# IPACS STRESS-DES

*Strengthening the Reporting of Empirical Simulation Studies*
A standardised checklist to improve the reporting of discrete-event simulation models.
https://doi.org/10.1080/17477778.2018.1442155 (Monks et al. 2019)

## 1. Objectives

### 1.1 Purpose of the model

The IPACS discrete-time simulation model provides a tool for ICB commissioners to support community (D2A) demand and capacity planning by evaluating the impact of alternative parameter configurations (time-dependent arrivals, capacity, lengths-of-stay) on queues and other efficiency metrics in a set of D2A pathways.

### 1.2 Model outputs

The model is primarily used for time-dependent output and displays (for each pathway modelled): mean outputs for a set of scenario combinations, and mean and quantile data for:

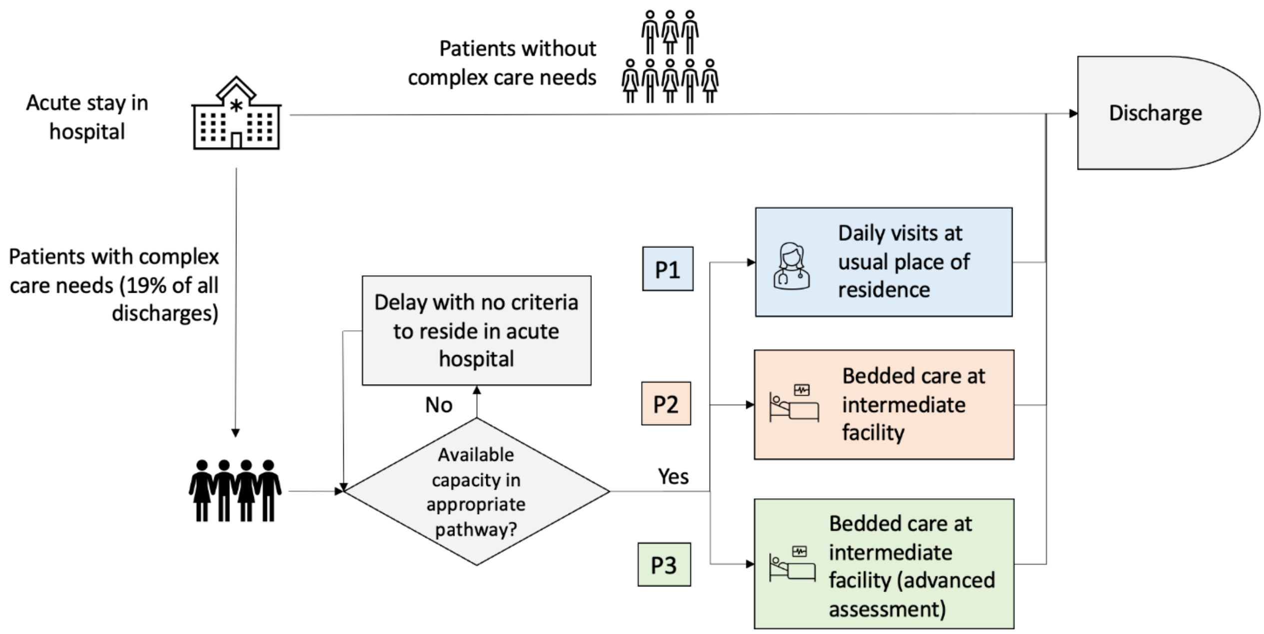
- The number of patients delayed (in hospital)
- The wait time of delayed patients
- The number of patients in service
- The system cost of the scenario configuration

### 1.3 Experimental aims:

The experiments compare results between user-defined scenarios by varying parameters for: arrivals, length-of-stay, and capacity. Up to 12 scenarios will be displayed, with all combination of parameters.

## 2. Model Logic

### 2.1 Base model overview diagram




### 2.2 Base model logic

Patients arrive into each D2A service as daily batched arrivals following a Poisson process. In the visits-based model (P1 type pathways), patients are generated a linear visit sequence, sampled from an initial visit requirement (IVR) and a final visit requirement (FVR). Where the visit sequence cannot be accommodated by remaining visit capacity, the patient is delayed until the following day, and so on, until the service has adequate capacity to accommodate the visit sequence across the sampled length of stay. In the bed-based model (P2/3 type pathways), patients are allocated a length of stay, and are delayed if there is no capacity.

**2.3 Scenario logic**
A baseline time-dependent arrivals vector defines the model run-time. The model initialises using the current number of patients in occupancy and in the queue (delayed discharge). The baseline lengths-of-stay and capacity are set. These parameters can be varied as user-defined scenarios. The final number of scenarios is the product of each of the parameter variations, including the baseline.
e.g. 2 arrivals scenarios, 3 capacity scenarios, 2 length-of-stay scenarios = 2x3x2 = 12 total scenarios.

2.4 Components

- There is a single patient entity for each pathway defined in the model.
- Arrivals may be probabilistic based on acute discharges into multiple pathways, or based on referral data into a single pathway.
- A single service node for each pathway, then discharge
- Resources are represented as number of visits, or number of beds.
- Queues are held prior to service, representing delayed discharge. The queue discipline is FIFO except in the visits-based (P1) model: in the instance where there are no available resources to start a service at time *t*, an arriving patient is scheduled to start at *t+1* so as not to hold back patients next in the queue who can be accommodated.
- The model has a single entry and exit point for each pathway.

**3.0 Data**
In BNSSG, data is sourced from North Somerset Local Authority social care services.
Pre-processing was used to obtain model parameter; these were validated by ICB care staff.
Input parameters:
Time dependent arrivals: mean per day of week 2022 data
LoS distributions are all lognormal. The model allows a normal distribution calculation also.
IVR/FVR distributions as described in 1.2.
Assumptions:
Queues are attributable to lack capacity
Capacity and length-of-stay parameters are static over run-time

**4.0 Experimentation**
**4.1 Initialisation**
The model is non-terminating.
The initial transient period can use a warm-up period or an initialisation method to approximate the current state at run-time. The default is to initialise the model using current system data.

**4.2 Run length**
The model uses a time-slicing approach in days
Run-time is determined by the time-dependent arrivals inputs
Multiple independent replications are undertaken to control confidence intervals. For model comparisons, 50 replications were undertaken (as default) using common random numbers between scenarios.

**5.0 Implementation**
**5.1 Software or programming language**
The simulation was developed using R 4.2.2.
The foreach package is used for parallel computing.

**5.2 Random sampling**
set.seed() is available in base R.

**5.3 Model execution**

The model implements a time-slicing approach. Unlike DES, which steps through discrete events in variable time periods, time-driven simulation considers a variable number of events within a fixed period of time.

**5.4 System specification**

The model was run on Intel i7-12700H CPU with 32GB RAM running Pop!_OS 22.04 Linux.
It has been tested on Windows and Macintosh computers

**6.0 Code access**

Simulation model code is available from the main branch of Githib repo:

https://github.com/nhs-bnssg-analytics/ipacs-model

Code is archived via Zenodo: