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Emergency admissions and hospital beds

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Key Words: Hospital bed occupancy, emergency admissions, 85% occupancy, bed planning, winter bed demand, seasonal cycles, available beds, paediatric, trauma, medicine

Key Points

- The method currently used to forecast the number of beds for emergency admissions is flawed and underestimates the real bed requirement
- An extended time series of total bed days should be used to estimate future bed requirements
- Even in the most length of stay efficient hospitals the size of the medical bed pool has increased over time
- The average occupancy applicable to hospitals depends on their size and is higher for larger hospitals
- However for the purpose of infection control the maximum average occupancy may be limited to 85%.
- Hence any specialty or bed pool with less than 100 beds will operate at an average occupancy less than 85%.
- The introduction of single sex wards during 2009/10 may lead to serious operational problems if the size of the bed pool is not increased.

Abstract

Parts one and two of this series discussed the component parts of various trends and longer-term cycles leading to increasing emergency admissions. In this final part of the series the issues around bed planning for emergency admission are discussed in the light of the annual summer/winter and long-term cycles. Provision for zero day and other short stay admissions is also discussed.

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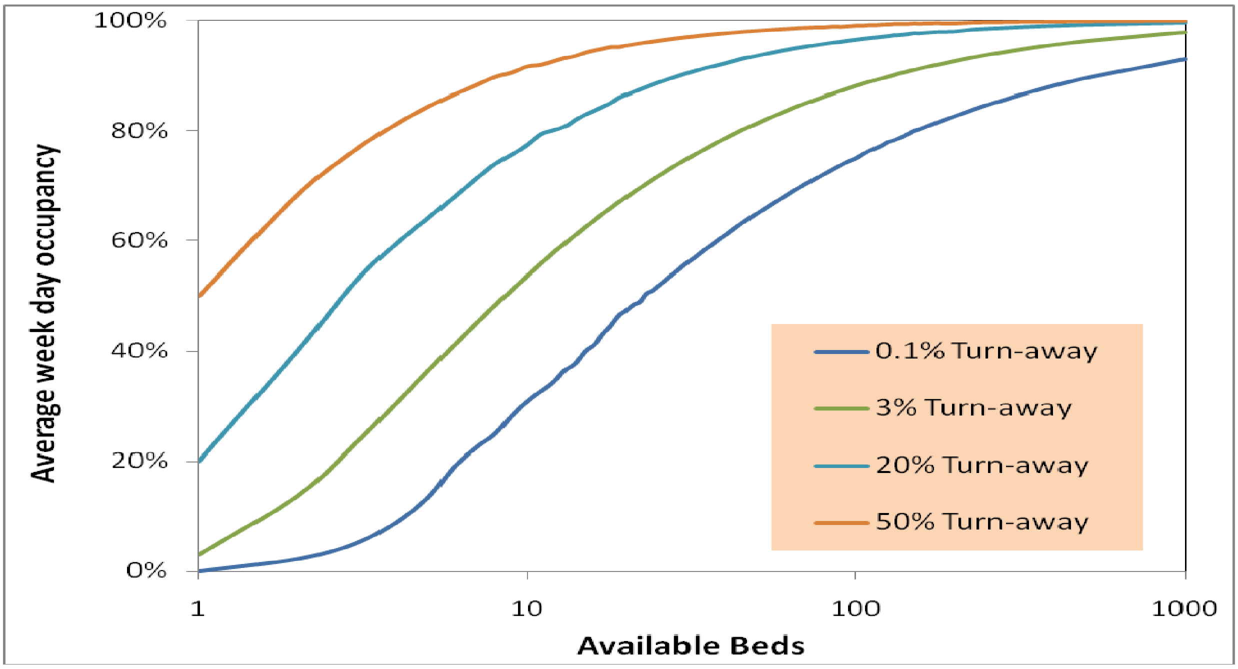
Introduction

The recent acute bed crisis in the winter of 2008/09 due to rising emergency admissions and the ongoing maternity bed crisis appear to point to the fact that there may be room to improve our understanding of how to plan to achieve an adequate number of acute beds suited to the needs of emergency/unscheduled care. Indeed just how does a hospital determine the number of beds it needs? The accepted methodology is to forecast future admissions and average length of stay (LOS); multiply the two and apply an occupancy level. Over six years ago I questioned the validity of this approach and concluded that it was prone to serious underestimation of true bed requirements due to methodological bias and the opportunity for deliberate manipulation of both growth and LOS (Jones 2002, 2003). It would appear that this flaw has been exploited to full extent in order to justify the smaller size of most private Finance Initiative (PFI) built hospitals (Dunnigan & Pollock 2003). Is it possible that the acute and maternity crises are partly self-inflicted? Is it a wise policy that allows, what are now virtually independent NHS hospitals, to close beds at will and to what extent do conflicting policy objectives contribute to planning ambiguity?

