



# Systems approaches to population health in Canada: how have they been applied, and what are the insights and future implications for practice?

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Received: 29 August 2018 / Accepted: 23 May 2019 / Published online: 8 July 2019  
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## Abstract

**Objectives** Systems approaches are promising yet under-utilized methods for tackling complex public health problems. This paper explores how systems approaches are understood in the public health literature, how they have been applied in Canada, the insights, and implications for future practice.

**Methods** A rapid review of the literature, including a content analysis and cross-case comparison, was conducted. It was used to distinguish concepts of systems approaches and identify case examples of the application of systems approaches in Canada. Seven cases with a population health perspective (non-health care related) were prioritized for analysis.

**Results** Systems approaches are a variety of qualitative and quantitative methods that aim to understand a system of interest. Most case examples demonstrated systems thinking methods. Systems science methods were applied predominantly in health care. Only one case of systems science for the social determinants of health was found. Findings indicate that systems approaches were utilized because traditional methods were proving ineffective. These approaches can introduce new ways of thinking, enable collaboration across diverse stakeholders, identify where best to focus action and with what intensity, and provide more robust evidence for decision-making.

**Conclusion** There is a need to build capacity among practitioners for more widespread adoption and use of systems approaches. Population health professionals need to move beyond reductionist approaches, generate more case examples, and use an iterative evaluation approach that prioritizes the application of processes. This will provide further insight into the usefulness of systems approaches as effective methods to address complex health problems.

## Résumé

**Objectifs** Les démarches systémiques sont des méthodes prometteuses mais sous-utilisées pour s'attaquer aux problèmes de santé publique complexes. Nous explorons ici la compréhension des démarches systémiques dans la littérature de la santé publique, leur application au Canada, les réflexions qu'elles inspirent et leurs conséquences pour l'exercice futur de la profession.

**Méthode** Nous avons mené une revue rapide de la littérature scientifique, dont une analyse de contenu et une comparaison croisée des cas. Cette revue a servi à distinguer les concepts des démarches systémiques et à trouver des exemples de cas d'application de ces démarches au Canada. Nous avons recensé sept cas adoptant une perspective de santé des populations (par opposition aux soins de santé) à analyser en priorité.

**Résultats** Les démarches systémiques sont une gamme de méthodes qualitatives et quantitatives qui visent à comprendre un système d'intérêt. La plupart de nos exemples de cas font appel à des méthodes de théorie des systèmes. Les méthodes axées sur la science des systèmes étaient principalement appliquées dans les soins de santé. Nous n'avons relevé qu'un seul cas de science des systèmes appliqué aux déterminants sociaux de la santé. Selon nos constatations, les démarches systémiques sont utilisées

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quand les méthodes classiques se révèlent inefficaces. Ces démarches peuvent introduire de nouvelles façons de penser, permettre la collaboration entre différents acteurs, indiquer le meilleur endroit où concentrer les interventions et à quelle intensité, et offrir des données probantes plus robustes à l'appui de la prise de décisions.

**Conclusion** Il est nécessaire de renforcer les capacités des praticiens pour généraliser l'adoption et l'utilisation de démarches systémiques. Les professionnels de la santé des populations ont besoin de transcender les démarches réductionnistes, de générer plus d'exemples de cas et d'utiliser une démarche d'évaluation itérative qui privilégie l'application de processus. Cela donnerait une idée plus précise de l'efficacité des démarches systémiques pour aborder les problèmes de santé complexes.

**Keywords** Population health · Systems thinking · Systems science · Social determinants of health · Modelling · Canada

**Mots-clés** Santé des populations · Analyse des systèmes · Science des systèmes · Déterminants sociaux de la santé · Modélisation · Canada

## Introduction

Public health problems such as tobacco, diabetes, poverty, or environmental challenges are wicked and complex. These problems are a function of complex adaptive systems, which feature various elements interacting together, emerging circumstances, adaptation, and feedback (Mahamoud et al. 2013; Nianogo and Arah 2015). The use of systems approaches for addressing complex health problems is a foundational element of a population health approach. A population health approach focuses on the societal conditions that influence the health status of a population, the social determinants of health (SDOH), and equity, with collaboration across multiple sectors and action targeted at community and societal levels (Population Health Division 1998). There is growing interest in applying innovative systems methods for population health (Rutter et al. 2017; Riley et al. 2015). The term 'systems approaches' is used in this paper, for ease of discussion, as an overarching term that refers to both qualitative systems *thinking* and quantitative systems *science* methods (discussed below); given that they share focus and intention, explicit distinction is made where necessary.

