Health Care Management: The Contribution of Systems Thinking

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ABSTRACT

This paper investigates the advantages of using Systems Thinking and System Dynamics in the analysis of health care systems. It demonstrates that the disappointing results observed in health care management are due to a lack of adoption of systemic methods to study these systems. The paper portrays the consequences and causes of policy resistance in health care systems and how they can be overcome by using the System Dynamics (SD) methodology. After a description of the previous areas of application of SD in health care management, an initial qualitative study of health care system reforms in the Republic of Georgia is described to demonstrate the extent of complexity involved in such systems.

Key words: System Dynamics, Modelling, Health Systems, Simulation, Systems Thinking

Introduction

Given its crucial role in the welfare and prosperity of societies, health care provision has become a top priority for many governments. Statistics suggest that in most countries, a significant fraction of public money is allocated to the health care sector. Despite these huge investments, health care systems have not yet delivered the expected improvements and populations are becoming more and more dissatisfied with the quality of health care services provided.

An important factor, which explains these chronic failures in health care systems management, is the inadequacy of the tools and methods used to analyse, design, and implement actions and policies to manage them. While health care systems are complex and include many interconnected elements, the rules and heuristics generating managerial decisions are too simplistic to cope with the complexity involved in such systems. The result is that the well-intentioned decisions, which aim to improve the performance of these systems, lead generally to completely opposite results, a syndrome known as "policy resistance".

A remedy to this syndrome is to change the way of framing, formulating, and analysing problems within health care systems. There is a crucial need to apply more holistic approaches, which do not concentrate only on the analysis of a part of the system, but incorporate all the sub-systems and their interconnections. This is necessary because an isolated action taken within the context of a part of the system may upset the current equilibrium of the whole system and cause the other sub-systems to resist the action and defeat it. The most suitable tools and techniques to tackle such situations are Systems Thinking and particularly System Dynamics (SD) methodology.

System Dynamics assumes that most problematic situations arise from the fact that systems are dynamic and complex in nature. It conceptualises systems as being constructed of complex networks of feedback loops in which time delays and non-linear relationships are important sources of dynamic complexity and policy resistance.

To address these problems, SD offers a systematic approach relying on a combination of qualitative and quantitative analyses. This includes mapping systems in terms of feedback loops and then translating these maps into a rigorous quantitative simulation model offering the possibility of analysing scenarios and consequences of policies and actions.

Given that health care systems exhibit high levels of dynamic complexity, SD has been used extensively to analyse them and help decision-makers design and implement effective policies. Areas of SD intervention include analysis of infectious disease spread mechanisms, study of effectiveness of screening programs, design of primary care systems, and finding the causes of waiting list escalation.

This paper explores the importance of applying Systems Thinking in health care management. The first section includes the definition of Systems Thinking and policy resistance. This is followed, in sections two and three, by the definition of dynamic complexity, its causes, and its effects on decision-making performance. In section four, the SD methodology is depicted and its steps briefly described. Section five explains the reasons which make health care systems dynamic and complex and, therefore, suitable to SD methodology. Some applications of SD in health care are presented in section six and the paper concludes by presenting a case study of the reform of health care systems in the Republic of Georgia reflecting the importance and usefulness of applying Systems Thinking approaches.

1. Importance and role of Systems Thinking

The external and internal environments within which organisations, health systems and the society operate have become very dynamic and complex. Such dynamism and complexity brings problems and opportunities and requires responsive organisations and systems that are able to adjust to the changes. Ability to respond depends on an ability to understand both the external and internal environments.

Traditionally applied tools and procedures are inadequate to understand these complexities, solve emerging problems and capitalise on opportunities. To manage the complexities and problems arising from a rapid pace of change, managers need to absorb a vast quantity of information, often beyond their capability, understand a complex web of interdependence among systems' elements and the problems in question, and keep pace with the constantly changing situations (Senge 1990). Consequently, more often than not, actions taken to address these problems lead to a breakdown in the system functioning and failure of the policy or strategy adopted, creating a feeling of helplessness among decision-makers. Even in organisations with the necessary ingredients for success, failure of policies or strategies is becoming the rule rather than the exception (Sterman 1994).

A reason advanced to explain these disappointing results is the tendency to simplify and underestimate the level of the complexity of the problem in question. Most often, problems are the result of the interaction between a complex set of interconnected elements. However, limited cognitive capacity of decision-makers results in a simplistic analysis of the situation and the problem in question. As a result, the most important sources of the problem are either missed or overlooked (Sterman 2000). The result is that the decisions taken to eliminate a problem can have unforeseen consequences and lead to undesirable outcomes, resulting in what is known as "policy resistance" (Sterman 1994,2001).

The way to reduce the adverse effects of "policy resistance", is to adopt a more holistic view of problems: Systems Thinking (Senge 1990, Forrester 1961). It is critically important that the decision-makers understand and appreciate that they are working within systems that include many interconnected and interdependent elements. Given this, problems should be seen as a result of interactions among the system's elements rather than the result of malfunctioning of a single component. This is the essence of Systems Thinking, "the ability to see the world as a complex system" (Sterman 2001) comprising many interconnected and interdependent parts. Systems Thinking allows consideration of the whole rather than individual elements and representation of time related behaviour of systems rather than static "snapshots" (Senge 1990). Systems Thinking combines an array of methods and techniques drawn from disciplines such as engineering, computing, cybernetics, and cognitive psychology. Systems Thinking allows managers to overcome the feeling of helplessness when confronted with complex problems. It gives them the necessary tools to analyse, understand, and influence the functioning of the systems they are trying to improve.

