time guarantee. Although clearly very attractive in some respects, many stakeholders have been highly concerned about the negative consequences of the policy on the utilization of public hospital resources. This paper illustrates the use of a queue modelling approach in the analysis of elective patient treatment governed by the maximum waiting time policy. Drawing upon the combined strengths of analytic and simulation approaches we develop both continuous-time Markov chain and discrete event simulation models, to provide an insightful analysis of the public hospital performance under the policy rules. The aim of this paper is to support the enhancement of the quality of elective patient care, to be brought about by better understanding of the policy implications by hospital planners and strategic decision makers.

### **3 - Optimal treatment policies for risk-averse patients with limited resources** **TUE-4B**

*Greggory Schell (University of Michigan)*  
*Mariel Lavieri*

Tuesday 4B | 16:00 - 17:30 | Carré 1B

We develop a modeling framework to determine when to initiate and switch medications to treat systolic blood pressure a risk factor for coronary heart disease. Within this framework, we use a Markov decision process to minimize the patients expected number of coronary heart disease events over the planning horizon while accounting for the patients risk aversion and limited resources. To capture the patients risk aversion, we use conditional value at risk measures of treatment outcomes. Resource scarcity is modeled through a resource amount that is available for expenditure on treatments over the planning horizon. Initial results from the model illustrate the diminishing returns of increased planning horizon resources. Furthermore, we identify features of the optimal policies and objective function value for varying patient types and risk aversion levels.

### **4 - Bed allocation using a generic Markov model** **TUE-4B**

*Shirin Geranmayeh (Nanyang Technological University)*  
*Chuan Heng Foh*

Tuesday 4B | 16:00 - 17:30 | Carré 1B

Decision making in health settings, mainly, deals with behavioral characteristics of doctors, nurses and stakeholders as service providers and patients and their families as service receivers. When a patient decides to approach a health setting and when he must be discharged are real time decisions made by people. On the other hand, long term decisions such as number of required beds in a hospital are tried to cover demands over time with minimum costs. Bed demand is direct consequence of arrival and discharge volume that can be volatile over time and place by place. In this research, we have developed a Discrete-Time Markov Model for two parallel queues representing different bed classes in a hospital ward independent from patients' arrival and discharge pattern. The developed model is used to minimize misplacement cost of patients over time by finding the best combination of number of beds in each class when the total number of beds is constant. Presented model which is based on conditional probabilities allows arbitrary distribution for patients' arrival, discharge and length of stay and is compatible with more complex optimization methods. The model is applied to Orthopaedic Department of a hospital in Singapore consisting of total four bed classes for private and subsidized patients. Each patient type could be served by only two specified bed classes without any inter-transmission of patients between them. The objective is to find the best proportional number of beds per class when the total number of beds in ward is constant. The empirical data available from hospital for arrivals, and patients' length of stay on daily basis is applied for case study.

**1 - Patient admission scheduling with operating room constraints****TUE-4C***Sara Ceschia (University of Udine)**Andrea Schaerf*

Tuesday 4C | 16:00 - 17:30 | Carré 1D

We propose an extension of the PAS problem described in our previous work (Ceschia and Schaerf, 2012), which considers also constraints about the utilization of operating rooms for patients that have to undergo a surgery. We design a solution approach based on local search, which explores the search space using complex neighbourhood operators.

**2 - Case mix and capacity planning: An application in a Belgian hospital****TUE-4C***Guoxuan Ma (KU Leuven)**Erik Demeulemeester*

Tuesday 4C | 16:00 - 17:30 | Carré 1D

Hospital case mix and capacity planning concerns both the long-term decision on patient volume and mix that can be treated annually and the medium-term decision on resource capacity and allocation within a whole hospital. Since the patient treatment involves the demand for different types of resources, such as beds and operation rooms, the hospital planning not only aims at improving the match between the stochastic patient demand and the limited resource capacity, but also at coordinating the utilization of multifold resources as best as possible. In addition, the seasonality of patient arrivals will affect the patient flow, e.g., the length of patient waiting lists, and the variable resource requirements of each patient also impact the resource utilization, which both increase the difficulty of the planning process. In this paper, we will discuss an application of the planning problem in a Belgian hospital, in which the seasonality of patient arrivals and the variability of resource requirements of patient cases are considered. The solution approach relies on mixed integer linear programming techniques together with a branch-and-price algorithm, and on a discrete-event simulation analysis. The case study clearly explains the efficiency and the effectiveness of the proposed planning methodology to advance the trade-offs between the resource utilization and the patient flow.

