

## **Preface**

Health care plays an important role in our daily lives. Quality of care and cure as well as the efficiency and efficacy of its delivery remain high on the public agenda. Operations Research plays and has played an important role in the development of new tools for medical care and optimizing health care delivery. A good example of the added value of Operations Research in health care is the development and the application of advanced algorithms in radiotherapy optimization. Two plenary speakers at the conference will highlight the past and future developments in this field as well as the usage of the Operations Research techniques in practice.

Logistical applications are traditionally one of the focus areas of Operations Research. Therefore, it is not surprising that several conference speakers will discuss cases, models and developments in logistical application areas such as ward management, ambulance scheduling, and appointment scheduling. But Operations Research can do more, as will be shown by, for example, talks on the development optimal screening policies for breast cancer in the Netherlands.

Thanks to the Erasmus University Medical Center, Rotterdam has excellent opportunities to bridge the gap between academic research and actual applications in health care. One of the latest developments in Rotterdam is the founding of *Erasmus Health Care Logistics* in which managers, operations researchers, and physicians cooperate to develop evidence-based health care logistics.

We are therefore pleased to host the second annual conference of the working group Operations Research & Health Care of the Dutch Operations Research Society (NGB). Thanks to our foreign plenary speakers and many contributions of researchers from both the Netherlands and abroad, we have an interesting and exciting conference program. There will be many opportunities for researchers and practitioners to synergize, possibly leading to future projects. We hope that this conference will positively stimulate the active Dutch working group on Operations Research & Health Care, thereby helping to improve medical care and its delivery.

**Jeroen van Oostrum**

(Erasmus University Rotterdam / Erasmus University Medical Center)

**Albert Wagelmans**

(Erasmus University Rotterdam)

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## Program

- 8:30-9:00      **Coffee and registration**
- 9.00-9.15      **Opening and Welcome (room: Athene / M1-19)**  
Geert Kazemier (Erasmus University Medical Center)
- 9.15-10.00     **Plenary (room: Athene / M1-19) – Chair: Albert Wagelmans**  
**Edwin Romeijn (University of Michigan)**  
*Optimization of radiation therapy treatment plans*
- 10.00-10.20    **Coffee break**
- 10.20-11.20    **Session 1 (room: Athene / M1-19) – Chair: Peter Vanberkel**  
***Improving hospital performance (I)***  
Hans-Jürgen Zimmermann (RWTH Aachen)  
*Optimal planning and control of processes in hospitals*  
  
Wineke van Lent (The Netherlands Cancer Institute – Antoni van Leeuwenhoek Ziekenhuis)  
*Identifying success factors for the implementation of simulation results to improve the patient flow and resource utilization in hospitals*  
  
Jan Telgen (University of Twente)  
*Buying individual care through procurement auctions*
- Session 2 (room: Lund / M1-18) – Chair: Jan Vissers**  
***Scheduling in hospitals***  
  
Kristiaan Glorie (Erasmus University Rotterdam)  
*Optimizing sterile net composition*  
  
Ivan Vermeulen (Centrum Wiskunde & Informatica)  
*Decentralized online scheduling of combination-appointments in hospitals*  
  
Maartje Zonderland (University of Twente / Leiden University Medical Center)  
*Capacity planning and scheduling for semi-emergent surgeries at a neurosurgery department*

11.20-12.20    **Session 3 (room: Athene / M1-19) – Chair: Peer Goudswaard**  
***Optimal ward management***

Arnoud de Bruin (VU University Medical Center)  
*Dimensioning hospital wards using the Erlang loss model*

Rene Bekker (VU University Amsterdam)  
*Bed reservation and merging for clinical wards*

Nico van Dijk (University of Amsterdam)  
*On dimensioning intensive care units*

**Session 4 (room: Lund / M1-18) – Chair: Ellen van Vliet**  
***Application of Operations Research models***

Joris van de Klundert (Maastricht University)  
*Measuring clinical pathway adherence*

Erwin Hans (University of Twente)  
*Individualized breast cancer follow-up - Cost-effectiveness analysis*

Paul Joustra (Academic Medical Center)  
*To pool or not to pool in hospitals: a theoretical and practical comparison for a radiotherapy outpatient department*

12.20-13.30    **Lunch**

13.30-14.30

**Session 5 (room: Athene / M1-19) – Chair: Jeroen van Oostrum**  
***Logistical models for blood supply***

Rene Haijema (University of Amsterdam / Wageningen University)  
*TIMO: A decision support tool for efficient blood platelet production, Part I – Methodology*

Nikky Kortbeek (University of Amsterdam / University of Twente)  
*TIMO: A decision support tool for efficient blood platelet production, Part II – Strategies for younger platelets*

Rommert Dekker (Erasmus University Rotterdam)  
*Supply chain management of pharmaceuticals*

