2 Systems Thinking for Health System Improvement

BARRY NEWELL, DAVID T. TAN AND KATRINA PROUST

2.1 Current Challenges in Health Systems Analysis

There has been a rapid growth of interest in the application of systems thinking and system science to health systems improvement (Adam, 2014; Chughtai & Blanchet, 2017). The Alliance for Health Policy and Systems Research produced *Systems Thinking for Health Systems Strengthening* (de Savigny & Adam, 2009) in 2009. This landmark document (1) called for greater use of system principles, including dynamic thinking, systems as causes, and feedback effects in understanding health systems; (2) illustrated how a single health intervention is mediated by and impacts on the wider health system; and (3) provided guidance on how systems thinking might be used to facilitate multisectoral planning and the evaluation of health system interventions. Since then, there have been several major publications, including 'Systems Thinking for Health Systems Strengthening in LMICs: Seizing the Opportunity', a special issue of *Health Policy and Planning*; 'Advancing the Application of Systems Thinking in Health Systems' in *Health Research Policy and Systems*, *Applied Systems Thinking for Health Systems Research: A Methodological Handbook* (de Savigny et al., 2017); and *Health Systems Thinking: A Primer* (Johnson et al., 2019). These papers describe system methodologies intended to improve understanding, planning and evaluation in health systems.

Despite this interest, there are relatively few examples of the application of systems thinking to health systems strengthening (Wilkinson et al., 2018). This is reflected in the large proportion of papers on the subject advocating the use of systems approaches for health systems improvement without actually applying them (Carey et al., 2015), reflecting gaps that need to be bridged to support practice. Lack of capacity and resources for such novel and complex methods is certainly a barrier, especially in low- and middle-income countries (LMICs) (El-Jardali et al., 2014). However, well-funded efforts at operationalisation in developed countries have also faced major difficulties (Sautkina et al., 2014).

The escalating calls for a systems thinking approach to health systems improvement demand a practical response. We have identified two key challenges that need to be addressed. First, while system methodologies are necessary for addressing complex problems, in practice such methods require collaboration between many stakeholders, most of whom will have no familiarity with systems thinking. It follows that implementing system methodologies requires not only technical systems know-how but also a well-developed capacity to facilitate cross-sector communication and engagement. One way of minimising the engagement barriers, and therefore advancing the use of systems thinking at health system level, is to adopt system methods that are concrete and as easily accessed as possible.

A second challenge is the lack of a usable systemic model of the overall health system. The relationships between the World Health Organization (WHO) building blocks, emphasised by de Savigny and Adam (2009), provide a natural point of entry to systems thinking. However, there is limited evidence of the use of feedback between health system building blocks in the analysis of interventions (Baugh Littlejohns et al., 2018; Mutale et al., 2017). This highlights the need to further develop the concepts first put forward in *Systems Thinking for Health Systems Strengthening* to make them usable by a wider range of health researchers and practitioners. A methodological approach capable of supporting efforts to integrate the wide range of situations, observations and policies that typify health systems is essential in efforts to address these two challenges.

Stephen Boyden (1986) outlined six essential characteristics of a methodology that can facilitate the development of a systemic model (Box 2.1). As Boyden's focus was broadly 'culture-nature systems', of which health systems are a part, his criteria can be used essentially unchanged to guide efforts in health systems improvement.

Consideration of the Boyden criteria led us to select *system dynamics* as the methodological basis for the case studies presented in this book. System dynamics is a method for learning in and about complex systems (Sterman, 2000). It is a mature discipline that, as pointed out by Newell (2015), meets all of Boyden's methodological requirements. As described more fully in Section 2.2, system dynamics is built on fundamental principles concerning the way system structure (i.e. the

Box 2.1 The Boyden criteria

A methodology capable of supporting the development of an integrated health system model needs to perform the following functions:

1. It should provide a rational basis for *organising information* relating to different aspects of the [health] system under consideration.
2. It should provide a structure for *analysing, visualising and communicating* about the interactions between the different aspects (natural and cultural) of human situations.
3. It should facilitate recognition and consideration of fundamental principles relating to the interactions between variables of different kinds.
4. It should encourage consideration of the *full spectrum of variables* which may be relevant in any particular situation under investigation. [In particular, it should ensure that full consideration be given to intangible aspects of reality as well as aspects that are tangible and easily quantified.]
5. It must encourage consideration of *changes over time* in the system under investigation as well as a sense of perspective with respect to rates of change and the scale of societal activities and impacts.
6. It must be *flexible*. That is to say, while it must be useful in the organisation of information and in communication, it should also encourage speculation and the formulation of new ideas; it must *never dictate* our way of thinking about human situations.

