Targets Guaranteed?

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Key Points:

- Variation in demand implies that individual NHS Trusts will have great difficulty in delivering an absolute guarantee of meeting waiting list targets
- Variation implies that there is no direct linkage between extra activity and reductions in the waiting list
- Assumed constant conversion rates between outpatients to inpatients are highly misleading
- The relatively high variation in demand also means that longer-term contracts with both PCT's, IS TC's and the private sector will be exceedingly difficult to specify

The NHS in England has a guaranteed wait of 18 weeks from GP referral to inpatient treatment. This paper (slightly revised in Jan-09) highlights some of the hidden operational issues behind a guaranteed waiting time.

One fundamental assumption that seems to be unquestioned is the link between additional activity and the reduction in the waiting list. This is important since most planning appears to rely on such an assumed linkage as does the programming embedded within most waiting list models. This assumption is however seriously flawed and all concerned need to understand why this is so.

The size of the waiting list is the end result of additions to the waiting list less the removals and admissions from the waiting list. While the admissions from the waiting list are assumed to be under the control of the hospital (another key assumption whose validity can also be questioned) both the additions and removals are subject to randomness. If this randomness proves to be high then the assumed simple relationship breaks down. For instance, we need to reduce the number waiting by 100 and hence we plan to do 100 extra operations, however, randomness results in 100 more additions than average and hence in actual fact we end up having to do 200 extra operations to achieve our target reduction of 100.

Before demonstrating that the randomness is in fact very large it will be useful to demonstrate how it arises.

For the surgical specialties the source of inpatient additions to the waiting list is the outpatient activity. Most waiting list models assume some constant conversion factor, e.g. 50% of Gynaecology or Plastic Surgery first appointments result in an addition to the waiting list.

Most would appreciate that the figure of (say) 50% is an average and hence the exact outcome may not always be 50%. This particular source of variation is described by what is called a Binomial Distribution. Hence for our assumed conversion rate of 50% for the next 10 patients anywhere between 1 and 9 can be added to the waiting list, for the next 100 between 35 and 65 and for the next 1,000 between 450 and 550 can be added to the waiting list. The variation decreases with increasing size but is still considerable even at relatively high numbers. Expected numbers to be added to the waiting list from the next 1,000 outpatient attendances are given in Table One for a range of conversion rates. Once again the variation increases as the expected number to convert to the waiting list decreases. The implication of this table to the specification of contracts with DTC's should be obvious – far greater flexibility is required that is at present being assumed.

In practice the conversion rate for each consultant is different and so is the conversion rate for urgent, soon and routine appointment types. There is also a conversion rate associated with follow-up appointments. Given that the volume of each of these types of appointment are themselves subject to variation the end result is considerably more than 10% variation in the additions to the waiting list in even the largest specialty within the largest of hospitals. For the smaller specialties and Trusts the variation can be as high as ± 50%.

Table One: Expected number to be added to the waiting list from the next 1,000 new outpatient attendances.

Conversion Rate	Minimum	Maximum
90%	870	928
80%	761	835
70%	655	744
60%	551	648
50%	452	549
40%	352	449
30%	256	345
20%	161	240
10%	72	130
5%	30	72

Removals from the waiting list for reasons such as moved away, no longer required, etc are also subject to the same randomness. The end result of all this variation in both the volume of urgent, soon, routine and follow-up patients with associated conversion rates and in the removal rate after addition to the waiting list is a distribution of demand which is approximated by what is called an Extreme Value distribution.

Strictly speaking the variation should follow a Poisson distribution, however, because there are multiple causes of the variation the outcome must be approximated by a different form of distribution (1). Extreme value distributions are commonly used to describe variation in natural events such as the intensity of flood flows, rainfall and the breaking strength of materials. It is of interest to note that an extreme value distribution also gives a good approximation of other inpatient characteristics such as variation in monthly average length of stay and in annual numbers of emergency admissions.

If we net off the additions and removals in any one year we have the actual demand for that year. This demand can be simply calculated by adding the change in the waiting list to the number of operations performed. For example, say we performed 1,750 operations and over the same period the waiting list went down by 250 then the demand would be 1,500. Having calculated demand in this way we can then use the underlying growth in demand to translate historical demand into the equivalent demand for next year. For example, if annual growth in demand is 10 per year and the demand was 700 in 1992/93 this becomes the equivalent of 790 in 2001/02, etc. This adjusted annual data can then be fitted to an extreme value distribution to give the expected distribution in demand for the year to come.

