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Editorial

Advances in Microsimulation Modeling of Population Health Determinants, Diseases, and Outcomes

Jacek A. Kopec,[1] Kimberley Edwards,[2] Douglas G. Manuel,[3] and Carolyn M. Rutter[4]

[1] *School of Population and Public Health, 2206 East Mall, Vancouver, BC, Canada, V6T 1Z3*
[2] *Centre for Sports Medicine, Division of Orthopaedic and Accident Surgery, University of Nottingham, C Floor, West Block, Queen's Medical Centre, Nottingham NG7 2UH, UK*
[3] *Ottawa Hospital Research Institute, 725 Parkdale Ave, Ottawa, ON, Canada, K1Y 4E9*
[4] *Group Health Research Institute, 1730 Minor Ave, Suite 1600, Seattle, WA 98101-1448, USA*

Correspondence should be addressed to Jacek A. Kopec, jkopec@arthritisresearch.ca

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The theme of the current special issue is microsimulation. In many scientific disciplines, computer simulation models have contributed to our understanding of the world and the value of strategies to modify the likely course of events. The benefits of simulation models can be seen in estimating the impact of human activity on climate change or the impact of policy initiatives, such as tax changes, on the economy. It is perhaps time for the health sciences to be similarly ambitious in understanding population health using computer simulation.

Simulation models have been used in health research since the 1960s [1]. Typical applications have involved hospital scheduling, spread of communicable diseases, effectiveness of screening programs, and economic evaluation [2]. Most of the models have been macrolevel models, which operate at the level of groups or systems. In contrast, microsimulation is a way to model the behavior and generate the life histories of individual units, such as persons or households. Microsimulation models have been used primarily for evaluating social and economic policies, such as income tax, social security, health benefits, or pension policies [3].

Over the past decade, there has been a growing interest in the development of microsimulation models capable of projecting the distributions of health determinants and diseases in the population, estimating the contribution of different risk factors to changes in disease incidence, prevalence, and mortality, and predicting the effects of disease prevention and treatment strategies on health outcomes [4, 5]. For modeling epidemics, interactive microsimulation models (agent-based models) have been implemented [6]. Recent efforts in model building have benefitted from the increasing power and decreasing cost of computing infrastructure, and the growing availability of population health data [7].

The seven articles featured in this issue represent a range of topics from researchers working in USA, UK, Canada, Australia, and Japan. Two methodological papers deal with critical issues in model development, namely, sources of data for model parameters and estimating uncertainty around model results. Five applied papers cover a broad range of important public health problems, such as screening and treatment for breast cancer, marijuana use across the life course, effect of physical activity on life expectancy, health impact and costs of obesity, and the social burden of the elderly. Below, we briefly summarize these diverse contributions which, taken as a whole, demonstrate both the challenges and promise of microsimulation modeling.

When modeling the spread of infections, accurate travel and contact data are paramount. M. Laskowski and colleagues discuss novel types of data sources generated by cell phone contacts, combined with detailed travel survey data and fine-grained trip data from a study of vehicles. Using examples from the province of Manitoba, Canada, they explain how such data can be integrated into the framework of agent-based models of infectious diseases.

The results from simulation models are subject to uncertainty, but in many modeling studies uncertainty is not properly quantified. B. Sharif and colleagues review the strategies for estimating two types of uncertainty in population-based microsimulation models of chronic diseases: the Monte Carlo error and parameter uncertainty. Steps in uncertainty

analysis, including sample size estimation, are illustrated with an example of a Canadian microsimulation model of osteoarthritis.

Breast cancer is the most common cancer among women in the United States, and Black women in the District of Columbia have the highest breast cancer mortality in the nation. A. M. Near and colleagues adapt an established microsimulation model developed as part of the Cancer Intervention and Surveillance Modeling Network program to help policy makers in DC develop strategies for reducing breast cancer mortality in this group. The authors estimate the effects of changing screening guidelines and improving the use of chemotherapy and consider both the benefits as well as potential harms associated with these interventions.

Understanding marijuana use patterns over the life course is important for developing effective harm reduction policies. However, empirical studies that are sufficiently long and cover the full range of user types are rare and very hard to carry out. S. M. Paddock and her colleagues combine data from several sources to develop a simulation model, the RAND Marijuana Microsimulation Model, that allows them to describe lifetime marijuana use trajectories in the population of the United States. The authors apply the model to estimate and compare the potential benefits from prevention and treatment strategies among various groups of users.

Sedentary lifestyle is a well-established risk factor for mortality. The question G. Rowe et al. consider is how much life expectancy in Canada would improve if everyone went for a walk instead of watching television. To address this question they develop a microsimulation model that uses detailed data on activity patterns from a large population survey. By analyzing the impact of hypothetical changes in behavior across different groups they also find a surprising answer to the question who should exercise for maximum population health benefit.

Population-based simulation models can be used to project future impact of aging, as well as major risk factors for chronic diseases, on health and healthcare costs. However, such comprehensive models are rare. Lymer and Brown describe the development and application of a health module for an Australian population and policy model called APPSIM. Rather than modeling individual diseases, these authors directly model the effects of risk factors on self-rated health. Preliminary results help assess the burden of obesity in terms of its impact on both health status and health expenditures in Australia.

Population aging, with its multiple and profound implications for society, has been studied by demographers and social scientists for decades. Yet, the complexity of the societal processes associated with aging makes long-term predictions of the social burden of the elderly elusive. The paper by T. Fukawa applies a microsimulation model called INAHSIM-II to better understand and predict changes in the living arrangements and dependency levels among the elderly in Japan over the next several decades.

What can epidemiologists learn from these papers? Epidemiology is sometimes considered a basic science of public health, but the link between epidemiological data and public policy is often tenuous and indirect [8]. Simulation models are helpful in synthesizing epidemiological data and translating them into applicable public health knowledge [3–7]. Results from microsimulation models are increasingly used to guide public health policy. For example, the United States Preventive Services Task Force recently incorporated evidence from such models in their recommended guidelines for breast cancer screening [9]. As the role of simulation models in shaping public health policies continues to grow, epidemiologists will be increasingly involved in model building and asked to help interpret findings from simulation studies. Microsimulation models in particular should be of interest to epidemiologists because they tend to rely directly on parameters derived from epidemiological studies, such as disease incidence, mortality, and relative risks.

Microsimuation models have the potential to become increasingly complex, incorporating different risks, pathways, and outcomes that are of interest to policy makers. Epidemiologists can play a key role in developing an understanding of how models tie together such complex issues. We believe that the series of papers published in this issue of ERI provide interesting, contemporary examples of microsimulation model applications in the context of population health research, as well as examples of current methodological challenges model developers are grappling with. They also offer useful insights into the kinds of research questions such models are capable of addressing.

Jacek A. Kopec
Kimberley Edwards
Douglas G. Manuel
Carolyn M. Rutter

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