However before discussing the issues around bed demand in greater detail we must first understand the relationship between available beds, occupancy rate and the adverse consequences arising from too high an occupancy level.

Figure 1: Average occupancy and undesirable 'turn-away'



Footnote: The x-axis in this figure is a logarithmic scale. From Jones (2009c)

Bed Occupancy

The issues surrounding bed occupancy are exceedingly poorly understood and there is considerable confusion around what figure to use as a planning assumption, i.e. 82% or 85%

occupancy. The former figure comes from the National Beds Inquiry conducted in the late 1990's (DH 2000) while the latter is from a study by Bagust et al (1999). Part of the confusion arises from misunderstanding of the study of Bagust et al (1999) who indicated the risk of an unavailable bed commences at around 85% average occupancy while at 90% average occupancy a hospital was effectively in bed crisis.

What was not widely appreciated was that these specific figures applied to an emergency bed pool of around 200 beds under the assumption of modest seasonal variation. They noted that seasonal cycles had a huge effect on the model outcome. This will be discussed in more detail in the section dealing with medical beds.

However a figure of 82% or 85% fails to explain why the smaller specialties such as ENT and Gynaecology typically operate at 40% to 70% average occupancy (Baillie et al 1997, Jones 2001c). Hence while it is useful to know that 85% applies to 200 beds (under a specific set of assumptions) a wider view encompassing all possible size of hospital or bed pool is required (Jones 2001c, 2009c) and is shown in Figure 1 where size, average occupancy and the frequency of adverse outcomes are shown to be inter-related. First of all note the highly non-linear nature of the relationships. Turn-away is the proportion of times that adverse events such as cancelled operations, diverts to other hospitals, trolley waits, etc will occur as a result of wider bed unavailability. Hence a figure of 50% turn-away implies that at the point of arrival 50% of patients will experience the undesirable consequences of bed non-availability. Experience shows that maternity, intensive care, paediatric, etc should have sufficient beds to operate on the 0.1% turn-away line while the wider acute bed pool can operate at around 3% turn-away. As a point of reference, studies by the author show that American hospitals in the 1990's operated at an occupancy well below the 0.1% turn-away line, i.e. there was immediate access to a bed under all extremes of demand. The figure of 3% suggested for English hospitals is therefore a significant compromise between affordability and access and implies considerable flexibility in the management of the elective waiting list to manage the slight under-capacity implied by 3% turn-away.

From Figure 1 we see that a medical bed pool with 300 beds can therefore operate at somewhere around 91% to 94% average occupancy, while at 500 medical beds around 94% to 96% average occupancy is possible. Most hospitals are operating well above this figure during the winter months and consequently experience serious operational difficulties (Jones 2002, 2003). While larger hospitals may be able to operate above 85% average occupancy the demands of adequate infection control may however dictate that somewhere around 85% average occupancy is the effective ultimate upper limit (Cunningham et al 2006). The final point of relevance is that the average occupancy of the whole hospital cannot be applied to the constituent bed pools. Each bed pool must be free to operate at its appropriate average occupancy dependent on its size. Having discussed these fundamental issues we are now in a position to investigate recent trends in available beds to see if there may be an emerging problem.

Available Beds

Table 1 gives the trend in total number of beds and the average occupancy over a number of years for hospitals in England. While this does not tell us about individual hospitals it gives the general drift and Figure 1 allows us to put these trends into context.

Firstly we see that despite an apparent reduction in average occupancy the situation in Mental Illness and Learning Disabilities could in fact have gotten worse given the much smaller average bed pool size in recent years. The particular issue related to maternity is easy to spot. Given the high sensitivity of maternity to average occupancy the 14% reduction in bed pool size and the increase in average occupancy will have contributed significantly to the maternity bed crisis (Jones 2001c, Jones 2009c). This is probably the inadvertent consequence of attempts to save costs in the absence of knowledge of the consequences implied by Figure 1. The situation for the geriatric bed pool has definitely gotten worse since the very high average occupancy has remained the same but the average bed pool size is much smaller. For the remainder of the acute bed pool while the overall figure of 84% average occupancy appears to be ‘good’ it is an annual average of smaller constituent bed pools of both elective and emergency admissions and ignores the averaging effect of the summer dip in medical bed demand (Baillie et al 1997).

Table 1: Decline in available beds in England

Year	Relative Number of Available Beds					Average Occupancy				
	Acute	Geriatric	Maternity	Mental illness	Learning Disabilties	Acute	Geriatric	Maternity	Mental illness	Learning Disabilties
2001/02	100%	100%	100%	100%	100%	84%	92%	60%	89%	87%
2002/03	100%	100%	95%	100%	88%	85%	91%	61%	87%	86%
2003/04	101%	98%	95%	98%	92%	86%	92%	63%	88%	84%
2004/05	101%	95%	93%	95%	78%	85%	91%	63%	88%	85%
2005/06	100%	88%	91%	91%	69%	84%	92%	65%	86%	84%
2006/07	96%	82%	88%	85%	61%	84%	91%	64%	87%	85%
2007/08	93%	74%	86%	82%	55%	84%	91%	64%	86%	82%

Footnote: Data is an average over all English hospitals and includes both elective and emergency admissions (DH 2009). Number of available beds is relative to 2001/02 as the base year.

What has not been shown in Table 1 is the underlying trend in occupied bed days. Analysis by the author of data for the South Central region shows that bed demand was relatively constant over the period 2001/02 to 2004/05. This was followed by two years of relatively lower bed demand (2005/06 & 2006/07) which lulled hospitals into a false sense of security and hence bed closures were accelerated in 2006/07 and 2007/08. The resurgence in bed requirements via increased admissions which commenced at the end of summer 2007/08 and continued in 2008/09 was not anticipated (Jones 2009a,b).

Mixed Sex Wards

The implication of Figure 1 to the abolition of mixed sex wards (in itself a highly desirable aim) in England during 2009/10 should be immediately apparent (West 2009). By virtue of cutting the effective bed pool size by half the occupancy rate which can be sustained drops and all hospitals in England are now too small and will experience increased levels of turn-away with associated operational challenges.

Having established a framework from which to interpret bed demand and the consequences of average occupancy we can now investigate the adequacy or otherwise of the current methods for bed planning with specific issues relating to emergency admissions.

Bed Planning

Why is the current method subject to inherent bias? What is called average length of stay (LOS) is simply total bed days divided by total admissions, i.e. LOS is a ratio describing a highly skewed frequency distribution made up from the individual LOS of every patient. Hence average LOS will have upper and lower confidence intervals (which in practice are quite wide but never calculated) and more importantly can fluctuate in unexpected ways over time especially when large numbers of zero day stay 'admissions' are included as a confounding factor. These issues were discussed in part one of this series (Jones 2009a). An alternative approach based on trends in actual bed days per se was concluded to offer far greater certainty in the forecasting of future bed requirements and a detailed discussion of all the technical issues has been given in these publications (Jones 2002, 2003).

The suspicion is that very few people (including external consultancies) actually understand the forces regulating emergency bed demand. The crux of the matter lies around the predictability or otherwise of emergency admissions. Unfortunately the former Modernisation Agency may have muddied the waters considerably by insisting that poor standardisation of processes lead to variation in bed demand and that bed demand was largely amenable to direct 'control' via process change (Rogers 2002). While partly true it fails to capture the fact that emergency admissions and bed demand is highly dependant on the weather (temperature, pressure, humidity, rainfall, air circulation, etc) and the level of viral and other infections (Jones 1997, Makie et al 2002, Rusticucci et al 2002, Rising et al 2006, Mangtani et al 2006, MET Office 2008). Even so-called planned (elective) admissions are subject to considerable uncontrollable variation due to seasonality in GP referral and statistical randomness (Jones 1996, 2000, 2001a,b).

