Allocation of Beds within the NHS

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In an earlier article we looked at the implications of the Erlang equation in describing the relationship between percentage occupancy of a bed pool and the associated turn-away rate (1). Turn-away was defined as the unavailability of a suitable bed in the correct specialty at the point of need. Turn-away results in the formation of a queue for entry with members in the queue accumulating at home, in inappropriate beds of another specialty, by diversion to another hospital, as a trolley wait or by cancellation of elective surgery and hence an increase in the size of the waiting list. The implications to the resulting workload placed on the surrounding primary care support structures were discussed.

The Erlang equation can also be applied to understanding the allocation of beds between regions and the bed requirements of the individual specialties within an acute hospital.

Turning first to the allocation of beds between regions it would be illustrative to look at the average turn-away experienced within various regions and hence the likelihood that those regions will attain targeted reductions in the waiting list. To do this we use the observation that most acute hospitals appear to operate as if they were sub-divided into a series of bed pools of approximately 100 beds. Using this assumption we can then adjust the reported occupancy for all the hospitals in a given region into a turn-away rate and then calculate the weighted average occupancy for the region.

The results of such a calculation using data for the 99/00 year are given in Table One. It should be fairly obvious that both the Trent and Northern Regions should achieve any waiting list targets with ease. Not only do they have the largest average bed pool size per hospital but they also have lowest average occupancy levels. They therefore have a considerable inherent advantage over other regions in meeting waiting list and other targets such as cancelled operations and trolley waits.

Table One: Average occupancy and turn-away for the acute hospitals within various UK Regions in 1999/00.

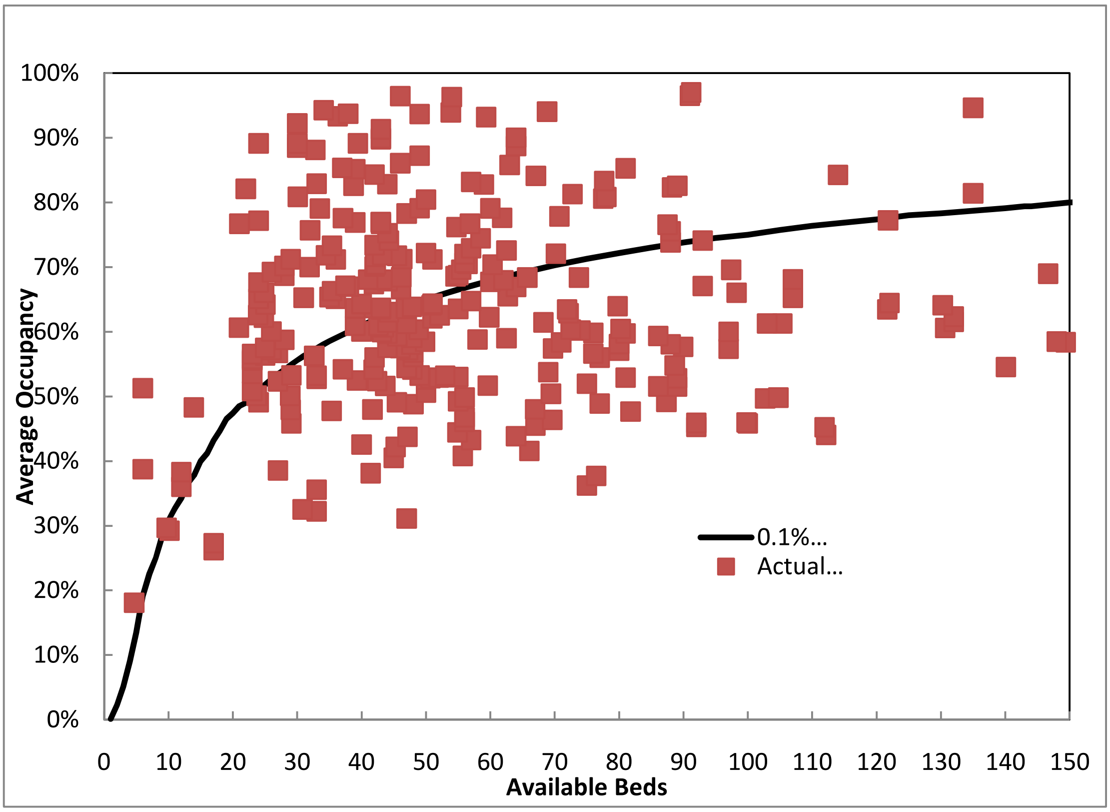
Region	Average Number of Acute Beds per hospital	Average weighted Occupancy	Average weighted Turn-away
Trent	425	80%	0.8%
Northern	440	80%	1.4%
South & West	390	82%	2.0%
North Thames	330	85%	4.4%
Anglia & Oxford	260	87%	4.7%
West Midlands	350	87%	4.9%
North Western	380	85%	5.3%
South Thames	370	88%	6.5%

Not stated previously was the fact that average percentage occupancy in NHS bed statistics is effectively a midnight occupancy. The daytime occupancy in particular specialties can be up to 4% higher than the midnight position, i.e. if the midnight occupancy is 82% then the daytime occupancy will be as high as 86%. In order to calculate the true operational turn-away experienced by a hospital the average occupancy for use in the Erlang equation is therefore at least1% to 2% higher than NHS statistics would tend to suggest, i.e. the effective turn-away is worse than the position calculated using NHS occupancy statistics.