**Session 6 (room: Lund / M1-18) – Chair: Arnoud de Bruin**  
***Optimization of hospital access***

Wim van Harten (University of Twente)  
*Improving access time of diagnostic procedures*

Paulien Out (CC Zorgadviseurs / VU university)  
*Optimal outpatient appointment scheduling*

Nico Dellaert (Eindhoven University of Technology)  
*Hospital admission planning to optimize major resources utilization under uncertainty*

- 14.30-14.50     **Coffee break**
- 14.50-15.50     **Session 7 (room: Athene / M1-19) – Chair: Paul Joustra**  
***Operations Research models in Health Care***
- Giovanni Righini (Università degli Studi di Milano)  
*Models and algorithms for ambulances location and re-location*
- Peter Vanberkel (University of Twente)  
*Reallocating Resources to Focused Factories: A Case Study in Chemotherapy*
- Gijs Rennen (Tilburg University)  
*Sandwich algorithms for approximating Pareto frontiers to make trade-off decisions in IMRT*
- Session 8 (room: Lund / M1-18) – Chair: Naomi Nathan**  
***Improving hospital performance (2)***
- Marjolein Jungman (ORTEC)  
*Data envelopment analysis in hospital benchmark studies*
- Sabrina Ramwadhoebe (University Medical Center Utrecht)  
*Implementation by simulation; strategies for ultrasound screening for hip dysplasia*
- Steef van de Velde (Erasmus University Rotterdam)  
*The stent supply chain at Erasmus Medical Center*
- 15.50-16.30     **Plenary (room: Athene / M1-19) – Chair: Albert Wagelmans**  
**Björn Hårdemark (RaySearch, Sweden)**  
*Application of operations research in advanced software in radiotherapy*
- 16.30-17.00     **Plenary discussion NGB section OR & Health Care**  
**(room: Athene / M1-19)**  
*Moderator: Joris van de Klundert*
- 17.00-18.00     **Drinks**

## Abstracts of plenary speakers

### ***Edwin Romeijn***

*University of Michigan, USA*

Presentation from 9.15 to 10.00 in room: Athene / M1-19

### **Title: Optimization of radiation therapy treatment plans**

#### **Abstract:**

During radiation therapy, beams of radiation pass through a patient. This radiation kills both cancerous and normal cells, so the radiation therapy must be carefully planned to deliver a clinically prescribed dose to certain targets while sparing nearby organs and tissues. Currently, a technique called intensity modulated radiation therapy (IMRT) is considered to be the most effective radiation therapy for many forms of cancer. In IMRT, the patient is irradiated from several different directions. From each direction, one or more irregularly shaped radiation beams of uniform intensity are used to deliver the treatment. In this talk, we provide an overview of the state-of-the-art of optimization models for static radiation therapy treatment planning. In addition, we discuss recent and ongoing technological developments which show that this area of research is a lively and promising one that can continue to help patients by improving the clinical practice of radiation therapy.

#### **Biography:**

Edwin Romeijn's general research area is optimization theory and applications. His recent research activities mainly deal with systems arising in radiation therapy treatment planning and supply chain management. In radiation therapy treatment planning, the main goal is to develop new models and algorithms for efficiently determining effective (i) treatment plans for cancer patients who are treated using radiation therapy, and (ii) treatment schedules for radiation therapy clinics. In supply chain optimization, his main interests are in the integrated optimization of production, inventory, and transportation processes, in particular in the presence of demand flexibility, limited resources, perishability, and uncertainty. Before joining The University of Michigan in 2008 he was on the faculty of the Department of Industrial and Systems Engineering at the University of Florida and the Rotterdam School of Management at the Erasmus University Rotterdam in The Netherlands. He is the author of seventy peer reviewed publications.

## ***Björn Hårdemark***

*RaySearch, Sweden*

Presentation from 15.50 to 16.30 in room: Athene / M1-19

### **Title: Application of operations research in advanced software in radiotherapy**

#### **Abstract:**

Professor Romeijn has given the background on external beam radiation therapy and described some optimization techniques used for producing treatment plans. In this talk, I will show how these and other methods are used in a treatment planning system and go through some of the mathematical difficulties related to the optimization procedures. Starting out in what has become known as ‘traditional’ IMRT optimization, i.e. fluence optimization, I will demonstrate some of its strengths and weaknesses and show how direct machine parameter optimization solves many problems. I will also briefly show what we refer to as ‘dose tracking’ where the deposited dose is tracked in a deforming patient geometry. This process involves solving optimization problems for finding the surfaces of the organs in the new geometries, and to find an elastic deformation of all tissue.