Variability in Bed Demand

To understand how bed demand could so quickly bounce back from the lower level seen in 2005/06 and 2006/07 we need to understand the nature of the diagnoses that are showing a fundamental increase over time and the nature of variation in those that are not. Table 2 presents the annual average beds occupied for a variety of diagnoses where bed demand was higher in 2008/09 than in 2001/02. Hence the average hospital in 2001/02 had 4 beds dedicated to renal failure growing to 7 in 2008/09 and 19 beds dedicated to urinary tract infection in 2001/02 growing to 31 in 2008/09, etc.

The next point to note is that the variation for each condition is quite large, hence for all trauma admissions it would appear that bed demand can fluctuate from 100% to 120% (range

20%) of the 2001/02 base figure. Likewise acute bronchitis can fluctuate between 91% to 111% (range 20%) of the 2001/02 figure and 2008/09 just happens to be at the top of this range. The probability of two low years in a row is 1 in 4 and hence the chance occurrence of two 'good' years appears to have fooled hospitals into closing beds while the longer term cycle in admissions then led to a bed shortage in late 2008 (Jones 2009b).

Table 2: Diagnoses with high emergency bed demand in 2008/09

Diagnosis or group	Beds	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08	2008/09
Acute and unspecified renal failure	4	104%	129%	138%	138%	169%	168%	171%
Urinary tract infections	19	119%	122%	145%	153%	132%	152%	166%
Noninfectious gastroenteritis	6	106%	118%	129%	135%	115%	134%	148%
Pleurisy, pulmonary collapse, etc	5	101%	118%	130%	119%	102%	127%	146%
Pneumonia	26	113%	117%	127%	122%	110%	126%	141%
Septicemia (except in labour)	5	114%	128%	111%	137%	133%	146%	128%
Other connective tissue diseases	5	104%	106%	106%	108%	90%	96%	123%
Other circulatory disease	5	106%	119%	115%	124%	117%	113%	120%
All respiratory conditions	**83**	**106%**	**112%**	**115%**	**115%**	**101%**	**104%**	**119%**
Biliary tract disease	7	102%	103%	103%	107%	110%	109%	118%
Complications of inpatient care	7	102%	110%	123%	112%	101%	114%	116%
Spondylosis, intervertebral disc, etc	7	113%	112%	125%	116%	91%	104%	112%
Acute bronchitis	16	97%	109%	109%	107%	95%	91%	111%
Complication of device, implant or graft	10	107%	108%	114%	112%	105%	113%	110%
COPD and bronchiectasis	19	107%	121%	118%	116%	95%	97%	109%
Other fractures	10	104%	104%	106%	122%	99%	112%	107%
Fracture of neck of femur (hip)	37	111%	112%	117%	103%	93%	101%	105%
Residual & ill-defined diagnoses	50	59%	52%	47%	29%	45%	40%	105%
Fracture of upper limb	10	107%	111%	114%	107%	102%	101%	104%
Fracture of lower limb	18	114%	125%	121%	115%	96%	97%	102%
All trauma (fracture, injury, wounds)	**97**	**114%**	**120%**	**119%**	**113%**	**104%**	**110%**	**102%**

Beds show the approximate number of occupied beds for an average hospital in 2001/02. In all cases 2001/02 is the reference point at 100%. Data courtesy of NHS South Central and was extracted from the Dr Foster 'performance Investigator' software. Diagnostic groups are those assigned by Dr Foster.

Table 3: Relative emergency bed demand in the four quarters of the financial year.

Diagnosis	April to June	July to September	October to December	January to March
Septicemia (except in labour)	91%	105%	97%	**108%**
Urinary tract infections	92%	96%	102%	**110%**
Chronic ulcer of skin	93%	96%	**112%**	99%
Pneumonia	93%	78%	95%	**134%**
Other gastrointestinal disorders	94%	**106%**	**106%**	94%
Complication of device, implant or graft	94%	101%	**109%**	96%
Fracture of lower limb	95%	101%	**106%**	98%
Other fractures	95%	104%	95%	**107%**
Acute bronchitis	95%	71%	94%	**139%**
General & Acute	**96%**	**98%**	**101%**	**105%**
Acute and unspecified renal failure	96%	97%	96%	**111%**
Chronic obstructive pulmonary disease	98%	82%	92%	**127%**
Fracture of upper limb	98%	**107%**	101%	94%
Syncope	99%	92%	103%	**105%**
Other nervous system disorders	99%	99%	**106%**	95%
Acute myocardial infarction	103%	93%	98%	**106%**
Paralysis	106%	**108%**	94%	92%
Nonspecific chest pain	**106%**	99%	95%	100%
Nonhypertensive congestive heart failure	**110%**	97%	93%	100%

Seasonal Factors

While various years may be higher or lower than others there is also considerable seasonal variation in bed demand which adds additional bed demand into the system, i.e. the high dependence of adverse outcomes due to the seasonal factors noted by Bagust et al (1999). This is illustrated in Table 3 where the seasonal demand in each of the four quarters of a financial year is given for a variety of diagnoses. As can be seen there is considerable variation around the annual average and a range of conditions peak in the last quarter of the financial year leading to a general 5% increase in bed demand during the last quarter. It should be appreciated that monthly bed demand shows even greater seasonal peaks and troughs (Baillie et al 1997). Analysis of the seasonal nature of bed demand at Specialty level shows that the surgical specialties (other than Trauma & Orthopaedics) show only modest seasonal peaks and troughs and hence bed demand can be adequately modelled using the trend in elective plus emergency bed days and an average occupancy level from Figure 1 can be applied to the bed pools of specific size. However for the medical groups of specialties there is considerable seasonal variation both in admissions and bed demand and a different approach must be employed (Jones 2009c).

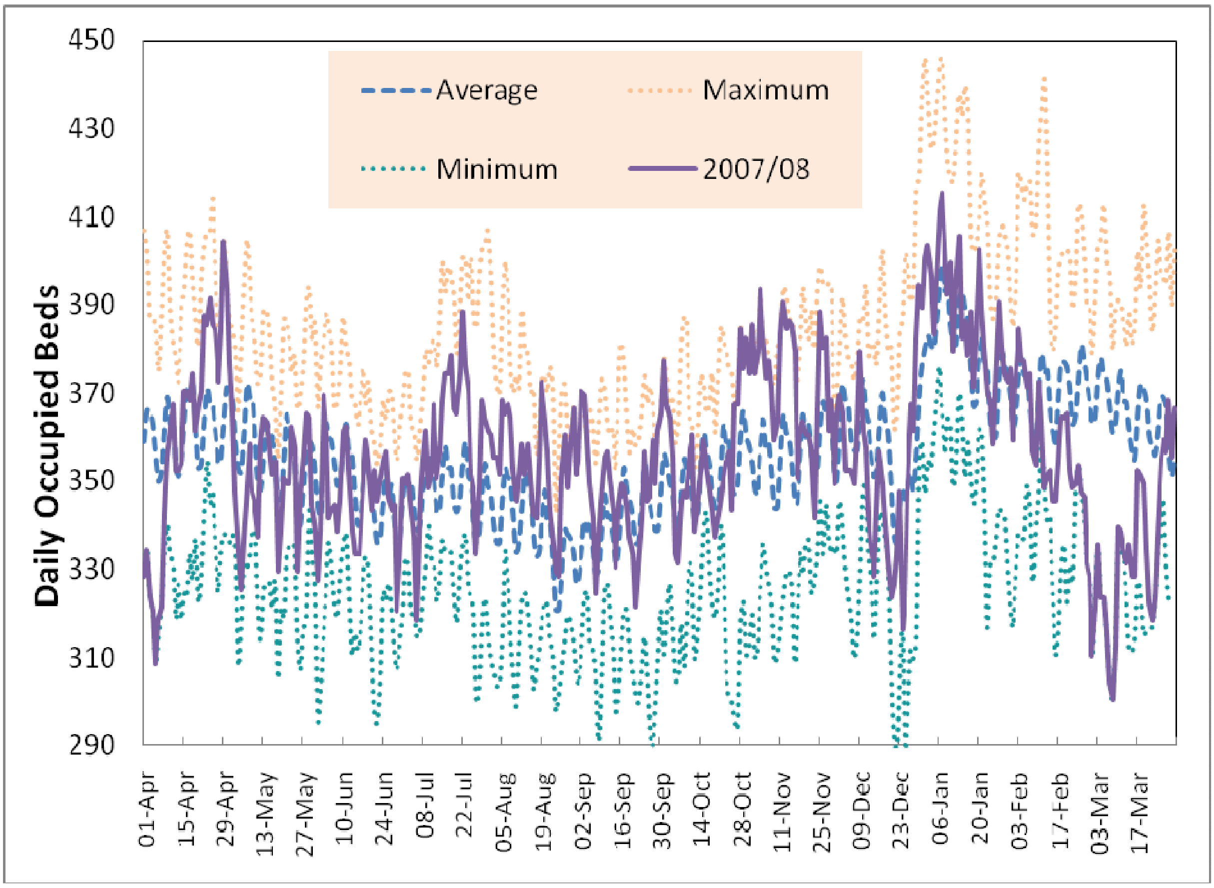
Medical Beds

The highly seasonal nature of medical bed demand is illustrated in Figure 2 where some vital insights into the real nature of the problem can be obtained:

