HEALTH

FOCUSED_ON LIMITED

Why Spreadsheets struggle to model Patient Flow

There have been some quite proper questions raised concerning why it is necessary to use simulation techniques (as in a Percept FlowModel) rather than using simpler techniques like spreadsheet analysis.

This note aims to address these questions.

Firstly we should bear in mind the main principles. A spreadsheet is no more or less than a set of inter-related numbers and formulae. As such it is very useful for looking at the structure of a system *"At a given point in time"*. A discrete event simulation model considers time and advances it from one event to the next, adjusting the system state as time progresses.

Patient Flow is the mantra for all modern techniques of analysing and improving Health Care delivery. By definition "Flow" involves movement over time and simulation is the most natural way of modelling flow. Does a still camera or a video camera give a better idea of a flowing stream? Of course, very rapid stills can be used to approximate to a video, but to follow the analogy would take spreadsheet planning to an absurd level of detail.

An example of some of the pitfalls of spreadsheet analysis are below.

Suppose we have an Intensive Care Unit (ICU) receiving around 800 patients per year. These Patients will generally come from three sources: Transfers-in from another ICU (10%), post-Elective Surgery (60%) or Emergency Admissions (30%). Each of the different cohorts has different Length of Stay (LoS) parameters and whereas the Transfers and Electives can be handled with two Patients per Nurse, the Emergencies need 1 to 1 Nursing.

The spreadsheet is below:

Time Parameters										
Hours / Day	24	Days / Year	365	Hours / Year	8760					
Patient Arrivals										
Mean Inter Arrival Time (Hrs)	11	Giving	796	Cases per annum						
Demand by Patient Type			**Length of Stay (Hrs)**				**Resources**			
Cohort	% of Total	Number of Cases	Min	Max	Likely	Mean	Bed Occupancy	Bed Demand (Hrs)	Nurses / Patient	Nurse Demand (Hrs)
Transfers	10%	80	48	168	96	104	90%	9,202	0.5	4,601
Elective	60%	478	16	48	24	29	90%	15,573	0.5	7,787
Emergency	30%	239	48	168	96	104	90%	27,607	1	27,607
							Total	**52,383**	Total	**39,995**
			Resources Needed				**Beds**	**6.0**	**Nurses/Shift**	**4.6**

This spreadsheet calculation works out the demand for Resources as: 6 Beds plus 4.6 Nurses per shift.

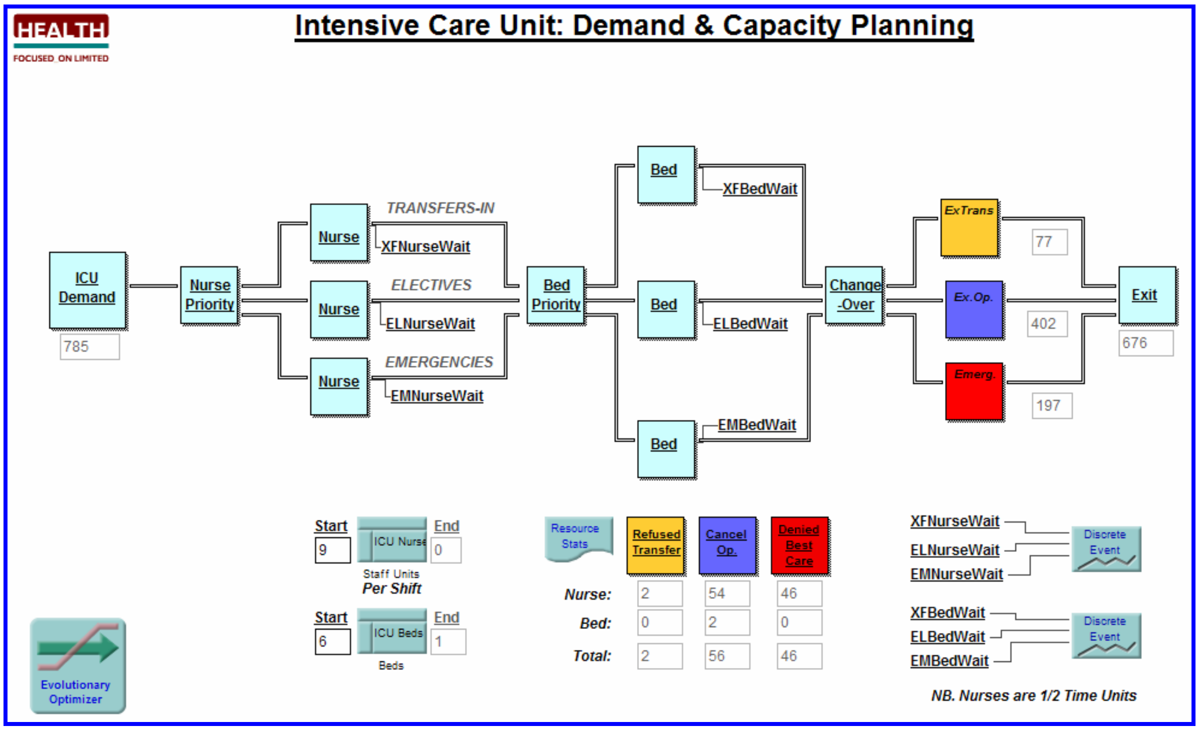
However, there are some significant flaws with this approach:

