VALUE IN HEALTH 18 (2015) 147–160

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/jval

ISPOR TASK FORCE REPORTS

Selecting a Dynamic Simulation Modeling Method for Health Care Delivery Research—Part 2: Report of the ISPOR Dynamic Simulation Modeling Emerging Good Practices Task Force

Deborah A. Marshall, PhD[1,], Lina Burgos-Liz, MSc, MPH, BSc Ind Eng[2], Maarten J. IJzerman, PhD[3], William Crown, PhD[4], William V. Padula, PhD, MS[5], Peter K. Wong, PhD, MS, MBA, RPh[6], Kalyan S. Pasupathy, PhD[7], Mitchell K. Higashi, PhD[8], Nathaniel D. Osgood, BS, MS, PhD[9,10], the ISPOR Emerging Good Practices Task Force*

[1]*Health Services & Systems Research, Department of Community Health Sciences, Cumming School of Medicine, University of Calgary, Calgary, AB, Canada;* [2]*Cumming School of Medicine, University of Calgary, Calgary, AB, Canada;* [3]*Department of Health Technology & Services Research, University of Twente, Enschede, The Netherlands;* [4]*Optum Labs, Boston, MA, USA;* [5]*Section of Hospital Medicine, University of Chicago, Chicago, IL, USA;* [6]*HSHS Illinois Divisions and Medical Group, Hospital Sisters Health System, Belleville, IL, USA;* [7]*Health Care Systems Engineering Program, Mayo Clinic Robert D. and Patricia E. Kern Center for the Science of Health Care Delivery, Rochester, MN, USA;* [8]*GE Healthcare, Barrington, IL, USA;* [9]*Department of Computer Science, University of Saskatchewan, Saskatoon, Saskatchewan, Canada;* [10]*Department of Community Health & Epidemiology and Bioengineering Division, Saskatoon, Saskatchewan, Canada*

ABSTRACT

In a previous report, the ISPOR Task Force on Dynamic Simulation Modeling Applications in Health Care Delivery Research Emerging Good Practices introduced the fundamentals of dynamic simulation modeling and identified the types of health care delivery problems for which dynamic simulation modeling can be used more effectively than other modeling methods. The hierarchical relationship between the health care delivery system, providers, patients, and other stakeholders exhibits a level of complexity that ought to be captured using dynamic simulation modeling methods. As a tool to help researchers decide whether dynamic simulation modeling is an appropriate method for modeling the effects of an intervention on a health care system, we presented the System, Interactions, Multilevel, Understanding, Loops, Agents, Time, Emergence (SIMULATE) checklist consisting of eight elements. This report builds on the previous work, systematically comparing each of the three most commonly used dynamic simulation modeling methods—system dynamics, discrete-event simulation, and agent-based modeling. We review criteria for selecting the most suitable method depending on 1) the purpose—type of problem and research questions being investigated, 2) the object—scope of the model, and 3) the method to model the object to achieve the purpose. Finally, we provide guidance for emerging good practices for dynamic simulation modeling in the health sector, covering all aspects, from the engagement of decision makers in the model design through model maintenance and upkeep. We conclude by providing some recommendations about the application of these methods to add value to informed decision making, with an emphasis on stakeholder engagement, starting with the problem definition. Finally, we identify areas in which further methodological development will likely occur given the growing "volume, velocity and variety" and availability of "big data" to provide empirical evidence and techniques such as machine learning for parameter estimation in dynamic simulation models. Upon reviewing this report in addition to using the SIMULATE checklist, the readers should be able to identify whether dynamic simulation modeling methods are appropriate to address the problem at hand and to recognize the differences of these methods from those of other, more traditional modeling approaches such as Markov models and decision trees. This report provides an overview of these modeling methods and examples of health care system problems in which such methods have been useful. The primary aim of the report was to aid decisions as to whether these simulation methods are appropriate to address specific health systems problems. The report directs readers to other resources for further education on these individual modeling methods for system interventions in the emerging field of health care delivery science and implementation.

Keywords: decision making, dynamic simulation modeling, health care delivery, methods.

* Address correspondence to: Deborah A. Marshall, Department of Community Health Sciences, Cumming School of Medicine, University of Calgary, 3280 Hospital Drive NW, Rm 3C56 Health Research Innovation Centre, Calgary, AB, Canada T2N 4Z6.

E-mail: damarsha@ucalgary.ca.

1098-3015$36.00 – see front matter © 2015 Published by Elsevier Inc. on behalf of International Society for Pharmacoeconomics and Outcomes Research (ISPOR).

http://dx.doi.org/10.1016/j.jval.2015.01.006

Background to the Task Force

In October 2013, the ISPOR Health Science Policy Council recommended to the ISPOR Board of Directors that an ISPOR Emerging Good Practices for Outcomes Research Task Force be established to focus on dynamic simulation modeling methods that can be applied in health care delivery research and recommendations on how these simulation techniques can assist health care decision makers to evaluate interventions to improve the effectiveness and efficiency of health care delivery. The Board of Directors approved the ISPOR Dynamic Simulation Modeling Emerging Good Practices Task Force in November 2013.