- A small weekday cycle in occupancy can be clearly seen
- The average seasonal pattern has a moderate maximum and minimum from 335 to 395 beds.
- However this is dwarfed by the upper and lower limits which show extreme variation from 295 to 445 beds.
- The maximum bed demand in January (and occasionally February) can be up to 67 beds higher than the long term average while the most common gap for the maximum bed demand is 30 beds higher than the average
- The average is simply a mathematical calculation and does not apply to any particular year
- In any one year (see 2005/06 as an example) bed demand can be anywhere between the upper and lower limits
- Considerable shifts in bed demand are the normal pattern and can occur in a very short space of time

Two common misconceptions can be exposed by the above observations. Firstly some have wrongly seized upon the small weekday cycle as the source of ‘the problem’ and attempted to change ward rounds, etc as a solution. Figure 2 clearly shows that this is the equivalent to clutching at straws. The second, more serious misconception is that reducing length of stay will solve ‘the problem’. Length of stay has almost nothing to do with the medical bed problem as it is the large shifts in bed demand arising from the external environment (weather and levels of infections) that drive the bed demand per se. These large shifts can be clearly seen in Figure 2 as illustrated by the data for 2007/08 where bed demand can flex anywhere between the maximum and minimum possible, for shorter or longer periods, during the space of a single year. Reducing length of stay only has a second order effect which applies to the bed days lying below the minimum line in Figure 2 and only has the potential to shift the whole chart down by say 5 to 10 beds, i.e. reducing length of stay can only be applied to the relatively non-seasonal case mix which occupies the baseline of 290 to 300 beds in Figure 2. Such gains are immediately lost by virtue of the long term growth trend. Reductions in length of stay have nothing to do with the large spread in the maximum and minimum bed demand which is entirely at the mercy of the environment, i.e. the large spread in the maximum and minimum has been relatively constant for 21 years despite considerable changes in average length of stay over this period. It is at this point that the current methods for calculating bed requirements have seriously erred and may have created a national problem.