The calls for the use of innovative systems approaches are aimed at all types of public health problems: communicable and non-communicable diseases (Nianogo and Arah 2015), risk factors including the social determinants of health (Mahamoud et al. 2013), health inequity among Indigenous people (Hernández et al. 2017), and obesity and the food environment (Rutter et al. 2017), for example. This is mirrored by an exponential growth in literature on systems approaches in public health since 2010 (Chughtai and Blanchet 2017).

These methods are useful for complex societal health problems as they provide a better understanding of the system of interest and offer ways to identify and leverage the best strategies for improvements (Atkinson et al. 2015). Systems approaches are not intended to be a panacea, rather, they are intended to complement existing public health approaches, as an additional set of methods to analyze and intervene where singular interventions will not suffice (Carey et al. 2015).

Systems approaches encourage researchers and practitioners to move beyond reductionist thinking (Rutter et al. 2017). Traditional reductionist study designs are limited in their ability to analyze multiple interventions and effects over time, or the unintended consequences that arise with complexity (Nianogo and Arah 2015). Systems approaches are well suited to shift the paradigm of reductionist approaches from linear, isolated views of health to patterns of interactions and emergent behaviours, which embrace complexity (Hernández et al. 2017).

Despite the advantages of systems approaches, and growing calls to action, they remain under-utilized in public health (Carey et al. 2015) and are rarely applied in ways that generate effective evidence or interventions (Rutter et al. 2017). Within the public health literature, there is a poor understanding and limited development of systems approaches (Chughtai and Blanchet 2017) and a gap on how to translate concepts into action (Carey et al. 2015; Riley et al. 2015). Incorporating systems approaches into population health research, policy, and practice will be essential in order to account for the complexity of societal health challenges (Carey et al. 2015; Rutter et al. 2017).

This paper explores how systems approaches have been applied in Canada from a population health perspective. The concepts of systems approaches in the public health literature are outlined as a basis to explore the application and insights from Canadian case examples and implications for future population health practice. The following priority questions will be addressed: (1) *How are systems approaches understood in the public health literature?* (2) *How have systems approaches been applied to population health in Canada, and what are the insights?* (3) *What are the implications for future population health practice?*

Several of the literature reviewed referenced the field of public health. It is discussed here in broad terms as an evolving field based on the central tenets of health promotion, protection, surveillance, and the prevention of disease and involves a population health approach as a key strategy (Canadian Public Health Association 2017).

## Methods

A rapid review of the literature, which included a content analysis and cross-case comparison, was conducted. The rapid review aimed to answer the question *How are systems approaches understood in the public health literature?* and to identify relevant Canadian case examples. The cross-case comparison and analysis aimed to answer the questions, *How have systems approaches been applied to population health in Canada, and what are the insights?* and *What are the implications for future population health practice?*

### Search terms and inclusion/exclusion criteria

The search terms applied were adapted from the recent systematic review of the field (Carey et al. 2015): [(‘systems science’) OR (‘systems thinking’) OR (‘complex systems’) OR (‘systems modeling’) OR (‘systems dynamics’)] AND (‘public health’), limited to full-text articles published from March 2015–September 2017, applied to several databases: [HealthEvidence.org](http://HealthEvidence.org), University of Alberta EBSCO Host, and Web of Science. The limitation on search dates (from 2015 to 2017) was applied in order to identify literature that has been published since the systematic review, which included articles up until March 2015. The search for Canadian case examples applied the same search terms as listed above, along with the inclusion of an additional term, AND (Canada). There was no limitation on dates; cases prior to 2015 were included as well. Additional search databases included Google Scholar and Google (the first 100 results from each were reviewed). Cases were also identified through a snowball technique. In the review of the initial results of conceptual articles and Canadian case examples, the titles and abstracts were scanned for relevance; 122 relevant articles were identified for full-text review.

The conceptual/theoretical articles were deemed relevant (inclusion criteria) if they focused on population health *practice* (not research), where the predominant discussion is theoretical/conceptual, highly relevant, and the population of focus is developed countries such as Canada, the USA, Australia, and the UK; 34 conceptual articles were deemed relevant. Articles were excluded if the focus was primarily research (rather than practice), developing countries, and/or the health care system. This is in comparison to the inclusion of articles from a population health perspective with interventions targeted beyond the health care system. The inclusion/exclusion criteria were set to maintain relevance to the priority questions and ensure a manageable scope.

