Using integrated modeling to support the global eradication of vaccine-preventable diseases

Radboud J. Duintjer Tebbens[1] and Kimberly M. Thompson[1]

1. Kid Risk, Inc., Orlando, FL, USA

Correspondence to: Radboud J. Duintjer Tebbens, Kid Risk, Inc., 10524 Moss Park Rd., Ste. 204-364, Orlando, FL 32832, USA, Email: rdt@kidrisk.org

Abstract

The long-term management of global disease eradication projects involves numerous inherently dynamic processes, health and economic trade-offs, significant uncertainty and variability, rare events, complex and inter-related decisions, and a requirement for cooperation among a large number of stakeholders. Over the course of more than 15 years of collaborative modeling efforts to support the Global Polio Eradication Initiative, we developed increasingly complex integrated models that combined numerous analytical approaches, including system dynamics, risk and decision analysis, discrete-event and individual-based simulation, probabilistic uncertainty and sensitivity analysis, health economics, and optimization. We summarize the integrated models, give examples of how these different tools provided complimentary insights about specific questions, and provide an example to illustrate how we integrated analytical tools. We discuss the central role of system dynamics in the overall effort. We further emphasize that due to the nature of disease eradication management efforts, the integration of different modeling approaches proved critical to develop the ability to holistically address policy questions as they arose. We discuss practical challenges we faced in the context of integrating different analytical tools and provide our perspective on the future of integrated modeling.

Keywords: integrated modeling, dynamic modeling, health economics, polio eradication

Introduction

The long-term management of global disease eradication projects involves numerous inherently dynamic processes, health and economic trade-offs, significant uncertainty and variability, rare events, complex and inter-related decisions, and a requirement for cooperation among many stakeholders. As we embarked in the early 2000s on a collaborative modeling effort to support the Global Polio Eradication Initiative (GPEI), we recognized that to adequately characterize the complexity, we needed to developed integrated models that combined numerous analytical approaches, including system dynamics, risk and decision analysis, discrete-event and individual-based simulation, probabilistic uncertainty and sensitivity analysis, health economics, and optimization. This paper provides a brief background on polio eradication, followed by an overview of the integrated models we used to support the GPEI. We specifically discuss the role of system dynamics modeling and systems thinking as a key foundation on which one can build such models. We then provide an example of how we integrated a discrete-event simulation within a global model for long-term poliovirus risk management. Finally, we discuss key lessons learned related to the use of integrated models. We expect to publish the full paper in the anniversary issue of System Dynamics Review.