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COMMENTARY

Health systems, systems thinking and innovation

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Introduction

Health systems play a critically important role in improving health. Well-functioning health systems enable achievement of good health with efficient use of available resources. Effective health systems also enable responsiveness to legitimate expectations of citizens and fairness of financing. By helping produce good health effectively, health systems also contribute to economic growth (McKee *et al*. 2009).

Well-functioning health systems are critical in mounting effective responses to emerging public health emergencies, and addressing burden of disease, ill health and poverty due to communicable (Coker *et al*. 2004) and non-communicable diseases and cancers (Farmer *et al*. 2010; Samb *et al*. 2010).

A number of factors influence ways in which health systems achieve good health efficiently. These factors include the capacity of both individuals and institutions within health systems, continuity of stewardship, ability to seize opportunities, and contextual characteristics such as path-dependency, socio-cultural beliefs, economic set up, and history of the country concerned (Balabanova *et al*. 2011). However, 'linking good health and successful health systems, in particular how health systems might be distinguished from other determinants of health, or ultimately how health systems are linked to good health, has proved challenging' (Chen 2012). A further challenge relates to understanding how innovations (such as new policies, new knowledge and novel technologies) can be effectively introduced in health systems and how these innovations interact with health system variables to influence health outcomes.

Resource scarcity, coupled with global economic crisis, has necessitated adoption of innovations in health systems to sustain effective responses and improvements in health outcomes. Yet, weak health systems hinder adoption and diffusion of innovations. Evidence-informed guidance and policies are needed to strengthen health systems and improve their receptiveness to innovations. However, there is limited understanding on how best to develop health system guidance and to translate it to policy while accounting for the complexity of health systems and varied contexts in which health systems are embedded (Lavis *et al*. 2012).

There is also limited understanding of why many well-intentioned policies and managerial decisions aimed at improving health systems do not achieve desired outcomes, but lead to unexpected or unintended consequences. One explanation for this phenomenon is that too often the tools used for analysing health systems and the heuristics used to generate managerial decisions are too simplistic for health systems that are complex. Inadequately considered interventions often upset the equilibrium within complex systems to resist such interventions, leading to 'policy resistance'.

This paper briefly discusses health systems and dynamic complexity. It examines complex adaptive systems created through the dynamic interaction of evolving contexts, health systems and institutions within health systems. The paper explores, through illustrative case studies, how adoption and diffusion of innovations are influenced in complex adaptive systems created through interaction between innovations, institutions, health systems and contexts, using a framework that helps unpack complexity, and enables systems thinking when developing solutions to address factors that hinder or enable adoption and diffusion of innovations in health systems.

Health systems, dynamic complexity and systems thinking

Health systems are variously defined (Shakarishvili *et al*. 2010). At its core, a health system is a 'means to an end'—a system which 'exists and evolves to serve societal needs'—with 'components' that '. . . can be utilized as policy instruments to alter the outcomes' (Hsiao 2003).

Health systems are open systems, with interlinked components that interact within the context within which the health system is situated (Atun *et al*. 2006; Atun *et al*. 2007), thereby forming a whole with properties beyond the component parts (Checkland 1981). Interacting elements influence each

other with positive (amplifying) or negative (balancing) feedback, collectively determining the system's behaviour (Senge 1990).

Many interconnected and interdependent elements within health systems and their contexts create extensive networks of feedback loops with variable time lags between the cause and effect of an action and non-linear relationships between system elements, collectively creating a 'dynamic complexity'. A system response occurs as a result of the interactions among the system's elements rather than the result of a change in one component. Understanding this interconnectedness and complexity is the essence of systems thinking that views the system as a whole rather than its individual component parts, taking into account behaviour of systems over time rather than static 'snapshots' (Senge 1990), with 'the ability to see the world as a complex system' (Sterman 2001). In systems, dynamic complexity arises when the short and long term consequences of the same action are dramatically different, when the consequence of an action in one part of the system is completely different from its consequences on another part of the system, and when obviously well-intentioned actions lead to non-obvious counter-intuitive results (Forrester 1961; Sterman 1989a; Sterman 1989b; Sterman 1994; Richardson 1995).

Decision-making in health systems is characterized by 'detail complexity'—reducing the amount of information used, simplifying mental cause–effect maps and limiting themselves to a number of static options when making decisions—instead of approaches that enable consideration of dynamic complexity characterized by networks of relations, feedback loops and non-linearity (Sengupta and Abdelhamid 1993). The prevailing reductionist and linear approach in health systems creates 'bounded rationality' (Simon 1982), failing to provide an accurate representation of the real world by ignoring possible wider impacts of policies and decisions. The limits to cognitive and information processing capability of the human mind means that often feedback structures, non-linearities in systems and the time-delays between actions and consequences are ignored. This leads to simplistic analyses of situations, with the most important sources of the problem either missed or overlooked, with 'misperception of feedback', so that even when information is available, consequences of interactions cannot rapidly and correctly be deduced—with the interventions aimed at eliminating these problems leading to unforeseen consequences and policy resistance (Sterman 1994; Diehl and Sterman 1995).