The disturbances in systems are due to a particular kind of complexity: "dynamic complexity". An understanding of "dynamic complexity" is a necessary step in understanding the underlying causes of complexity and the importance of Systems Thinking.

2. Dynamic complexity

An underlying reason for poor decision-making in complex systems is that most managers focus on "detail complexity" that refers to a type of complexity in which the decision depends on choosing an alternative from a large number of static options. Given the large number of options, the selection of a single option may be difficult, but decision making can be aided by mathematical modelling and computing.

However, system failure is often due to the inability of managers to manage "dynamic complexity". Dynamic complexity arises when: (a) the short and long term consequences of the same action are dramatically different; (b), the consequence of an action in one part of the system is completely different from its consequences on another part of the system, and; (c) obvious well-intentioned actions lead to non-obvious counter-intuitive results (Morecroft 1999, Sterman 1992, Senge 1990, Richardson and Pugh 1981, Forrester 1961). Understanding dynamic complexity is a mean to identifying the leverage points in a system to improve its performance and avoid policy resistance.

There are three drivers of dynamic complexity in systems: (1) presence of feedback loops; (2) time delays between the cause and effect of an action, and (3) existence of non-linear relationships among the system's elements. It is well recognised that natural and human systems are multi-loop, dynamic, complex, and non-linear systems (Forrester 1961, Richardson 1995, Blower and Gerberding 1998, Sterman 2000,). We further expand on the sources of dynamic complexity:

i). Presence of feedback loops: Most human thinking is based on the event-oriented, linear, and open loop view of the world (Sterman 2001). Such thinking limits the explanation of situations being a result of successive events linked by linear cause-effect relationships. However, in reality, such an indefinite linear chain of cause and effect links does not exist. Any action taken by an agent in a system will only upset the current system's equilibrium and trigger reactions from other agents to restore the system's balance. These reactions generally affect the initial trigger of the action establishing a circular loop. This circular relationship, which indicates that an influence is both a cause and an effect, is known as "feedback" and lies at the heart of Systems Thinking approach (Sterman 1994, 2000, 2001, Senge 1990, Forrester 1961). Therefore, from a systems thinking perspective, systems consist of many interrelated feedback loops in which actions are just an attempt to alter the equilibrium of some of these loops. The reaction of the other feedback loops to these actions is the principal cause for "policy resistance" observed in the real world as the system attempts to restore its initial equilibrium. Similarly, the counter-intuitive results of many actions are the result of inadequate understanding of the structure of the feedback loops present in a system. Further, the so-called "side-effects" of actions are just effects, which the decision-maker did not predict as a result of flawed and incomplete conceptualisation of the feedback loops involved in the problematic situation (Sterman 2000).

There are two types of feedback loops: Reinforcing (positive) loops and self-correcting (negative) loops. The former describes situations in which any disturbance within the loop variables is reinforced and amplified causing an exponential growth (or decline) in the system. The latter represents situations in which any disturbance is resisted as the system is directed towards a state of equilibrium to achieve a desired goal. Although it is easy to infer the behaviour of each of these loops in isolation, if a system includes many interacting feedback loops, as is often the case, it becomes impossible to predict how the system will behave. In fact, all the dynamics observed in systems arise from shifts in loop dominance as the system evolves over time (Ford 1999, Richardson 1995). In this context, actions can be interpreted merely as influences trying to shift the balance of power among the system's feedback loops.

ii) Time delays: Commonly, it is assumed that an action immediately follows its trigger. However, in reality, causes and effects are often not close in time and space (Sterman 2000, Sengupta et al 1999). These delays make systems more dynamically complex as they slow the learning process by reducing the ability to accumulate experience, test hypotheses, and apply findings to intervene to improve a particular situation (Sterman 2000). Further, if consequences of actions are not immediately apparent, agents will continue to take actions to make the system converge to a desired state without giving it the necessary time to absorb the effects of these actions and respond adequately. The result is an oscillating behaviour in which systems either overshoot or lag behind their equilibrium. This behaviour becomes even more dramatic in situations where some delays are "unobservable": a context in which effective decision-making based on intuition or experience becomes an elusive goal. As pointed out by Sengupta et al (1999), "delays constitute one of the most important characteristics of dynamic tasks, and the ability to handle them is essential for effective performance in such environments".

iii) Non-linear relationships: This source of dynamic complexity means that the response (effect) of the system to an action (cause) is not always linearly proportional. The presence of such relationships in a system increases dynamic complexity because the response of the system to a disturbance will be different, as it will depend on its current state. The same action may trigger completely unpredictable consequences, as the response of the system is contingent upon the current balance of power among its feedback loops. Non-linear relationships may enable an action to become the trigger of a shift in dominance from one loop to another, which exacerbates the frequency of changes of power among the system's feedback loops, hence increasing its dynamic complexity.

3. Effect of dynamic complexity on decision-making performance

High levels of dynamic complexity adversely affect human decision-making. Indeed, often the decisions do not generate optimal, or even reasonable outcomes. There are many reasons for such under-performance in dynamically complex situations, but two reasons are of significant importance.

