MODELLING AND SIMULATING UNPLANNED AND URGENT HEALTHCARE: THE CONTRIBUTION OF SCENARIOS OF FUTURE HEALTHCARE SYSTEMS

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ABSTRACT

The current financial challenges being faced by the UK economy have meant that the NHS will have to make £20 billion of savings between 2010 and 2014 requiring it to be innovative about how it delivers healthcare. This paper presents the methodology of a research project that is simulating the whole healthcare system with the aim of reducing waste within urgent unscheduled care streams whilst understanding the impact of such changes on the whole system. The research is aimed at care commissioners who could use such simulation in their decision-making practice, and the paper presents the findings from early stakeholder discussions about the scope and focus of the research and the relevance of stakeholder consultation and scenarios in the development of a valid decision-support tool that is fit for purpose.

KEYWORDS

Healthcare systems; methodology; simulation; stakeholder consultation; unplanned healthcare.

INTRODUCTION

Unscheduled and urgent care comprises the biggest activity and cost domain for the NHS. Over the last two years the local NHS commissioner has been engaged in an exercise led by Accident and Emergency (A&E) consultants and General Practitioner doctors (GPs) to reduce costs through a combination of scaled down capacity and a reduction in demand. There is some predictive information that suggests what the impacts of these changes might be, but currently this is largely unsophisticated and unproven and there is a need for more robust and detailed modelling of the local urgent healthcare system. The research team is developing

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a model capable of running dynamically over time to identify the points at which patients interact with resources available in terms of access to, flow and progress through the system focusing on key decisions points and bottlenecks. The model will map and enable the simulation of health events against service capacity, and will measure demand and service and resource utilisation concentrating on the dynamic flow of patients through the unplanned healthcare system. The model will allow decision-makers to test its sensitivities by increasing or decreasing elements within it to observe the likely impacts of decisions upon service before they are made on the ground.

This paper presents the research methodology and findings from a series of key meetings held to date with primary and secondary healthcare planners, commissioners and clinicians to develop an understanding of the unplanned care system. This understanding is a pre-requisite to the development of the simulation model as it provides the scope of the care system in terms of its components and their interdependencies. This understanding will also identify the flows between those components that can be interrogated in terms of cost, value, waste and benefits from various stakeholders' perspectives and hotspots within the care system that will form the focus for discussion of future healthcare configuration scenarios. This will also provide the baseline against which scenarios of alternative healthcare decisions can be simulated and potentially implemented when the model is used to explore different care configurations and the contribution of scenario building to the overall methodology of the research will be discussed.

INAPPROPRIATE UNSCHEDULED HEALTHCARE

The UK government's spending review in 2010 requires the NHS to make £20 billion of savings by 2014 (BBC, 2012) and for Salford's Clinical Commissioning Group established in 2010, although a group of local GPs had been taking greater control of budget decisions starting from 2008, to save £9.7m of the £402.8m savings to be made by Greater Manchester by 2015 (Manchester Evening News, 2011). In such times or financial austerity, publically funded bodies such as the NHS are being asked to do the same or more with less finance, but how might they achieve this? One of the options available to healthcare planners is the reduction of inappropriate healthcare which comprises the largest cost and activity domain for the NHS in the UK. In this UK this means that the cost to the taxpayer who funds healthcare has to be considered as well as the benefits to the patient when a judgement about appropriateness is made, an argument that is supported by authors such as Buchanan et al (1991) who 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". The case for the reduction in inappropriate admissions and care is clear: For example, the HaCCRU report (Dhoot and Pearson, 1997) found 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. Inappropriate admission was a problem elsewhere with rates of 38% being reported in 1991 (Winickoff, Restuccia and Fincke, 1991). 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.

AN APPROACH TO MODELLING AND SIMULATING FUTURE HEALTHCARE SYSTEMS

In order to validly and reliably model current and future healthcare systems, the input of the healthcare planners expected to use a simulation model to support their decision-making must be sought. The size and complexity of the system and availability of data at the necessary level of granularity mean that it will not be possible to simulate every care pathway in the first instance. Therefore, this stakeholder group will scope the research by defining the key efficiency problems facing the system, validate understanding of the system and later determine how the use of a simulation model could be mainstreamed into daily decision-making practice alongside other tools being used. This stakeholder group will also identify the scenarios they need to explore based upon current constraints and opportunities for future healthcare and their understanding of current efficiency hotspots within the system.