Figure 2: Daily medical bed demand at a large acute hospital

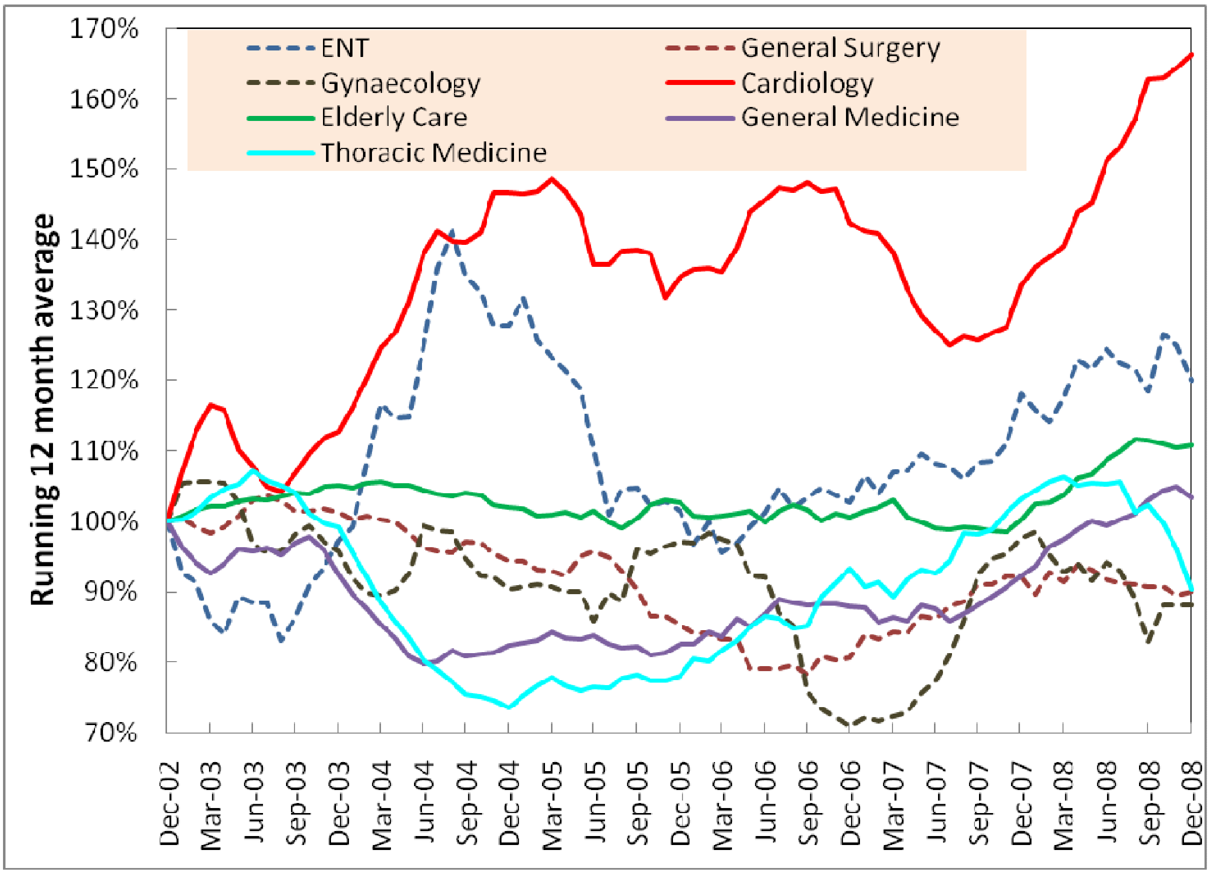


Footnote: Data is from a 21 year time series of daily bed occupancy which has been adjusted for growth in demand over the time series. All years have been adjusted to commence on the nearest first Sunday of the financial year. By kind permission of the Royal Berkshire Hospital NHS Foundation Trust.

Bed planning for the medical group of specialties therefore presents the greatest challenge to operational management in any hospital and the current method for estimating bed demand is totally unsuited to the medical specialties. For example, the current method for bed planning would calculate somewhere around 355 beds as the annual average occupied bed requirement and allowing say 90% occupancy would come up with a requirement for 395 beds. This would then be declared to be unaffordable and heroic assumptions around reducing length of stay would be applied to get the bed numbers back to an ‘affordable’ size. This probably explains why nearly all hospitals struggle during most winters. They simply have insufficient beds to cope with the realities of winter bed demand. Few can afford the luxury of a bed pool as large as the winter peak in a ‘bad’ year may require, i.e. the maximum line in Figure 3 during January. Indeed most hospitals appear to attempt to function with a medical bed pool which is adequate for an average summer and wonder why they have large numbers of medical outliers in surgical beds during even the most innocuous winter. What is needed will usually be a ‘flex’ ward(s) of around 30 to 40 beds which can be opened and closed as needed. Choosing the size of the core medical bed pool then becomes a matter of judgement and in the example from Figure 3 a core pool somewhere near to 380 beds will be required.

The crux of the problem was highlighted in part one of this series. Hospitals are totally unable to flexibly allocate resources in an efficient manner in the absence of an external source of weather-related health forecasts (Jones 2009a). Expecting them to be able to do so is to expect the impossible. In this respect one study which used air temperature and the level of influenza-like illness was able to forecast bed occupancy 32 days in advance (Jones et al 2002).

Figure 3: Change in relative bed demand



Footnote: Charts are a 12 month running total of monthly bed days which are relative to the twelve month period December 2001 to December 2002. By kind permission of the Frimley Park Hospital NHS Foundation Trust.

Cyclic Factors

Part two of this series highlighted the cyclic nature of admissions and especially those for the medical group of specialties. A trigger event occurring in late 2007 was observed to lead to increased emergency admissions. The effect of this will feed into bed demand and this is illustrated in Figure 3 for sub-specialties within the medical group of specialties and several surgical specialties. A running twelve month total has been used to average out the shorter summer/winter cycle in bed demand.