Canadian case examples were included for full-text review if they demonstrated a clear application of systems approaches to population health in Canada or were a call to action directly related to Canada. Articles were excluded if they were a case example from a different country, or

if they discussed a conceptual systems approach that was dated prior to 2015 (to maintain consistency with the exclusion criteria stated above). Twenty-three Canadian case examples were identified through 31 supporting articles and extracted for full-text review.

The criteria to prioritize case examples for discussion and analysis were defined as the application of systems approaches in Canada with a population health approach focused on the social determinants of health and equity, an emphasis on health prevention and promotion (beyond the health care system and communicable disease control), collaboration across sectors, and action targeted at the community or societal levels (Population Health Division 1998). There were 8 case examples that met these criteria. Canadian case examples were excluded if they were conceptual articles (8 cases), or primarily focused at the individual level on health care or communicable disease control (7 cases) as its use in these areas is more known (Nianogo and Arah 2015). Final selection of relevant cases for discussion was narrowed from 8 to 6 cases (as 3 cases were a subset of each other). One health care example was added as a novel and robust example of qualitative modelling across sectors, subsequently resulting in 7 relevant case examples for analysis. See Table 1 for Canadian case examples.

### Critical appraisal

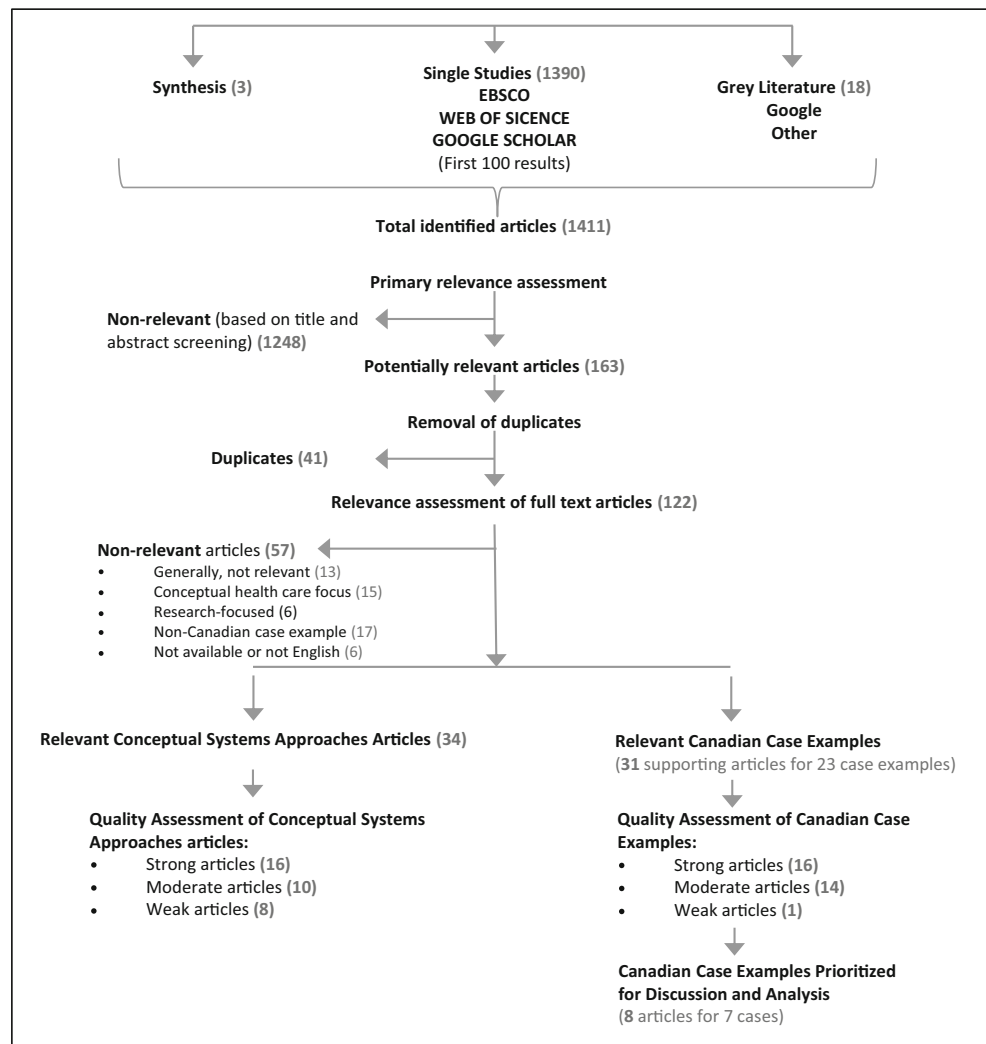
Academic literature was appraised for quality using Public Health Ontario’s Meta-tool for quality appraisal of public health evidence (Rosella et al. 2015) based on the extent to which the articles demonstrate relevancy, reliability, validity, and applicability. Grey literature was appraised using the AACODS checklist (Tyndall 2010), which assesses literature based on the extent to which it demonstrates authority, accuracy, coverage, objectivity, date, and significance. Of the 34 relevant conceptual/theoretical articles, 16 were appraised as strong, 10 moderate, and 8 weak. Of the 31 relevant Canadian case examples, 16 articles were appraised as strong, 14 moderate, and 1 weak. See Fig. 1 for an overview of the search process.

