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Hospital bed occupancy demystified and why hospitals of different size and complexity must run at different average occupancy levels

Dr Rodney P. Jones (ACMA)
Statistical Advisor
Healthcare Analysis & Forecasting, www.hcaf.biz
hcaf_rod@yahoo.co.uk

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Key Points

- Queuing theory explains why the average occupancy depends on the size and functional requirements of each specialty bed pool.
- Smaller bed pools need to operate at lower average occupancy.
- As average occupancy increases the undesirable effects of 'turn-away' (the proportion of time a bed is not available for the next arriving patient) starts to occur and increases in an exponential manner.
- 'Turn-away' can be understood as queues for a bed, cancelled operations, medical patients in surgical beds, inability to achieve waiting time targets and the general appearance of organisational chaos including antidepressant medication for staff, hospital errors, cross-infection and deaths.
- A national average occupancy of 78% applies to hospitals with 1,000 beds in the USA and the national average figure for Europe is around 77%
- Average occupancy of 87% in the UK is the result of a policy to build smaller hospitals but has considerable undesirable implications to staff and patients.
- The average occupancy at the South Staffordshire hospital in England is used to illustrate the unrecognised role of excessive whole hospital occupancy which, along with other factors, contributed to an estimated >400 excess deaths over a four year period.
- The challenge is to develop predictive supporting tools which allow hospitals to minimise cost by staffing the patients in a bed rather than the beds per se.

Abstract

Part one of this series investigated the adequacy of current models used to forecast bed demand. This part explores the issues surrounding the correct level of occupancy required to deliver effective and safe health care. Economy of scale as explained by queuing theory is a significant factor in understanding bed occupancy. However, irrespective of the occupancy specific to different sized hospitals an absolute maximum occupancy (even during the winter months) in the range 82% to 85% is required to maintain the level of hospital acquired infection at the minimum possible level.

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Introduction

Recent articles have highlighted the importance of understanding the multi-factorial issues of hospital size and bed occupancy (Bain et al 2010, Jones 2010b, Keegan 2010, McCarthy 2010). In this respect the work of Danish mathematician A.K. Erlang (1878-1929) on queuing theory enables us to gain valuable insight into the intricate issues surrounding hospital average occupancy (Marjot 1987, Brockmeyer et al 2004, Bain et al 2010). While queuing theory was developed to determine the capacity of telephone networks all that is required is a change of name to understand its direct application to health care. Telephone lines become hospital beds; the rate at which calls arrive becomes the admission rate into beds and the average call duration becomes the average length of stay.

What does queuing theory tell us?

The simplest form of queuing theory is called Erlang-B where it is assumed that if there is not an available bed then the arriving patient is diverted elsewhere. Maternity and intensive care most closely conform to Erlang-B; however, what this equation does provide is an estimate of the level of 'turn-away' (Jones 2002a-c, 2003). The easiest way to appreciate what turn-away may imply is to consider it as a measure of the chaos, difficulty and effort implied in running the hospital, i.e. ambulances diverted elsewhere, patients held on trolleys in the emergency department, medical patients in surgical beds, cancelled operations, managers and clinicians hastily re-arranging schedules, bed management meetings and general operational complexity. Indeed high bed occupancy has been demonstrated to increase almost all of the key measures of 'poor performance' such as the waiting time to find a bed, staff stress, dissatisfaction and prescriptions for antidepressants, levels of hospital acquired infection, errors and excess deaths (Forster et al 2000, Borg 2003, Cunningham et al 2005, Sprivulis et al 2006, Cunningham et al 2006, Borg et al 2008, Clements et al 2008, Gidney 2008, Virtanen et al 2008, Borg et al 2009, Hillier et al 2009, Schilling et al 2010, Keegan 2010). The key point from Erlang-B is that a small incremental increase in average occupancy leads to an exponential increase in organisational chaos, complexity of management and adverse outcomes.

Using data from English hospitals one study was able to demonstrate that Maternity units need to have sufficient beds to operate at a turn-away level between 0.1% and 1% (Jones 2002a-c). A similar calibration process showed that the various specialty bed pools need to have sufficient beds to operate at the equivalent to 3% turn-away, i.e. elective waiting lists, queues in A&E and the bed management process gave sufficient of a buffer to allow this higher level of complexity to be maintained (Jones 2002a-c, 2003, 2010b). The figure of 3% turn-away was considered to be a pragmatic compromise between operational efficiency and the capital cost issues applicable to the UK but comes at the cost of not being able to guarantee waiting time targets. This work was used to explain why hospitals in different regions may experience greater difficulty in achieving inpatient waiting time targets (Jones 2010a).