As can be seen medical bed demand can show fundamental shifts to higher bed demand, however, in relative terms cardiology bed demand responded most strongly to the 2007 trigger event. The cycle for Thoracic Medicine is seen to follow a different set of fundamental mechanisms as does ENT and General Surgery. Gynaecology appeared to also respond to the 2007 trigger event but in a different way than that seen in the medical group. Whatever the nature of specific cycles Figure 3 demonstrates the absolute importance of following the trends in bed demand over an extended period of time before making decisions regarding future bed requirements.

Analysis by the author of a 21 year time series at the Royal Berkshire Hospital show that the long term trend in medical bed demand has only ever been to higher bed requirements, in the context of shorter term cycles around the longer term trend line. This hospital is one of the most length of stay efficient hospitals in England and so this apparent ‘failure’ to reduce the medical bed pool size has nothing to do with efficiency *per se* but is simply the outcome of longer term increasing admissions coupled with cyclic trigger events specific to medicine and the fundamental relationship with the environment.

In other words there is little point making heroic assumptions around average length of stay to force this fundamental size down to a more ‘affordable’ level. All that is simply required is the study of a long enough time series of occupied bed-related data in order to derive an acceptable view of the true size of the medical bed pool. Attempts to do this calculation using forecast admissions times forecast length of stay will only produce meaningless, but doubtless ‘affordable’ figures.

Bed Equivalents

A large part of the 26% reduction in geriatric beds seen in Table 1 has been due to the creation of non-acute bed equivalents such as community hospitals, nursing homes, at home support packages, etc. These are a necessary and desirable feature of the shift toward non-acute care (Ontario Hospital Association 2006). However Figure 1 clearly shows us that there is not an implied one for one relationship, indeed, the progressive shrinking of the size of an acute bed pool leads down a road to diminishing returns due to the lower average occupancy supported by smaller bed pools. It also goes without saying that the non-acute bed equivalents must be maintained or else the bed demand will re-surface in the acute bed pools.

Trauma & Paediatric Beds

Experience shows that calculating the correct number of Orthopaedic trauma and paediatric beds follows a process similar to that for medical beds. A long time series of data needs to be analysed. In this case the long-term cyclic point of maximum bed demand will become the size for the bed pool (Jones 2002, 2003), i.e. at points in the cycle of bed demand the occupancy will rise for a short space of time to around 100% and it is this maximum demand that sets the overall bed pool size. Occupancy at other points in the cycle will be lower.

Zero Day Stay

The bulk of zero day stay patients are usually admitted via assessment or A&E observation wards and these units therefore need to be adequately sized to prevent overspill into the overnight bed pool. When such overspill occurs the day time bed occupancy will be increased leading to higher turn-away. This is because most patients arrive at hospital between the hours of 9 am and 6 pm.

Conclusions

The current bed crisis is none other than too few beds going into a year when bed demand has reverted back to the longer term cyclical demand trend. What remedies can be applied to avoid a repeat of this situation?

Firstly a national framework needs to be applied to ensure that adequate beds are maintained in the system. Many will remember the National Beds Inquiry back in the late 1990’s – it would seem that the lessons learned have been quickly forgotten or ignored (DH 2000). While 82% to 85% average occupancy has been recommended the more comprehensive methodology used in Figure 1 demonstrates that bed pools of different sizes have different optimum average occupancy levels and that too high an occupancy leads to undesirable ‘turn-away’. A mechanism needs to be established to ensure that hospitals maintain sufficient beds to cope with winter demand peaks, the vagaries of the long term trends in emergency admissions, influenza pandemics and the needs of routine infection control.

Recognition needs to be given to the fact that the size of the medical, orthopaedic trauma and paediatric bed pools are set by the external environment and that applying heroic length of stay assumptions are inappropriate to the fundamental mechanism behind the demand for such bed pools.

The absolute necessity for forecasts of bed demand based on weather and other environmental factors to enable hospitals to optimise staff and bed availability and minimise costs cannot be overemphasised. At the moment all concerned are in a no-win situation.

All of the above imply a pragmatic approach is necessary. For whatever reasons each hospital and health economy has the number of beds and bed equivalents that it currently has available. The issue of affordability and PFI will not go away unless Payment by Results (PbR) is suitably modified (Jones 2009). The full implications of single sex wards are a matter for serious consideration and may prove to be the right policy but at an inopportune time. At the end of the day hospital managers' are doing an excellent job of delivering patient care within a set of highly conflicting constraints but it is not immediately apparent just how these conflicts can be resolved.

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