Examining the role of simulation models in health planning

Steffen Bayer, Imperial College

Sally Brailsford, University of Southampton

Tim Bolt, University of Southampton

Imperial College Business School

South Kensington Campus, London SW7 2AZ, UK

s.bayer@imperial.ac.uk

Simulation models can occupy very varied roles in the planning of health care infrastructure and services. They can be a close replica of the real world used to produce exact answers or a tool in building consensus among stakeholders with different views and objectives as a boundary object. The role a simulation model can have in a decision process is constrained by the degree to which the model and its results are accessible to stakeholders with no or limited experience with modelling. The visual representation of the model and its results are likely to be of a major influence on the accessibility of the model. However, whether a visually more accessible model will result in improved stakeholder buy-in, creative problem solving and more effective decision processes remains an empirical question. This paper draws on a currently ongoing research project on the use of system dynamics and discrete event simulation tools in health care and presents some early conceptual work on the role of modelling in the planning process.

Introduction

Since the 1960s, simulation models have been applied to a range of healthcare problems (Brailsford, 2008). Despite the proliferation of papers in the academic literature, and individual anecdotal success stories, there are still major issues around getting these models widely accepted and used as part of mainstream decision-making by clinicians, health managers and policy-makers.

Modelling in health care planning often occurs in situations where understanding has to be created across professional and organisational boundaries. Creating such cross-disciplinary understanding in healthcare settings is difficult. (Ferlie et al, 2005). While many models have been developed for planning purposes in health care, successful and sustainable use of modelling remains a concern (Brailsford, 2005; Pitt et al. 2008).

Models can be used to make predictions about outcomes in the real world and allow decision-makers to experiment in a safe, quick and cheap way with different courses of action. However, as has been shown in the case of engineering, (Dodgson et al., 2007b) simulation modelling can also help to shape the conversation between stakeholders in problem solving and foster collaboration. In the modelling literature a tension between conceptualising modelling as representing reality and as negotiating a social order has been identified. (Zagonel, 2002). Within health care applications, these different roles of modelling are evident and vary with the purpose of the modelling exercise, the accessibility of the model and the modelling process, the type of modelling approach as well as the preferences of those involved in the modelling process. A particular interpretation of the roles for modelling in the decision-making process would be as a boundary object, i.e., an artefact of practice shared between communities which have their own specific informational requirements (Star and Griesemer, 1989; Carlile, 2002; Sapsed and Salter, 2004). This raises the question under which circumstances models in health care planning are indeed used as boundary objects and when they fulfil other roles.

Health care planning

Delivering effective care services to patients frequently requires coordinating activities of several providers: GPs and other primary care services such as rehabilitation, acute hospital and social care providers might all potentially need to come together to provide services for an individual patient. Planning such services is difficult: communication as well as the coordination of the flow of resources between many stakeholders across organisational boundaries needs to be managed. Planning services requires that the differing needs of stakeholders be understood and addressed. Local political needs, complex and sometimes perverse financial incentives, differing values between professional groups from different parts of the system (such as social services and acute care) can lead to open or hidden conflicts and misunderstandings. In arriving at decisions, not only is the factual accuracy of assumptions and the rationality of the decision itself important, but also the decision process. Processes which give some degree of structure and rationality, by highlighting uncertainties, encouraging stakeholder dialogue, supporting and documenting the decision, are therefore desirable.

A variety of modelling approaches have been used in health care planning ranging from behavioural modelling to mathematical modelling. Simulation models in the healthcare area have been developed since the mid 1960s. Over recent decades, the amount of work in the area has increased substantially

(Brailsford, 2008; Pitt et al., 2008). More powerful computers, more accessible software and growing capabilities in the computer graphics and animation area have all helped to spread the use of simulation modelling and made simulation models and the modelling process more accessible to non-specialist users.

Simulation modelling in health care

Many different approaches, including spreadsheets and simulation models, are used in healthcare planning. Among the different types of simulation modelling approaches applied, system dynamics and discrete event simulation are particular prominent. Other approaches applied in health care include Monte Carlo simulation and agent-based modelling.

In system dynamics modelling, it is the aggregate flows in the system, as opposed to individual patients, which are modelled. This approach is therefore best suited to problems where the relevant behaviour of the system is less influenced by what happens to the individual patient and more by influences on an aggregate level. In particular, the effect of feedback and delays within the whole system can be particularly well represented and studied. (Wolstenholme 1993) System dynamics models are commonly used to analyse strategic questions, often in a quick and intuitive way. System dynamics can be used to study the whole system effect of an innovation as it is implemented and becomes effective over time. System dynamics modelling is ideal in cases where a static comparison of different models of care delivery is not enough and the time dimension has to be taken into account (Bayer et al 2004) and also when several interventions are to be evaluated together (Homer et al 2003; cf. Hirsch et al 2004). It is also very useful for settings where a whole-system approach is required, for example emergency health care, where there are multiple, interacting stakeholders and it is not possible to divide the system into separate “silos” of care provision (Brailsford et al 2004).

Discrete event simulation has a more disaggregated focus than system dynamics and is more suited for detailed, operational models. Applications of this modelling approach typically emphasise the journey of individuals through the care system. In discrete event models emphasis is often placed on the effects of random variations (e.g. of arrivals of new patients, treatment durations, etc.). Such stochastic effects are less often considered in system dynamics models. Often discrete event simulation models are used for operational decisions about care delivery, as opposed to strategy and policy. This type of simulation has been used for many different healthcare applications including the organisation of specific clinics such as a vascular-surgery (Dodds, 2005) or emergency department activity (Connelly and Bair, 2004), care service innovation such as intermediate care (Kotiadis, 2004) or the evaluation of screening programmes (Davies et al., 2002; Brailsford et al. 2006).

System dynamics models favour a visualization of systemic relationships such as feedback loops, while discrete event simulation lends itself to a visualisation of the journey of individuals. Since it is likely that these differences in the visual interface of the simulation models will shape the insights stakeholders can gain from the model, the influence of the visual interfaces afforded by different modelling approaches should also be factor in deciding the most suitable approach for a particular planning challenge. In practice, however, choices between the different approaches will not only be influenced by the features of the problem and its complexity, but also by the expertise of those involved.

Boundary objects, visualisation and the role of modelling

Boundary objects can address some of the difficulties of communicating and creating knowledge across (disciplinary and organisational) boundaries. These difficulties include not only the syntactic and semantic challenges of having to overcome differences in language and interpretation, but also the challenges inherent in creating new shared knowledge and dealing with the negative consequences for the participants arising out of this shared knowledge creation process. (Carlile, 2002) Boundary objects such as repositories of knowledge, standardized forms and methods, objects or models or maps of boundaries have been shown to support interdisciplinary working. (Star 1989) Simulation models show promise in being able to serve as such a boundary object. However, while boundary object can be the basis of negotiation and knowledge exchange, they can also be ineffectual, precisely because their role is at the margin of communities. (Sapsed and Salter, 2004)

In a variety of domains, modelling has been shown to be able to support situations where disparate stakeholders need to create new knowledge. In large, complex transdisciplinary areas, models can become the facilitators of interdisciplinarity, integrating the different knowledge bases. (Mattila, 2005) Simulation modelling has been shown to act as a boundary object in engineering (Dodgson et al. 2007a) helping to bridge disparate communities in innovating and in particular allow disparate groups engage with innovation projects and contribute potential solutions to engineering problems. (Dodgson et al. 2007b)

The role of simulation models in planning will be influenced by the visual practices associated with their development and use. Visual practices shape learning within and across projects, as some practices are more suited to developing specific types of knowledge (Whyte et al., 2008). However, the potential role for models as boundary objects hinges on their accessibility to stakeholders who will often lack familiarity with mathematical models. It can be hypothesized that models can more easily be accepted as a representation of reality or of a vision for reality if the visual interface supports both understanding and experimentation. The use of simulation technology varies, as stakeholders have choices as to how and to what ends they use simulation technology. These choices over simulation processes and approaches are likely to influence the outcomes of the planning processes in terms of buy-in by stakeholders, the quality of the decision and the ultimate success of implementation (figure 1).

