EURO 2018 – Innovative methods and uses of operations research in health and care applications

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The EURO-k conferences are forums for communication and collaboration among European operations researchers who are active in the entire spectrum of Operations Research (OR) and to the free exchange of knowledge, experience, new ideas and promising results relating to the theory and practice of OR. In the 40-year history of the EURO-k series, the conferences have been held in 18 different countries.

EURO 2018 was the largest and most important conference for Operational Research and Management Science (OR/MS) in Europe organized by EURO – the European Association of Operational Research Society and the Spanish Statistics and Operations Research Society. It was held by the two major Valencian universities, Universitat de València and Universitat Politècnica de València. The conference was a success beyond all the expectations of the Program and Organizing Committees, chaired by Greet Vanden Berghe, Ramón Álvarez-Valdés and Rubén Ruiz. EURO 2018 hosted 1747 participants from 70 different countries. Overall, about 2050 oral presentations were delivered at EURO between 9-11 July 2018, and the number of abstract submissions reached 2636 (for further details see https://www.euro-online.org/media_site/reports/EURO29_Report.pdf).

The Program Committee (PC) was chaired by Greet Vanden Berghe (KU Leuven, Belgium) who was joined by an impressive list of PC members: Ramón Álvarez-Valdés (Universitat de València, Spain), Luce Brotcorne (INRIA Lille, France), Rita Laura d'Ecclesia (Università La Sapieza di Roma, Italy), Carlos Fonseca (Universidade de Coimbra, Portugal), Sarah Fores (EURO), Bernard Fortz (Université Libre de Bruxelles, Belgium), Attila Gilányi (University of Debrecen, Hungary), Luís Gouveia (Universidade de Lisboa, Portugal), Geir Hasle (SINTEF, Oslo), Bernard Ries (Université de Fribourg, Switzerland), Rubén Ruiz (Universitat Politècnica de València, Spain), Sibel Salman (Koç University, Istanbul), Raik Stolletz (Universität Mannheim, Germany), Michal Tzur (Tel Aviv University, Israel), Christos Vasilakis (University of Bath, UK), Daniele Vigo (Università di Bologna, Italy), Albert Wagelmans (Erasmus University (Rotterdam), Netherlands), Jyrki Wallenius (Aalto University, Finland), Gerhard-Wilhelm Weber (Poznan University of Technology, Poland), Stefan Wrzaczek (Austrian Academy of Sciences (Vienna), Austria). Together, these people created a high-quality scientific program, with a very large number of presentations in operations research.

The submissions for EURO 2018 were subdivided in 25 areas under the responsibility of the Program Committee (PC). Christos Vasilakis was the PC member responsible for the OR in Health, Life Sciences

and Sports area, which attracted 83 abstracts organized in 22 sessions. The authors were invited to submit their work to this special issue of the Operations Research for Health Care (ORHC) journal with the aim of collecting high-quality papers focused on innovative methods and uses of OR in health and care applications. ORHC is the perfect journal for this special issue as it focuses on the development and use of OR and advanced analytics in health and health care, while requiring case studies or numerical experiments to be based on real world problems and data. Furthermore, ORHC successfully published a special issue on the previous edition of Euro-k conferences (EURO 2016) [10].

Amongst the 23 papers submitted, 9 papers were accepted for publication in this special issue after a careful peer review process. The selected papers cover a wide range of health care applications: planning and scheduling decisions in hospitals, patient flow in emergency departments, length of stay forecasting, cost-effective analysis in hospitals, healthcare associated infections, and transplants. Table 1 shows an overview of the papers that are included in this special issue. These papers provide a good sample of the wide range of new applications of operations research to improve health care management across different national contexts and health systems (Belgium, Canada, Spain, the Netherlands and United States). Each contribution is briefly described hereafter.

Paper	Area	Decisions	Methods	Uncertainty	Case/Data
[1]	Hospitals	Length of stay	Forecasting	X	USA
[2]	Hospitals	Planning and scheduling	Chance-constrained stochastic optimization, Meta-heuristics	X	Belgium
[3]	Hospitals	Alternatives for cost-effectiveness analysis	Markov, non-Markov	X	USA, Clinical Trial
[4]	Emergency Department	Patient flow	Simulation-based optimization, DES	X	Spain
[5]	Hospitals/ Infectious diseases	Limiting healthcare-acquired infections	Social network analysis		USA
[6]	Hospitals	Planning and scheduling	Stochastic programming	X	The Netherlands
[7]	Transplants	Sharing variance	Mixed integer programming		USA
[8]	Hospitals	Planning and scheduling	Stochastic programming, Heuristics	X	The Netherlands
[9]	Hospitals	Scheduling	Multiobjective optimisation, Integer programming		Canada

Table 1: Overview of the papers published in the special issue

Zhang et al. [1] provide a novel method for fitting length of stay (LOS) distributions in hospitals. Since LOS distributions have distinct attributes (such as having multiple modes and being skewed), fitting those is challenging. The authors propose three approaches for fitting LOS distributions and provide simulation-based validations of the estimations obtained. Real world data is used to demonstrate how these novel approaches perform compared to other fitting methods. Being able to accurately predict a patient's length of stay in hospital would help to inform many planning decisions along a patient's

journey and also other patient journeys. Hence, the developed approach is potentially of high practical relevance.

Vancroonenburg et al. [2] contribute with a chance-constrained scheduling model for determining the admission dates of elective surgical patients. The aim is to minimize operating theatre costs and patient waiting times, while avoiding bed shortages at a fixed certainty level. The stochastic model is converted into a deterministic model using sample average approximation which is then solved by local search. To illustrate the applicability of the model, the approach is tested with a dataset of hospital admissions and surgery plans of UZ Leuven, an academic hospital in Belgium. The results show that the stochastic approach enables to avoid bed shortages while still optimizing operating theatre costs and patient waiting times.

The paper by del Campo et al. [3] provides a comparison of models that can support cost-effectiveness analyses from an operations research perspective. The authors compare Markov and non-Markov methods and discuss individual advantages and disadvantages. Focusing on cervical cancer as an example case study, the authors discuss the relevance of assuming stationary transition probabilities and the effect of omitting this assumption, as well as providing a detailed description of the model building process. The exemplary calculations carried out and presented in the paper led to notable differences in Markov and non-Markov approaches.

Cildoz et al. [4] propose a simulation-based optimization model to determine the optimal queue management policy at an emergency department (ED). The authors consider the accumulative priority queue (APQ), APQ with finite time horizon (APQ-h) as well as pure priority queuing strategies. They evaluate the results using a discrete-event simulation (DES) mimicking a variety of EDs and find that APQ and APQ-h policies outperform the pure priority strategies.

Kang et al. [5] tackle the challenge faced by most health and care providers, that of healthcare associated infection (HAI). Specifically, they sought to determine which care provider-level properties, such as care provider (worker) type, patient contact factors etc., have the greatest impact on the transmission of such infections within a care facility. Drawing on data from electronic medical records of a hospital in the USA, the authors use Poisson regression model and social network analysis to show that studying patient and care provider (worker) interactions could provide valuable insights into the development of interventions to limit the transmission of HAIs.

Otten et al. [6] consider the stochastic Earliness/Tardiness (E/T) scheduling problem by minimizing the total expected deviation of surgery completion times from the planned completion times. The authors introduce the concept of E/T-concavity and use this concept to generate an optimal schedule for the multiple machine variant of the E/T problem. One real-life instance from a benchmark set from several hospitals in the Netherlands is used to test the proposed approach. The authors conclude that under the assumption of E/T-concavity, a simple Shortest Variance First rule is optimal and demonstrate the benefits of this rule compared to several commonly used scheduling rules.

Mohammadi et al. [7] propose a mixed integer optimization model to investigate the impacts of Organ Procurement Organization (OPO) partnerships in order to maximize the number of shared organs among the partnered OPOs. For a given OPO, the model provides the best partner OPOs to form a sharing variance with, that is a set of OPOs with which to exchange available organs before releasing them at the regional or national level. The model is tested using the liver allocation system in in the state of Georgia. The results demonstrate that better transplant rates and waiting list sizes can be achieved using optimization to determine the sharing variance.

Kamran et al. [8] propose a modified block scheduling policy and consider a reserved slack policy to accommodate the arrival of emergency patients. A stochastic mixed integer linear programming model and two 2-phase heuristics are developed in a rolling horizon framework to solve an adaptive operating room planning and scheduling problem. The approaches are tested with real data from the general surgery department of Radboud University Medical Center (Nijmegen, The Netherlands) which currently works under the block scheduling policy. The proposed features (i.e. modified block

scheduling policy, reserved slack policy, and stochastic surgery durations) result in more efficient solutions for the hospital.

Oliveira et al. [9] study the problem of scheduling surgical patients in the context of patient prioritisation (where urgent patients are scheduled for a surgical procedure or operation ahead of non-urgent). Although patient prioritisation is common in many care settings and surgical specialties, its integration with sophisticated patient scheduling mechanisms is less clear. This paper puts forward an integrated approach encompassing patient prioritization and patient scheduling to improve both operating theatre efficiency and to ensure that more urgent patients are served first. As the initial approach was shown to have a deleterious effect on the waiting times of less urgent patients, a dynamic utility updating method is also put forward to address a potential unintended consequence. Numerical results are obtained from applying the model to a case study inspired by the Urology Department of a Canadian hospital.

Comparing with the special issue on EURO 2016 - New Advances in Health Care Applications [10], the selected papers are more focused on decisions and modelling in hospitals whereas in [10] there is a broader area of application (e.g. primary care, home care, acute care and emergency medical services). All the selected papers are motivated by a real case study in fewer countries, with most of them taking place in the United States and the Netherlands.

We would like to thank all the authors for submitting such high-quality papers to this special issue, and we commend them for their work. We also take this opportunity to express our gratitude to all the reviewers who provided constructive comments and suggestions in a timely manner and contributed to improve the quality of the papers. Finally, we thank the Editor-in-Chief of ORHC, Stefan Nickel, for the opportunity of publishing this special issue.

References

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[3] Cristina del Campo, Jiaru Bai, L. Robin Keller. Comparing Markov and non-Markov alternatives for cost-effectiveness analysis: Insights from a cervical cancer case.

[4] Marta Cildoz, Amaia Ibarra, Fermin Mallor. Accumulating priority queues versus pure priority queues for managing patients in emergency departments.

[5] Hyojung Kang, Marika E. Waselewski, Jennifer M. Lobo. Understanding provider-level properties that influence the transmission of healthcare associated infections using network analysis.

[6] Maarten Otten, Aleida Braaksma, Richard J. Boucherie. Minimizing Earliness/Tardiness costs on multiple machines with an application to surgery scheduling.

[7] Mohsen Mohammadi, Vikram Koli, Monica Gentili, Shanthi Muthuswamy. An Optimization Framework to Determine an Optimal Local Sharing Variance for Organ Allocation.

[8] Mehdi A. Kamran, Behrooz Karimi, Nico Dellaert, Erik Demeulemeester. Adaptive operating rooms planning and scheduling: A rolling horizon approach.

[9] Mariana Oliveira, Valérie Bélanger, Inês Marques, Angel Ruiz. Assessing the impact of patient prioritization on operating room schedules.

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