(a) Bounded rationality (Simon 1979, 1982): The principle of "bounded rationality" stipulates that humans suffer from two bounds of rationality. The first is due to the limited information processing capabilities of the human mind. When humans are faced with the complexity of the real world, they focus on a reduced amount of information and simplify their mental cause-effect maps by using linear thinking and ignoring the side effects of decisions. Therefore, their mental models are not an accurate representation of the real world. The second bound of rationality is due to the cognitive skills and memory limitations of the human mind. Even if humans have perfect information about the cause effect maps of a feedback system, they are unable to work out the consequences of their actions over time in a complete and logical way. In such situations, only a formal modelling approach can act as a learning catalyst and improve the decision-making performance. As Sterman (1994) points out: "These two different bounds of rationality must both be overcome for effective learning to occur".

(b) Misperception of feedback: The principle of "bounded rationality" applies in all types of decision-making. But its effect is amplified in dynamic situations. It has been observed that humans perform very poorly, relative to their potential, in situations involving dynamic complexity. Experiments have shown that the performance of humans decreases dramatically in the presence of high levels of dynamic complexity (Sengupta and Abdelhamid 1993, Sterman 1989 a, b). This is even true when subjects in the experiments have considerable experience or when financial incentives have been given to reward better performance (Diehl and Sterman 1995, Paich and Sterman 1993). These experiments have been used as an evidence to prove the validity of the "misperception of feedback" hypothesis, which suggests that mental models used by people to guide their decisions are dynamically deficient. Humans ignore feedback structures, do not appreciate time delays between actions and consequences, and are insensitive to the non-linearities between a system's elements as the system evolves over time. (Diehl and Sterman 1995).

4. System Dynamics methodology

System Dynamics (SD) was developed at the end of the 1950s and the beginning of the 1960s at the Massachusetts Institute of Technology's Sloan School of Management by Professor Jay Forrester who tried to apply the principles of engineering feedback control principles and techniques to management and social systems.

The principal philosophical basis of System Dynamics method is that the behaviour (time history) of a system is principally caused by its internal structure (Roberts 1978). In this context, SD assumes that the system structure is essentially composed of feedback loops in which delays and non-linearities are important drivers of a system's behaviour. SD aims to model and predict possible responses of such complex systems to different decisions so that their leverage points are identified or their structures are redesigned to eliminate undesirable behaviour (Lane and Oliva 1998).

The SD intervention process is divided into three phases (Lane and Oliva 1998, Forrester 1961)

(i) Definition of a study purpose: Any SD model should have a purpose, a defined problem, or an undesirable behaviour to be corrected. The variables of interest are described in a reference model that is a graphical representation of their observed history path. The factors believed to cause the behaviour are identified and the relationships between them described and modelled in the form of causal loop diagrams (CLDs). The relationship between the causal structures and the observed behaviour is called the "dynamic hypothesis": an initial possible explanation of how a system's structure is causing the observed behaviour. A parallel description of the decision-making process is conducted to determine how agents in the system transform information into decisions in order to include the information flows in the CLDs. This phase is essentially the conceptual qualitative phase of the intervention. It is important to emphasize here that this phase should not be conducted by the "SD modelling expert" alone. Recent developments in SD demonstrate the importance of involving the people in the problematic situations early into the mapping process in order to "capture" their mental models and elucidate their knowledge about the possible causes of the problem (Vennix 1996, Vennix and Gubbels 1992, Morecroft and Sterman 1992).

(ii) Model building: Once the qualitative structure describing the problem situation has been framed into CLDs, the next stage is to build a computer-based behavioural model which reflects the qualitative structure. The stocks (variables subject to accumulation and depletion processes over time) and the flows (which determine the time related movement of units from one stock to the others) are determined and the relationships between them defined. In this phase, a link is established between the variables and their dynamic behaviour. The quantitative nature of this phase makes it the most important one in terms of generating insights about the situation. It is important to notice here that many specialist software programmes have been written for SD modelling (Richmond 1987, Richardson and Pugh 1981) to make the process easy and accessible to people even without strong computational background.

(iii) Using the model in the problem situation: Before the model is used for the purpose of policy analysis, it is necessary to built confidence into it. This process is called validation of the model. Because a model is a trial to "replicate" the reality, it is necessary to make sure that it can replicate, at a satisfactory level, the time path of the variables in the system. Many procedures are described in the literature to test model validity and build confidence into it (Barlas 1996, Forrester and Senge 1980). Once the model is validated, it can be used for different purposes. This may include, testing the impact of different policies, exploring what-if scenarios or optimising some sub-structures in the system. Ultimately, the model is used as a base to derive policies or structural changes.

5. Suitability of System Dynamics modelling for health care systems

Health systems are complex. This may explain the disappointing results of policies to improve the performance of health systems. From an SD point of view, they exhibit high levels of dynamic complexity and are, therefore, subject to counter-intuitive behaviour and policy resistance. Although a significant fraction of many governments' budgets are allocated to health, results have hardly matched expectations as many health system performance indicators have shown limited improvement. In this context, SD modelling can be an effective tool to address many of these concerns and contribute towards improved health system performance or better health care provision. This contribution can be significant as the SD modelling methodology can deal effectively with strategic and tactical problems involving aggregate flows of patients and resources (Dangerfield 1999), and key elements in a health system. SD modelling offers a unique opportunity to improve decision-makers' understanding of the sources of their systems' under-performance as it allows both qualitative and quantitative analysis, which lead more easily to consensus building, improved shared understanding, and enhanced organisational learning (Wolstenholme 1993).

Before describing briefly the different areas in which SD modelling has been applied in health systems and health care management, it is necessary to explore the reasons that make health systems highly dynamic and complex.