Adapted from Boyden (1986, 198) – italics in the original. The criteria have been numbered for ease of reference.

network of interactions between key state variables) drives system behaviour over time (thus meeting criteria B3 and B5). It is flexible in that it deals in elementary building blocks (stocks, flows, feedback loops) that can be combined, Lego™-like, to represent system structure in essentially any context (B6). Because of this versatility, it provides a means of organising information from different disciplines and thereby supports the development of practical integrative approaches

(B1, B4). The generic nature of its concepts encourages consideration of a wide range of variables when teams formulate their 'dynamic hypotheses' (tentative identification of system structures that can generate observed behaviour). It provides practical tools (such as causal loop diagrams (CLDs) and stock-and-flow maps and models) that can be used to facilitate the visualisation, testing and communication of these hypotheses (B2). Finally, while system dynamics rests on powerful mathematical foundations, in practice its basic concepts are usually expressed in terms of simple metaphors that can be easily understood by people with a wide range of backgrounds.

System dynamics methods are not confined to quantitative modelling – in fact the discipline supports a seamless progression from systems thinking to dynamical modelling (Forrester, 1961; 1968; 1969; 1990). The book *Thinking in Systems: A Primer* (Meadows, 2009) is a readable introduction. Elsewhere, Sterman (2000) provides a thorough discussion in *Business Dynamics: Systems Thinking and Modelling for a Complex World*.

2.2 System Dynamics Concepts and Tools

The accessibility of system dynamics concepts depends on the discipline's use of easily understood conceptual metaphors (Lakoff & Johnson, 2003; Newell, 2012). For example, the notion of 'stocks and flows' is usually introduced in terms of the bathtub metaphor (Table 2.1). In this metaphor, the bathtub stands for a specific component of a complex system. At any particular time, the 'state' of the component is represented by the amount ('stock') of water that has accumulated in the tub. Changes in this variable (seen as changes in the water level) represent changes in the state of the system component. The processes that change the state of the component are represented by the 'flows' of water into and out of the tub. Stocks can be tangible quantities like water, money or the number of people infected with a virus, and they can be intangible quantities like social capital, political will or happiness.

System dynamics provides a disciplined visual language that can be used to communicate assumptions about the interactions between the parts of a system. This language includes stock-and-flow maps. A simple example is shown in Figure 2.1. In this diagram, the boxes represent the levels of variable quantities ('stocks') that indicate the

Table 2.1 *The bathtub metaphor*

A bathtub	→	[1]A system component
The water in the tub	→	An accumulation, a 'stock', a variable that represents the current state of the system component
The amount of water in the tub	→	The amount accumulated, the 'level' of the stock, the state of the system component
Water entering the tub from the tap	→	An 'inflow', a state-change process that increases the amount accumulated
Water leaving the tub through the drain	→	An 'outflow', a process that decreases the amount accumulated
Water leaving the tub by splashing	→	Another outflow that decreases the amount accumulated

Source: Newell (2012).

[1] The arrows represent the expression 'corresponds to'.

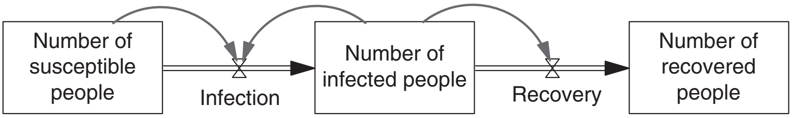

Figure 2.1 The susceptible–infected–recovered (SIR) system. This stock-and-flow map represents the causal structure of the system that governs the spread of infectious diseases. In epidemiological practice, this structure is known as the SIR model. The three stocks shown in the map are connected by two flows that represent the processes of infection and recovery, respectively. The rates of these state-change processes are controlled by the levels of the stocks.

current state of the system of interest. The double-line arrows represent state-change processes ('flows') that can alter the stock levels (i.e. change the state of the system). The tap symbols in the arrows represent process 'flow rates'. The single-line arrows represent 'influence links' whereby stock levels control process flow rates.

