A MULTI-FACETED APPROACH TO OPTIMISING A COMPLEX UNPLANNED HEALTHCARE SYSTEM

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Abstract

Unscheduled and urgent health care represents the largest area of activity and cost for the UK's National Health Service (NHS). Like typical complex systems unplanned care has the features of interdependence and having structures at different scales which requires modelling at different levels. The aim of this paper is to discuss the development of a multifaceted approach to study and optimise this complex system. We aim to integrate four different methodologies to gain better understanding of the nature of the system and to develop ways to enhance its performance. These methodologies are: (a) Lean/ Flow theory to look at the process and patients and other flows; (b) Simulation/ System Dynamics to undertake analytical analysis and multi-level modelling; (c) stakeholder consultation and use of system thinking to analyse the system and identify options, barriers and good practice; and (d) visual analytic modelling to facilitate effective decision making in this complex environment. Of particular concern are the boundary issues i.e. how changes in unplanned care will impact on the adjacent facilities and ultimately on the whole Healthcare system.

Keywords: complex systems, simulation, methodology, healthcare.

1. INTRODUCTION

Healthcare service providers are facing unprecedented challenges in the early 21st century which are affecting the pressure on the system in real terms as budgets are frozen or even reduced but also in the nature of provision as demographics and lifestyle changes result in increasing demands for different types of services and support. In the United Kingdom (UK) it is clear that efficiency gains will need to be made to ensure the continued provision of healthcare, but as healthcare is a complex system it will be essential to understand the knock-on implications of altering different types of service provision and by extension the boundaries and interrelationships between different healthcare service providers. Simulation provides an opportunity for different healthcare scenarios to be explored ahead of implementation on the ground meaning that decisions which could have either dangerous or financially costly implications can be investigated fully for feasibility. However, the validity and reliability of the simulations will be dependent upon the quality of the data collected so it is important that the research methodology employed to develop and use such simulations to support decision-making is robust. This paper presents the methodology that will be used to develop simulations of unplanned care in a large hospital in Greater Manchester in the UK with the aim of reducing unscheduled admissions which should be dealt with by alterative healthcare services and the costs associated with these. This research is being conducted by the Health and Care Infrastructure Research and Innovation Centre (HaCIRIC) [1] which is funded by the Engineering and Physical Sciences Research Council (EPSRC) [2].

2. THE PROBLEM OF INAPPROPRIATE UNSCHEDULED HEALTHCARE

The HaCCRU report [3] published in 1997 identified that 17% of admissions to Manchester hospital beds could potentially have been managed in alternative ways and that 70% of these required a setting that provided a lower level of care than an acute hospital. During a similar time period rates of inappropriate admission were reported to be even higher in New England at 38% in 1991 [4]. When determining appropriateness of care it is important to consider both the benefits to the patient and the cost which in countries such as the UK is the cost to the taxpayer and therefore society which has led authors such as Buchanan et al (1991) to argue that care is appropriate when "the expected health benefits exceed the expected risks of treatment by a wide enough margin and at a cost acceptable to society and the individual" [5]. Unscheduled and urgent care comprises the biggest domain of activity and cost for the NHS in the UK. Whilst there is a need to reduce the financial cost, any unnecessary activity and demand, which can be achieved by increasing public awareness about the range of alternative healthcare services available, service level will need to be at least retained at current levels if not improved further. Figure 1 shows the current Accident and Emergency (A&E) system in the case study area regarding unplanned healthcare.