#### **Biography:**

Björn Hårdemark came into contact with RaySearch in his final years at the Royal Institute of Technology in Stockholm, where he studied physics. He had taken a survey course in medicine so he wanted to do his thesis-related traineeship at a company involved in medical technology. The year was 2002. Today Björn is the project manager of RaySearch’s collaboration project with Varian and has been on an eventful journey with the company to date. “Since I came on board at a time when RaySearch's operations were barely out of the gate, I was able to experience just about everything right from my first day at work. The discussions I’ve been involved in have often influenced the course the Company decided to take. Even though I’ve only worked here for six years, I am one of the ones who have been with the organization the longest, so I’ve developed expertise in several areas. Consequently, I spend a lot of my time acting as sounding board for my colleagues and for the business partners and clinics with which we cooperate. I feel appreciated and needed both inside and outside the organization,” says Björn. Björn spent his initial period in research in the research department where he worked with various application issues. With the help of the knowledge he acquired there, he made a lateral move to the development department so that, working with one of RaySearch’s partners, he could translate the research results into new products. And here he is today, the project manager. According to Björn, the best thing about the work is that it is specifically defined, in that he is involved in the entire process from the derivatives of the various optimization functions to the action of specific machinery components in the treatment room. “All in all, it’s very hands-on,” he says. “The results of our algorithm development have been implemented at hundreds of clinics used by people in real-life medicine. That is really something,” he says.

## **Abstracts of parallel sessions**

### ***Session 1 – Improving hospital performance (1)***

Presentations from 10.20-11.20 in room: Athene / M1-19

#### **Optimal planning and control of processes in hospitals**

Hans.-Jürgen Zimmermann  
*RTWH Aachen*

##### **Abstract:**

The costs of hospitals are one of the mayor parts of the costs of healthcare systems. Some of the reasons can only be considered within moral dimensions. Others, such as, medication, facilities, and personnel can hardly be reduced without reducing the quality of service. AN area in which costs can be reduced without decreasing the service level is, however, the planning and control of processes in hospitals. In the meantime computer systems exist and have already been successfully installed, that can help to reduce costs considerably without disadvantages for patients. The presentation will briefly describe these systems and report the improvements that have been achieved in the USA and in Germany.

#### **Identifying success factors for the implementation of simulation results to improve the patient flow and resource utilization in hospitals**

Wineke A.M. van Lent  
*Netherlands Cancer Institute - Antoni van Leeuwenhoek Hospital*  
Peter Vanberkel  
*University of Twente*  
Wim van Harten  
*Netherlands Cancer Institute - Antoni van Leeuwenhoek Hospital /*  
*University of Twente*

##### **Abstract:**

###### Aim:

To identify factors that contribute to the implementation of simulation results in hospitals. Objective of the simulation is capacity utilization and patient flow.

###### Methods:

- Literature overview of relevant research
- A systematic review of simulation applications hospitals that strive to improve processes
- Interviews with hospital staff that have used simulation will be held to verify and validate the success factors of simulation as an improvement tool.

###### Preliminary results:

- Little is known on implementation conditions for simulation results in hospitals. If success factors are mentioned these are mostly based on the author's experience.
- Very few publications of healthcare simulation applications confirm that the simulated interventions are implemented.

- The literature review revealed that data availability, a good understanding of the process being modelled, commitment of the end user, inclusion of sufficient relevant aspects in the model are essential conditions to implement the results of a simulation study.

## **Buying individual care through procurement auctions**

Jan Telgen

*University of Twente*

### **Abstract:**

Health care and social care are usually provided for on the basis of a contract between the care provider and an organisation that pays for that care provision (insurance company, government, etc.). Typically those that receive health care or social care are not a party to the contract. Neither are the contracts specific to an individual: the contracts typically cover all that receive the care under one single set of conditions, there is no possibility for individual differences.

This fact (one set of conditions) may be a consequence of the (desired) solidarity involved in health care and social care. But we believe it may also be a consequence of using inappropriate contracting mechanisms that limit the influence of market factors such as timing of demand, total demand per period and market access.

We provide practical examples from maternity care and social care to show the availability and use of alternative contracting mechanisms (individual procurement auctions). The ultimate goal of this research is to establish conditions under which various contracting mechanisms are appropriate.

## ***Session 2 – Scheduling in hospitals***

Presentations from 10.20-11.20 in room: Lund / M1-18

### **Optimizing sterile net composition**

Kristiaan Glorie

*Erasmus University Rotterdam*

Jeroen van Oostrum

*Erasmus University Rotterdam / Erasmus University Medical Center*

Albert Wagelmans

*Erasmus University Rotterdam*

#### **Abstract:**

Over recent years, improving management of logistical processes in hospitals has attracted attention as a way to control rising health care costs. Sterile inventory management is such a logistical process. The process deals with the organization of sterile instruments flowing in a return cycle between the various hospital departments – where they are used – and the central sterilization department – where they are cleaned. Sterile instruments are generally grouped in so-called nets, which is done based upon expected requirements during surgery. Two of the most used approaches to improve the efficiency at central sterilization departments is to either optimize the current inventory of instrument nets (possibly with minor adjustments to the net compositions) or to set up an optimal net composition scheme from scratch (along with required inventory levels per net). For this second case, we present an integer linear programming formulation. We propose a heuristic column generation approach to solve the model. In this approach we first solve a relaxed version of the ILP by column generation. Second, we present a heuristic to transform the optimal net types for the relaxed problem into a set of net types for the integer problem. We conclude with an outlook on further research.

### **Decentralized online scheduling of combination-appointments in hospitals**

Ivan Vermeulen

*Centrum Wiskunde & Informatica*

Sylvia Elkhuisen

*Academic Medical Center*

Piet Bakker

*Academic Medical Center*

#### **Abstract:**

We consider the online problem of scheduling combination appointments for outpatients in hospitals. Scheduling multiple appointments on a single day is high on the list of outpatient preferences. It is hard to achieve for two reasons: first, due to the typical distributed authority in hospitals, scheduling combination appointments requires coordination between departments. Second, there is a trade-off between local scheduling efficiency and the fulfillment of patient scheduling preferences. We present a distributed approach, where patient schedules are coordinated with department calendars. For individual departments, we design an efficient yet flexible

local scheduling method with dynamic usage of capacity. Department use this method and use its flexibility to trade-off local efficiency against making single-day combination-appointments. We show in a stylized model of a real hospital setting that this distributed scheduling approach is highly effective and allows a hospital to set a desired level of efficiency versus fulfilled patient preferences.

## **Capacity planning and scheduling for semi-emergent surgeries at a neurosurgery department**

Maartje Zonderland

*University of Twente / Leiden University Medical Center*

Richard Boucherie

*University of Twente*

### **Abstract:**

We consider a neurosurgical department. Patients with a semi-emergent status arrive according to a random process, and need to be operated within either one or two weeks. The neurosurgical department feared that dedicating (scarce) OR time to the uncertain stream of semi-emergent patients would lead to an excessive amount of unused OR capacity, and therefore planned only elective patients in the available OR time. As a consequence, in daily operation, a large portion of elective surgeries is cancelled in order to accommodate semi-emergent surgeries.

In this study we develop a mathematical model that enables a cost trade-off between the cancellation rate of elective surgeries and unused OR time, compute the OR capacity needed to accommodate all incoming semi-emergent surgeries, and provide a reservation mechanism for semi-emergent surgeries. We conclude with a tool that supports the scheduling process.

### ***Session 3 – Optimal ward management***

Presentations from 11.20-12.20 in room: Athene / M1-19

#### **Dimensioning hospital wards using the Erlang loss model**

Arnoud de Bruin

*VU University Medical Center / VU University*

Rene Bekker

*VU University*

Lillian van Zanten

*VU University Medical Center*

Ger Koole

*VU University / VU University Medical Center*

#### **Abstract:**

How many beds must be allocated to a specific clinical ward? This question is often discussed by medical professionals, hospital consultants, and managers. In these discussions the occupancy rate is of great importance and often used as an input parameter. Most hospitals use the same target occupancy rate for all wards, often 85%. In this paper we demonstrate that this equity assumption is unrealistic and that it might result in an excessive number of refused admissions, particularly for smaller units. Queuing theory is used to quantify the relation between the size of unit, occupancy rate and probability of a refused admission. We developed a decision support system, based on the Erlang loss model, which can be used to evaluate the current size of nursing units. We validated this model with hospital data over the years 2004-2006. Finally, we demonstrate the efficiency of bed pooling.

#### **Bed reservation and merging for clinical wards**

Rene Bekker

*VU University*

Ger Koole

*VU University*

Dennis Roubos

*VU University*

#### **Abstract:**

Based on economies of scales it generally seems preferable to have large clinical wards, since they can operate at higher occupancy rate under a reasonable number of refused admissions. This advocates to merge clinical wards as much as possible. However, merging wards, or bed pooling, is not always beneficial or desirable. This might be the case when the difference in average length of stay between patients is large or when one type of patient should be prioritized. In this talk, practical alternatives for merging wards, including bed reservation policies (earmarking) are presented. These practical alternatives generally perform well and are compared with merging (bed pooling) and an optimal policy minimizing the weighted number of refused admissions.