An example of this is given in Table Two where the combined surgical demand of a large trust has been forecast for 2001/02. As can be seen there is a considerable range in the expected demand for the year. If this hospital attempts to keep the waiting list stationary it could plan to do the average expected demand of 23,081 operations.

Not apparent from Table Two is the fact that the most common outcome (the mode) is higher than the average at 23,215 operations. However, should this Trust plan to do 23,081 operations the waiting list could therefore end up changing anywhere between an amazing reduction of 3,936 to an increase of 929. In fairness it must be stated that these two extreme cases occur with almost negligible probability and that a range of a reduction of 655 to an increase of 436 is more likely to represent the bulk of possible outcomes.

Table Two: Forecast range in the combined demand for seven surgical specialties within a large acute Trust (2).

Demand	Percent of Outcomes less than
19,145	0%
22,426	10%
22,678	20%
22,846	30%
22,970	40%
23,081	50%
23,181	60%
23,280	70%
23,381	80%
23,517	90%
24,010	100%

Activity in these specialties for 2000/01 was 22,168. This implies that if the hospital were to repeat last year's activity the waiting list could end up anywhere in the range of an increase of between 258 to 1,349.

The question begs to be asked – given this large variation in demand how can any hospital be expected to guarantee the delivery of a promised reduction in the number on the waiting list?
Many would answer that all hospitals should therefore individually plan to do slightly more than the expected average demand in order to collectively overcome the effect of

randomness. After all everyone knows that elective activity is under the direct control of hospital management. Therefore by implication failure to achieve target is a failure of management.

Unfortunately the role of randomness is more universal via its effect on the daily variation in emergency admissions to the surgical specialties. This manifests when bed availability is the limiting factor for total activity since both elective and emergency admissions are competing for the same bed pool.

Analysis shows that most hospitals in the south of England are constrained by a shortage of available beds. This is expressed as high occupancy and hence high turn-away (3). In this instance the turn-away manifests as cancelled elective operations. Hence the earlier statement that admission from the waiting list is 'nominally' under the control of the hospital. It is true that any hospital can plan their elective admissions but as they have no control over the randomness of the emergency admissions. They therefore have no control over the number of cancelled operations arising from the competition of emergency and elective admissions for a limiting bed pool.

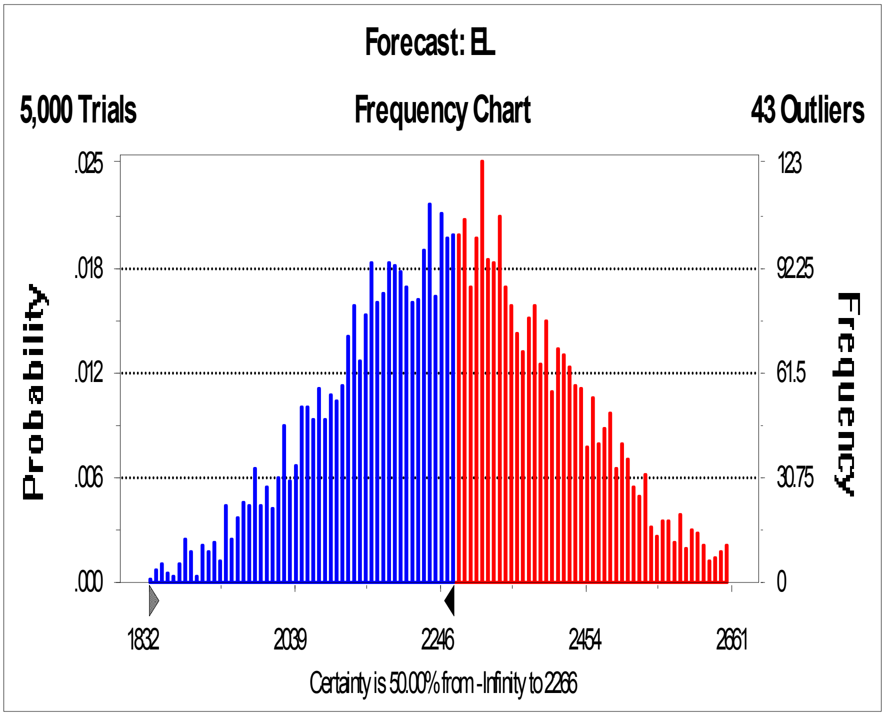
To actually predict how many admissions can be made through a given bed pool requires the use of a computer simulation that accounts for simultaneous variation in emergency admissions and the average length of stay of both the elective and emergency admissions.

The output from such a simulation is given in Figure One where it can be seen that the activity arising from a fixed bed pool is far from guaranteed. In this simulation the number of elective operations for the year can vary between1,832 to 2,661. This is nothing to do with poor scheduling or lack of management. It is simply the outcome of randomness in both emergency admissions and the length of stay of those elective and emergency patients who are admitted each month.

Imagine that the hospital needs to deliver 2,266 operations to achieve its target. The simulation clearly shows that there is a 50% chance of an outcome lower than this number. In real life the theatre capacity represents a constraint on the range of activity above the average and hence the actual opportunity to do additional activity may not be realised in its full extent.

Randomness also provides an explanation to the curious anomaly as to why Trusts appear to be able to predict emergency admissions but are apparently unable to align their actual and forecast elective admissions. This is because the average expected number of emergency admissions is the consequence of a 'predictable' average arising from random daily events. Hence a monthly total for emergency admissions can be reasonably forecast, however, the number to arrive on any one day cannot. It is the number arriving on any single day and their associated length of stay that leads to highly random cancellation of elective operations and even whole lists. The imposition of a fixed bed pool results in the daily randomness in emergency admissions expressing itself in the inability to fully 'plan' elective operations.

Figure One: Expected variation in elective admissions to a General Surgery department with 70 beds and an average of 3,930 emergency admissions per annum. Theatre capacity is assumed never to be limiting.



Before concluding it is of interest to evaluate the implications of these factors to current waiting list initiatives. If we assume that the underlying demand is for 12 million overnight & day case episodes then using a simple Poisson assumption we can see that the minimum possible standard deviation associated with demand will be ± 3,460 episodes. Thus assuming maximum variation of 3-times the standard deviation gives maximum variation of ± 10,390. This seems a modest number in proportion to such a high level of demand. However, say the government target for the year was for a waiting list reduction of 130,000 (the likely number required during 2003/04 to a **guaranteed** maximum waiting time of 6 months by Dec-05) then we can see that to deliver this target would involve anywhere between 119,600 and 140,400 extra operations higher than demand.

When this is split down to Strategic Health Authority level we have demand of roughly 400,000 operations per region and a corresponding regional target to reduce the waiting list of around 4,000. The maximum variation associated with the smaller regional size is ± 1,800 and hence each region has the possibility of doing anywhere between 2,200 to 5,800 more than demand to achieve their share of the national target. Taken down to PCT level the variation in the numbers gets considerably larger and at Trust level is equivalent to the example shown in the earlier part of the article – except that this is a very large Trust and some 80% of Trusts are smaller and hence subject to even higher levels of variation.

The question needs to be asked – how is the money equitably allocated in view of this natural variation in demand? The answer s that it is not and hence we can see that financial inequality is a further consequence of attempts to achieve waiting list targets.

In conclusion, the delivery of waiting list targets is not a simple consequence of management action. The level of randomness associated with both elective demand and emergency admissions mean that planning becomes a somewhat academic exercise…. almost the pursuit of statisticians rather than operational managers.

The only way to guarantee any waiting list target is therefore to have excess capacity both in terms of beds and theatre capacity. For many Trusts this will imply extensive use of the private sector although the magnitude of randomness will obscure the exact volume of work required. This will also imply that longer-term contracts with both PCT's and the private sector may be exceedingly difficult to specify.

Finally this randomness in demand makes the process of matching money to demand extremely difficult. Simplistic proportional-based allocations end up leading to financial inequality or from another viewpoint to the so-called postcode lottery. Indeed retrospective allocation is the only truly equitable way to deal with such high inherent variability in demand.

References:

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About the Author

Dr Rod Jones has a Ph.D. in Chemical Engineering and is a chartered accountant (Chartered Institute of Management Accountants). Outside of healthcare he has experience in process engineering, project management, R&D, teaching, TQM and laboratory proficiency testing. He has over 15 years experience in healthcare both as a senior manager and as an independent consultant with Healthcare Analysis & Forecasting. Many thousands of hours of research into healthcare resource allocation has led to the development of new methods for sizing hospitals and bed pools, forecasting healthcare demand, understanding resource allocation problems and the actuarial basis of financial risk in healthcare.