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Evaluating the impact of a simulation study in emergency stroke care

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HIGHLIGHTS

- We study the impact of changes to a stroke pathway following a simulation study.
- We evaluate quantitative system performance and critique the modelling process.
- Patient treatment rates increased fourfold while arrival to treatment times halved.
- User involvement in conceptual modelling was affected by selection bias.
- VIS proved more useful for initial engagement and project buy-in.

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ABSTRACT

Very few discrete-event simulation studies follow up on recommendations with evaluation of whether modelled benefits have been realised and the extent to which modelling contributed to any change. This paper evaluates changes made to the emergency stroke care pathway at a UK hospital informed by a simulation modelling study. The aims of the study were to increase the proportion of people with strokes that undergo a time-sensitive treatment to breakdown a blood clot within the brain and decrease the time to treatment. Evaluation involved analysis of stroke treatment pre- and post-implementation, as well as a comparison of how the research team believed the intervention would aid implementation compared to what actually happened. Two years after the care pathway was changed, treatment rates had increased in line with expectations and the hospital was treating four times as many patients than before the intervention in half the time. There is evidence that the modelling process aided implementation, but not always in line with expectations of the research team. Despite user involvement throughout the study it proved difficult to involve a representative group of clinical stakeholders in conceptual modelling and this affected model credibility. The research team also found batch experimentation more useful than visual interactive simulation to structure debate and decision making. In particular, simple charts of results focused debates on the clinical effectiveness of drugs — an emergent barrier to change. Visual interactive simulation proved more useful for engaging different hospitals and initiating new projects.

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1. Introduction

This paper describes the implementation and evaluation of changes to an emergency stroke care pathway in a large acute hospital within the United Kingdom. These changes followed a discrete-event simulation (DES) study that was undertaken to both identify improvement opportunities and support the implementation of improvement between the clinical stakeholders in the pathway. The aim of the intervention was to increase the proportion of patients with acute ischaemic stroke that receive a time sensitive treatment to break down a blood clot within an artery in the brain (thrombolysis with the drug alteplase). The full technical details of the simulation model are published elsewhere [1]. The purpose of this paper is to evaluate the impact of the study in improving the real-world system. We define impact in three ways: did the results of the model influence decision making in the context of the problem; did the changes implemented improve real world performance as defined in the project; and did the modelling intervention/process influence the chances of implementation as the research team expected. The evaluation of impact was conducted using a two-stage methodology: an analysis of data pre and post implementation and a comparison of how the

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research team believed the intervention would aid implementation compared to what actually happened.

The DES literature contains many case studies of computer models that compare alternative policies to identify costs and efficiency savings within industry [2] and healthcare [3]. While these case studies are numerous the evidence that such modelling leads to the implementation of simulation results is lacking. Although not exclusively limited to a particular domain, this lack of implementation evidence has been particularly well documented in systematic reviews within healthcare DES modelling [3–7]. Notably, over the period of 12 years spanning the publication of these reviews only a small number of studies describing the implementation of simulation results in healthcare have been published (e.g. [8,9]).

Evaluations of implementation processes are increasingly conducted in other areas of health services research such as health technology assessment [10] and health program evaluation [11], but are rare in Operational Research (OR). A plausible reason for the apparent lack of implementation accounts and follow up evaluation is the tension between the time needed to implement change within an organisation and the timescale for publication of model results; although it is arguable that such a tension is not unique to DES and OR. One reason that may be specific to OR is the tension between what is seen as legitimate research and what is consultancy [12]. Academics in OR gain little reward for publishing relatively standard models using text book methodology, although implementing results of such models may be of great help to organisations. On the other hand, evaluation research is valuable to the academic community, particularly in the context of increasing recognition of the need to value the positive impact of research in society. Not only does evaluation demonstrate effectiveness or issues with use of methods, but it at its core challenges researchers to revisit and test their assumptions about how they expect a modelling intervention to work [13]. A larger evidence base in the area of evaluation should lead to improved methodology for conducting modelling interventions using methods such as DES.