Before progressing further we first need to prove to the sceptics that a mathematical equation can in fact be used in the real world of an acute hospital. To do this we need to look at the results from a closed bed pool. While the statistics reported within the NHS are not generally suited to this analysis there are several exceptions that can be used to demonstrate the point. These exceptions are Maternity, Paediatric and the Intensive Care bed pools. All are closed bed pools in that Maternity and Paediatric beds are not available to other specialties and ICU beds are likewise not available to general admission.

Data for maternity from the year 2008/09 are given in Figure One. This figure very clearly demonstrates what most NHS staff would know to be the reality of every day life, namely, some hospitals operating well within the required bed allocation while others are struggling with far too few beds.

Fig. 1: Maternity beds and average occupancy for English hospitals in 2008/09



Footnote: A level of turn-away around 0.1% is recommended for a well resourced maternity unit.

The levels of turn-away can be checked by actual measurement. For example, an ICU could count the number of times a patient was refused admission and could then calculate the turn-away rate. In actual fact the Erlang equation has been validated against just such a scenario and shown to give excellent agreement with the real world (2).

Having demonstrated the applicability of this approach to data from acute hospitals we can now use the Erlang equation to calculate appropriate occupancy for the bed pool associated with different specialties. The result of these calculations can then be compared with the recent NHS directive to achieve less than 82% average occupancy before 2004 (3).

The results of one such exercise, which includes all overnight admissions (emergency and elective), are given in Table Two and are typical of a large acute hospital with around 39,000 annual overnight inpatient admissions.

Table One clearly shows the delicate relationship between beds, occupancy and turn-away. For the larger specialties much higher average occupancy can be sustained at manageable levels of turn-away. For example, 1% turn-away occurs at 90% and 43% average occupancy in the Medical and Ophthalmology bed pools respectively.

Table Two: Calculated bed pool size and associated occupancy and turn-away for groups of specialties within an acute hospital.

Specialty Group	**Arrival Rate (FCE per day)**	**Average Length of Stay (days)**	**Beds**		**Average Occupancy**	
(Turn-away rate)➔			**1%**	**0.1%**	**1%**	**0.1%**
General Surgery	16.7	3.5	72	80	80%	73%
Urology	5.6	3.7	30	35	68%	59%
Ophthalmology	2.2	1.4	8	10	38%	31%
ENT/Oral/Paediatric	22.0	2.2	61	68	78%	71%
Gynaecology	5.9	2.7	25	29	63%	55%
Trauma & Orthopaedic	14.6	5.5	96	105	83%	76%
Haematology/Oncology	5.0	6.3	42	48	74%	66%
Medical/Elderly Group	37.3	8.1	337	356	90%	86%
Total	**107**	**5.1**	**671**	**731**	**84%**	**78%**

Also obvious from Table Two is the fact that for the particular mix of specialties in the example the average occupancy at 1% turn-away is 84%. This is probably unacceptable for a large acute trust given the current emphasis on reducing waiting lists. Hence a move toward 0.1% turn-away would probably be recommended giving an overall occupancy of around 78%. Given the fact that our example hospital is probably operating at close to 90% average occupancy the beds required to support such a low level of occupancy are probably well beyond their ability to acquire. How could a hospital in such a position hope to achieve large reductions in the inpatient waiting lists?

Unfortunately the only answer to this dilemma is to operate at higher levels of turn-away and hence high levels of cancelled operations. To explore the implications of this statement we need to be aware of the relationship between throughput and occupancy, namely:

$$\% \text{ Occupancy} = \frac{\text{Throughput (FCE per day) x Average LOS (days) x 100}}{\text{Beds}} \quad \text{or}$$

$$\text{Throughput per day} = \frac{\% \text{ Occupancy x Beds}}{\text{Average LOS x 100}} \quad \text{or}$$

$$\text{Throughput per bed per day} = \frac{\% \text{ Occupancy}}{\text{LOS x 100}}$$

Hence it should be fairly obvious that for a constant number of beds the only way to increase throughput (and hence reduce waiting lists) is to increase the occupancy and/or to reduce the average LOS. For an efficient hospital with a high day case rate the opportunity to reduce the average LOS is limited.

Highest possible throughput is therefore attained at 100% occupancy. To achieve this specialty would schedule say 15 patients for admission, i.e. maximum possible theatre capacity, and then cancel as many as needed to achieve 100% occupancy and hence maximise throughput. In doing so they would find it almost impossible to achieve guarantees relating to the readmission of cancelled operations.

The only possible solution to this almost insurmountable dilemma is to reallocate beds between specialties. Under this strategy a hospital would deliberately allocate more beds to the specialty with the most pressing waiting list targets (usually Orthopaedics) hence reducing % occupancy to the point where there is no turn-away (i.e. achieve guarantees relating to cancellation). Overall throughput is increased via the increased number of beds even though throughput per bed is reduced. Those specialties with fewer patients on their waiting list would then have to cope with a reduction in number of beds and maintain current throughput by operating at slightly higher occupancy.

For example, in Table One the nine extra beds required by T&O to go from 1% to 0.1% turn-away would be removed from other bed pools taking them to slightly higher than 1% turn-away.

Conclusions:

- The usefulness of the Erlang equation to predicting turn-away in acute hospitals is demonstrated for the Maternity, Paediatric and Intensive Care bed pools.
- Maximising throughput is incompatible with minimising turn-away
- A specialty can only achieve challenging inpatient waiting list targets by increasing the available bed pool

References:

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