CLDs can play a useful role in situations where a stock-and-flow model is not required or cannot be easily constructed. An example is shown in Figure 2.2. In this type of diagram, blocks of text represent the levels of state variables (stocks). The arrows are 'influence links' that represent the state-change processes (flows). A change in the level of the driver variable (at the tail of the arrow) causes a change in the

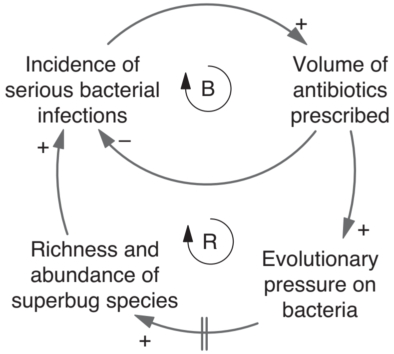

Figure 2.2 A causal loop diagram (CLD). This diagram depicts the story of the fight against increasingly prevalent antibiotic-resistant bacteria. An increase in the incidence of serious bacterial infections leads to an increase in the volume of antibiotics prescribed. The prescription of antibiotics leads to a reduction in the incidence of serious infections. At the same time, however, the increased use of antibiotics increases the evolutionary pressure on bacterial populations, leading to an eventual increase in the richness and abundance of drug-resistant species and a consequent increase in the incidence of serious infections. While the latter effect takes time to appear, it eventually dominates.

level of the affected variable (at the arrowhead). The plus and minus signs are link ‘polarities’. A positive polarity (+) indicates that an increase in the level of the driver variable will cause the level of the affected variable to eventually rise above the level it otherwise would have had, and that a decrease in the level of the driver variable will cause the level of the affected variable to eventually decrease below the level it otherwise would have had. A negative polarity (–) indicates that the relationships are inverse. The small parallel lines crossing one arrow are a ‘delay mark’ – they indicate that the effect of a change in the level of the driver variable will take a relatively long time to appear. The encircled ‘B’ indicates a balancing feedback loop, and the encircled ‘R’ indicates a reinforcing feedback loop. Provided that these rules of ‘visual grammar’ are followed, CLDs can help articulate dynamic hypotheses that account for the response of a health system to imposed policy and management initiatives.

From a system dynamics point of view, ‘[the] feedback loop is the . . . basic unit of analysis and communication of system behaviour’ (Richardson, 1991). There are just two types of feedback: reinforcing loops that amplify change and balancing loops that resist change. The

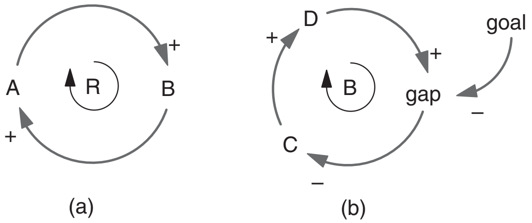

Figure 2.3 Two types of feedback structure: (a) reinforcing feedback; (b) balancing feedback. In general, a dynamic hypothesis that aims to explain the behaviour of a real-world system will comprise a network of competing reinforcing and balancing loops.

generic structures shown in Figure 2.3 illustrate these cases. In panel (a), reinforcing feedback exists when an increase/decrease in the level of variable A causes an increase/decrease in the level of variable B, which causes a further increase/decrease in A, and so on, around the loop. This causal structure drives accelerating growth (or accelerating collapse) of both A and B. In panel (b), balancing feedback occurs when management efforts (or natural processes) work to hold the level of variable D close to a particular goal. The case shown represents the situation where D lies *above* the goal. An increase in C causes an increase in D. This change in D increases the gap between D and the goal, which triggers mechanisms that work to reverse the change in C and so bring D back towards the goal. The goal may be deliberately set (e.g. the chosen setpoint on a thermostat), an outcome of the collective interactions among many actors (e.g. how much money one is expected to spend on a birthday present) or a systemic level that may be natural or anthropogenic (e.g. the body temperature maintained by homeostasis).