## **On dimensioning intensive care units**

Nico van Dijk

*University of Amsterdam / Wageningen University*

Nikky Kortbeek

*University of Amsterdam / University of Twente*

### **Abstract:**

Due to a limited ICU capacity patients can be rejected at both the Operating Theater (OT) and at the Intensive Care Unit (ICU) within hospitals. The corresponding ICU-rejection probability is an important service factor for hospitals. A simple expression for this probability is not available. With  $c$  the ICU capacity (number of ICU beds), this paper provides analytic support for:

- (i) An  $M | G | c | c$ -approximation.
- (ii) A secure  $M | G | c - 1 | c - 1$  upper bound.

Both results rely upon a special OT-ICU tandem queue formulation. The upper bound can be of practical interest so as to dimension the size of an ICU to secure a sufficiently small rejection probability.

## ***Session 4 – Application of operations research models***

Presentations from 11.20-12.20 in room: Lund/ M1-18

### **Measuring clinical pathway adherence**

Joris van de Klundert  
*Maastricht University*

#### **Abstract:**

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

### **Individualized breast cancer follow-up - Cost-effectiveness analysis**

Erwin Hans  
*University of Twente*  
Jesse van Elteren  
*University of Twente / Medisch Spectrum Twente*  
Sabine Siesling  
*Regional Cancerregistry*  
Leo van der Wegen  
*University of Twente*  
Joost Klaase  
*Medisch Spectrum Twente*

#### **Abstract:**

Roughly one in eight women in the Netherlands develops breast cancer. Prognosis after primary treatment is improving. This leads to an increased number of patients in follow-up, and thus an increased workload. One of the main goals of follow-up is to improve the survival of patients. Follow-up influences survival by detecting local recurrences and second primary tumors in an early stage, thereby reducing the risk of metastases.

In the Netherlands, most patients are currently assigned the same follow-up: five years long, with a frequency of two consults per year. Many doctors feel that for some patients a less intensive follow-up is more appropriate. We aim to determine a more individualized follow-up in order to give women the follow-up they need and to reduce workload in hospitals. We classify 150 patient groups according to age, tumor size and lymph node status. We choose follow-up scenarios based on their type of

consult (surgeon face-to-face, nurse practitioner face-to-face, nurse practitioner telephone), frequency (1x, 2x per year) and length (1, 3, 5 years).

To determine the cost-effectiveness of follow-up schemes for each patient group, we model the process of breast cancer in a discrete-event state-transition model, and use both discrete event simulation and a Markov model to measure the cost-effectiveness of various follow-up schemes for all patient groups. The data used by the model, e.g. regarding the risk of local recurrence, second primary tumors, and risk of distant metastases, are obtained from online tools “Adjuvant! Online” and “IBTR!”, cancer registration databases, and the literature.

The outcomes show that implementing individualized follow-up can lead to savings of up to 89% of the number of consults needed. We provide schematic guidelines for doctors to select an appropriate follow-up scheme for various patient groups. We have found that, in general, patients younger than 50 require a more intensive follow-up than patients older than 70. Older patients have a lower life expectancy, and therefore there are less QALYs to be gained and the effectiveness of follow-up is lower. More specific results will be given in the presentation.

### **To pool or not to pool in hospitals: A theoretical and practical comparison for a radiotherapy outpatient department**

Paul Joustra

*Academic Medical Center*

E. van der Sluis

*University of Amsterdam*

Nico van Dijk

*University of Amsterdam*

#### **Abstract:**

This paper studies whether urgent and regular patients for a consultation at a radiotherapy outpatient department should be pooled or not. Results are presented as based upon both queuing theory and by discrete event simulation for a realistic case study. For both the theoretical and practical approach it is shown that pooling is not always beneficial for the waiting times of urgent patients and for the total number of first consultations required to meet the waiting time performance target for urgent as well as regular patients. The results seem to be of general interest for hospitals.

## ***Session 5 – Logistical models for blood supply***

Presentations from 13.30-14.30 in room: Athene/ M1-19

### **TIMO: A decision support tool for efficient blood platelet production Part I – Methodology**

Rene Haijema

*University of Amsterdam / Wageningen University*

Nikky Kortbeek

*University of Amsterdam / University of Twente*

J. van der Wal

*University of Amsterdam*

Nico van Dijk

*University of Amsterdam*

#### **Abstract:**

The production and issuing of blood platelets at blood banks is complicated by short term perishability, highly uncertain demands and weekend production stops. As platelet concentrates have a fairly short fixed maximal shelf life of 4-7 days, current outdated figures in many countries is in the order of 15% or even more. An optimal production strategy balances shortages and outdated.

Optimal production volumes are obtained by solving a (downsized) Markov decision problem (MDP). Nearly-optimal rules, e.g. an order-up-to S rule with fixed weekday-dependent levels, can be read by simulating the MDP strategy. The method acknowledges production stops during weekends, multiple classes of demands, and different choices of the issuing policy. Furthermore the ‘age-distribution’ of the issued platelets is kept track of, as the age of the concentrates (roughly) resembles the quality of the platelets.