The number of high profile, publically funded information systems that have been deemed to have failed either as a result of inflated development costs, lack of uptake by end users, abandonment or a combination of the above means that it is important for this simulation model to be flexible but relevant to the users it will be supporting. For example the Ministry of Defence’s IT infrastructure project was due July 2007 but delivered 18 months late and £182m over budget and at a time of financial austerity in the UK there is little appetite for further costly mistakes with projects funded by tax payers. A lack of clearly defined user needs is often cited (for example Sauer, 1993) as a reason for this in addition to lack of in-built flexibility of the system to address the changing contexts in which it will be used. Whilst the latter is less of a problem for this research, it remains essential that methodology by which the model is developed is also fit for purpose and is one of the reasons why the approach being used for this research combines contributions from stakeholder consultation with lean theory and two approaches to technology, system dynamics and the more human-centric visual analytics. The methodology is shown in figure 1. This diagram does not however capture the iterative process by which the model will be developed and tested with healthcare planners to ensure its validity.

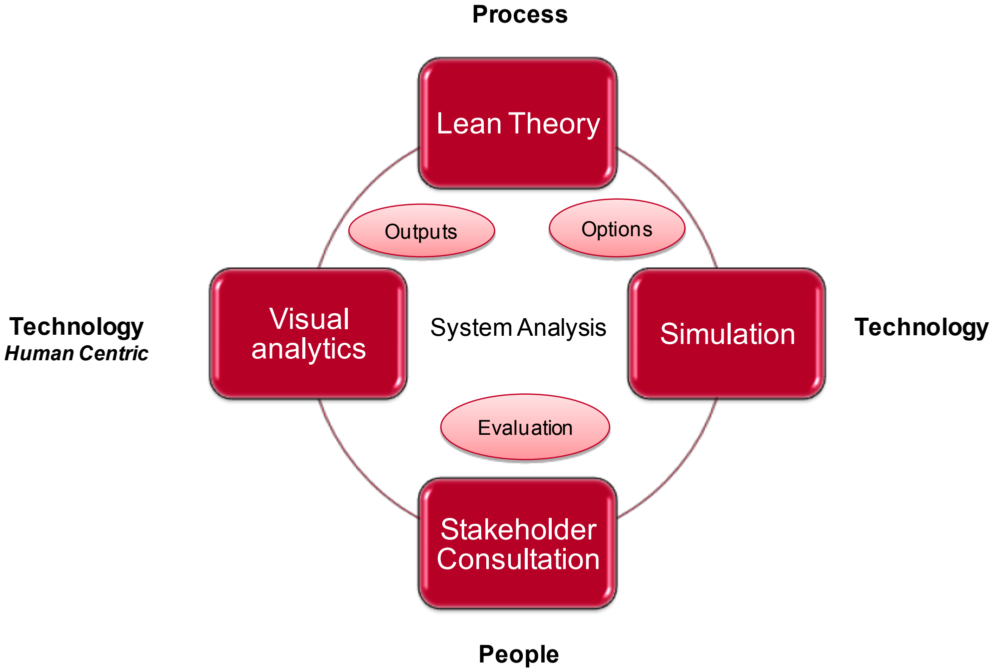

Fig.1. Research methodology

1.1. Mode 2 knowledge and the role of stakeholder consultation

The research being conducted is an example of what Gibbons et al (1994) have described as Mode 2 in nature and that will produce knowledge that is applied to solve different problems, is produced in a qualitatively different way and refers to a different set of norms. Mode 2 is contrasted with Mode 1 which they describe as being produced in accordance to the Newtonian model, the norms, methods and values of which are accepted as scientific practice in terms of the ways the knowledge is produced, validated and shared and as such the academic community alone define the problems and produce the knowledge. Conversely, Mode 2 problems are developed by the wider community and within the context in which the knowledge will be applied. As such knowledge is contextually based and usually produced by a wider range of discipline groups or practitioners it is subsequently heterogeneous and trans-disciplinary in nature and to contributions of each contributing discipline may be less apparent than for Mode 1 knowledge.