(a) <u>Health systems involve many interacting feedback loops:</u> These loops occur as many elements in the health systems interact and have mutual influence on each other. Such interactions cannot be adequately captured by linear representation as they are inherently a circular chain of cause and effect relationships. For example, in studies by Van Ackere and Smith (1997, 1999) and Dangerfield (1999) on the effects of consultants' behaviour on NHS waiting lists, relationships between the actions taken by consultants and the waiting list size was embedded in two feedback loops (See figure 1). In this structure, the first negative feedback loop B represents the behavioural response of patients to increased length of waiting lists. If the latter increases significantly, more patients will tend to switch to the private health care sector for rapid treatment reducing, as a result, the pressure on the NHS and the waiting list size. This second positive loop, however, represents the side-effects of this policy, which intended to reduce waiting lists (a desirable outcome from the NHS perspective). The reinforcing loop R indicates that this desirable situation is not always achieved as consultants in the NHS may also practice in the private sector. Therefore, if more patients switch to private health care sector, the demand on this sector will grow accordingly leading to consultants spending more time in private health care, that is less time in the NHS (given a fixed total availability of consultants), hence an increase in waiting lists.

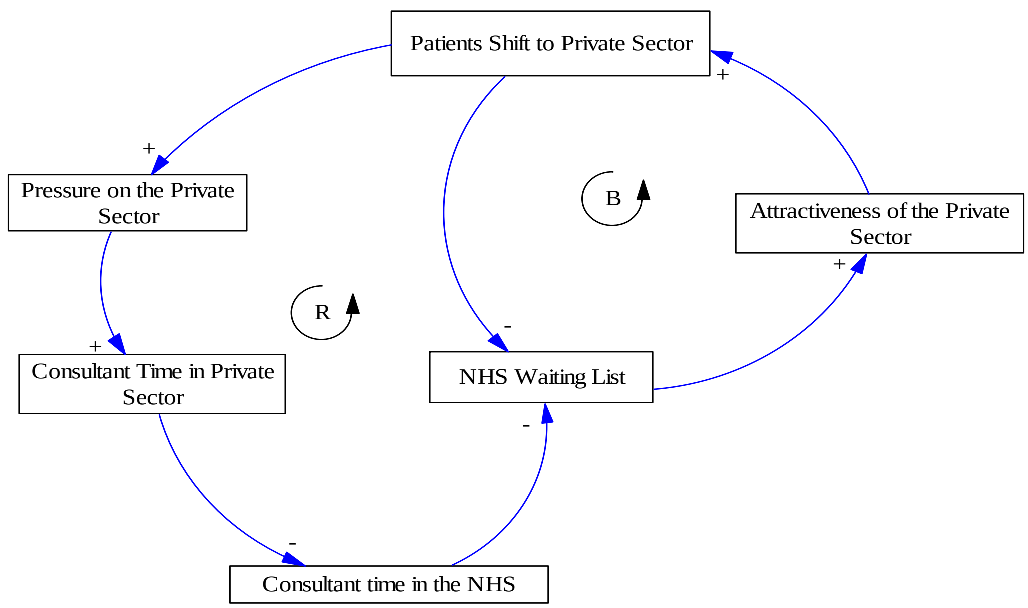

Figure 1: Example of Feedback structures in health care management

(Source: Dangerfield 1999)

From this simple example it is clear that the presence of interrelated feedback loops make the design of robust policies more complicated than it may initially appear. As the previous example showed, a well-intentioned action to reduce waiting lists has switched the power from the negative to the positive feedback loop leading to completely unpredictable results.

From this simple example one can observe that the health systems involve feedback structures, which make them highly dynamic and complex. The use of SD modelling is of paramount importance if better performance of these systems is to be achieved.

(b) Health systems decisions involve many delays: This means that cause and effect in these systems are not close in time and space. This renders management of such situations problematic because if consequences of actions are not immediately visible, decision makers tend generally to take dysfunctional actions while trying to restore the system to a desirable state. For example, there is a time delay between the time at which a doctor is needed and the time at which this doctor is fully trained and available. Similarly, there is a delay between appearance of symptoms and care seeking. For instance in a study reported in Royston et al (1999), it was found that patients with *Chlamydia* disease did not seek treatment once symptoms appeared but delayed consulting a doctor until the infertility became apparent and when the treatment was no longer effective.

Understanding delays and dealing effectively with their consequences is a difficult challenge especially if they are coupled with the presence of strongly interconnected feedback loops. The remedy, in this case, is to adopt a formal modelling approach such as SD for better problem representation and analysis.

(c) Health care systems involve many non-linear relationships: This means that the response of an element in the system to an input (action) can be completely different from what may be intended or predicted because the response will depend on the system's current conditions. This indicates that the effects of the same managerial action can be different as they are contingent upon the state of the system when the action is taken. For example, a study by Coyle (1984), found that the time in hospital for a particular condition was non-linearly linked to the time spent by a patient in the waiting list before the hospital admission. If a patient was promptly admitted to hospital, his treatment time was short. However, if a patient waited for a long time before admission, the treatment time was considerably longer as the patient's health situation worsened significantly while waiting for treatment, preventing other admissions and lengthening waiting times for patients on the waiting list. If a shorter length of admission is allocated to the particular patient, the probability of relapse after treatment is increased, which may lead to subsequent admission to hospital, occupation of a bed, and lengthening the waiting list. The presence of non-linear relationships makes it difficult to accurately predict the behaviour of health systems and complicates management decision-making.