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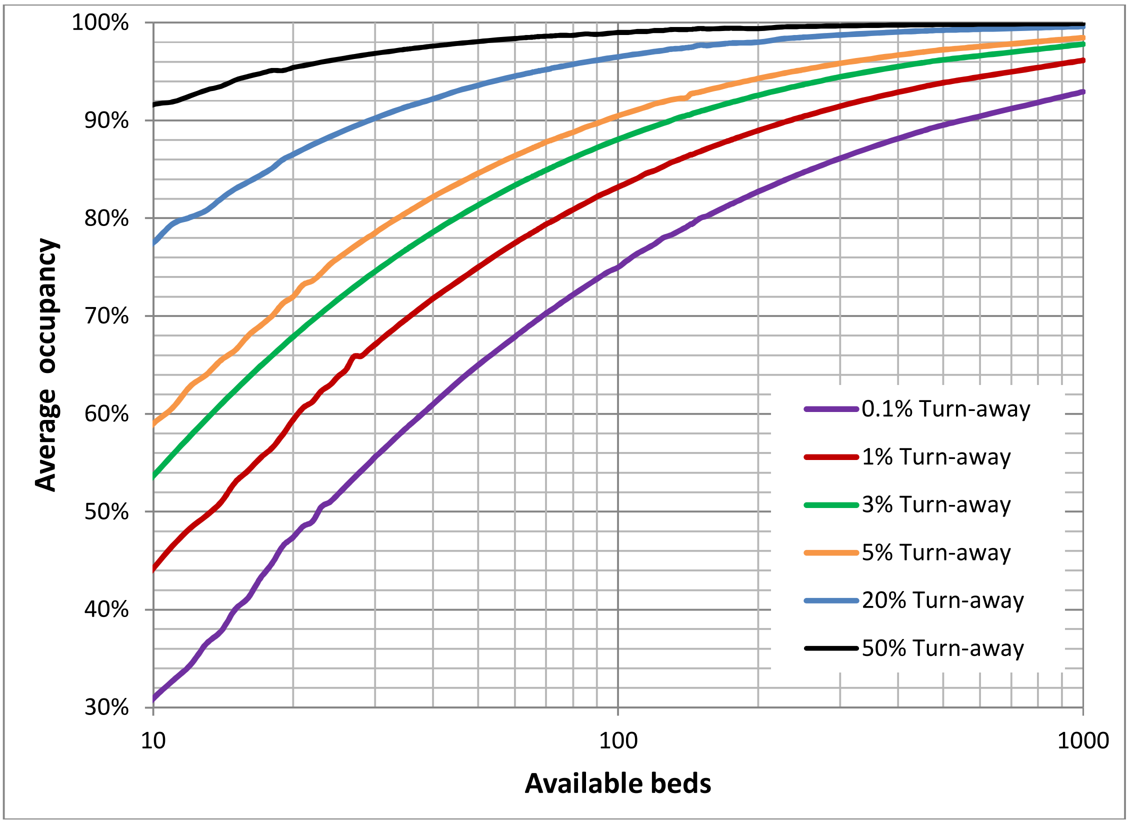
The next key observation from Erlang-B is that smaller units have to run at lower average occupancy and this explains the observed higher nursing cost per bed day in smaller wards (Raspin 2009) and the lower average occupancy observed to be associated with the smaller specialty bed pools in ENT, Gynaecology & Paediatrics (Baillie et al 1997). This is illustrated in Figure 1 where the number of available beds in a single function bed pool, average occupancy and lines of constant turn-away are all displayed on the same graph. At this point it should be appreciated that any specialist bed pool needs to have its individual occupancy margin determined by its size and not by some one-size-fits-all hospital average. The number of available beds multiplied by the average occupancy gives the number of occupied bed days or average occupied beds.

