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ISPOR TASK FORCE REPORT

Applying Dynamic Simulation Modeling Methods in Health Care Delivery Research—The SIMULATE Checklist: Report of the ISPOR Simulation Modeling Emerging Good Practices Task Force

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ABSTRACT

Health care delivery systems are inherently complex, consisting of multiple tiers of interdependent subsystems and processes that are adaptive to changes in the environment and behave in a nonlinear fashion. Traditional health technology assessment and modeling methods often neglect the wider health system impacts that can be critical for achieving desired health system goals and are often of limited usefulness when applied to complex health systems. Researchers and health care decision makers can either underestimate or fail to consider the interactions among the people, processes, technology, and facility designs. Health care delivery system interventions need to incorporate the dynamics and complexities of the health care system context in which the intervention is delivered. This report provides an overview of common dynamic simulation modeling methods and examples of health care system interventions in which such methods could be useful. Three dynamic simulation modeling methods are presented to evaluate system interventions for health care delivery: system dynamics, discrete event simulation, and agent-based modeling. In contrast to conventional evaluations, a dynamic systems approach incorporates the complexity of the system and anticipates the upstream and downstream consequences of changes in complex health care delivery systems. This report assists researchers and decision makers in deciding whether these simulation methods are appropriate to address specific health system problems through an eight-point checklist referred to as the SIMULATE (System, Interactions, Multi-level, Understanding, Loops, Agents, Time, Emergence) tool. It is a primer for researchers and decision makers working in health care delivery and implementation sciences who face complex challenges in delivering effective and efficient care that can be addressed with system interventions. On reviewing this report, the readers should be able to identify whether these simulation modeling methods are appropriate to answer the problem they are addressing and to recognize the differences of these methods from other modeling approaches used typically in health technology assessment applications.

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

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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 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 five 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 two task force reports would be needed to be thorough, covering the essential points, yet keep the report readable and digestible. With *Value in Health*'s permission, the material has been split into two articles.

This first article 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 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 developed by the task force.

The second report will provide more depth, delving into the technical specifications related to the three dynamic simulation modeling methods. It will systematically compare each method across a number of features and provide a guide for good research practices for the conduct of dynamic simulation modeling. This report will appear in the March/April 2015 issue of *Value in Health*.

Introduction

Health care delivery systems are inherently complex and fragmented social systems consisting of governments, payers, and multiple providers responsible for delivering health care services to patients in defined regions [1–3]. Social systems are different from other systems in that people make decisions, interact among themselves, and also interact with other parts of the system in an interdependent nature. It is hard to plan health care services in these types of complex systems because decisions and choices by people are dynamic (i.e., can change over time and interactions between parts of the system and with other systems are adaptive). In the era of patient-centered care, customizing care to the needs of individual patients further escalates the complexity of health care delivery systems [4–9].

Complexity challenges decision makers to evaluate interventions that can improve the effectiveness and efficiency of health care delivery because of the emergent behavior of the system (i.e., the potential intended and unintended consequences). Although modeling approaches such as decision trees and Markov models have been standardized as methods to evaluate health care interventions, these approaches are not sufficient for analyzing complex health care delivery systems. Dynamic simulation modeling offers advantages with recent advances in accessible computing power and data analytics that make it possible to simulate the impact of system interventions on health care delivery systems without costly and time-consuming direct experimentation. The results of such simulation models can anticipate the comparative effectiveness of a novel system intervention as well as its cost-effectiveness.

This task force report presents dynamic simulation modeling methods to evaluate system interventions for health care delivery. It is a primer for researchers and decision makers who face complex challenges to deliver effective and efficient care. Based on experience from the fields of industrial engineering and operations research, three dynamic simulation modeling methods are well suited for and commonly applied to these types of problems: system dynamics (SD), discrete event simulation (DES), and agent-based modeling (ABM) [9–13].

This report provides an overview of these dynamic simulation modeling methods and examples of health care system interventions in which such methods could be useful. It is intended to assist researchers and decision makers in deciding whether these simulation methods are appropriate to address specific health system problems. An eight-point checklist referred to as the SIMULATE (System, Interactions, Multilevel, Understanding, Loops, Agents, Time, Emergence) tool is included to assist in determining whether these dynamic simulation modeling methods are suitable to address the problem of interest. The report also directs readers to other resources for further education on the topic of modeling system interventions in the emerging field of health care delivery science and implementation. On reviewing this report, readers should be able to identify whether these dynamic simulation modeling methods are appropriate to answer the problem they are addressing and to recognize the differences of these methods from other modeling approaches.