### Analysis and synthesis

Latent content analysis was conducted. An inductive approach was used to answer *how are systems approaches understood in the public health literature?* Both a deductive and inductive approach was conducted for *how have systems approaches been applied to population health in Canada, and what are the insights?* To explore the cases, five analytical questions were applied to each case, which asked about the priority area, context that deemed systems approaches appropriate, type of systems approaches used, insights, and lessons about future

**Table 1** Canadian case examples included in analysis

Organization	Initiative	Priority area	Predominant approach	Description
1 BC Children's Hospital (Amed et al. 2015)	Sustainable Childhood Obesity Prevention Through Community Engagement (SCOPE)	Childhood obesity	Systems thinking	A multi-setting, multi-component program to enhance community capacity and deliver strategies for healthy eating, physical activity, and healthy weights among children, based on the collective impact model.
2 Tamarack Institute (FSG 2013)	Vibrant Communities	Poverty reduction	Systems thinking	A national multi-tiered effort, with national leadership, yet local priorities and strategies in more than 50 participating communities across Canada, also based on the collective impact model.
3 Canadian Centre on Substance Abuse (2012)	Systems Approach to Substance Use Services in Canada—Tiered Model	Mental health and addictions	Systems thinking	A multi-tiered framework for structuring mental health system design and availability of services.
Centre for Addiction and Mental Health (Provincial Support System Program 2014)	Service Collaboratives			An adoption of the Canadian Centre on Substance Abuse (2013) systems approach concepts for the provincial Service Collaboratives initiative, for improved linkages, accessibility, and coordination of provincial mental health services.
4 MaRS Solutions Lab (Shahmazari et al. 2016)	Applied Behavioural Insights and Promotion of Healthy Eating	Healthy eating	Systems thinking	The implementation of behavioural insights interventions for healthy eating, in cafeterias, home, and retail settings in Toronto, ON, emphasizing the connections between all three intervention settings.
5 Credit Valley Conservation Authority (Bunch 2016)	The Credit River Watershed	Conservation	Systems thinking: scenario planning	An initiative that aimed to link the health benefits of the existing watershed to potential conservation actions, based on an Ecohealth approach.
6 Ontario Ministry of Health and Long-Term Care (MOHLTC) (Esensoy and Carter 2015)	Patient Flow Through the Health Care and Long-Term Care System	Patient flow	Systems thinking: causal loop diagrams	A large causal loop diagram for better understanding of patient flow and its effects across the health and long-term care system.
7 Wellesley Institute (Mahamoud et al. 2013)	Modelling the Social Determinants of Health and Intervention Impacts	Social determinants of health	Systems science: systems dynamics modelling	A systems dynamics model of five social determinants of health (health care access, behaviour, income, housing, and social cohesion) for the city of Toronto.

**Fig. 1** Overview of the search process (HealthEvidence 2009)

application. Finally, an inductive approach was used for *what are the implications for future population health practice?*

## Results

### How are systems approaches understood in the public health literature?

The term ‘systems’ is used many different ways, in a variety of contexts with different interpretations of its meaning. For example, the terms ‘systems approaches’, ‘systems science’, and ‘systems methods/tools’ were often used interchangeably. This is likely due to the expansive field and various influences that have shaped the development of contemporary systems approaches (Ison 2010). There is a general distinction between systems *thinking* methods, which tend to be qualitative social processes that focus on social learning about the system, as compared to systems *science* methods, which are more rigid,

quantitative approaches focused on creating software-based models of the system.

The concepts of systems approaches found in the public health literature are outlined below and are intended as a background for the exploration of Canadian case examples. This overview also builds on previous work of other scholars. A comprehensive review of the concepts and methods of systems thinking and systems science can be found in many of the papers referenced and elsewhere (Carey et al. 2015; Checkland and Scholes 1990; Mahamoud et al. 2013; Nianogo and Arah 2015; Atkinson et al. 2015; Paxton and Frost 2017).