The approach is applied for a data set of the Dutch North-East Blood Bank and shows that a strategy with virtually no shortages and outdated is possible. The developed software is made more professional in a later stage, and named TIMO. In this first part of the talk, the methodology behind TIMO is presented. In Part II of the talk, a case study will be presented and strategies to increase the quality of the issued platelets are discussed.

### **TIMO: A decision support tool for efficient blood platelet production, Part II – Strategies for younger platelets**

Nikky Kortbeek

*University of Amsterdam / University of Twente*

Rene Haijema

*University of Amsterdam / Wageningen University*

J. van der Wal

*University of Amsterdam*

Nico van Dijk

*University of Amsterdam*

**Abstract:**

Initiated by the Dutch South-East Blood Bank, the MDP-Simulation approach is applied to practice in a new case study. In this study also age has been taken under consideration for optimization as the quality of the pools upon transfusion is negatively correlated with their age. Several ways to improve platelet quality are presented given the MDP-Simulation approach to obtain fixed order-up-to levels.

Motivated by the positive results in cooperation with the Dutch South-East Blood Bank, the software developed for purpose of research is made more user friendly. This tool, called TIMO (Thrombocytes Inventory Management Optimizer), has meanwhile been implemented and will be tested with practical data for a half year period.

**Supply chain management of pharmaceuticals**

Rommert Dekker

*Erasmus University Rotterdam*

**Abstract:**

In this talk we consider the inventory control of pharmaceuticals at pharmacies and wholesalers. We will first describe the current processes and developments in The Netherlands. Next we will indicate how inventory models can be used to improve performance. This will be done from several viewpoints, the pharmacy, the wholesaler and the insurer (paying for the medicines). Finally we will show how information sharing in the chain can lead to improvements.

## ***Session 6 – Optimization of hospital access***

Presentations from 13.30-14.30 in room: Lund/ M1-18

### **Using simulation to reduce the access time at the diagnostic department of a comprehensive cancer centre.**

Wim van Harten

*Netherlands Cancer Institute - Antoni van Leeuwenhoek Hospital / University of Twente*

Wineke van Lent

*Netherlands Cancer Institute - Antoni van Leeuwenhoek Hospital*

Joost Deetman

*University of Twente*

R. Gilles

*Netherlands Cancer Institute - Antoni van Leeuwenhoek Hospital*

Erwin Hans

*University of Twente*

#### **Abstract:**

##### Aim:

Using simulation to evaluate alternative scheduling methods to reduce the access time in a diagnostic department while maintaining an acceptable utilization, overtime and patient waiting time.

##### Methods:

- Case 1: using discrete-event simulation to predict the performance of the ultrasound modality in different scenarios for improving same day access.
- Case 2: using simulation to identify the maximum attainable throughput time of the diagnostic track for a CT-scan.

##### Results:

- Case 1: it is possible to increase the ratio of same day access for outpatient ultrasound visits from 25% to theoretical maximum of 85%. A start was made with a pilot, this was received with enthusiasm by the department.
- Case 2: it is attainable to reduce the throughput time for non-urgent outpatients from 16,9 to 5 days.

##### Conclusions:

These case studies have proven that simulation can be used to enable the introduction of one-stop-shop diagnostic procedures.

### **Optimal outpatient appointment scheduling**

Paulien Out

*CC Zorgadviseurs / VU University*

#### **Abstract:**

This research extends the work of Kaandorp and Koole (2007) on optimal outpatient appointment scheduling. We added the arrival of emergency patients and allow general service time distributions, which can be different for scheduled and emergency arrivals. We use a local search algorithm to find the optimal schedule with respect to a weighted sum of expected idle time, average waiting time and tardiness. Numerical results will be presented.

## **Hospital admission planning to optimize major resources utilization under uncertainty**

Nico Dellaert

*Eindhoven University of Technology*

Jully Jeunet

*Université Paris Dauphine*

### **Abstract:**

Admission policies for elective inpatient services mainly result in the management of a single resource: the operating theatre. However, other bottleneck resources may lead to surgery cancellations, such as bed capacity and nursing staff in Intensive Care (IC) units and bed occupancy in wards or medium care (MC) services. Our incentive is therefore to determine a master schedule of a given number of patients that are divided in several homogeneous categories in terms of the utilization of each resource. On the operational level, this tactical master schedule must be adapted to account for the actual arriving number of patients in each category. We develop several strategies and test them by simulation. The strategies result from the combination of several options to create a feasible operational schedule from the tactical plan: overplanning, flexibility in selecting the patient groups to be operated and updating the tactical plan.

