

# Improving Access to Emergency Departments

An Application of System Dynamics Modelling in Healthcare

S. McAvoy<sup>1</sup> and A. Staib<sup>2</sup>

MRI-UQ and Mater Health. [s.mcavoy@business.uq.edu.au](mailto:s.mcavoy@business.uq.edu.au)

Princess Alexandra Hospital [Andrew.Staib@health.qld.gov.au](mailto:Andrew.Staib@health.qld.gov.au)

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## ABSTRACT

The aim of this study is to demonstrate that a system dynamics patient flow model can show which levers effectively reduce delays and backlogs in the Emergency Department (ED). The System Dynamics (SD) Modelling process was used to construct an SD patient flow model, where the scope was the ambulatory and ambulance arrivals, the Emergency Department acute and fast track processes, pathology and radiology services, the ED Short Stay Unit (SSU)

## 1 INTRODUCTION

McAvoy et al. (2019) have identified a solid value proposition for the uptake of system dynamics models in healthcare to inform robust policy and strategy platforms. System Dynamics has been employed to explore access to emergency care, however, the uptake has been slow and there is much room for further investigation and validation (Mohiuddin et al., 2017; Paul et al., 2010; Salmon et al., 2018). Mapping interdependencies at the systems level and viewing access decisions as system behaviour brings several potential benefits: (1) those involved in the emergency care supply chain better understand it (2) the model provides a comprehensive view of the drivers of patient experience, efficiency and cost, and (3) a systems engineering tool for testing interventions (Reid et al., 2005)

### 1.1 Importance

ED admissions are growing by an average of 2.6% per year (Australian Institute of Health and Welfare, 2016-17). The National Emergency Access Target (NEAT), measured by the ED, is a reportable KPI measuring the ED's ability to treat and release patients within four hours. Operational interventions to manage growth in arrivals so that efficiency is optimised and NEAT targets are met can have financial and social implications beyond the ED. McAvoy et al. (2019) advocate for a systems lens to ensure decisions in one part of the emergency care

and the Medical Assessment Planning Inpatient Unit (MAPU). Five separate historical weeks were tested. The model can accurately replicate where and when patient backlogs and delays occur. Using "what if" scenario analysis, the model was able to show the impact of changes in the ED's modifiable factors (beds, doctors) on bed vacancy and ambulance ramping (patient on stretcher).

supply chain do not have unintended consequences in other areas. This study developed a strategic simulation tool that provides a virtual reality in which to test proposed interventions.

## 2 MATERIALS AND METHODS

### 2.1 System Description

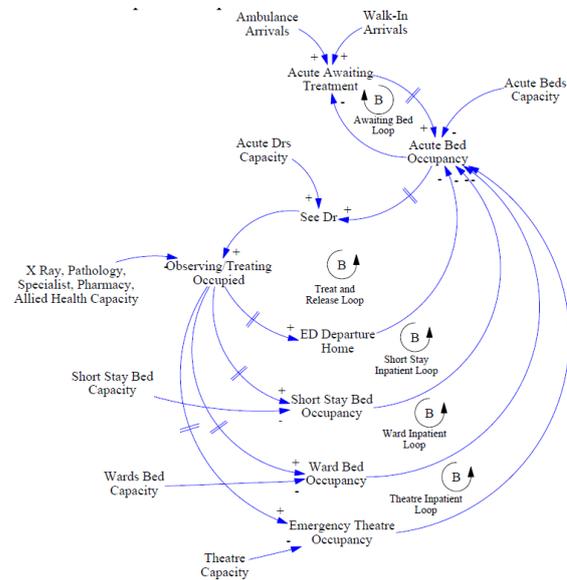


Figure 1 Causal Loop Diagram of the ED

In Figure 1, McAvoy et al. (2019) present a causal loop diagram informed by a problem conceptualisation workshop. The ED under the lens

is dual stream with higher acuity patients processed on an acute pathway and lower acuity patients taking a FastTrack pathway characteristically operating more like a primary care facility than a hospital ward. Figure 1 highlights the dominance of balancing loops in the ED, necessary to ensure constrained acute beds clear and patients can flow. Each loop is characterised by a capacity constraint (e.g. acute beds) that acts to create delays, which lead to backlogs of patients in waiting rooms or ramping. In Figure 2, McAvoy et al. (2019) present a modular depiction of the dynamic hypothesis (boundary) where each block represents a sub-set of the stock and flow model developed. The thick arrows represent patient flow. The thin arrows highlight some key interdependencies influencing the state of the stocks.