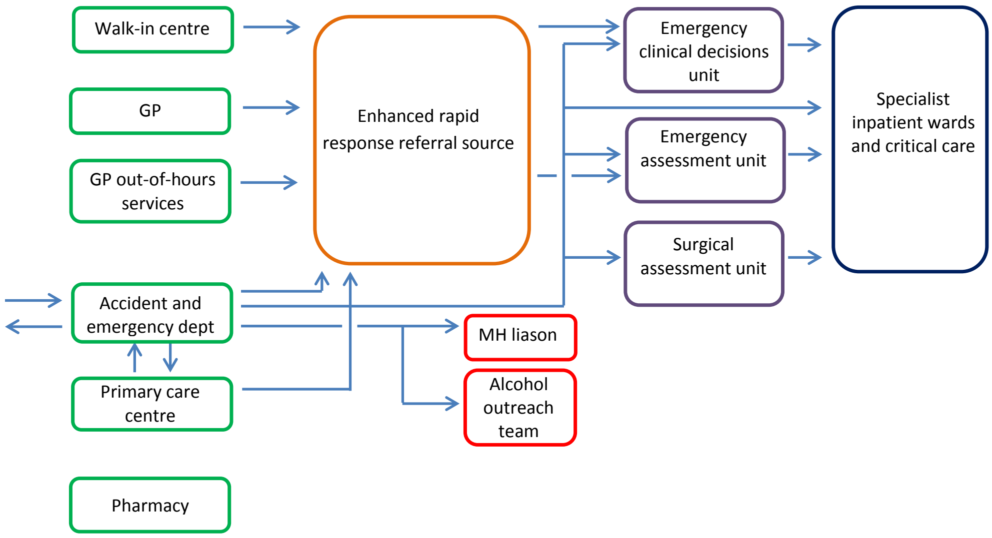

Figure 1 – Flowchart representation of the current unscheduled healthcare system

Figure 1 identifies the different components of the healthcare system with which patients might come into contact with as they enter, move through and are discharged from it. These components comprise the services that a patient can be expected to use during their healthcare journey – such as General Practitioner doctor (GP) surgery, pharmacy, assessment unit and mental health liason – or a particular department within the hospital to which they may then be admitted for further care. The patient should enter the hospital in a planned way having been referred by their GP for specialist care, or they may enter as a result of genuine accident. This research is focussed upon the hospital admissions that could be managed by services provided in settings away from the hospital and investigating how such unnecessary hospital admissions can be reduced.

3. MODELLING FUTURE HEALTHCARE SYSTEMS

3.1 Approaches to simulation and modelling

There are many published studies in literature on the use of simulation and system dynamics in health care modelling. However what distinguishes this study is that it aims to simulate a highly complex system and augment modelling with other methodologies. In a recent study by Dattee and Barlow [6] they emphasise the crucial property of complex health care systems of possessing a particular structure at differ scales and hence the scale of analysis is critical. That requires modelling the systems at different levels. Hence the importance of using the different modelling tools at appropriate levels e.g. System Dynamics (SD) at a strategic level and simulation at more detailed operational level. This multi-level modelling will also enable assessment of the impact of changes in the unplanned care system on the whole health care system. Lengu [7] reviews the application of simulation and SD in healthcare and notes that there are very few published studies in the literature that examine the use of simulation of unscheduled care in healthcare.

System dynamics approaches to modelling complex healthcare systems have been used since the 1970s e.g. Dangerfield [8] and Brailsford et al [9], primarily to map the dynamic relationships between multiple factors within a complex system and this can help to develop an understanding of the possible consequences of the relationships. As far as this research is concerned this will provide a powerful representation of the impacts of changes that will be made to one part of the system and on other related components of the system which may or may not have been well understood. Another benefit of this type of modelling tool is its facility to identify the sensitivity of the system to changes that occur either within the system – for example delays or structural changes – or the context in which it is located such as changes to policies. In contrast discrete event simulation can be used to replicate the performance of an existing system to a finer level of detail but the performance of the model is dependent upon the accuracy of data representing its operation in the past. In common with system dynamics, discrete event simulation provides a decision-maker with the capability to model and compare the system's performance over a range of alternatives.

Modelling and simulation tools provide a number of important benefits for healthcare. The large number of high profile Government-funded IT systems in the UK that have been delivered late and over budget, for example the Ministry of Defence's IT infrastructure project due July 2007 but delivered 18 months late and £182m over budget, means that there is little appetite for further costly mistakes with projects funded by tax payers. Therefore the ability to experiment with a wide range of new ideas or scenarios and to compare and evaluate these in a risk-free simulation environment where there are no costs or safety implications for patients or the tax payer is important. Also, by presenting the system using a visual interface that is easier to understand, it is possible to develop a collective understanding of the system, including variability in processes and behaviours and relationships between key processes and people, and to identify more clearly bottlenecks in service that prevent better productivity.

The emerging field of visual analytics offers a powerful tool to handle huge amounts of data and information by integrating human judgement by means of visual representations and interaction techniques in the analysis process [10]. Visual analytics has been defined as "the science of analytical reasoning facilitated by interactive visual interfaces" [11]. The environment for visual analytics implies interaction between the users and the data [12]. The driving force for automated analysis includes statistics and mathematics [12]. Visual Analytics can offer a user-friendly and interactive visual platform for the exploration of "what-if" scenarios by decision-makers. Compared to modelling and simulation which allows the impacts of changes to one component of the system to be examined on the system as a whole, visual analytics allows more specific and detailed interrogation of the data sets within the model and for the data to be presented in a very user friendly way. For example, a simulation model can present expected admissions rates to A&E and the expected variations in this throughout a normal week and potential changes in admissions with the opening of a new intermediary care facility, but the visual analytics model will allow more detailed information associated with each patient being admitted to be presented so that it is possible to filter admissions based upon a known criterion such as age, health problem, arrival method, home address which allows more in-depth analysis to be completed.