This research will produce Mode 2 knowledge relevant specifically for healthcare planners at different levels of the organisational hierarchy from GPs through to the Managing Director for the region. The complexity of the healthcare system and the range of stakeholders mean that a range of disciplines, experiences 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. The value of this is a solution that adds more value and relevance than one discipline alone could provide and that the production of a research framework that will be distinct to the problem and evolve over time to reflect the contributions of the various disciplines. Such a framework can be expected to transcend any one individual discipline contribution over time. A consequential feature is that knowledge is produced in a number of different locations and no longer in universities and colleges alone, and it is linked in a variety of ways including social, organisational, informal and technical networks.

The healthcare decision makers will be involved primarily with guiding the research team to understand the current healthcare system, focusing primarily on the unscheduled presentations of patients at A&E. From this understanding it will be possible to identify the key hot spots within the system that will need to be simulated and the care pathways or processes associated with these hotspots. Lean thinking was developed within the manufacturing sector where it was applied successfully, most notably by Toyota, to improve product quality whilst reducing costs through the removal of waste in the production processes. These principles have been applied successfully to both the construction and healthcare sectors and its use within the later enabled Denver Health and Hospital authority to cut costs, increase productivity saving it $54m between 2005 and 2010 without reductions in the workforce (Denver Post, 2010). Table 1 shows the types of waste that a lean approach to healthcare can eliminate.

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*

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 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.

Once the key healthcare flows have been identified, the healthcare decision-makers will validate the research team's understanding of the how the system currently and ideally should function through a series of meetings. Once there is general consensus on this, a workshop with decision-makers will develop scenarios of future healthcare provision based upon known constraints and drivers and these scenarios will be simulated so that the wider impacts of changes to patient flows and care interventions can be established on the wider system.

1.2. Modelling and simulation approaches

Although much research has been published on the use of simulation and system dynamics, this research is distinguished by its aim to simulate a complex system with a methodology that augments modelling approaches with those from lean thinking and stakeholder consultation. Dattee and Barlow (2010) emphasised the importance of being able to perform analysis of health care systems at different levels of granularity due to their complexity and for this reason this research is using simulation at a detailed operational level and system dynamics for strategic level modelling to explore the impacts on the whole healthcare system of changes to the unplanned care components in the A&E department. A review of the use of simulation and system dynamics in healthcare found few studies applying these approaches to unscheduled healthcare (Lengu, 2011).

System dynamics modelling approaches have been used since the 1970s to help understand the relationships and their consequences within complex systems (Dangerfield, 1999; Brailsford et al, 2008) and a key benefit of this type of modelling is the capability of exploring sensitivities of the system to changes within the system of the context in which it is based, for example policy change. Discrete event simulation will enable the performance of the existing system to be replicated to a finer level of detail and whilst it will support the decision-maker with the capability to model and compare alternatives and their impacts on the system's performance, both approaches are dependent upon the quality and accuracy of the data they use.

Fig.2. Examples of visual analytics interfaces

In order to support the decision-makers and their use of the data in the model as effectively as possible, visual analytics will be used as the platform by which users will be able to explore 'what-if' scenarios. One of its strengths is the ability to handle large amounts of data, integrate human judgement and represent the outcomes using a user-friendly interface (Keim et al, 2008) which justifies its definition by Thomas and Cook (2005) as "the science of analytical reasoning facilitated by interactive visual interfaces". Rather than enabling investigation of impacts of changes upon the system as a whole, visual analytics allows the user to drill down in detail into a particular problem and interrogate very specific data sets and the data. Figure 2 shows a typical visual analytics interface which demonstrates how the data can be queried using a geographical interface as well as represented in chart form. For example, whilst a simulation model could be used to identify expected changes to A&E admissions rates throughout a typical day, week or year associated with the opening of a new intermediary care facility, the visual analytics model will allow the data associated with individual patients to be investigated (age, health problem, arrival method) which enables more in-depth analysis for example of socio-economic factors associated with particular system behaviours.

It is the facility 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 that is an important feature of this research. 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.

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.