(d) Health systems involve "hard" and "soft" elements: Making decisions on the basis of the information on "hard" variables is not difficult as this information is easily available, understood, and not subject to much argument. However, health systems involve a strong human element and the "soft" variables that represent aspects of human behaviour and responses must be taken into account. Examples of such variables are doctors' motivation, productivity, fatigue, quality of practice, patient anxiety, response to incentives, and the responses of hospital managers to different pressures. These variables complicate problem analysis as they are not easily quantifiable and their effects are not subject to rapid consensus. SD methodology can easily accommodate such variables and allow more realistic analysis of health care systems.

The previous examples illustrate that health systems are highly dynamic and complex and, hence, SD is an appropriate methodology to represent and analyse them. However, technical adequacy and the elegance of the method are not the sole reasons which encourage the adoption of SD modelling. In addition to the technical capability, the methodology offers many advantages over the "hard" modelling techniques. These advantages include the ability to involve the different stakeholders in the modelling process and more rapid interaction with those involved in managing health systems or developing policies and strategies to improve them. This results in a more rapid use and integration of knowledge, a greater opportunity for assumption and hypothesis revision, an enhancement of "joint" thinking and group learning, and easier convergence to shared understanding of problems (Royston et al 1999, Sterman 2000). For these reasons, SD has become a widely used technique in health care management although application to health systems modelling has yet to be explored. The main areas in which the technique has been applied are presented in the next section.

6. SD applications in health care management

SD offers many advantages in terms of modelling and analysis of health systems and has been widely applied to aid health care management decisions for a multitude of problems ranging from simple and well focused health care delivery programmes to larger and more complex socio-technical issues (Royston et al 1999). The most important areas in which SD modelling has been applied include,:

- Disease transmission and public health risks assessment.
- Screening for disease.
- Managing waiting lists.

6.1 Disease transmission and public health risks assessment

This stream of research includes the modelling of infectious diseases and the impact of different intervention strategies to limit their spread in human populations. Given the dramatic consequences of such diseases on public health and the economic and social costs associated with them, developing effective policies to contain them while ensuring a best use of the available resources is crucial. This area of application included, for example, the modelling of HIV/AIDS infection. These models, developed over a long period of time to accommodate new knowledge about the disease, aimed to understand the transmission mechanisms (Dangerfield 1999, Dangerfield and Roberts 1994, 1996, 1999, Dangerfield et al 2001). These models included variables such as AIDS incubation period, stages of the disease, availability and effectiveness of treatment, stage at which treatment starts, and survival periods. These variables were used to quantify the effects of different prevention and treatment policies such as the Highly Active Anti-Retroviral Therapy (HAART). Similarly, another study modelled the effects of intervention policies to tackle Dengue fever epidemics in Mexico (Ritchie-Dunham and Mendez-Galvan 1999). The model portrayed the dynamics resulting from the interaction of mosquitoes, humans, transmission virus, and government intervention policies and included variables such as the size of the mosquito population, mosquitoes' infectivity, susceptible population size, mosquito to human density ratio, human living conditions, and epidemic control techniques. The model was used to evaluate the effects of different policies and to guide decision making for the Mexican health authorities.

6.2 Disease screening

The performance of different screening policies as well as their cost-effectiveness has constituted an important area of application of SD modelling in health care. Given the importance of screening as a tool to detect a disease before it causes harm, and its impact on disease transmission mechanisms, it was important to evaluate the medical, social, and financial consequences of different screening strategies. A first model, to study the screening of cervical cancer, was developed with the aim to investigate the effects of time interval between successive screenings and the proportion of the susceptible population to be covered by the screening program (Royston et al 1999). The model was built to assist the UK Department of Health to achieve its target to reduce the disease prevalence. The model offered useful insights into how the interaction between the screening variables and the disease transmission dynamics impacted the disease incidence level. It enabled the decision-makers to decide about the best screening policy. In the same context, another model was developed to investigate the cost effectiveness of *Chlamydia* screening programmes (Townshend and Turner 2000). It included variables related to the transmission of the disease, sexual behaviour of the susceptible population, treatment effectiveness, and population groups. The model has led to useful recommendations regarding the health care and financial consequences of different screening programmes.

6.3 Modelling of waiting lists

Waiting lists are a "hot" political issue. It is not surprising, therefore, that the problem has attracted a great deal of SD modelling. The dynamics of waiting lists have been studied in different contexts and many models have been built to analyse variables influencing their size and length as well as the impact of policy decisions. For example, Wolstenholme (1993, 1999) studied the cause of waiting lists escalation in the context of the UK Government decision to shift elderly community care responsibility from the Department of Health to the Local Government social services. The model showed that the intended policy of saving health care budget had a counter-intuitive effect as waiting lists increased.

In another model, Coyle (1984) examined the policy of shortening the period of hospital stay in order to reduce the waiting lists. His model demonstrated that this policy had a counter-intuitive affect as short stays increased the probability of patient relapse and readmission to hospital for treatment: inflating waiting lists.

More recently, a model of the UK national waiting list was developed (Van Ackere and Smith 1997, 1999). This model related the waiting list to the availability of resources (surgeons, beds), the demand on the NHS sector, and the available capacity in the health care private sector. The model showed that the policy to shift more patients to the private health sector when NHS waiting lists become lengthy was not sustainable. The reason was that whenever NHS waiting lists were reduced, patients tended to shift back to the NHS sector, therefore increasing the NHS waiting lists, hence the original problem.

