

SIMULATION IN HEALTHCARE



Prifysgol Cymru
Y Drindod Dewi Sant
University of Wales
Trinity Saint David

Adam Moore, BSc Computing (Data and Information Systems)

(1) Abstract

The NHS must find innovative solutions to mounting problems [1][2][3]. As pressure builds, the quality and availability of healthcare becomes compromised, putting lives at risk [4][5]. This project explores Discrete Event Simulation (DES) as a potential solution to this issue.

(2) Introduction

The NHS in Wales is increasingly failing to meet performance targets in areas including emergency department waiting times, referrals for treatment, and many more [2][3][6]. This is in part due to a workforce crisis, high demand for NHS care, and the aftermath of the Covid-19 pandemic [3]. Transformative plans have been laid out by Welsh Government and Health Boards, but in order to achieve these goals, innovative solutions to existing problems are required. One such solution could be the use of Discrete Event Simulation to re-design and optimise departments and services within the NHS. This could be achieved through more efficient patient pathways, and optimised resource planning.

(3) Aims

To provide problem-owners and department managers across Hywel Dda University Health Board with access to a web-application based discrete event simulation model that can be used, with ease, to run a multitude of scenarios through alteration of parameters and easily analyse the results of any changes made to the system. The ability to perform 'what-if' scenario analysis is crucial to allow managers to assess and quantify the impact of any change to a system in a risk-free way. This in turn will promote the use of simulation in healthcare and encourage problem-owners to build and utilise discrete event simulation to optimise operations, resulting in better performance and higher quality care for patients.

(4) Objectives

- 1) Build a discrete event simulation model with adjustable demand and a split-shift roster that can easily be interpreted by inexperienced problem owners.
- 2) Create and publish as a web-application with a simple and functional user interface to maximise accessibility.
- 3) Build a suite of visualisations that enable interpretation of the impact any changes have had on the system.

(5) Methodology

The programming language, R, will be used to build a bespoke discrete event simulation model with several features including custom interarrival periods, dynamic roster building, and parameterization that can be scaled. Reproducibility is a key element and will be achieved using seeds. The 'Simmer' R package will be used to provide a framework to build the DES model. The justification for completing this work in R, despite the majority of published DES works using specialist software [7], is to leverage existing infrastructure and skills within Hywel Dda and the wider NHS Wales community.

'Shiny', an R package that provides a framework for web-application development using reactive programming will also be used. This will enable users to engage with the final published application in a web-browser. Visualisations will be produced to enable interpretation of simulation results.

(6) Evaluation

Since publishing the complete web application, it has been used 88 times by internal employees. These individuals have spent over 32 hours collectively utilising the application. The web-application is easily accessible in a web-browser via a URL, there are no deployment burdens or constraints internal to Hywel Dda. The completion of the project has enabled the Data Science team at Hywel Dda to offer DES as an analytical solution to stakeholders. The web-application has been well received and multiple work requests specifying a desire to explore simulation as a solution have been received.

(8) Conclusion and Recommendations

The next stage within HDUHB is to utilise DES in a project in which the aim is to implement findings and transform a department or service. Achieving this will save the Health Board anywhere from tens of thousands of pounds a year, to millions of pounds a year. Resources would also be better utilised, enabling better system performance. Implementation of findings is the most difficult thing to achieve with respect to DES, and so this project has determined that the first and primary consideration given when considering utilising DES within the Health Board is the feasibility of implementation. Frameworks set out by Harper and Pitt (2004) [8] and Bolt *et al* (2010) [9] will be used to guide management of DES projects.

(9) References

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(7) Baseline versus test scenario, test scenario has +10% demand