Influence diagrams (IDs) (Figure 2.4) are the simplest systems thinking tool offered by system dynamics. They are similar to CLDs but do not have polarities assigned to their causal links. This makes them suitable for initial discussions where some polarities may be uncertain and difficult to determine.

IDs provide a flexible means of articulating assumptions about cause–effect structure. Thus they can function as a visual cause–effect language supporting a team's early efforts to co-develop knowledge. Individual team members can use IDs to describe their assumptions about the boundaries and causal structure of their system of interest.

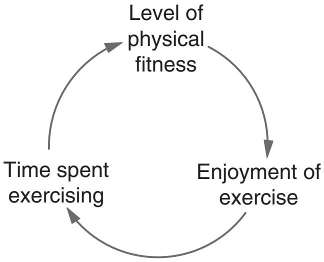

Figure 2.4 An influence diagram (ID). This example represents a feedback loop where *Time spent exercising* affects *Level of physical fitness*. This change affects *Enjoyment of exercise*, which leads to a further change in *Time spent exercising* – and so on around the loop. IDs do not have polarities assigned to influence links.

The team can then use the collection of individual diagrams to explore similarities and differences in their thinking about (mental models of) the system (Newell & Proust, 2018).

Overall, system dynamics can support a wide spectrum of activities. At the systems thinking end of the spectrum, the collaborative development of IDs or CLDs can help *any* multi-disciplinary team co-develop hypotheses concerning system structure and behaviour (Newell & Proust, 2012; 2018). The systems thinking principles listed in Box 2.2 summarise a typical system dynamics perspective.

At the system modelling end of the spectrum, working stock-and-flow models can support exploration of the dynamics of various complex system structures. In practice, policy development needs to begin at the systems thinking end of the spectrum with a broad investigation of potentially relevant variables and interactions. How far the team can then progress toward quantitative modelling (and the desirability of attempting to do so) depends on many factors, including the nature of the system of interest, the availability of reliable historical data and the team members' skills and experience.

The use of system dynamics can provide a coherent way to facilitate iterative problem exploration and framing. This helps ensure that governance problems are addressed at the right level. It also supports co-production of new knowledge by a multi-disciplinary team, a process that leads to better policies. It is important to note, however, that system dynamics and system models are not a panacea for health systems improvement. The utility of any diagrams or models will be limited by the team's knowledge of the system of interest.

Box 2.2 Systems thinking principles for health system improvement

1. **The Feedback Principle:** Feedback effects are dominant drivers of behaviour in any health system.
2. **The Holistic Principle:** The behaviour of a health system emerges from the feedback interactions between its parts and therefore cannot be optimised by optimising the behaviour of its parts individually.
3. **The Inertia Principle:** The filling and draining of stocks is a pervasive process in health systems. The presence of stocks causes delayed responses, thereby giving rise to system inertia.
4. **The Surprise Principle:** Any action taken in a health system will have multiple outcomes, some expected and some unexpected. The expected outcomes might occur — unexpected outcomes will always occur. The unexpected outcomes are usually unwanted and delayed — the delays make it difficult to identify the triggering actions.
5. **The History Principle:** Knowledge of past activities and patterns of behaviour is essential in any attempt to understand how a health system works.
6. **The Myopia Principle:** No one person can see the whole of a health system.
7. **The Collaboration Principle:** The boundaries of a health system cut across the boundaries of traditional disciplines, organisations, governance sectors and sub-cultures. An effective systems approach therefore requires deep collaboration between people with different backgrounds, worldviews, values and allegiances.

Adapted from Newell and Proust (2018), Box 5.1.