Although these are the key areas in which SD modelling has been applied, there are other models which focus on specific health care management issues such as health care work-force planning and emergency health care provision (Royston et al 1999, Lane et al 2000), effect of joint health care provision by different sectors (Wolstenholme 1999), and the effect of a shift from the free-to- service to self-paying service (Hirsch and Immediato 1999). These models demonstrate the rich variety of areas in which SD may play a significant role in health policy design.

7. Applying Systems Dynamic Modelling to health systems: The case of Georgia Health Systems Reform

The case study described in this section focuses on the investigation of the reform of health care system in the Republic of Georgia. The target is to define the elements affecting the provision of family medicine (FM) health care. Clearly, the system involves many elements, which are highly interconnected, and to improve the provision of health care we will explore how these elements are related to each other. From a Systems Thinking perspective, we will demonstrate that the structure of the system is quite complex and can be, as a result, subject to the adverse effects of policy resistance, unless the holistic system is studied and its structure depicted.

In this description, we will start by describing a simple structure which includes the main elements in the system and then we will expand the description to show that the system can grow rapidly in size and complexity.

The basic structure is represented in figure 2. It shows that the provision of FM health care depends on the availability of FM physicians, FM health centres, and the financial resources. If the number of patients registered with FM centres increases, the need for FM physicians also increases leading to more increase in the number of FM physicians trained and available. The other effect of increasing patient numbers is the need to license more FM centres to respond to the demand. The number of patients also affects the financial resources available in the system. High numbers of patients means more financial resources and more trained FM physicians.

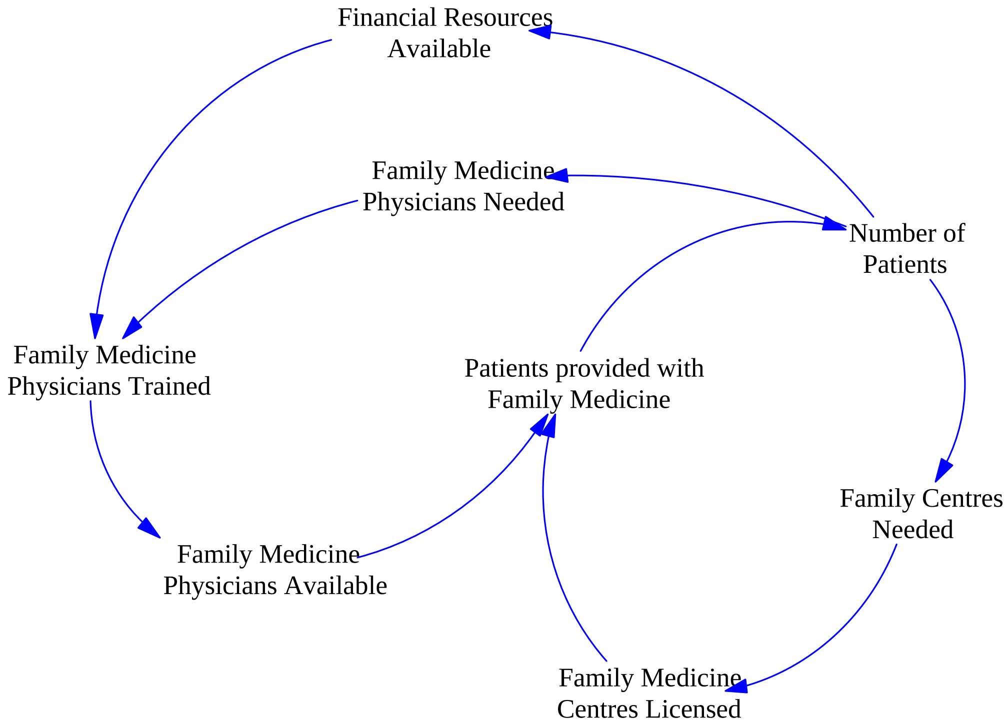

Figure 2: First model of the Family Medicine Health System Provision in Georgia

Starting from this simple structure, it is clear that many of its elements are affected by many other factors (see figure 3). If the number of FM physicians needed increases, so will the number of FM physician in training. However, these trainee FM physicians have to go through a licensing process before they can practice in FM centres. Therefore, the number of FM physicians licensed, which become available for providing FM care, will increase as they finish training and join FM centres.

The number of FM physicians in training is affected by two other factors. First, the number of graduates from medical schools; the higher the number of graduates, the higher the number of FM physicians in training. The second factor is the number of trainers as graduate training cannot be completed unless a sufficient number of these trainers is available. The latter number itself is contingent upon the financial resources available in the FM health system.