Table 1 – Types of waste associated with healthcare

Type of waste	Example
Waiting	Patients waiting for assessment; Staff waiting for results
Overproduction	Recording the same information multiple times
Rework	Reassessment of patients by several members of staff
Movement	Staff walking to reception and back to use photocopier
Processing	Staff ordering unnecessary investigations
Inventory	Stock being unavailable when required or out of usable date
Transportation	Patients going to CT scan which is distant to the emergency department

3.2 Lean healthcare

The principles of lean, the identification and removal of waste from production processes, have been developed and applied successfully to the manufacturing sector, most notably the Toyota system where it has been demonstrated that savings can be made and the quality of the product improved. The same principles have been applied to the construction sector and the construction and maintenance of healthcare facilities: For example Denver Health and Hospital authority has been able to cut costs, increase productivity and increase revenue without reducing its workforce and save $54m in the five years from 2005 [13]. The types of waste that a lean approach to healthcare can eliminate are shown in table 1.

4. METHODOLOGY: A MULTI-FACETED APPROCH

The problem that the research team is addressing is an example of what Gibbons et al [14] have described as Mode 2 knowledge; knowledge that is produced differently, refers to different sets of norms and is applied to solve different types of problems. They refer to Mode 1 knowledge as that which is produced according to the Newtonian model which is guided by very clear and widely accepted ideas, values, norms and methods and which is accepted as scientific practice in its production, legitimation and diffusion. In contrast, Mode 2 problems are not defined and solved solely by the academic community but by the community and within the context in which the knowledge developed will be applied and as a result the knowledge is trans-disciplinary, heterogeneous, socially accountable and involves a wider set of practitioners who will need to collaborate to solve the given problem. The knowledge that this research will produce will be relevant specifically for healthcare planners at different levels of the organisational hierarchy from General Practitioner doctors (GPs) through to the Managing Director for the region, but due to the complexity of the system and the range of stakeholders a range of disciplines and methods will contribute to this research both from the practitioner and research sides including but not limited to organisational science, lean manufacturing, healthcare management, simulation and modelling, and the social sciences. It is expected that the resulting solution will add more value than that which could be contributed by one discipline alone and that the research framework will be distinct to the problem and evolve over time to reflect to contributions of the various disciplines but that during this process the theoretical methods, research structures and modes of practice distinct to each discipline at the start will develop into something that each discipline may not later recognise as pure and true to that discipline, so the framework will transcend the contributing disciplines. Another key feature of Mode 2 knowledge is its heterogeneity which is a result of the skills and experiences the people involved bring. The outcome is knowledge that is produced in a number of different locations, no longer in universities and colleges alone, and linked in a variety of ways including via social, organisational, informal and technical networks.

4.1 Aim & objectives of the research

The overall aim of the research is to simulate future healthcare service configurations that allow cost savings to be made whilst retaining or adding value. In order to achieve this, the research team will need to understand the current healthcare system in terms of data, systems, decisions, people and flows or processes, and the interrelationships between the different healthcare service providers within that system and sub-systems regarding these components. The team will then simulate the current healthcare system which will allow a range of scenarios for alternative service configurations for unplanned and urgent care to be explored based on the parameters that inform practitioners' decision-making. The final stage of the research will involve the identification of the barriers and enablers associated with embedding simulation and modelling technologies into healthcare decision-making practice.

4.2 Theoretical background

The application of lean principles will improve unscheduled care through investigation of the flows of patients around the healthcare system, both before they enter the Accident and Emergency (A&E) department as well as during their movements around it and out of the system to other care services, it will provide a better understanding of triage services in A&E. As a result of this understanding it will be possible to identify whether the processing of these patients is efficient and if not, where waste of the types identified in table 1 is being created which could be managed more effectively. The aim of the application of a lean approach is to identify the care pathways and identify why patients are presenting themselves at A&E unnecessarily when alternative and more appropriate care pathways are available to them.