### Overview of systems approaches

Both qualitative systems *thinking* and quantitative systems *science* draw from a shared set of systems concepts that inform their distinguishable methodological approaches. These concepts (Paxton and Frost 2017) include the following:



- *Dynamic complexity*—the behaviour of a complex system, often counterintuitive, and influenced by several elements over time.
- *Inter-relationships*—the interactions among elements of a system that influence its behaviour.
- *Feedback loops*—when an output of the system goes back as an input into the same system.
- *Boundary critique and mental maps*—looking at different possible limits or ‘boundaries’ for examining an issue.
- *Leverage points*—those places to intervene in a complex system where small inputs could lead to large impacts.
- *Policy resistance*—when interventions do not work or create different unanticipated problems.

**Systems thinking** is a shift from linear, isolated views of cause and effect to recognition of patterns, interactions, and emergent behaviours of a particular system of interest. Emphasis is placed on the whole system, and its multitude of interdependent elements interacting together, with an appreciation that the system cannot be understood by solely looking at its parts. It includes dealing with uncertainty, relationships, and different perspectives (Carey et al. 2015; Rutter et al. 2017).

**Systems thinking methods** emphasize reflection, sense-making, and social learning processes. Common methods include *soft systems methodology* (Checkland and Scholes 1990) and *critical systems heuristics* (Carey et al. 2015). *Causal loop diagrams* are qualitative illustrations of the variables, causality, and feedback loops of a particular system of interest. *Scenario planning* is a method to identify future events and outcomes using qualitative or quantitative assessments. *Rich pictures* are detailed drawings of complex systems using pictures and symbols (Paxton and Frost 2017). *Multi-stakeholder dialogue* is also essential and has been a foundational element of a population health approach that has been in use for years (Paxton and Frost 2017; Population Health Division 1998). Additionally, new methods are often created that integrate the concepts of systems thinking so as to respond to the unique social contexts in which systems thinking is applied.

**Systems science** is a broad term for a range of quantitative analytical methods that seek to understand and inform the behaviour of complex systems (Carey et al. 2015). These methods tend to be technology based and rely primarily on quantitative data. Systems science methods aim to ‘identify where best to focus public health action, and with that intensity, and ... what can be reasonably left out of strategies for prevention’ (Atkinson et al. 2015, p. 2).

**Systems science methods** predominantly found in public health literature are as follows. *Systems dynamics modelling* is an aggregate modelling technique that adapts a qualitative systems map into a quantitative mathematical model to simulate possible interventions or policies (Atkinson et al. 2015). Systems dynamics models ‘offer ways of understanding these

properties by simulating causal relationships of multiple variables over time under different assumptions (e.g., different policy environments), and act as “what if” tools for identifying high leverage policy interventions’ (Mahamoud et al. 2013, p. 248). *Agent-based modelling* is an individual-based modelling technique (as compared to systems dynamics that focuses on aggregate-level) and has been used for communicable disease and epidemics. There is also *social network analysis* and *discrete event simulation* (Nianogo and Arah 2015). These quantitative modelling methods are new to public health, particularly non-communicable diseases, and are intended to complement existing approaches (Carey et al. 2015; Nianogo and Arah 2015).

### How have systems approaches been applied to population health in Canada?

Seven Canadian case examples were identified and prioritized for discussion and analysis based on a population health perspective. The cases target childhood obesity (Amed et al. 2015), the SDOH in a large urban setting (Mahamoud et al. 2013), watershed management and conservation activities for health (Bunch 2016), poverty reduction (FSG 2013), mental health and addictions (Provincial Support System Program 2014), healthy eating among youth (Shahnazari et al. 2016), and patient flow within health care (Esensoy and Carter 2015). The cases illustrate the complex nature of health problems as they stemmed from systemic causes and multiple socio-ecological levels, included issues between various sectors, and featured elements of complex adaptive systems (Nianogo and Arah 2015).

#### Application of systems concepts

Systems approaches are helpful for thinking and working in new ways (Rutter et al. 2017). Many of the cases turned to a systems approach because the current approach was not working. For example, poverty reduction efforts in Canada had stalled, and innovation and collaboration were needed to make a greater impact (FSG 2013). Childhood obesity interventions tend to be individualistic, without a cohesive strategy across settings (Shahnazari et al. 2016). Working in ‘silos’ is also common, making conversations across organizations and sectors more difficult (Bunch 2016). These highlight the *dynamic complexity* and counterintuitive system behaviour of these population health problems (Paxton and Frost 2017).

The *inter-relationships* of elements of the system interacting together to influence its behaviour are the context of all the cases. To tackle the SDOH, Mahamoud et al. (2013) look at the interactions and causal pathways between certain population health risk factors and health outcomes. The premise of the watershed management initiative is that ‘ecosystem health and human health are emergent properties of interconnected and co-

evolving human and natural systems’ (Bunch 2016, p. 624). Last, both childhood obesity and healthy eating are influenced by several interdependent factors in families and communities (Amed et al. 2015; Shahnazari et al. 2016).

Systems approaches value *multi-stakeholder dialogue*, purposeful engagement of diverse perspectives, and the notion that the system can only be fully understood when all viewpoints are represented. There is an extensive range of sectors and stakeholders that participated in each case, with an average of six sectors per example. Certain cases were also explicit about involving community members in planning, particularly people from marginalized groups, because they provide a different insight and help get to the root issues (Amed et al. 2015; FSG 2013). While the cases that used modelling methods were explicit about embracing a ‘collaborative modeling approach’, neither case study involved consultation with community members (Mahamoud et al. 2013; Esensoy and Carter 2015).

The cases also demonstrate the identification of *lever-age points* and *where best to focus action*. Through systems dynamics modelling, Mahamoud et al. (2013) demonstrate how to balance different broad types of interventions for best effect on the SDOH. With causal loop diagrams, Esensoy and Carter (2015) generate hypotheses on the outcomes and unintended consequences of interventions for patient flow. Both models aim to uncover a better understanding and hypothesis of current and future system-wide behaviour. The watershed initiative recommended health valuation of ecosystem services in order to develop scenarios for conservation actions (Bunch 2016). MaRS Solutions Lab aims to select the smallest interventions with the largest impact for healthy eating (Shahnazari et al. 2016).

### Systems thinking methods utilized

As outlined in Table 1, qualitative systems *thinking* methods were predominant in six of the cases.

**Causal loop diagrams (CLD)** A large causal loop diagram was developed by the Ontario Ministry of Health and Long-Term Care to depict and analyze patient flow between home care volume, emergency department visits, and long-term care referrals (Esensoy and Carter 2015). It is ‘the first of its kind in Canada, and one of the broadest scopes in the literature in terms of care sectors considered’ (Esensoy and Carter 2015, p. 21). It has 163 variables and 53 feedback loops linked to the flow of patients across these sectors.

The model highlights the importance of informal care and the need for greater capacity in rehabilitation, home, and community care. It also identifies areas that could experience unintended negative consequences; for example, it showed that greater outpatient rehab could burden homecare services

beyond their current capacity. The model provides hypotheses on strategies available to influence patient flow and was used to analyze causal relationships, competing feedback loops, and potential interventions (Esensoy and Carter 2015).

**Scenario planning** The Credit River Watershed conservation intends to use scenario planning for valuing of ecosystem services to support decision-making on conservation actions and health (Bunch 2016). Scenario planning encourages ‘thinking creatively about possible complex and uncertain futures in which...external driving forces as well as distinctly different management and policy interventions are explored’ (Bunch 2016, p. 625).

### Tools used to prioritize systems interventions

**The hexagon decision-making tool** The Centre for Addiction and Mental Health’s Service Collaboratives reflected on the entire mental health system and the inter-relationships across other sectors such as health, housing, education, and enforcement. This tool was used to systematically evaluate the need, fit, resource availability, evidence, readiness for replication, and capacity to implement each intervention being considered. It helped build consensus among stakeholders and frame how interventions matched the needs and intended outcomes in different contexts (Provincial Support System Program 2014).

**Desirability, feasibility, viability, and impact framework** The MaRS Solution Lab focused on leverage points in three settings (restaurants, home, and food retail environments) as places to intervene to promote healthy eating. This framework was used to analyze 16 potential applied behavioural interventions in these settings and prioritize those in which small inputs could lead to large impacts (Shahnazari et al. 2016).

### Systems science methods utilized

**Systems dynamics modelling** Only one example of quantitative modelling of the SDOH was found: *Systems dynamics modelling for the social determinants of health* (Mahamoud et al. 2013). This model was built through a participatory process with stakeholders from multiple sectors who provided insight and feedback in the construction of the model over several sessions. The resulting model simulates changes in health status, social determinants and disparities over a 40-year period for five risk factors: health care access, behaviour, income, housing, and social cohesion within the city of Toronto. It simulated that ‘the greatest impact in chronic illness over a 40 year period would come from the combination of a 30% improvement in social cohesion with a 30% improvement in adverse housing for both low-income and high-income groups’ (Mahamoud et al. 2013, p. 253). This output can help

inform interventions for the SDOH and may be a key factor in designing policies for health issues that have previously been *policy resistant*. It can also be used to promote conversation across stakeholders and sectors on where best to focus action and with what intensity (Mahamoud et al. 2013).

