systems

Editorial

Systems Thinking and Models in Public Health

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In responding to population health challenges, epidemiologists want to identify causal associations between an exposure (e.g., tobacco smoking) and disease (e.g., lung cancer) so we can intervene to improve human health. In epidemiology, these kinds of 'causal' questions are addressed by comparing exposed and unexposed groups to identify individual component causes (or 'risk factors') of disease. This counterfactual approach aims to hold everything constant except the factor of interest and, if successfully achieved, this can tell us if 'X causes Y'. However, a focus on single risk factors necessarily overlooks the complexity and multifactorial nature of most health outcomes, particularly chronic disease outcomes. The causes of disease can operate at the macro or micro level, across the life course, and they are also inextricably intertwined with social, economic and political environments. The single 'risk factor' approach to understanding disease outcomes is limited in the face of this complexity [1–3]. Similarly, demonstrating that an intervention works in a highly controlled study setting does not necessarily mean that it will work in the same way when implemented in a dynamic population in the presence of these other complex determinants of disease.

There are alternative methods that explicitly characterize and model complex systems, and epidemiologists and public health practitioners are increasingly working in multidisciplinary groups to apply these methods to capture the complexity and dynamics of human populations and systems. Computational simulation and systems thinking—approaches used extensively in other disciplines such as ecology, engineering and computer science to guide decision making and priorities resources—can capture the dynamics and complex determinants of disease. These approaches use a combination of existing primary data sources, evidence from the literature, stakeholder engagement and dynamic hypothesis testing to better characterize how an exposure or an intervention is likely to affect disease outcomes in populations. Several reviews have highlighted the strong interest in applying systems thinking and modeling to public health [4–6].

Models allow the testing of 'what if' scenarios and can be used to determine a course of action more efficiently than by a typical 'trial-and-error' approach to the implementation and evaluation of population health interventions. Framed as 'decision support tools', models can help local and national decision makers determine where best to target investments and with what intensity so that the impact of limited resources can be optimized [7–9]. The greatest value of computational simulation is achieved when it is embedded in the program evaluation cycle and used not only as a decision support tool for policy or service planning, but also to prospectively support implementation, monitoring and evaluation. These tools can help identify data collection priorities, realistic targets for impact and important indicators for evaluating progress against those targets.

We present a series of articles that demonstrate the importance of systems thinking and the use of computational simulation models to address public health questions. The articles in this issue address a diversity of contemporary topics in public health, and also demonstrate how public health problems can be examined using a range of complementary modelling approaches, including system dynamics models, agent based models, and discrete event simulation models.

Shojaati and Osgood [Contribution 1] and Shojaati et al. [Contribution 2] investigate models of community-based management of opioid use and its impact on treatment retention and opioid-related harm [Contribution 2], and also the impact of social influence and social networks on illicit opioid use among young people during and after periods of school closures using agent based models [Contribution 1]. A series of articles focus on health services use, in particular emergency department (ED) use and hospital admissions, including the modeling of patient flow and wait times [Contribution 3], the optimisation of limited healthcare resources [Contributions 4–7], and the benefits of using systems thinking approaches to inform the implementation of triage and referral systems [Contribution 8]. Goldberg et al. [Contribution 9] present findings from a system dynamics model of suicidal behaviour, and investigate the potential impacts of combinations of population and health service interventions to prevent suicide and attempted suicide. Loo et al. [Contribution 10] also use system dynamics modeling to historically evaluate the prevention and management of cholera outbreaks in Yemen.

The central importance of participatory approaches involving stakeholders and model users is also highlighted in this Special Issue, in terms of understanding the system and in the design, parameterization and implementation of models for decision support in public health [Contributions 3, 8, 9]. Co-design and consultation is key for tools to have policy and planning relevance [Contribution 11]. This is explicitly demonstrated by Tian et al. [Contribution 3] in the development and use of a multi-criteria framework to identify and prioritize interventions to reduce ED wait times. The authors provide a rich description of the processes related to involving stakeholders in prioritization of model scope and refining the model thanks iterative feedback with stakeholders. Finally, we also include a scoping review of emerging infectious disease (EID) in the wake of the COVID-19 pandemic [Contribution 12], which emphasises the ongoing importance of ensuring that our analytic approaches are informed by current evidence. In this review, Mansouri et al. [Contribution 12] describe the types of systems-oriented approaches that have been used to investigate EIDs. The authors emphasize the importance of the quality, geographic specificity, and timeliness of data needed.

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List of Contributions

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