Systems thinking can help address the linear and reductionist approaches which prevail in health systems, by enabling testing of new ideas in social systems (Forrester 1961). In systems thinking an organization and its respective environment (context) is viewed as a complex whole of interrelated and interdependent parts rather than separate entities (Cummings 1980). Systems thinking takes into account the structures, patterns of interaction, events and organizational dynamics as components of larger structures, helping to anticipate rather than react to events, and to better prepare for emerging challenges.

In practice, systems thinking means careful consideration of possible consequences of policies and actions, generating scenarios through group working and joint thinking: taking into account the interactions between health system elements and the context, and when possible combined with systems dynamics modelling (Lane and Oliva 1998) to simulate system behaviour under explicit assumptions (Sterman 1989a; Sterman 2001). System dynamics modelling can be used in health systems for hypothesis testing and generation of scenarios, as well as enhanced joint thinking, group learning and shared understanding of problems (Wolstenholme 1993; Dangerfield *et al.* 2001; Atun *et al.* 2005a; Atun *et al.* 2007a; Atun *et al.* 2007b; Lebcir *et al*. 2009; Lebcir *et al*. 2010).

Innovations in health systems and systems thinking

Innovations in health systems refer to new medicines, diagnostics, health technologies, new ideas, practices, objects or institutional arrangements perceived as novel by an individual or a unit of adoption. Innovation is crucial for improving health outcomes in high-income countries (Cutler 2001) as well as in countries of low and middle income, and for achieving the Millennium Development Goals (Howitt *et al*. 2012).

Contextual factors, health systems characteristics, institutions within health systems, and the adopting entities within these institutions collectively interact to influence the receptivity of health systems to new innovations, as well as the speed and scale of their adoption and diffusion (Atun *et al*. 2010a; Atun *et al*. 2010b). The perception of the problem which the innovation is addressing, by the innovation, by the adopting individuals, adoption systems and institutions, also influences the adoption and diffusion of innovations (Figure 1). These bidirectional interactions create complex adaptive systems and dynamic complexity. Hence, approaches that foster systems thinking are particularly useful when planning the introduction of innovations into health systems to improve health outcomes, efficiency and equity, or when analysing the reasons for rapid or poor uptake of affordable innovations with proven benefits. The model shown in Figure 1 when used in analysis of adoption of innovations fosters systems thinking by considering key components of a complex adaptive health system which interact to influence innovation adoption.

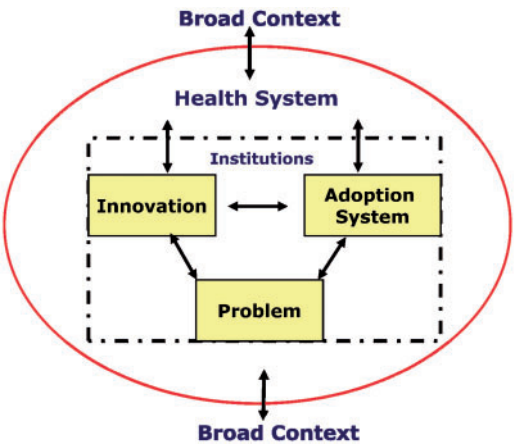

Figure 1 Framework for analysing adoption and diffusion of innovations in health systems

While many health innovations have been adopted and successfully diffused in low- and middle-income countries to save many lives, there are many instances where innovations of varied complexity are poorly adopted. Often, the reasons for slow adoption and diffusion of health innovations are less to do with the perceived benefits of the innovation, but the way the problem, which the innovation is designed to address, is perceived by the individuals and the adoption system within health institutions, the health system and the broad context. For example, an estimated 40% of health care equipment in low-income countries is out of service, compared with less than 1% in high-income countries (Perry *et al*. 2011). Oxygen concentrators donated to Gambia could not be used due to incompatibility of electricity voltage (Howitt *et al*. 2012). Low adoption and diffusion of innovations in low- and middle-income countries are briefly discussed using the model shown in Figure 1 with illustrative examples from HIV, maternal and child health, malaria and tuberculosis.

Expansion of antiretroviral treatment (ART), a technological innovation, in low- and middle-income countries is undoubtedly one of the greatest global public health achievements, with millions of lives saved in the last decade (Resch 2011). Yet, weak health systems, socio-cultural stigma and weak political leadership meant by the end of 2010 ART coverage in sub-Saharan Africa was only 49%, with only 14% of patients with AIDS in the Democratic Republic of Congo receiving ART, 23% in Europe and Central Asia, and 10% in North Africa and the Middle East (WHO 2011). In Russia, poor uptake of ART and harm reduction interventions was due to: the perception of the HIV/AIDS problem being a problem of injecting drug users and sex workers (Tkatchenko *et al*. 2008), even though in reality the at-risk populations share similar socio-economic and educational characteristics with the general population (Wall *et al*. 2011); socio-cultural incompatibility of the innovation (harm reduction) to the individuals and institutions in the adoption system and the broad context; varied interpretation and application of policies within health systems (Atun *et al*. 2005b); and vertically designed health systems which hindered appropriate care (Tkatchenko *et al*. 2010).