By using simulation tools in conjunction with a lean approach, it is possible to sustain some of the improvements that the lean approach will enable. This includes the use of simulation as an educational tool that can develop understanding of the current system and its problems and build consensus for future action through the communication of different scenarios and their implications for staff and patients alike. Therefore simulation can be used to engage staff in a decision-making process that might otherwise be lacking in clarity and as it provides a risk-free experimentation environment the removal of the fear of failure increases the chance that more creative ideas and solutions can be explored and issues will be raised that might have not been apparent to all decision-makers and stakeholders previously. Finally, the ability to experiment with different scenarios allows for improvements that strip waste and add value to the patient care to be identified from those that do not and the presentation of these through a visual analytics interface means that specialist, technical expertise is not required to interpret the model, thus widening the access to evidence to support effective decision-making.

In order to develop a model that validly and reliably simulates the current healthcare system, it will be essential to consult with the stakeholders who would be expected to use the model to inform their decision-making. Whilst the healthcare planners are the gatekeepers to the data that the model will use, their input will be essential in shaping the model and determining how it could be main-streamed into daily decision-making practices. They will define the key problems that the healthcare system is facing because the system is so large and complex that it will not be possible to simulate and produce scenarios for every individual care pathway and service provider in the first instance, although this will also be guided by the availability of data. They will also identify the sorts of scenarios that they will want to explore based upon current constraints and opportunities for future healthcare. The planners will also help to validate the model through their attendance at focus groups which will seek to gain recognition that the model does accurately represent the system that they know and to identify tacit knowledge associated with the system that may be based upon experiences that is not captured by the more formal data sets that the National Health Service (NHS) is obliged to obtain and keep. The healthcare planners will also be consulted about the systems and data that they currently use to help them to make decisions about care provision, which may or may not be formally recognised by the organisation and which may not necessarily be technical in nature, for example regularly scheduled meetings, knowing which colleagues to call etc. The final contribution that these stakeholders will make will address issues associated with embedding good practice into decision-making, including the use of decision-support tools such as simulation and modelling technology and exploring the current barriers and enablers to enhanced practice such as people, skills, cost and time.

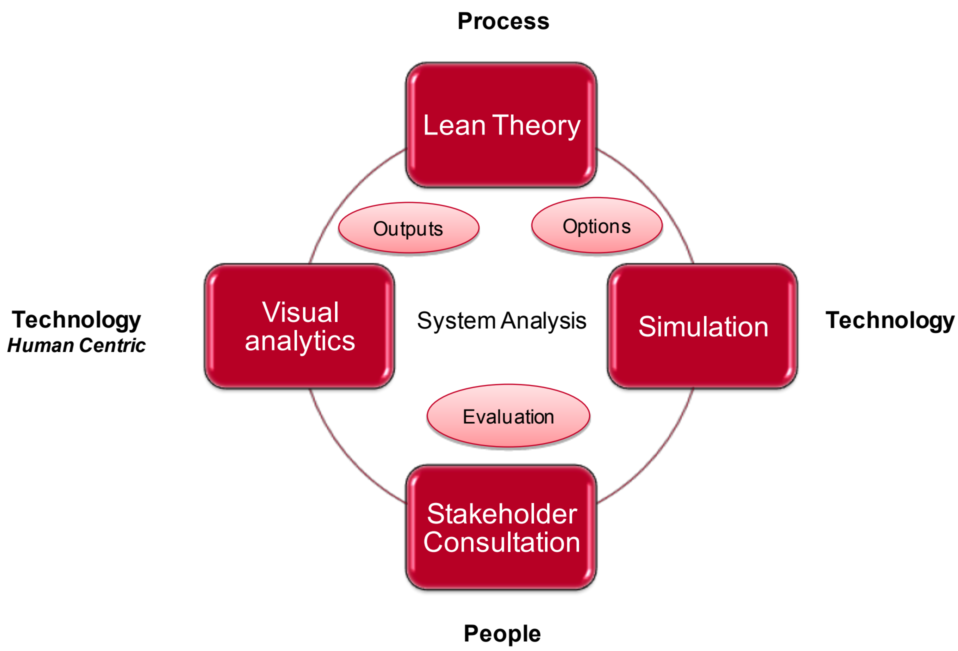

Figure 2 – Research methodology

Figure 2 shows the different theoretical components of the research which all have a contribution to make. What this figure does not capture is the iterative nature in which the simulations will be developed and tested with stakeholder groups to ensure validity.

5. CONCLUSIONS

The complexity of the healthcare system and the number and nature of the interrelationships between its different components has necessitated the development of a methodology that brings together methods from lean production theory, simulation and system dynamics, stakeholder consultation and visual analytics. It is anticipated that this methodology as it is currently described will develop iteratively over time in response to its application to the Mode 2 problem that it is addressing including the development and application of the simulations that will help to support more informed decision-making by healthcare planners.

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