Editorial
Special issue on *Healthcare Behavioural OR*
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Guest Editors:

Sally Brailsford
University of Southampton, UK

Michael Carter
University of Toronto, Canada

Paul Harper
Cardiff University, UK

Konstantinos V. Katsikopoulos
University of Southampton, UK, and
Max Planck Institute for Human Development, Germany

Behavioural OR seeks to (*i*) advance our understanding of how behavioural factors affect the conduct of, and interact with, model-based processes that support problem solving and decision making, and (*ii*) to leverage this understanding for improving outcomes (Hämäläinen *et al*, 2013). Arguably, the recent revival of Behavioral OR is a return to the roots of OR (Franco and Hämäläinen, 2016).

As comprehensive reviews of the application of OR to healthcare (Brailsford *et al*, 2009; Hulshof *et al*, 2012) reveal, relatively little prior consideration has been devoted to behavioural aspects in this field. Contrast this state of affairs with the need for behaviourally informed approaches in important issues of healthcare, such as:

- Patient and staff behaviours relating to services and patient access to them, including service design, patient no-shows, provider response to congestion;
- Patients' understanding of public health campaigns, including screening and treatment recommendations, and the decision making of patients;
- Physicians' understanding of the evidence base, benefits and risks of recommendations, and the decision-making support physicians provide;
- Effects of physicians' professional networks on physician performance;
- Effects of patients' social networks on the transmission, propagation, and reaction to disease.

The aim of this special issue is to engage those working within OR for healthcare who have an interest in behavioural aspects and in how these impact on theory and application. Conceptual, modelling, and empirical papers are included in this special issue, but all take a behaviourally informed approach, and they seek to create a new body of knowledge concerning the role and impact of behavioural factors such as those illustrated above.

For the papers included in this special issue, a range of OR methods have been utilised with each paper focussing on a different methodology and approach to behavioural OR. Adopted methods are: game theory, queueing theory, discrete event simulation, system dynamics, machine learning, scheduling and descriptive analytics. The range of healthcare domains is equally diverse and interesting, including emergency departments, ambulance services, hospital financing, neonatal services, appointment scheduling and waiting time management.

Our special issue opens with a comprehensive review by Kunc *et* al: "A review of implementation of behavioural aspects in the application of OR in healthcare". A detailed analysis of 130 articles is presented and shows that the majority are focused on improving service delivery at an organisational level. The most common OR methods depicting behaviour are simulation and qualitative methods, but there is evidence of use of a range of methods. The authors highlight the importance of future work to make more explicit the assumptions used to represent behaviour, test the sensitivity of models to different behavioural assumptions, and to offer more information about how users employ models to make decisions.

Mohebbi *et al*. in their paper "Designing an incentive scheme within a cooperative game for consolidated hospital systems", investigate collaborating hospitals and incentive schemes modelled using a cooperative game. The authors focus on the coordination and behaviour of hospitals with physicians and the referral system as the two main players. Interaction within these players shapes the coordinating scheme to improve the overall system performance. A multi-objective mathematical model is developed to obtain transfer patterns and design an incentive scheme to coordinate decisions towards system optimality.

In "Machine learning for healthcare behavioural OR: Addressing waiting time perceptions in emergency care", Gartner and Padman examine the links between patient satisfaction and waiting time perceptions. The authors evaluate machine learning methods to understand waiting time estimation behaviour in two emergency department areas. Outputs are subsequently fed into a discrete-event simulation model to demonstrate that changing staffing patterns can lead to a substantial drop-off in overestimation of waiting times. Such insights can be employed to control waiting time perceptions and increase patient satisfaction.

No-shows in healthcare settings are known to cause under-utilisation of resources and increase waiting times. In "A probabilistic patient scheduling model for reducing the number of no-shows", Ruiz-Hernández *et al*. extend work in this area to include behavioural issues associated with the patient's socio-demographic characteristics and diagnosis. A model to reduce the impact of no-shows is proposed with experimental results showing that using novel behavioural insights can reduce both waiting list length and increase revenue when comparing to a model that assigns patients to the first available slot.

Determining the impact of using clinical judgment on neonatal services performance is the focus of research by Lebcir in his paper: "Should doctors use

their judgment? How a System Dynamics model elicited knowledge in neonatal care services". Neonatal services in the UK are under financial pressures and are heavily regulated, affecting efficiency. One possible solution that is explored in this paper is to reduce the length of stay of babies and thus allow a degree of doctors' clinical judgment in making such decisions. The paper discusses implications of this approach and the ability of system dynamics to foster learning and alter participants' perceptions and behaviour.

Motivated by an empirical study of emergency department service times, in "Server behaviours in healthcare queueing systems" Harper explores the nature of the relationship between service times and workload in order to assess and quantify workforce (server) behaviours. An analytical queueing model is considered with switching thresholds to allow for multi-speed service, which for example captures the congestion in the waiting room and the resulting change in speed of the workforce to try and cope with the backlog of patients. Related behavioural characteristics resulting from workload fatigue and service breakdown are also considered. The research helps to demonstrate the importance of more accurately capturing server behaviours in workload-dependent environments.

VanBerkel *et al* in their paper "Treatment process differences with and without an ambulance offload zone" compare the emergency department treatment processes which occur when an Ambulance Offload Zone (OZ) is functioning and when it is not. An OZ is a monitored waiting space for ambulance patients which is designed to allow ambulance crews to return to service more quickly. The authors use concurrent comparison data and show how treatment processes and the behaviour of emergency department actors change when the OZ is functioning and how in turn this impacts the effectiveness of the OZ.

As guest editors we are extremely grateful for the support received by the editors and editorial team at JORS, Taylor & Francis, The OR Society, and all those who kindly reviewed submissions. We hope that research presented in this collection of papers helps to demonstrate the importance of more accurately reflecting and capturing behaviours in healthcare systems modelling, and that this might help spawn an emergence of behavioural healthcare OR literature. Indeed, at the time of writing amidst the Covid-19 pandemic, it is clear for example that adherence to social distancing and related behaviours including responses by governments, plays a vital role in reducing the spread and impact of the disease. UK government's chief medical officer Chris Whitty explicitly said that an important part of the science is behavioural science. Clearly there is an interplay between designing and delivering the logistics required to deal with an outbreak of this magnitude with better understanding and inclusion of the social determinants, adherence and response to the crisis, including stress responses. Healthcare behavioural OR research is therefore vital to help inform policy makers and requires far greater consideration and application.

References

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