Financing and highly effective innovative preventive medication are available during pregnancy to prevent mother to child transmission (PMTCT) of HIV. Yet, in 2010 globally only 48% of HIV-positive pregnant women received treatment to prevent transmission of HIV to their child (25% in Central and Western Africa, and 42% in Southern Africa), with the unacceptable consequence that in 2010, almost 400 000 children were born with HIV—all readily preventable (WHO 2011). The reasons for poor uptake of PMTCT, a highly cost-effective innovation, ranged from weak health systems, to poor attention given to the problem by health professionals, to low political commitment (Tudor Car *et al*. 2012). As with PMTCT, in the 68 high-burden countries for maternal and child deaths, most of the cost-effective innovations available to address maternal, perinatal and child health problems along the care continuum are poorly adopted and scaled up, and with the exception of immunization and Vitamin A supplementation have average coverage levels well below 50%, with uptake of artemisinin-based combination treatments for malaria at 22%. The uptake of innovations for the poorer segments of populations is consistently far lower than that for the richer socio-economic groups (Bhutta *et al*. 2010).

As with ART, rapid scale up between 2005 and 2010 of the distribution of long-lasting insecticidal nets (LLINs) to reach universal coverage in most countries of Africa is undoubtedly a great success. High coverage of LLINs in the most affected malarial burden countries has prevented thousands of deaths in children aged under 5 years (Akachi 2011). Yet, in the same countries where the LLINs, a highly effective preventive innovation, were rapidly taken up, the uptake of another highly cost-effective and safe preventive innovation, intermittent preventive treatment of pregnant women for malaria (IPTp), languishes at an average uptake of 8% of eligible women, far below the 80% global coverage target (Bhutta *et al*. 2010). The reasons for poor uptake are attributed to women's poor knowledge of this safe innovation (low awareness of the adopting individuals) leading to late initiation, health system weaknesses leading to insufficient stocks of the medication at the health facilities when needed, restrictive guidelines on IPTp delivery leading to confusion among the health workers in health care facilities (within the adoption system) as to when and how many doses of IPTp to administer, and low performance of health workers when delivering antenatal care (Gross *et al*. 2011).

Global uptake of internationally recommended tuberculosis treatment for drug-sensitive tuberculosis and the directly observed treatment short course (DOTS) strategy, a complex innovation with multiple elements, has steadily increased between 1995 and 2009, with 49 million tuberculosis patients treated globally, 41 million of them successfully (Glaziou *et al*. 2011), with the exception of Russia and Ukraine where the introduction of DOTS has been hindered by contextual, health system and individual barriers within the adoption system (Atun *et al*. 2005c; Atun and Olynik 2008). Yet, the uptake of very cost-effective innovations to prevent tuberculosis in HIV-affected individuals is extremely low, with only 50 000 of the estimated 33.4 million people living with HIV offered isoniazid preventive treatment (WHO 2012), such that in 2009 there were an estimated 0.38 million deaths among HIV-positive individuals (Glaziou *et al*. 2011)—deaths that are mostly preventable. In sub-Saharan Africa, where the coverage of tuberculosis care is the lowest globally, uptake of innovative care delivery models which have helped expand coverage and improve outcomes, such as public–private mix, have been limited due to lack of political interest (Atun *et al*. 2010; Lal *et al*. 2011). Similarly, in sub-Saharan Africa and beyond, contextual and health systems barriers have hindered adoption and scale up of innovations to address the burgeoning problem of multi-drug resistant tuberculosis in prisons (Lee *et al*. 2012).

Conclusions

Lessons emerging from instances of low innovation adoption suggest that when addressing health problems, reductionist and linear approaches that provide technical solutions alone are not adequate to mount effective responses, as the adoption and diffusion of innovations which underpin responses to health problems are influenced by complex health systems, the

socio-political context within which the health systems are embedded and the innovation adoption system.

Multiple interacting factors influence adoption of innovations, ranging from new technologies, to novel service delivery models and to health policies. Therefore, a broader and more sophisticated analysis of the context, health system elements, institutions, adoption systems, problem perception and the innovation characteristics within these will enable better understanding of the short- and long-term effects of an innovation when introduced into health systems. A simplistic situational analysis may result in barriers and enablers to innovation adoption being overlooked, and risk unforeseen consequences and policy resistance. One way to reduce this policy resistance is to adopt systems thinking to look at all interacting elements within the complex adaptive health systems in a holistic manner to devise effective responses.

Combining technological innovations with other innovations in health systems (such as innovative approaches to governance, financing, service delivery, awareness creation and demand mobilization) enables effective adoption of innovations in health systems.

Systems thinking can help understanding of the dynamic complexity that characterizes complex adaptive systems. The dynamic complexity which emerges from bidirectional interaction among innovations, entities adopting innovations, institutions, health systems, and the context in which health systems are embedded will need to be understood to help devise policies and tactics to enable effective adoption and diffusion of innovations in health. While health systems as adaptive systems are complex, their understanding informed by systems thinking need not be complicated.

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Conflict of interest

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