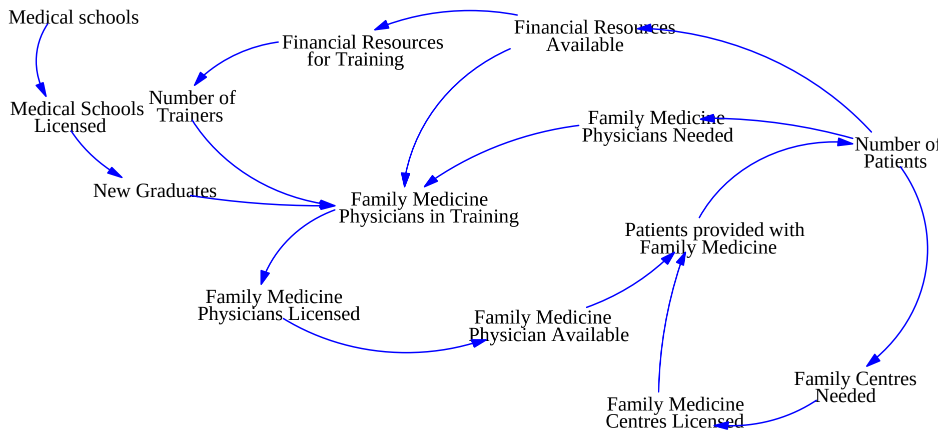

Figure 3: Second model of the Family Medicine Health System Provision in Georgia

The system described earlier cannot be made operational unless some of its elements are licensed (see figure 4). This includes mainly the medical schools and the FM centres. If there is a need for more graduates in the FM sector, it is necessary to license the medical schools from which this pool of graduates is taken. This means that there is pressure for more licensing capacity. Similarly, because the FM centres have also to go through the licensing process, this will increase the total licensing capacity needed. The system response is assumed to be that more licensing capacity is made available leading to more licensed medical schools and FM centres.

Apart from physicians and medical centres, the FM system also needs nurses to operate. The number of nurses needed is related to the number of patients opting for FM health care provision. If the latter number goes up, the number of nurses needed will grow accordingly and the system should respond by recruiting and training more nurses.

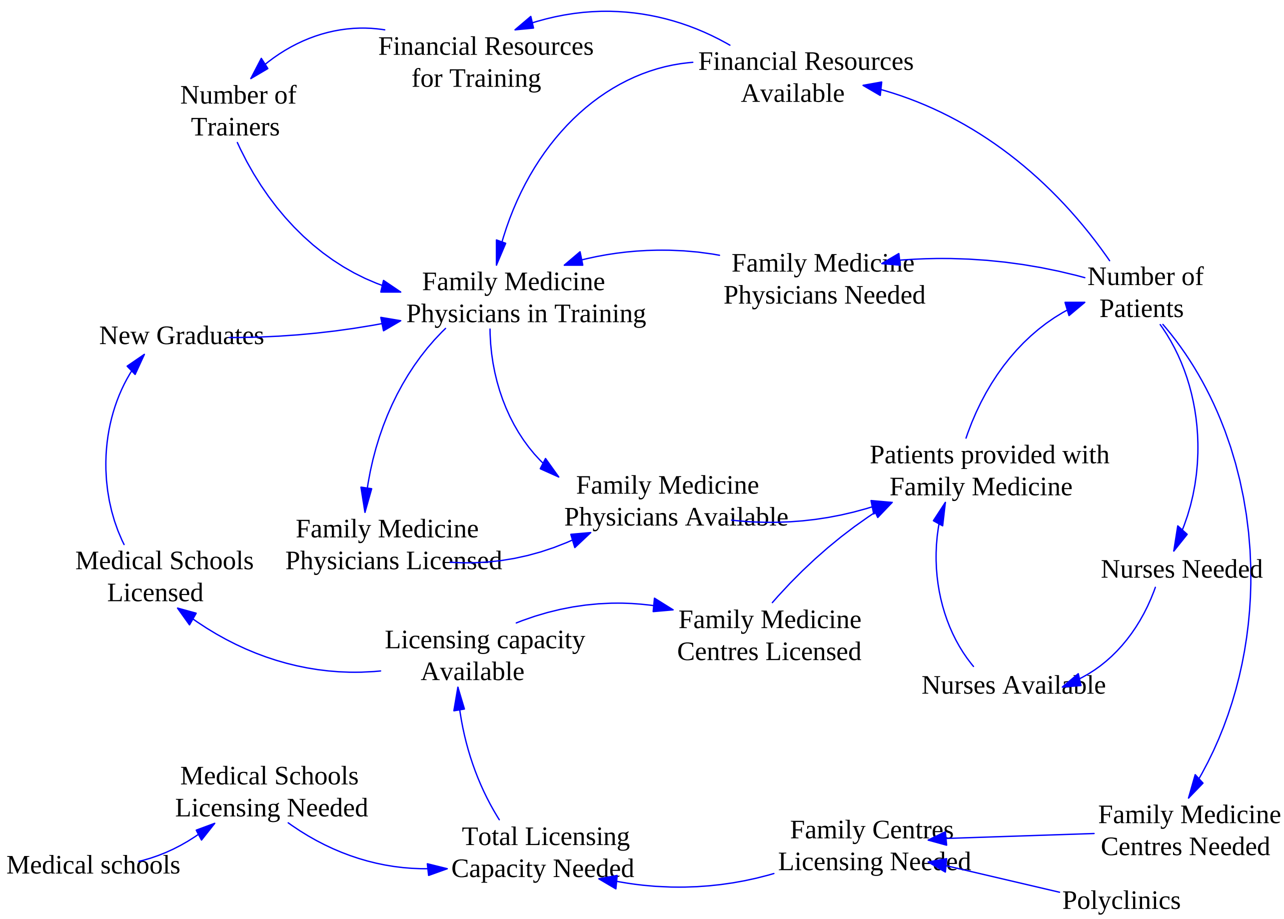

Figure 4: Third model of the Family Medicine Health System Provision in Georgia

The system described so far can be expanded by formally modelling the number of patients opting for FM and its influence on the financing structure. The number of patients registered with FM will depend on the total number of patients in the system, therefore the higher the former value, the higher the latter. The number of patients also affects the financial resources available in the FM health care system. If the fraction of patients contributing financially to the FM scheme is increased, more financial resources become available. Given that some of this funding is directed towards covering the FM physicians' training program, it will have an effect on the number of FM physicians in training, and ultimately, the number of FM physicians available (see figure 5).