Figure 1: Occupancy in dedicated bed pools



Footnote: *A dedicated bed pool could be a single specialty bed pool such as Maternity or Paediatrics; or a functional group such as female surgical, male medical, Trauma and Orthopaedics, Gynaecology, etc. Tables of average occupancy for 0.1% to 1% turn-away are available from* [*http://www.oldwww.com.dtu.dk/teletraffic/erlangbook/pps268-275.pdf*](http://www.oldwww.com.dtu.dk/teletraffic/erlangbook/pps268-275.pdf)

It has been pointed out (Jones 2009b) that the figure of 85% average occupancy which arose from the work of Bagust et al (1999) needs to be interpreted in the context of the assumptions applied in their study, namely, seasonal variation in bed demand is small and that the bed pool only has 200 beds. As can be seen in Figure 1 at 200 beds the average occupancy required to achieve a theoretical 1% turn-away is indeed close to 85%,

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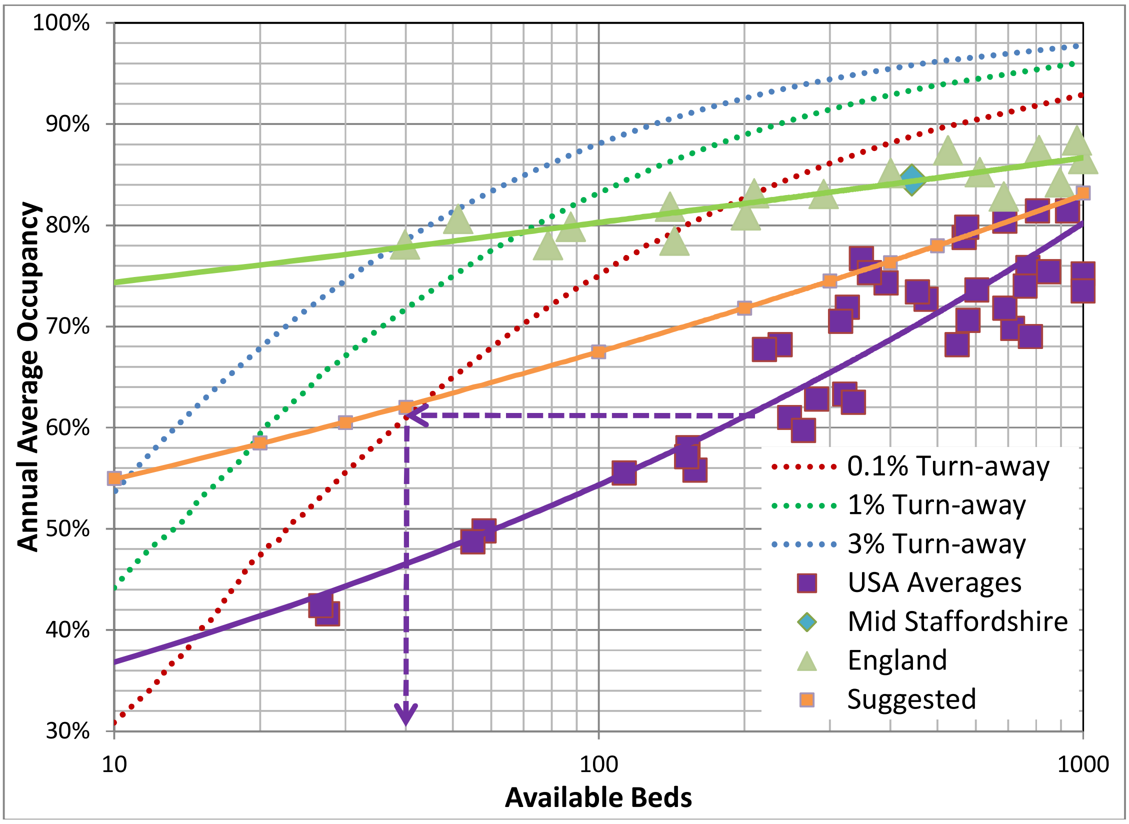
however, the real world encompasses hospitals and specialty bed pools which range from very small to very large. In situations where there is a high degree of seasonality such as Medicine, Paediatrics or Orthopaedics (Jones 2002d, 2009) then a summer/winter component needs to be introduced into the understanding of bed requirements (Jones 2008, 2009). An alternative figure of 82% arose out of the National Beds Inquiry conducted during 2000 in England (Department of Health 2001).