Overall, this review found that modelling methods have been applied mainly within health care delivery and communicable disease control (seven Canadian examples were identified), with only one example of modelling towards the SDOH. This highlights a gap in Canadian literature and practice and is of concern because comprehensive health strategies are required across multiple sectors to address the majority of health determinants that lie outside of the health care system (Population Health Division 1998).

## What are the insights from applying systems approaches?

### Benefits and limitations of systems approaches

Qualitative models, such as causal loop diagrams, are very effective at integrating diverse perspectives to develop a comprehensive hypothesis about the system of interest. They can be built in the absence of statistical data sets but still require expertise from the field, a facilitator, and an expert to construct the model. These models can be readily changed without the need for additional data analysis. However, there is an ongoing need to check the model with stakeholders. Prototyping and adaptation are dependent on an iterative review process (Esensoy and Carter 2015).

Quantitative models, such as systems dynamics modelling, can simulate where best to focus action; however, they are constrained by availability of data and capacity for implementation (Esensoy and Carter 2015). Reductionist and epidemiological approaches have been considered the gold standard, and large quantitative statistical data sets are much more readily available within health care. Data sets related to the SDOH are largely owned by sectors outside of health and may be more challenging to access, or not available at all (Baum 1995). Significant time is required to see an impact from interventions targeting health disparities (Danaher 2011), and establishing correlations and causations can be challenging.

Evidence of the impact of systems approaches on population health is still emerging and should continue to garner attention (Carey et al. 2015; Rutter et al. 2017). Tamarack's 'Vibrant Communities' improved policies and systems and mobilized millions of dollars to support Canadians affected by poverty (FSG 2013). The Centre for Addiction and Mental Health's Service Collaboratives have shown that a system-wide approach can improve coordination and collaboration across agencies (Canadian Centre on Substance Abuse 2013). Modelling the SDOH

and patient flow identified where actions could lead to large impacts and how to minimize potential unintended consequences (Esensoy and Carter 2015; Mahamoud et al. 2013). Overall, systems approaches improve planning for health interventions or policies by incorporating broader perspectives, demonstrating where to invest action for greatest impact, and providing more robust evidence for decision-making.

### Insights about the process of applying systems approaches

**The process facilitates engagement across multiple sectors and stakeholders** Systems approaches facilitate engagement across multiple sectors and stakeholders. They help create a shared understanding and enhance integrative practice among different disciplines. Inter-sectoral collaboration can be complicated and context-specific. Lack of a common vision or mandate and lack of connection between organizations are often barriers to success (Danaher 2011).

These methods helped break down silos, spearhead dialogue between diverse stakeholders, explore a broader range of relationships, especially outside their expertise, improve identification of potential stakeholders for policy decisions, explore different components of the system, and support engagement activities (e.g., strategizing, advocacy, community dialogue) (Mahamoud et al. 2013; Bunch 2016; Esensoy and Carter 2015; Canadian Centre on Substance Abuse 2013).

**The establishment of and investment in partnerships takes time** Establishing and nurturing relationships among stakeholders is key for moving systems approaches from knowledge to action (Riley et al. 2015). The formative years of developing partnerships are foundational (Bunch 2016). However, establishing and investing in partnerships takes time. There can be considerable 'lag times' with social innovation as stakeholders get acquainted and adopt new ways of working (Tamarack 2012). The shift from divergent thinking to alignment requires time and space to process concepts (Holmgren 2017).

**The application can be messy and confusing** The process of applying systems approaches and promoting large-scale change can be messy and confusing (Holmgren 2017). This is due to the diversity of perspectives and the emergent, non-linear characteristics of complex systems. Practitioners need to be aware of these dynamics, constantly reflect, and be flexible in their response to emerging circumstances.

## Discussion

This paper explores how systems approaches are understood in the public health literature. Seven Canadian case examples



were analyzed and reveal important insights about the application of these approaches. The majority of cases demonstrated qualitative systems *thinking* approaches, while quantitative systems *science* approaches were found predominantly in health care, which reflects the under-use of these methods for population health. Systems approaches help facilitate cross-sectoral engagement, and an iterative process of development, implementation, and evaluation is encouraged. These methods can make a difference to decision-making and surface potential unintended consequences. The following implications for practice are provided to build capacity, advance meaningful application of systems approaches, and generate new evidence to improve the health of populations.