The contributions of this study are therefore threefold: evidence that the results of healthcare DES modelling interventions are implemented in practice; quantitative evidence that changes recommended by DES can lead to real system improvement and improved stroke patient outcomes; and revised propositions about how simulation modelling interventions aid the changes of implementation.

The paper begins with the background to the simulation study including an overview of the model, expected performance, the changes implemented, and how the research team believed the intervention would work. We then present the results of a quantitative evaluation confirming that the hospital has seen substantial improvement following the study. This is followed by a qualitative comparison of how the research team believed the intervention would support implementation compared to what actually happened. The final section draws together the qualitative and quantitative aspects of the evaluation and assesses the accuracy of how the research team believed the intervention would work. Final comments discuss the need for systematic research into the implementation of results from similar projects.

2. Background to the simulation study

2.1. Thrombolysis for acute ischaemic stroke

Ischaemic events account for over 80% of all cases of stroke [14]. The only licensed treatment for acute ischaemic stroke is thrombolysis with alteplase, a treatment intended to restore blood flow within an artery occluded by thrombus (blood clot). Due to the high metabolic demands of brain tissue, the effectiveness of thrombolysis is critically time dependent [15,16]. The earlier a patient receives treatment the greater the chances of recovery with minimal or no disability, such that the effectiveness of the treatment halves with each 90 min period that passes from onset [17]. As with all drug treatments there are also risks. In this case treatment increases the risk of symptomatic intracranial haemorrhage (SIH: bleeding within the brain), that often leads to death. However, when treatment is given within 6 h of onset, the accumulated evidence shows that the benefit of stroke thrombolysis in reducing disability outweighs the risk of intracranial haemorrhage [16,18].

In Europe, alteplase was originally licensed in 2003 for use within a three hour period from the onset of ischaemic stroke. In that time the patient needs to travel to hospital and be assessed and treated in an emergency department (ED), including brain imaging. Uptake of the treatment has been slow, often because of difficulties with completing the diagnostic process within the short time window, with between 3.5% and 5% of patients receiving the treatment [19]. Efforts to increase this proportion have focused on two areas: randomised controlled trials (RCTs) assessing the efficacy of extending alteplase treatment from three to four and a half hours (or beyond); and public education campaigns to increase awareness of stroke symptoms (e.g. the act FAST campaign in the UK) in order to encourage earlier presentation to hospital with suspected stroke. The benefit of thrombolysis is measured in terms of the increase in the proportion of patients with minimal or no disability at follow-up (usually 90 days), attributed a modified Rankin Scale (mRS) score of 0 or 1. The mRS is an ordinal scale of disability scoring between 0 (no symptoms or disabilities) and 6 (death; [20,21]).

2.2. The modelling intervention

Similar to many other hospitals in the UK and elsewhere our hospital treated 4%–5% of all acute strokes annually with alteplase, with the majority of treatment delivered close to the three-hour treatment deadline. The project reported here was initiated in late 2010 as a collaboration between hospital clinicians and medical school academics to investigate the most effective operational changes that could be made to increase thrombolysis rates and reduce stroke-related disability. We chose to use DES to model the stroke pathway as we believed it represented a compromise between the expert and facilitative modes of engagement with stakeholders [22] that others have described as pseudo-facilitative [23]. We chose this approach based on three core beliefs. First, we believed that in order to achieve any agreement on change within the hospital we needed to operate in the facilitative mode of engagement during conceptual modelling [24]; aiding the relevance, transparency and credibility of results to the stakeholders' problem. Second, DES provides the opportunity to use visual interactive simulation (VIS). We believed that VIS would increase the engagement of stakeholders, enabling validation and experimentation, thereby improving the transparency of the model, both of which are prerequisites for effective implementation [25]. Third, we believed that modelling in general would provide a common reference point and structure debate between stakeholders with competing interests. These three hypotheses represent how the research team expected the modelling intervention to support the implementation of the results of the DES study. The final section of this paper reflects on these hypotheses and evaluates if these assumptions were indeed the key factors that aided implementation.

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