However the main conclusion from Figure 1 is an infinite range in occupancies which will apply to bed pools of differing size, function and complexity and that figures such as 82% and 85% only apply to a specific set of circumstances and almost certainly not to whole-hospital bed occupancy.

Figure 2: Whole hospital occupancy



Footnote: *National and regional averages for the number of available beds and average occupancy in the USA during 2008 for a range of different sized hospitals (less than 50 beds, small, medium, large and greater than 500 beds) was extracted from the 'Statistics on US hospitals' section of the Agency for Health Care Research & Quality website (http://hcupnet.ahrq.gov/HCUPnet.jsp?Id=5D189B17D1B20268&Form=SelDB&JS=Y&Action=%3E%3ENext%3E%3E&_DB=NIS08). Data for English hospitals in 2008/09 was obtained from the Department of Health website (http://www.performance.doh.gov.uk/hospitalactivity/data_requests/beds_open_overnight.htm) the average available beds and occupancy was calculated from the data ranked by hospital size (number of beds) using groups of 10 hospitals. Data was selected from those groups showing lowest average occupancy.*

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Having shed light on the issue of occupancy in single function/specialty bed pools we now need to understand the issues around whole-hospital average occupancy and to achieve this Figure 2 displays average occupancy data for hospitals of different size in the USA and England. The trend line through the data for each country is the equivalent to a trend line for national average occupancy. The need for specialty bed pools (i.e. Paediatrics, Medicine, Surgery, Trauma & Orthopaedics, etc) with their own unique size and occupancy as described by the lines of constant turn-away explains why the whole hospital average occupancy for US hospitals appears to be low, i.e. the hospital average occupancy is the average of the unique occupancies of all its constituent bed pools.

The issue as to why the trend line appears to defy queuing theory as hospital size gets smaller can be explained as follows. Lines of communication are far shorter in smaller hospitals and resulting operational management is direct, rapid and effective. In addition, smaller hospitals are characterised by a less complex case mix which implies that beds can be treated as a single pool rather than an amalgam of smaller 'closed' specialist pools. Many of these smaller hospitals are also semi-elective in that they decant patients from nearby larger acute facilities whenever a bed becomes available. The issues specific to the extremely high national average trend line in England will be discussed later.

If we assume that the US health care system operates at somewhere close to 0.1% turn-away we can estimate the average bed pool size within different larger hospitals. In Figure 2 the dashed line from average occupancy at 200 beds goes across to the 0.1% turn-away line and down to 40 beds, hence the average US hospital with 200 beds is comprised of specialty bed pools with an average size of 40 beds (including male/female split). Using the same process gives specialty pools with an average size of 155 beds for hospitals with a total of 1,000 beds.

Other Factors

The alliance between health care and government is necessarily tempered by the policies of the incumbent government and the wealth/austerity imposed by the longer term economic cycles. Acute bed demand is subject to forces which are poorly understood and hence it has been easier to rely on the existing methodologies for forecasting hospital size than to ask uncomfortable questions regarding the adequacy of those methods (Jones 2002a-c, 2003, 2010).

An example of such tension lies in two recently released documents from the Department of Health (DH) in England which have re-iterated a desire for fewer hospital beds. The 'Operating Framework for 2010/11' refers to reductions due to cardiac rehabilitation and quality/productivity respectively (DH 2009a) while 'From Good to Great' lists a range of initiatives which will shift acute care into the community and claims that up to 77% of inpatient bed days may be devoted to the care of patients with long term conditions (DH 2009b). These are statement of how bed demand is expected to 'perform' rather than a reasoned analysis of all the contingent factors responsible for bed demand and its associated safe occupancy levels.