- We've fixed the "Average" Bed Occupancy at 90%, but what happens when Bed Occupancy reaches 100%? - We'll be forced to Cancel Elective Operations and Refuse Emergency Admissions.
- What happens when most of our Nurses are with one-to-one Emergencies? – Same bad consequences.

The cancelled Electives adversely affect the Trust in Patient satisfaction, PbR revenue, and Surgeon motivation. The Declined Admissions can have very much more severe Patient effects.

If, instead of using "Averages" we look at the operation of ICU over, say a year, we can see the times within the year when we might have a sudden rush of demand and hence experience Shortages of Beds or Nurses.

We can also define Maximum Wait times for Admission to the Unit and we can account for the Cancelled Operations and Refused Admissions. In the model below we might assume that if we have no available beds, then we can't admit anyway, but we can allow waiting time for Nurses to be 12, 6 or 4 hours for Transfers, Electives or Emergencies.



The above FlowModel was run with the spreadsheet numbers of 4.5 Nurses per shift and with 6 Beds.

It shows that we could expect a Shortage of Nurses to cause 54 Cancelled Operations, 46 Declined Emergency Admissions, and 2 Refused Transfers. If we increase the number of Nurses to 7 but leave Beds at 6, then we'll be faced with about 100 breaches due to Bed Shortages!

If we ascribe costs to these "breaches" and costs for additional Nurses and Beds, we can run the Evolutionary Optimiser. This was done with this model and the model left to run overnight. After 7000 iterations the model reported the optimum balance to be 7 Nurses with 9 Beds. In this case, the cancelled operations will vary from 5 to 12 (annually) and the Declined Admissions vary from 5-10 (annually) – well within limits that might be mitigated with some minor effort at the time.

The above is a trivially simple model. It might take a skilled Analyst perhaps two days to create it and validate it. If a Spreadsheet were to be used to its limits with Sensitivity analysis and Goal Searches, it might take the same time and yet it is logically impossible that a snapshot spreadsheet can pick up the contention problems of intermittent Nursing or Bed shortages. *The spreadsheet calculations rely on averages.*

If the simulation model were to be extended, probably the next factor to be brought in would be an uncertainty on Discharge from the Unit, depending upon whether the Surgical or Medical Wards had an available Bed. You might like to imagine creating a realistic spreadsheet for that.

There is some activity in the Academic area to use spreadsheets to teach understanding of simulation. While this is very fine, if Excel is to be used, then either there must be no significant interactions between the system components or the spreadsheet designers have to be skilled VBA programmers, because they will be trying to use an inappropriate tool for the job. Even with the most complicated Macros, spreadsheets will never get beyond “multiple still photos”.

In summary, the strengths and weaknesses of the Spreadsheet/Simulation techniques are:

Task/Feature	**Spreadsheet**	**Simulation**
Capacity Analysis	OK for single shot. Ignores interim Queue Lengths and Waits	Strong
Flow Analysis	No perception of time. Therefore not good	Very Strong
Handling Randomness (the key feature of Patient Arrivals / NHS Procedures & Treatments)	Multiple Runs - Difficult recording of results. Complicated design of experiments.	Very Strong
Interacting Events / Resources	Very Difficult	Very Strong