## ***Session 7 – Operations research models in health care***

Presentations from 14.50-15.50 in room: Athene/ M1-19

### **Models and algorithms for ambulances location and re-location**

Giovanni Righini

*Università degli Studi di Milano*

Roberto Cordone

*Università degli Studi di Milano*

Federico Ficarelli

*Università degli Studi di Milano*

Andrea Pagliosa

*Az. Osp. “Ca’ Granda” Niguarda*

Andrea Pinciroli

*Università degli Studi di Milano*

Giovanni Sesana

*Az. Osp. “Ca’ Granda” Niguarda*

#### **Abstract:**

We present some mathematical programming formulations and queueing theory models to address the problem of locating ambulances of the “118” EMS in the city of Milan and to re-locate them in real-time according to the state of the system.

We also present an interactive simulator developed for the operating room of the “118” service. The simulator is based on data taken from a geographical information system and a historical data-base recording all past missions carried out by the ambulances. It allows the user to take decisions about the allocation of the requests to the ambulances and about the re-location of available ambulances to different parking places. Several optimization sub-problems have been solved to develop the software which in turn is used as a tool to solve other optimization sub-problems. We will survey these problems and the corresponding models and algorithms.

### **Reallocating resources to focused factories: A case study in chemotherapy**

Peter Vanberkel

*University of Twente*

#### **Abstract:**

This study investigates expected service performance associated with a proposal to reallocate resources from a centralized chemotherapy department to a breast cancer focused factory. Using a slotted queueing model the paper quantifies the amount of additional resources required in both the focused factory and existing department, which will ensure the existing service level is maintained. The model relies only on typical outpatient scheduling system data making the methodology easy to replicate in other outpatient clinic settings. Finally, the paper highlights important factors to consider when assigning capacity to focused factories. These considerations are generally relevant to other resource allocation decisions.

## **Sandwich algorithms for approximating Pareto frontiers to make trade-off decisions in IMRT**

Gijs Rennen

*Tilburg University*

When determining a IMRT-treatment plan, a trade-off has to be made between several conflicting objectives. Currently, this trade-off is often made by assigning weights to the objectives and optimizing the weight sum of the objectives. However, determining suitable weights is a difficult and time-consuming task. Instead it would be better to generate a set of Pareto efficient solutions and to let the doctor choose from this set. Pareto efficient solutions have the nice property that is not possible to improve one objective without deteriorating another objective. Approximating the Pareto frontier containing all Pareto efficient solutions is however a difficult task for 3 or more objectives. In this presentation, I will discuss and compare three existing sandwich algorithms for approximating these Pareto frontiers and introduce a new fourth method.

## ***Session 8 – Improving hospital performance (2)***

Presentations from 14.50-15.50 in room: Lund/ M1-18

### **Data Envelopment Analysis in hospital benchmark studies**

Marjolein Jungman  
*ORTEC bv*

#### **Abstract:**

In benchmark studies the performance of organizations (or units within organizations) is compared with the best practice among a peer group. In most cases, ratios are used to compare different aspects. Examples of used ratios within hospital benchmarks are the number of staff per bed, the bed occupancy rate, the costs per inpatient day and the cost per outpatient visit. A disadvantage of the use of ratios is that many individual ratios are needed to measure the performance on different aspects. This makes it difficult to create one overall performance score. This is why ORTEC uses Data Envelopment Analysis (in addition to ratios) in her benchmark studies. The presentation shows in what way we used DEA to create an overall performance score per hospital, including efficiency as well as quality aspects.

### **Implementation by simulation; strategies for ultrasound screening for hip dysplasia in the Netherlands**

Sabrina Ramwadhoebe  
*University Medical Center Utrecht*  
Godefridus van Merode  
*Maastricht University*  
Magda Boere-Boonekamp  
Ralph Sakkers  
Erik Buskens

#### **Abstract:**

##### Objective

In cost effectiveness studies variables associated with organization and available capacity may affect the overall results. The influence of the variation of these variables on the cost effectiveness can be evaluated by computer simulation following a carefully designed experimental design. This combination provides a means to examine a full range of possible scenarios. This was done to calculate the cost effectiveness for the implementation of a new screening strategy for detecting developmental dysplasia of the hip (DDH).

##### Methods

First, current workflow and performance is analyzed. Then, important output factors are identified and alternative scenarios are determined with the use of experimental variables with according levels. For the determination of the levels literature and interviews among stakeholders are used.

##### Results

The 4 experimental variables are the location of the consult, integrated with regular consult or not, the number of ultrasound machines and the discipline of the screener. In total 72 possible scenarios are identified. 'Possible' means that they can be evaluated with the simulation model. In our model experimental variables related to the number of ultrasound machines in combination with an extra consult is influencing the cost effectiveness the most.

### Conclusions

The combination of simulation models and an experimental design greatly enhances cost effectiveness studies where organizational and capacity variables are important. Relevant information to determine the levels of experimental variables can be revealed with literature and directly from experts. Using an experimental design one can a priori explore how variables affect the outcome and explore different strategies for implementation.

