Taking extra care

The SIMCARE project proposes to boost the performance of healthcare systems. **Professor Boris Sobolev** explains how computer simulations can be employed to quantify the impact of policy changes

To begin, what is the overarching mission of your research project? What led you to establish SIMCARE?

The grand challenge of public health is the gap between the healthcare that is possible and the healthcare that is delivered. As a health services researcher, my mission is to contribute to closing this gap. The SIMCARE project was established in order to compare the outcomes of cardiac care delivered under different policies when intervention studies are not feasible.

Could you expand on the idea that the evaluation of organisational changes in the delivery of health services should include the simulation of health system operations?

Health services research informs policy by pointing to differences in outcomes across patient groups exposed to various policies. However, empirical testing of the connection between the organisation and the outcomes of health services is difficult because of constraints on conducting experiments in the patient care setting. As a result, empirical research offers only limited evidence on how changes in the organisation of healthcare delivery may affect the outcomes of care. Computer simulation of systems' operations provides a method to quantify the effects of proposed policy changes based on our current understanding of the system.

Could you elaborate on how computer simulation is used to test various policy alternatives that have been developed by decision makers within the healthcare system?

We assess proposed changes in the organisation and management of healthcare processes by comparing the performance of the system under various simulation model configurations. A simulation experiment consists of multiple runs of the model with inputs representing the patient population, the healthcare services provided and the proposed policy alternatives. Each simulation run generates care paths for patients served in a modelled hospital. During each run, the simulation software records the occurrence and timing of simulated events for the modelled patient population, such as appointments, procedures and cancellations. Experimental outcomes are then computed from patient-level records generated by the simulation runs.

If simulation of healthcare is not new, why are simulation studies not used more widely to improve the delivery of healthcare services?

There are several reasons. First, the analytical framework that places computer simulation studies within the paradigm of intervention research had not been developed until our work. Second, only recently has the health services delivery been understood as a reactive system, which necessitated the use of a special type of diagram known as Statecharts for the realistic representation of systems' operations and studied policy. Another reason is that previously, simulation studies tended to focus on few outcomes, which prevented a full understanding of the policy effects.

What is the purpose of using Statecharts diagrams for representing concurrent activities in the care process?

In presenting the reactive nature of healthcare processes, we follow the approach of computer scientist David Harel, who developed the Statecharts graphical formalism for describing reactive systems. We apply the formalism of Statecharts to describe individual patients' progress through surgical care. We model the patient's pathway as a series of asynchronous updates in patient records generated in reaction to events produced by concurrent clinical and managerial activities. In doing this, we have observed that the Statecharts diagrams successfully capture the behavioural aspects of surgical care delivery by specifying the permissible chronology of events, conditions and actions.

Could you explain the patient-level models used to simulate the steps in health service delivery and the response pathways for individual patients?

Within our framework, the use of simulation experiments for evaluating healthcare policy is based on two premises: first, that simulated individual care paths collectively represent the delivery of healthcare services to a patient population; and, second, that simulation produces care paths that are likely under the policy being evaluated.

What is the benefit of using subject-matter expertise rather than numerical optimisation algorithms for evaluating policy alternatives?

Policy is devised by experts. We produce evidence by evaluating policy. When policy making is based on the results of some calculations, we still have to evaluate the effect of the policy. We therefore developed an approach that incorporates the simulation of health system operations into the evaluation of policy initiatives.

What would you say have been the highlights of your research?

As a result of SIMCARE, we have been able to develop a comprehensive methodology of conducting simulation studies for evaluation of complex interventions in surgical care. This includes the tools for identifying the clinical and managerial activities of the care process, determining the model requirements, implementing simulation models, designing simulation experiments, analysing the experimental data, and interpreting and reporting results.

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Trial before implementation

By using computer simulation, the Vancouver-based SIMCARE project evaluates the proposed changes to improve the delivery of health services, adding to traditional empirical health services research

CANADA'S HEALTHCARE SYSTEM provides universal coverage for all of its population. The Canada Health Act, legislation passed in 1984 governing the health policy in the country, set the goal of giving all Canadians access to medically necessary services regardless of their personal income or any other barrier. Coordinated by the federal government, medical care is publicly funded and administered by provincial and territorial bodies. Although the trend is declining slightly from a historic peak of Canadian healthcare spending in 2009 totalling 11.9 per cent of GDP, expenditure is still dazzling, and last year it reached CAD $200 billion.

Public opinion polls show that Canadians are demonstrably proud of their country's health system. Moreover, at around 80 years, life expectancy in Canada is consistently higher than in the US or the UK, and the country also has one of the lowest infant mortality rates among industrialised nations, according to World Health Organization figures. That said, there is still room for improvement. As in many other countries with a publicly-funded healthcare system, an evidence-based approach to healthcare management is a far-reaching objective, and the current state of knowledge offers only limited insights into how changes in the organisation and management of a healthcare system may affect the quality and outcomes of care. Supported by a strategic initiative from the Canadian Institutes for Health Research, the SIMCARE project was set up under the leadership of Professor Boris Sobolev from the UBC School of Population and Public Health, Vancouver to evaluate the effects of proposed changes in managing access to cardiac care before they are implemented in practice.

COMPARING ALTERNATIVES

The ultimate goal of SIMCARE is to inform policy making about the most effective options for improving the delivery of medical care. The project thoroughly investigates alternative practices and policies put in place in medical institutions to ascertain their effects on the patient and on the system. Given the complexity of this sector, achieving this offers a unique set of challenges. As Sobolev points out, healthcare delivery is driven by a wide spectrum of professional expertise, multiple organisational arrangements, a slew of treatment protocols and numerous interactions between managerial and clinical activities. This inherent complexity underpins every aspect of healthcare delivery, and can be seen at the heart of surgical care which includes a continuum of diagnostic, preoperative, operative and postoperative procedures.