2.3 Application of the Systems Dynamics Approach in This Publication

Using the Malaysian health system as an example, this book illustrates the use of a systems dynamics approach in health systems analysis. We address the two challenges identified above, namely, engaging non-systems experts and creating a useful system model of the health system. In doing this we also address the learning goals described in Chapter 1.

This book is a product of collaboration between experts across government policy, the private sector, health experts and academics. The process involved sustained engagement and collaboration between health experts and systems thinkers through discussion, debate and iteration towards a genuinely co-produced and co-owned product with capacity-building as a further by-product. We suggest that this approach could be considered for use as a model for endeavours in this field (see Sterman, 2000, chapter 3).

Section II discusses the development of the Malaysian health system. Chapter 3 provides an overview of the larger historical context for the Malaysian health system, followed by an analysis of the individual building blocks of the health system (Chapters 4–12). The service delivery building block is divided into four thematic areas: primary care, secondary and tertiary care, disease control, and environmental health.

Two collaborative approaches between health experts and systems thinkers were taken in applying systems thinking in Section II. The first was used to examine the development of the overall health system building blocks. Each of the health system building block chapters begins with an overview of the development of that building block. The documentation of the development of the Malaysian health system and the lessons learned were led by health experts, who undertook a process of document review and interviews in consultation with the editorial team.

Examining the development of the health system building blocks over the past 60 years was a substantial challenge. Documentation of many important events in the earlier development of the Malaysian health system was scarce and located largely in the grey literature. Thus the health experts and the editorial team relied on individuals with knowledge of the grey literature and with first-hand experience of the key events. These histories are thus selective due to methodological limitations, but also because of space constraints. Nonetheless, they are critical for identifying trends and patterns that provide systemic insights into the development of the health system. In describing the development of each building block, emphasis was placed on linkages with other building blocks and with important drivers, enablers and obstacles outside the health system. The systems thinkers then reviewed these findings to derive systemic observations from the histories.

The second approach was used in the case studies that address significant systemic interventions, problems or events within individual building blocks. Here, the health experts and systems thinkers undertook a more in-depth co-production process for developing the case studies, using the methodology described by Tan et al. (2019). While we endeavoured to have at least one case study for each health system building block, case study selection was largely driven by the availability of health experts willing to engage in the process and the extent of their expertise. Accordingly, the case studies are not an attempt to provide a comprehensive overview of issues in health systems or in systems thinking.

An iterative sense-making process was used to determine the system of interest in each case study; it involved: (1) narrative problem framing by the health experts; (2) interrogation of the narrative by the systems thinkers to discover interrelations, causal links, feedback and emergence; and (3) development of CLDs by the systems thinkers to represent the narrative developed by the health experts. The preliminary CLDs often served as a mirror that helped the health experts refine or revise their problem framing. When this process was complete, the feedback structures in the CLDs were analysed to improve understanding of the systemic issues, problems and enablers seen in the case studies.

The choice of approaches maximised the goals of the publication within the time and resource constraints. The case studies provided a sufficiently well-defined problem space for the health experts and systems thinkers to engage in meaningful co-production within a limited timeframe. The different levels of systems insights from the two approaches provide an example of what can be achieved at varying levels of investment into system analysis. The case studies illustrate how a problem-based approach works – regardless of the level of the problem.

To obtain a full range of perspectives, including both the historical development of the building blocks and the case studies, a series of stakeholder meetings was convened for comments and critique. Several of these meetings revealed very different perspectives concerning some issues. These differences were shaped by differences in experience and understanding that reflected the position from which individual stakeholders had engaged the issue. The input from these meetings led to further investigation of disputed data and iteration of system analysis.

Section III of this book consolidates the learnings from the investigations reported in Section II. Chapter 13 synthesises key health system development lessons from experience generated within the Malaysian health system. These lessons should be relevant to health systems worldwide, especially those in LMICs. Chapter 14 reflects on lessons concerning the application of systems thinking to health systems. There, we attempt to derive a broad, systemic model of health systems that connects the system models developed in the tightly defined problems of the case studies. By combining a whole-systems approach with detailed case studies, we hope to provide multiple examples of how systems methodologies can be applied at all levels of health systems strengthening to produce outputs and understandings that are accessible to all.

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