## **The stent supply chain at Erasmus Medical Center**

Steef van de Velde

*Erasmus University Rotterdam*

### **Abstract:**

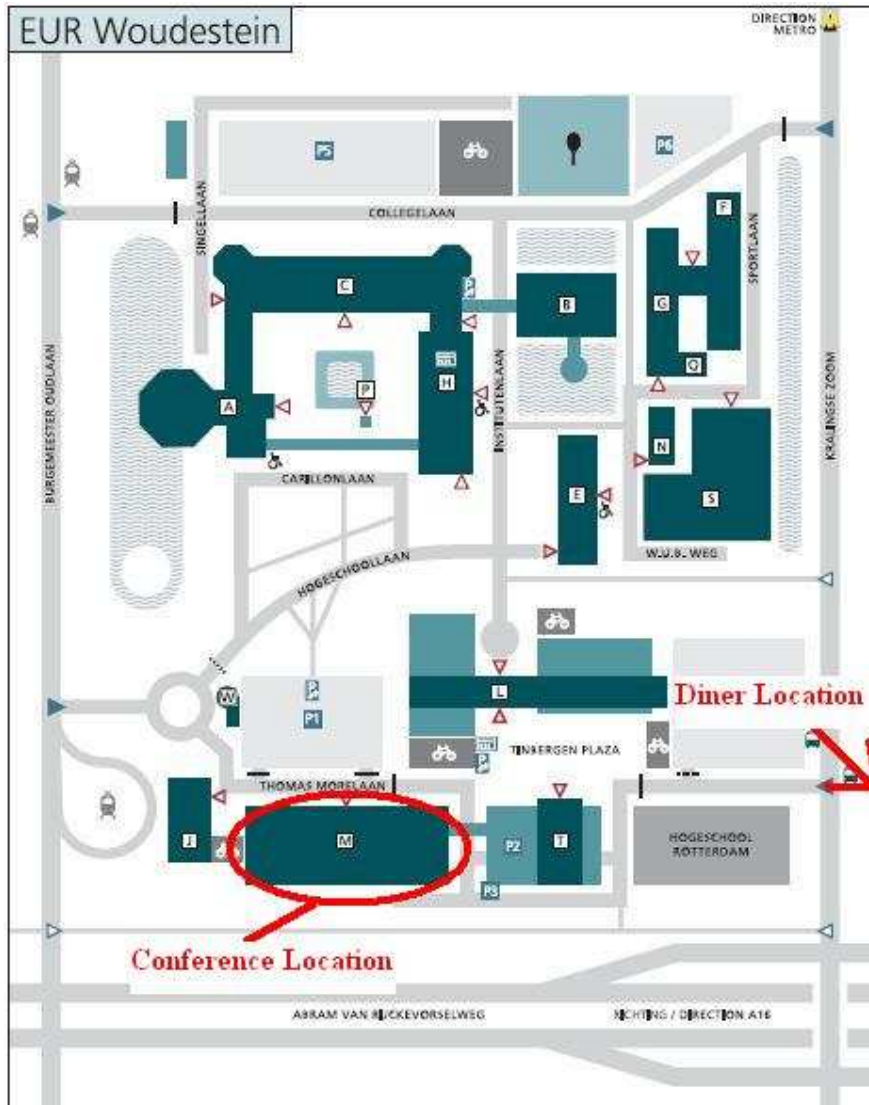
Material logistics is often off the radar in health care institutions. This neglect can easily lead to a mismatch in demand and supply of medical supplies, resulting in excessive write-offs, costs of obsolescence, high working capital, and stock-outs.

We narrate the story of Erasmus Medical transforming its stent supply chain from a push model into a pull model and analyze the surprising choices it made in its supply chain redesign.

## Conference diner

On **Monday November 17**, the NGB conference diner will be held at Novotel Brainpark Rotterdam. The diner room is available from **6 p.m.**, the diner officially starts around 6.30 p.m.

The Novotel Brainpark Rotterdam is located next to the university campus and easily visible. See map below for some more details, walking time is approximately five minutes. There are guarded parking lots available at the hotel, please ask inside for free cards to get out.



<http://www.accorhotels.com/nl/hotel-1134-novotel-rotterdam-brainpark/index.shtml>

## **List of Participants**

## Colophon

### **Organizing Committee:**

Jeroen van Oostrum  
Albert Wagelmans

### **Board NGB-working group *Operations Research in Health Care*:**

Erwin Hans  
Joris van de Klundert  
John Poppelaars  
Albert Wagelmans

### **Composition program book:**

Elli Hoek van Dijke

### **Photo's on cover page:**

Erik Zwartter

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