Adopting the view of the economics Nobel laureate James Joseph Heckman, SIMCARE experts have used policy analysis in order to evaluate the likely effects of proposed policy alternatives in the delivery of cardiac surgical care. Policy analysis from this perspective better enables the group to inform policy, either to adopt or discard any given suggested change in the process of care. And this need to make more evidence-based decisions is ever-more vital in light of continued global economic uncertainty and the ensuing public deficit.

SIMULATION MODELLING

The opportunity to work on improving the effectiveness of medical care is one of the benefits afforded by SIMCARE. More important still, is the project's focus on surgical care, a highly pressured field in which life-or-death decisions must be made every day, and consequently, an area in which little space can be left for experimentation. In this context, it is hard to test the considered changes empirically – that is to say, to implement factual trial and error processes to identify which is the best alternative in health services delivery. To successfully overcome this difficulty, SIMCARE researchers use computer simulation studies as a tool for contrasting the performance of a system under proposed policy and management alternatives.

The result is a new interdisciplinary approach that blends intervention research and simulation modelling within one analytical framework. This way simulation experiments are carried out with sufficient rigour, paying special attention to the interpretation of output data on which the comparison between proposed alternatives will be based: "A simulation experiment consists of multiple runs of the model with

SIMCARE

OBJECTIVES

- To place computer simulation studies within the paradigm of intervention research concerned with comparing the outcomes of healthcare delivered under various policies. In particular, it includes:
- Merging intervention research and computer simulation modelling within one analytical framework
- Developing a research agenda on the premise that the evaluation of organisational changes in the delivery of health services should include the simulation of health system operations

KEY COLLABORATORS

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inputs representing the patient population, the healthcare services provided and the proposed policy alternatives," explains Sobolev, adding: "During each run, the simulation software records the occurrence and timing of simulated events for the hypothetical patient population, such as appointments, procedures and cancellations. Experimental outcomes are then computed from patient-level records generated by the simulation runs".

TESTED CHANGES

SIMCARE showcases policy analysis for identifying effective solutions for the everyday practice of healthcare. Cardiac surgical care, which features more structured treatment protocols, is a clear example by which to illustrate the outcomes of the research; simulation modelling in this area involves policies including patient admittance in hospitals, booking of appointments, capacity planning and waiting list management, to name but a few. Sobolev's approach was to analyse various ways of improving access to surgery in which the advice of various specialists and hospital managers was called upon. The resulting simulation experiments showed that using a single queue system reduces the clearance times, allowing more patients to get an appointment. Similarly, SIMCARE studied methods of screening patients for surgery.

The team compared the method of screening all patients with an alternative model in which only some of them are screened before admittance to hospital, and found that the number of surgery cancellations was lower following the first method. The project also contrasted ways of booking elective surgery appointments, one by pre-booking appointments at the time when the decision to operate is made, and another using waiting lists to manage appointments for the operation rooms. These simulation experiments showed that when surgery appointments are booked in advance, the number of cancellations falls.

> SIMCARE showcases policy analysis for identifying effective solutions for the everyday practice of healthcare

The use of Statecharts diagramming has played an important role in developing SIMCARE's simulation studies. Created by renowned computer scientist David Harel from the Weizmann Institute of Science, this graphical language is used to represent interactions in healthcare using three key concepts of reactive systems: hierarchy, parallelism and event broadcasting, as Sobolev elucidates: "Hierarchy describes steps within hospital activities; parallelism provides the means to specify concurrent activities; and event broadcasting provides the means to trigger a series of actions in one activity according to transitions that occur in another". As a result of this approach, Statecharts can depict with accuracy the connection between disparate events taking place in the course of different care services.

WEALTH OF KNOWLEDGE

The theories behind SIMCARE have already crystallised into two books, *Analysis of Waiting-Time Data in Health Services Research* and *Health Care Evaluation Using Computer Simulation*. The two books published by Springer are intended for use as authoritative references in this domain of knowledge; indeed, the invaluable lessons emerging from these titles can be readily applied by health service researchers. The first title was released in 2008, and represents one of the most comprehensive collection of examples of, and case studies about, waiting-time data analyses to date. With over 1,400 electronic copies downloaded since 2009 (the latest figure from Springer), it has met with a warm reception from scholars and professionals around the world. The latter title could easily serve as a textbook in conducting simulations for policy alternatives evaluation, providing new insights on the study of healthcare access using statistical tools.

CONTINUED SUPPORT

In terms of financial backing, the SIMCARE team has received the trust and confidence of several institutions. The primary location for this research is the Centre for Clinical Epidemiology and Evaluation at the Vancouver Coastal Health Research Institute. The Canadian Institutes for Health Research, the Canada Research Chairs, the Canada Foundation for Innovation and the Michael Smith Foundation for Health Research have all supported the project with funding and grants totalling over $3 million.

Looking ahead, SIMCARE aims to build on its success so far. Initially, its primary focus was on surgical coronary revascularisation but new lines of investigation have been successfully opened on orthopaedic surgery. Another challenge for Sobolev now lies in expanding his methodology across jurisdictions. This crucial step involves not only communicating his findings on computer simulation to policy makers, but also achieving a wider adoption of the project's approach on both a regional and federal level. Little changes can make a big difference. Proving that incremental change can make a tangible difference, SIMCARE is able to generate evidence through simulation experiments in which a proposed reform can be truly tested and assessed. This is the closest that science can get to predicting the future.