The task force leadership group is composed of experts in modeling, epidemiology, research, systems and industrial engineering, economics, and health technology assessment. Task force members were selected to represent a diverse range of perspectives. They work in hospital health systems, research organizations, academia, and the pharmaceutical industry. In addition, the task force had international representation with members from Canada, The Netherlands, Colombia, and the United States.

The task force met approximately every 5 weeks by teleconference to develop an outline and discuss issues to be included in the report. In addition, task force members met in person at ISPOR International meetings and European congresses. All task force members reviewed many drafts of the report and provided frequent feedback in both oral and written comments.

Preliminary findings and recommendations were presented in forum and workshop presentations at the 2014 ISPOR Annual International Meeting in Montreal and ISPOR Annual European Congress in Amsterdam. In addition, written feedback was received from the first and final draft reports' circulation to the 190-member ISPOR Modeling Review Group. Comments were discussed by the task force on a series of teleconferences and during a 1.5-day task force face-to-face consensus meeting. All comments were considered, and most were substantive and constructive.

Comments were addressed as appropriate in subsequent versions of the report. All written comments are published at the ISPOR Web site on the task force's Webpage: http://www.ispor.org/TaskForces/Simulation-ModelingApps-HCDelivery.asp. The task force report and Webpage may also be accessed from the ISPOR homepage (www.ispor.org) via the purple Research Tools menu, ISPOR Good Practices for Outcomes Research, heading: Modeling Methods.

In the course of task force deliberations, in response to specific comments and suggestions from reviewers, and a growing concern about length, it became apparent that the material would need to be covered in two task force reports to be thorough, covering the essential points, yet keep the report readable and digestible. With permission from the editors of *Value in Health*, the material was split into two articles.

The first article "Applying Dynamic Simulation Modeling Methods in Health Care Delivery Research—The SIMULATE Checklist: Report of the ISPOR Dynamic Simulation Modeling Applications in Health Care Delivery Research Emerging Good Practices Task Force," is a primer on how dynamic simulation modeling methods can be applied to health system problems. It provides the fundamentals and definitions, and discusses why dynamic simulation modeling methods are different from typical models used in economic evaluation and why they are relevant to health care delivery research. It includes a basic description of each method (system dynamics, discrete-event simulation, agent-based modeling), and provides guidance on how to ascertain whether these simulation methods are appropriate for a specific problem via the SIMULATE checklist that was developed by the task force.

This second report provides more depth, delving into the technical specifications related to the three dynamic simulation modeling methods. It systematically compares each method across a number of features and provides a guide for emerging good practices for outcomes research on dynamic simulation modeling. This report concludes by providing recommendations on the application of dynamic simulation modeling methods to add value to informed decision making, with an emphasis on problem definition and stakeholder engagement and identifies areas where further methodological development will likely occur given the growing "volume, variety, velocity" of "big data" [1].

Introduction

The translation of evidence into policy and clinical care through implementation in the health care system is a core issue facing health care delivery system transformation around the world. Evidence-based practices can be implemented through the aid of operations research methods to redesign health care delivery systems and improve patient outcomes and health system performance [2]. In a previous article [3], the ISPOR Task Force on Dynamic Simulation Modeling Applications in Health Care Delivery Research Emerging Good Practices introduced the fundamentals of dynamic simulation modeling by defining complexity and health care systems interventions and identifying the types of health care delivery problems for which dynamic simulation modeling can be used. The article introduced three dynamic simulation modeling methods most commonly used—system dynamics (SD), discrete-event simulation (DES), and agent-based modeling (ABM)—and reviewed where they differ from models more typically used in economic evaluation such as Markov models and decision trees. Finally, the System, Interactions, Multilevel, Understanding, Loops, Agents, Time, Emergence (SIMULATE) checklist was developed and presented as a tool to help researchers decide whether dynamic simulation modeling is an appropriate method for modeling the effects of a particular policy or health care intervention on a health care system. The SIMULATE checklist identifies eight elements (System, Interactions, Multilevel, Understanding, Loops, Agents, Time, Emergence) that characterize problems that could be addressed more effectively using dynamic simulation modeling methods rather than other modeling methods.

This report builds on this work by systematically comparing each of these three dynamic simulation modeling methods, and by identifying criteria for selecting the most suitable method among these three alternative methods depending on the type of problem being addressed. In cases in which different dynamic simulation modeling methods may be used for the health care delivery problem, several specific elements were identified for differentiating the methods such as the perspective, the origin of dynamic interactions in the system, and resource requirements in terms of manpower and costs. Following the description of the three modeling approaches, we provide emerging good practices different from guidance for other modeling studies reported elsewhere, covering all aspects from the engagement of decision makers in the model design through to model maintenance and upkeep. We conclude with recommendations about how to apply these methods in practice to inform decision making and by identifying areas for continued methodological development in applying dynamic simulation models to health care delivery research.