

Warwick Complexity DTC

Mini-Project Proposal

The NHS is a complex system in which many semi-autonomous organisations interact in order to deliver healthcare and to prevent ill-health for the population they serve. Many attempts have been made to develop models that reflect the behaviour of the system, often using system dynamics to model high order or macro-economic behaviour, or discrete event simulation of detailed processes, most often in hospitals. Most of these models have been developed by academic or commercial bodies and have not resulted in generally applicable models that managers in the wider NHS can use.

The NHS Institute has funded the development of one simulation model aimed at strategic planners in the NHS. Scenario Generator is built on top of the SIMUL8 discrete event simulation product and represents the healthcare delivery system as a series of parallel pathways of care that together describe a whole health community. It has proven useful for planning provision of care where the main focus is on changes to the processes or pathways of care provision. However, managers find it harder to use the model when the main focus is on other aspects of care planning, such as improving health or service quality outcomes, reconfiguring whole healthcare services (such as decommissioning of small hospitals), or optimal means to achieve efficiency savings. Furthermore, DES models such as this do not readily allow for modelling impact of non-process based influences such as human behaviour or public preferences.

Some of these latter challenges might be addressed using a system dynamic model but this technique is no more familiar or accessible to health service managers than discrete event simulation modelling. The tools do not reflect the concepts and objects that are the day to day language of managers, such as organisations, services, contracts, patient pathways etc.

None of the approaches have yet resulted in a widely applicable tool that could be used by health service managers to assist in planning for current challenges such as finding more cost effective models for delivering healthcare to a population, or for reducing demand on their health services.

Could an agent-based modelling approach offer advantages for such strategic planning needs over SD or DES? There are two obvious possibilities – first, synthetic populations could be created that reflect the characteristics of the population of a local health community, allowing more realistic models of demand to be created; and second, organisational units (hospitals, clinics, GPs, clinical teams etc.) that provide services could be represented as discrete agents with a set of defined behaviours and ways of interacting with each other and external influences.

A first step to exploring this possible application of agent-based modelling could be to attempt to construct a model of the second type above, using the existing model included in Scenario Generator as a starting point.

The proposed mini-project

The proposed mini-project is, therefore, to design, construct and compare the utility of an agent-based model of a local healthcare delivery system with that contained within Scenario Generator.

As mentioned above, Scenario Generator this contains a model of the typical NHS healthcare delivery system, which is represented as a set of pathways of care – high level process models for mental health, urgent care, planned care and maternity services. Each step in the pathway represents a ‘bundle’ of clinical activity provided, generally, in one kind of organisation, having optionally a unit cost and duration of care. Routing from one step to subsequent ones is determined as a probability of referral through each possible outbound route, determined where possible from national data sources on current healthcare activity patterns. The user can add their own pathways that in effect ‘specialise’ one of the generic ones (for example ‘stroke’ takes a defined proportion of activity destined for the urgent care pathway). There is also a simple model of available resources to which steps can be mapped and that constrain flow of activity through the pathway. These might be ‘GP consultation’, outpatient department, diagnostic scanner, team of health visitors. Healthcare activity is generated as an annual number of ‘events’ to be fed through each pathway, which are determined from the product of the estimated population and prevalence of disease.

The pathway model allows tracking of cost, activity and transit time through each pathway. Scenarios in which one or more changes have been made to any of the model parameters can then be compared to judge the impact of different planning assumptions. However, the model has some shortcomings: as a high level DES model it does not have any representation of clinical outcome, measure of quality of service, flow of information etc.; the model handles large numbers of events (millions per annum) and runs very slowly when constrained by enabling the mapping of steps to the resource model (even when only a small number of constrained resources are modelled); the model is seen to be very technical and not well suited to use by senior health service managers.

This mini-project would entail an analysis of the existing Scenario Generator model (supported by Nick Gaunt, who has good working knowledge of the tool) and development of an agent-based representation. Consideration would need to be given to user configuration of pathways and resources, to availability of data and to the impact of running the agent-based simulation against large population sizes.

The principal output of the project would be a report which addresses the possible approaches to an agent-based representation of this problem, the feasibility of taking this approach, the benefits (if any) of this over the original design, and if a working model has been produced, its performance.

Potential follow-on project(s)

Depending upon a positive conclusion of the mini-project regarding the feasibility and benefit of taking an agent-based approach to this problem domain, the research could be substantially extended with a much more detailed analysis of the utility of the model for planning purposes, with the identification of additional agents and behaviours to allow exploration of efficiency (both allocative and technical) and quality of outcome, and to the design of more accessible and compelling user interfaces better suited to non-technical senior health service managers.

Dr Nick Gaunt
Lead on Modelling & Simulation
NHS Institute for Innovation and Improvement
nick.gaunt@institute.nhs.uk

07775 802736

8th February 2010

Yasmin Merali
Associate Professor
Warwick Business School
Yasmin.Merali@wbs.ac.uk

024 765 22456