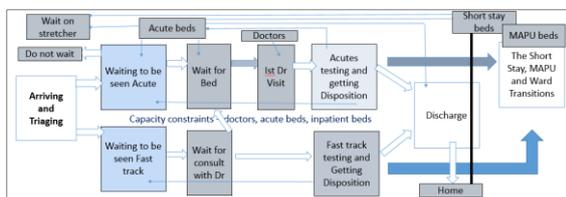


Figure 2 Architecture of Stock and Flow Model

Patient arrivals are treated as being exogenous. The model flows patients through a series of stocks where patients could experience delays. Some flows between stocks involve a change in location for the patient. Patients progress through the ED according to resource constraints to inpatient admission or discharge. Patients in the system at midnight are included because it is possible for more than fifty percent of available acute beds to be full at midnight. Historical data informed the distribution of patients through imaging and/or pathology. In Figure 2, this is referred to as testing. Over fifty percent of patients progress to an inpatient bed, so inpatient bed availability is a feedback to acute bed availability. Those not waiting are removed at triage.

## 2.2 Study Design

The design involved two-steps. Firstly, the conceptualisation workshops and behaviour over time process data collected for five historical weeks informed the mapping of the architecture of the ED qualitatively, complete with pathways and key input variables and metrics. Data was collated for the first week in February for 2017 though to 2019, the first week in October 2017 and the first week of June 2019. Secondly, a quantitative stock and flow model was developed and parameterised. The model runs for 7 days. The target length of stay in the ED is four hours; however, a patient who becomes an inpatient

in a short stay bed may have a length of stay (including short stay) of up to two days. The choice of seven days ensures the patient’s entire journey is captured and that several iterations of full journeys are captured. The chosen time step, 15 minutes, reflects the estimated duration of a first doctor consult.

## 3 RESULTS

The model replicated historical bed use patterns for acute beds as in Figure 3, from McAvoy et al. (2019):

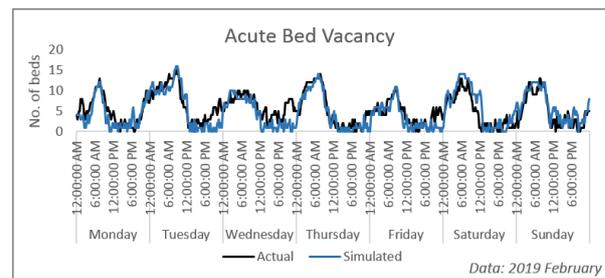


Figure 3 Simulated versus actual acute bed usage.

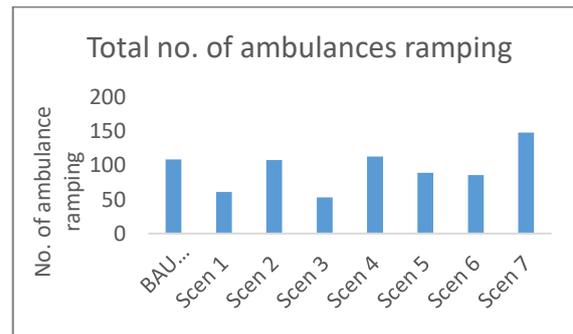


Figure 4 Comparison of Scenarios for Ramping

A number of scenarios were tested based on changing the ED’s modifiable factors to see what flow in historical weeks might have looked like. The scenarios tested were measured in terms of two impacts: the impact on acute beds and the impact on ramping (remain on stretcher). The scenario outputs were compared to business as usual for the historical June 2019 data set. Figure 4, from McAvoy et al. (2019) suggests scenario 3, which adds additional acute beds, short stay beds and doctors, best minimises ramping.

## 4 CONCLUSIONS

Viewing ED interventions and access decisions as systems behaviours made transparent the relationship between resources and patient flow whilst providing insights into system limits, wider access blocks and the efficacy of proposed interventions. The outputs

clearly show the impact of resource interdependencies on ED flow.

## 5 ACKNOWLEDGEMENTS

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