1.3. Scenarios for future healthcare

Scenario planning is method used by organisations to explore alternative futures, potentially to develop flexible strategic plans, by combining known facts about the future with a range of driving factors that may be less well established. It is a particularly useful tool when used by a diverse group within the organisation who may have different viewpoints, experiences and needs related to the problem under consideration as it strives to make explicit the complexity of factors impacting upon the organisation including those which may be subjectively understood by individuals and therefore lack consensus of status or required action or whose combination may not be understood. The process usually involves identifying the question or problem that is to be answered, the timeframe in which the scenarios are expected or required to be effected, the stakeholders able to influence the realisation of any given scenario as well as those affected directly as a result of its implementation, identification of the known trends and drivers and the uncertainties and their importance, further definition and description of the scenarios and an assessment of the scenarios and their implications or consequences for the organisation. Scenario building and planning has been used in healthcare to facilitate organisational culture change (Korte and Chermack, 2007), establish healthcare demand in response to a flu pandemic (Genugten, Heijnen and Jager, 2003) and encourage systems thinking and organisational learning (Drew, 2006).

METHODOLOGY AND FINDINGS TO DATE

1.4. Research aims, objectives and methodology

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.

This will be achieved by an iterative approach to the development of the simulation model overall that will apply techniques relevant to each of the contributing disciplines. As well as scoping the research overall by sharing their understanding of the current healthcare system, the healthcare planners will also help to validate the simulation model through their attendance at research meetings and focus groups that will seek to gain recognition that the model does accurately represent the system that they know. This will allow their tacit knowledge associated with the system, based upon experiences that are not captured by the more formal data sets that the National Health Service (NHS) is obliged to obtain and keep to be drawn out. 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.

1.5. Findings to date

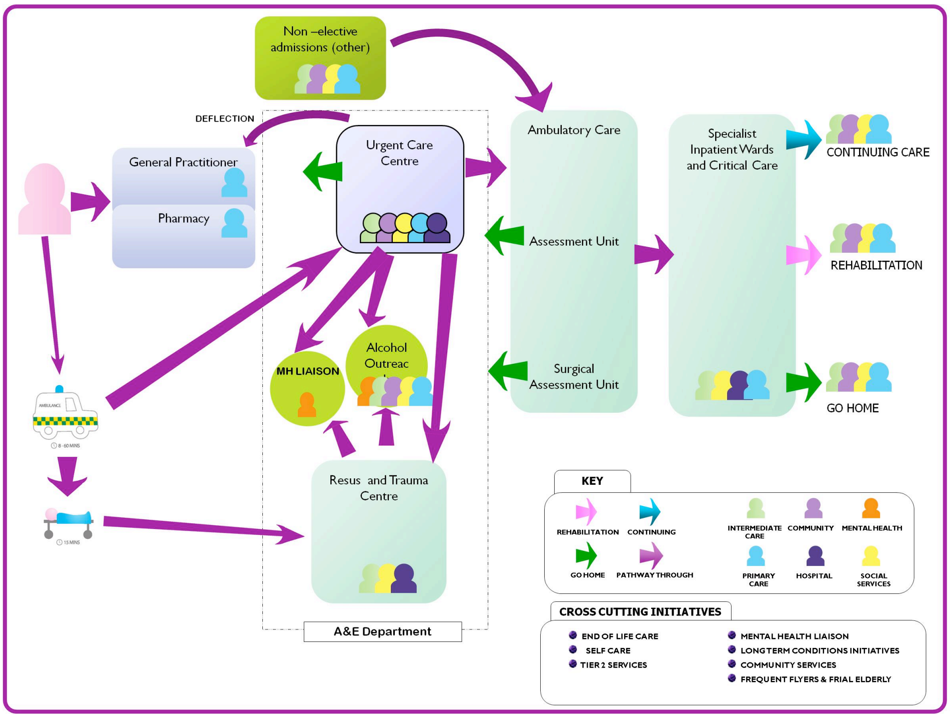

Fig.3. Diagram of the healthcare system

Figure 3 provides and illustration of the healthcare system that was provided by the healthcare decision makers at the hospital during the first stage of the research. This figure 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 GP's 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. It is important to note that figure 3 provides an idealised version of the way the system should work.