**3 - Predicting hospital resource utilization: A fuzzy regression approach****TUE-4C***Manisha Rathi (University of Westminster)**Theirry Chaussalet*

Tuesday 4C | 16:00 - 17:30 | Carré 1D

Hospital staff and managers are under pressure and concerned for effective use and management of scarce resources (Patel et al., 2006). The hospital admissions management requires many decisions that have complex and uncertain consequences for hospital resource utilization and patient flow. Thus, poor decisions of prediction lead in poor hospital management which is not acceptable (Berman et al., 2001). It is interesting for health care systems to estimate the utilization of hospital resources by estimating future admissions and their length of stay in hospital. However, it is challenging to predict utilization of hospital resources due to uncertainties in future admissions and length of stay of a patient. The unplanned admission of a patient can be at high risk or low risk (Demir et al., 2008). Similarly, length of stay (LOS) of a patient can be as long, medium or short length of stay. These categories (high, medium or low) are vague or fuzzy. However, current methods and tools used to predict patients at risk of

admission fail to deal with uncertainty. The main objective of this paper is to predict patients at high risk of admission and their length of stay in the hospital for efficient hospital resource utilization. An introduction of machine learning techniques along with statistical methods like Regression methods can be a proposed solution approach to the above problem. An approach that adapts fuzzy regression methods to handle uncertain variables or uncertain relationships among the input variables (predictors) and response variable can be an efficient solution to predict patients at high risk of unplanned admission and their LOS in the hospital.

#### **4 - Analyzing the use of hospital resources: Applying mathematical programming**

**TUE-4C**

*Luiz Guilherme Nadal Nunes (Sarah Network of Rehabilitation Hospitals)  
Sandro Barbosa de Oliveira*

Tuesday 4C | 16:00 - 17:30 | Carré 1D

**Objectives:** Present a simple mathematical programming model for analyzing the use of hospital resources. The model was specifically developed for an elective hospital, with no emergency services, on which patients are called from waiting lists of different specialties and serviced with medical appointments, exams, hospitalizations and surgeries, if necessary.

**Methods:** This study consists of survey data on patient care and analysis of hospital capacity. We analyzed 7238 medical records in order to compute all subsequent services performed between 2009 and 2011. We considered hospital capacity with respect to bed occupancy, surgery, magnetic resonance imaging exam and urodynamic tests. We formulated a mathematical programming model and explored the analysis provided by the model.

**Results:** Through the analysis of the model results, it was possible to identify bottlenecks in the care process and establish a control for new patients admissions from different specialties, considering the objective of maximizing the number of patients served, while at the same time promoting the efficient use of hospital resources.

**Conclusion:** The application of mathematical programming to analyze patients admissions, while at the same time considering the use of hospital resources, is not a new issue. However, as it was proposed in this study, it is a very simple model, easy to implement, and if well suited, can provide an important management tool for decision makers.

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**4D - Implementing Scheduling Budgets: From Theory to Practice****Room: Carré 1C***This session is sponsored by ORTEC.*

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**1 - Optimal staffing under annualized hours****TUE-4D***Egbert van der Veen (ORTEC / University of Twente)*

Tuesday 4D | 16:00 - 17:30 | Carré 1C

For organizations it is often challenging to determine the budgets for workforce staffing each month, in order to match dynamics in workforce availability with dynamics in workforce demand. A legal measure allowing employers to let employees work more in busy periods and less in others is the so-called annualized hours regime. We discuss a case study of the University Medical Center Nijmegen, and apply an MILP to solve the annualized hours problem. In addition, we discuss various business questions that can be addressed with our model.

**2 - Controlling workforce scheduling budgets using decision support****TUE-4D***Martin Woudstra (ORTEC)*

Tuesday 4D | 16:00 - 17:30 | Carré 1C

Once workforce scheduling budgets have been set, they have to be monitored. In each scheduling period the assigned shifts are matched to the (financial) workforce capacity. Decision support can help doing this efficiently. The decision support system discussed in this presentation is developed in close cooperation with nine care and cure customers and is part of ORTEC's workforce scheduling software ORTEC Harmony.

**3 - Implementing workforce scheduling budgets: A case study****TUE-4D***Paul Trossèl (Amerpoort)*

Tuesday 4D | 16:00 - 17:30 | Carré 1C

We present a case study of Amerpoort, an organization for Mental Health Care in The Netherlands. We address how workforce scheduling budgets are determined based on available capacity and demand. In addition, we discuss practical implementation issues, and outline how decision support is used to determine and control scheduling budgets. Finally, we discuss how we managed to improve workforce scheduling efficiency at Amerpoort.