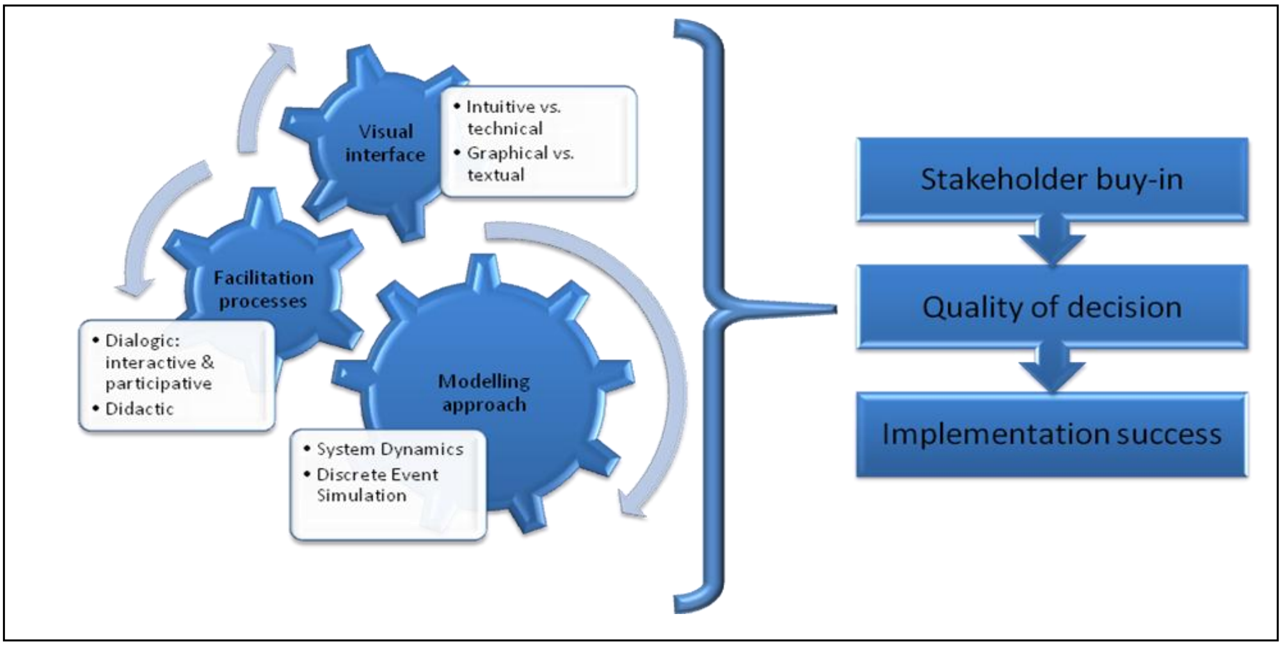

Figure 1: Modelling approaches, facilitation processes, visual interfaces and outcomes

Analysing the role of models in planning processes of the NHS

We are currently in the early phases of a project collecting evidence (through observation and interviews) for at least four cases of decision processes where health care actors are supported by external modelling consultancies in the planning of healthcare services. While the work will be carried out within the National Health Service in England, the findings of the research project are likely to be of relevance for model use in health planning in other settings as well.

This work will examine whether models (embedded in a particular modelling process) can facilitate knowledge exchange and creation in health care planning. We will analyse whether models can - possibly influenced by their visual interfaces - operate as effective boundary objects: establishing a shared syntax to represent individual knowledge, creating a way to communicate differences and dependencies across boundaries and facilitating a process of joint knowledge transformation.

By understanding under which circumstances models are used to produce exact answers (being seen as close replicas of the real world by the stakeholders) and when they predominately serve as a tool for building consensus among stakeholders with different views and objectives, we contribute to both the modelling and boundary objects literatures. The work is intended to develop guidance to support decision-makers and consultants to the sector in using simulation modelling in health care planning processes.

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