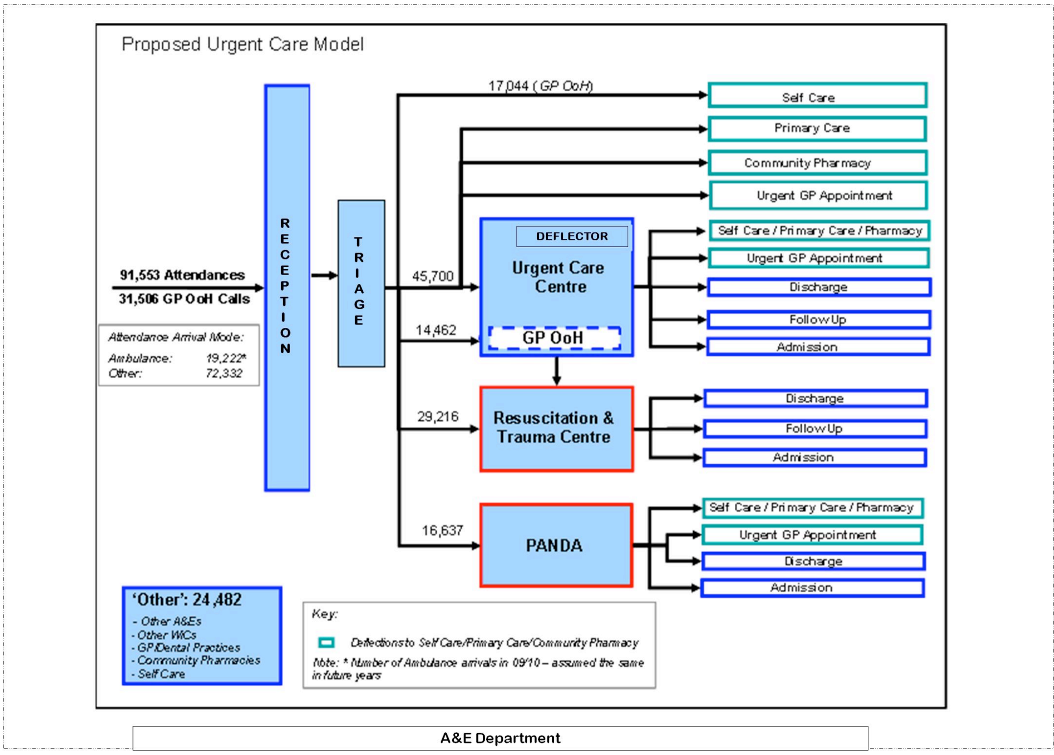

Fig.4. Patient flows in the emergency department of the system

Figure 4 provides more detail of the patient flows in the emergency department of the system which was supplemented by a tour of the hospital which allowed the research team to observe the A&E department in action. During the tour the research team was able to familiarise itself with the layout of the A&E department as a number of journeys were made through the hospital based on arrival method and the outcomes of key decision points. The tour identified a couple of limitations in the system that will be considered for future investigation. First, there is a clear efficiency gain to be made by considering how patient records are handled. Currently, when a patient arrives at the hospital their details and clinical decisions are noted on a paper form which initially stays with the patient and is later digitised. The hospital has a new IT system that could potentially be used and it was requested that options for this process are modelled. Secondly, there is some built-in personnel rigidity in the system which might be affecting the way that information flows within the system; doctors work across the system from the urgent care system to resuscitation but the nurses work in pools allocated to named care departments. Finally, flow into and out of the system will need to be modelled to address a current bottleneck with discharging patients from the hospital and into social care, a problem exacerbated by different funding mechanisms and that results in elderly patients in particular remaining in hospital beds longer than is necessary. It was identified that the time taken to hand over patients and re-stock ambulances may impact the out-flow rates in particular and should be given some attention.

CONCLUSIONS

This paper has discussed the methodology being used to develop a simulation model of the whole healthcare system. The aim of the research is to reduce the urgent unscheduled care that takes place in A&E but it is acknowledged that the complexity of the care system means that it will be essential to understand the implications on the whole system of changes made to components associated with urgent care. Simulation will allow these interrelationships to be explored in a safe environment before costly decisions are made on the ground, but the contribution of the key healthcare commissioners and planners will be essential to validate understanding of the current system before alternative healthcare scenarios can be investigated both with and without the aid of the simulation models. As the research team now has a good understanding of the current A&E part of the system, a first version of the high level simulation model has been produced. It is accepted that running the simulation model with care decision-makers may identify differences between their understanding of how the system works and how it works in reality, and this validation of the simulation will not only help the research team to gain consensus with the care commissioners on the system scope and functioning, but it will provide a starting point for discussions about future care configurations and the development of alternative scenarios which is the next stage of the research.

The authors would like to acknowledge the Engineering and Physical Sciences Research Council (EPSRC) that is funding this research.

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