## Implications for practice

### Engage with a greater range of systems methods

Population health researchers and practitioners should engage with a greater range of systems approaches. They need to take advantage of the toolbox of analytical approaches from systems science, particularly with a population health approach, beyond the health care system. Quantitative modelling is identified as one of the most promising methods to address complex health problems. Yet, qualitative systems thinking methods might be most useful to population health as they align well with knowledge exchange and policy development and provide a way to move beyond reductionist approaches (Carey et al. 2015). Many practitioners already make use of certain methods; greater attention to the integration of practices would be useful.

### Gain insight from those with experience in applying systems methods

For greater uptake of knowledge to practice (Riley et al. 2015), further research is needed to gain insight from practitioners and policy makers who have experience applying systems methods. This would provide a pragmatic understanding of the needs, resources, challenges, limitations, and potential for practice of systems approaches. Analysis of the cases above generated many insights: for example, create an agreement on language among diverse stakeholders (Bunch 2016), identify a central organization for support (Tamarack 2012), and navigate power dynamics to incorporate perspectives of people with lived experience (FSG 2013).

### Generate more case examples of systems approaches

Within systems science literature, less than one third of articles are examples of modelling methods (Carey et al. 2015), including a scarcity of literature on systems dynamics modelling for healthy public policy (Atkinson et al. 2015). Prevention

practitioners are calling for more examples of the application of systems approaches (Wutzke et al. 2016). To translate concepts to action, it is recommended that knowledge is co-produced (Riley et al. 2015). Many case examples also emphasize knowledge exchange to keep partners informed about progress and learning (Amed et al. 2015; Canadian Centre on Substance Abuse 2013).

### Train population health professionals in systems approaches

Few population health professionals are familiar with systems approaches (Chughtai and Blanchet 2017). For greater application of these methods, there is a need to build capacity among population health professionals, policy makers, analysts, researchers, planners, and service providers, for example, to complement existing methods and expertise (Atkinson et al. 2015).

In 2017, ‘systems thinking and systems methods’ was cited as one of five critical capabilities of the public health practitioner of the future. The article suggests embedding systems thinking and systems science methods, and examples of application, throughout the core public health curriculum (Erwin and Brownson 2017). Another option is to create a distinct course on systems approaches based on existing curriculum (Paxton and Frost 2017).

### Focus evaluation on the process of applying systems approaches

To advance the application of systems approaches for population health, the dynamic process of implementing systems interventions requires methodology that can adapt to the changing needs and feedback of the system: traditional evaluation methods will not suffice. Both the literature and several cases emphasize process evaluation as a priority (Amed et al. 2015; FSG 2013; Rutter et al. 2017), for example, incorporate measures that capture a shift in values, perceptions, and priorities among stakeholders (Atkinson et al. 2015). Multi-layered evaluation methods need to be developed that do not focus solely on outcomes but also on understanding the reach of complex initiatives and their processes. Establishing a shared measurement system among multiple stakeholders is also recommended (Amed et al. 2015).

With systems approaches, the identification of population health strategies is an iterative process; it is not clear or linear (Tamarack 2012). Ongoing dialogue among agencies is important to facilitate improvement cycles and encourage the opportunity to experiment and learn (Shahnazari et al. 2016; Canadian Centre on Substance Abuse 2013). The investment of time is required for effective application of systems methods. Particularly, time to develop relationships, adopt new ways of working, process concepts, and respond to emerging circumstances. Allowing adequate time for

processes to occur is integral to overcoming the challenges of complex systems where traditional reductionist approaches are not working. Unexpected outcomes may emerge, which evaluation methods need to be able to identify and track (Holmgren 2017). Many of the case examples had incorporated an iterative review process of design, feedback, and redesign (Esensoy and Carter 2015; Mahamoud et al. 2013; Shahnazari et al. 2016).

## Limitations

This review does not provide a complete exploration and description of the use of systems approaches for population health across Canada, nor are the risks and benefits of the approaches fully explored. Other Canadian literature and examples could provide valuable insights and recommendations to advance the application of systems approaches.

## Conclusion

The concepts and methods provided by systems approaches have the potential to tackle complex societal health problems where traditional interventions have seen limited effect. These practical insights and recommendations for future application of systems approaches can support greater adoption in Canada, and beyond, and help move these methods from promise to action.

## Compliance with ethical standards

**Conflict of interest** The authors declare that they have no conflict of interest.

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