This brief description shows that the FM health system is quite complex, although the description given here is very simple and does not include all the system aspects. However, it is clear that the system is complex and includes many elements which are tightly connected and have mutual effects on each other. The other conclusion is that it is necessary to use a holistic view of the system if its performance is to be improved.

Conclusion

This paper briefly demonstrated that the under-performance of health care systems can be tracked down to the inadequacy of the tools and methods currently used to analyse them. While these systems are dynamic and complex in nature, the methods and heuristics guiding decision-making in these systems do not capture adequately the effects of the most important elements in these systems and their interconnections resulting in their observed poor performance. The remedy to this situation is to adopt principles of Systems Thinking and System Dynamics to formulate, model, and analyse these systems.

Although these methodologies are gaining considerable ground in health care management, there are still many opportunities for a wider use of Systems principles to improve health care systems. The initial analysis of the consequences of policy changes in the health system in the Republic of Georgia has shown that the system under redesign is highly dynamic and complex. This offers a great opportunity to apply these systemic techniques to improve its performance and guide the process of its structural changes.

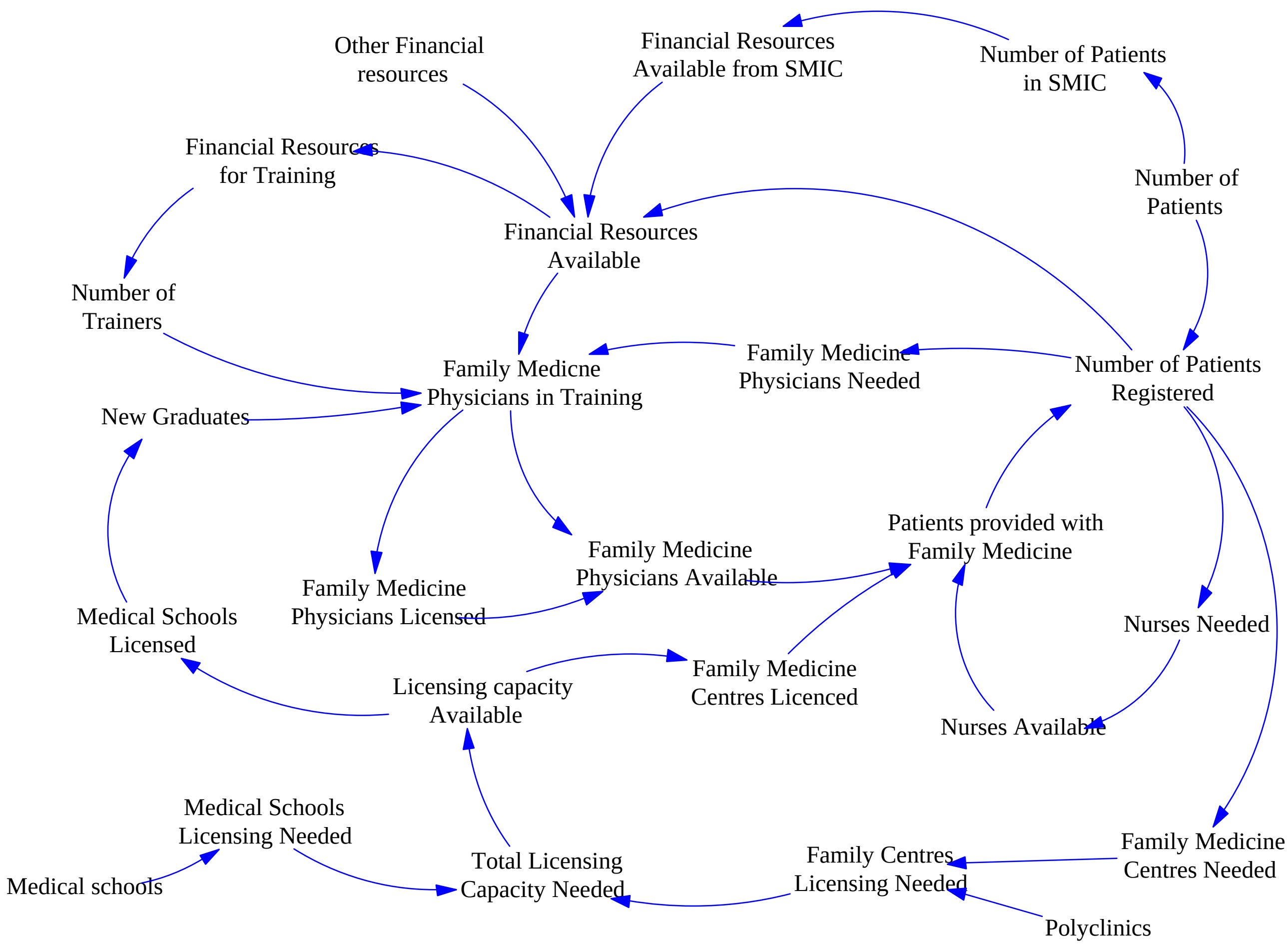

Figure 5: Fourth model of the Family Medicine Health System Provision in Georgia

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