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Over the period 1997/98 to 2009/10 average occupancy in English general and acute beds has risen from 80.5% to 86.6% which is a reflection of a deliberate policy to build smaller hospitals (Pollock et al 2002, Jones 2009d). According to the HFA Database (http://www.hope.be/03activities/quality_eu-hospitals/key_figures/06-acute_care-bed_occupancy_rate.pdf) the UK has the highest average bed occupancy in Europe with the next highest occupancy in Malta, Austria and Spain at around 80%. The European average is 77% and this roughly corresponds to the average occupancy in the USA for hospitals with 1,000 beds. The hospital average occupancy comes from a mixture of individual bed pools. Some of these bed pools, such as Paediatrics and Maternity, are 'closed' bed pools and by virtue of size operate at far lower average occupancy (Baillie et al 1997, Jones 2002a-c). This explains why, even at an annual average occupancy of 85%, the adult bed pools in hospitals still operate at close to 100% occupancy for extended periods during the winter months – with resulting queues in the emergency department and patients placed in inappropriate bed pools. For example, a hospital with 1,000 acute beds operating at a whole-hospital average occupancy of 92.9% would imply 0.1% turn-away but there would be no specialty, gender or age boundaries and the next arriving patient would go wherever a bed became available, i.e. elderly medical patients in paediatric beds, etc. Such a hospital has achieved maximum theoretical bed occupancy efficiency but at the total expense of patient care. Bed occupancy in England appears to be dangerously close to meeting this criterion.

In theory, the entire surgical bed pool should be a 'closed' pool, as common sense (indeed good medical practice) dictates that no one with a medical condition should ever be placed near surgical patients, and for this reason one suspects that the European and USA average of 77% is probably closer to the real requirement for a national average hospital occupancy rate (individual hospital averages depending on size and specialty mix). This is especially true if the absence of mixed sex wards is considered a desirable objective (Jones 2009b).

Case Study

Between 2005 and 2008 it is estimated that 400 (maximum possible 1,200) excess deaths may have occurred at the Mid Staffordshire Hospital in England. In the period January to March 2006 the rate of Clostridium difficile per 1000 bed days was twice the national average (Healthcare Commission 2009) and general poor coding standards coupled with under-reporting suggest this figure was actually higher. As can be seen in Figure 2 in the year 2007/08 this hospital had a hospital-wide annual average occupancy of 84.5% (http://www.performance.doh.gov.uk/hospitalactivity/data_requests/beds_open_overnight.htm), yet no where in the ensuing report on the failings at this hospital was excessive hospital average occupancy mentioned as contributory factor. This point is reinforced by studies which have demonstrated that high hospital occupancy (measured on the day of admission) leads to excess in-hospital deaths (Sprivulis et al 2006, Schilling et al 2010). It would appear that the generally high average occupancy in England had blinded the regulators to the potentially catastrophic consequences of attempting to run any hospital at such high occupancy levels. At this point it needs to be pointed out that the trend line

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for England applies to hospitals with the lowest average occupancy; hence the real average is higher. Indeed in 2008/09 some 28% (112 out of 398 hospitals with greater than 100 general and acute beds) in England had reported whole-hospital annual average occupancy above the 0.1% turn-away line, i.e. by implication, patients are being placed into any available bed rather than the bed pool suited to their specific needs.

Given the fact that the annual average occupancy in England is around 87% and that this average includes lower average occupancy specialties (Baillie et al 1997) and the summer/winter average; suggests that the bulk of the adult bed pool in most English hospitals operates at a daily average occupancy close to 100% for at least six months of the year. The work of Sprivulis et al (2006) demonstrated that such high daily occupancy leads to a 30% increase in in-hospital deaths; hence the ‘average’ for in-hospital death in England is an entirely elevated ‘base-line’ against which the excess deaths at Mid Staffordshire were evaluated.

The policy to build smaller hospitals appears to have placed the NHS in England in a perilous position where very high average occupancy presents opportunity for all hospitals to become another ‘Mid Staffordshire’. The close proximity between patients afforded by such high average occupancy amplifies the potential for large numbers of excess deaths. The much lower average occupancy in US hospitals provides a buffer to limit the wider impact of breaches of governance, were they to occur.

Given the fact that parts of the US health care system have excess capacity the line labelled ‘Suggested’ is provided as a potential reference point from which to understand what may be an adequate annual average whole-hospital bed occupancy level. As can be seen this ‘Suggested’ line passes through the higher average percentage occupancy characterising large inner city hospitals in the highly populated Northeast region (Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island and Vermont) of the USA. The occupancy figures for England then become a worst case position for a hospital system which could be said to be operating on the brink of operational chaos, the inability to place patients into the most effective bed pool to achieve efficient care and what may be internationally high levels of in-hospital excess mortality. The known effects of high occupancy and throughput on staff stress, burnout and dissatisfaction (Virtanen et al 2008) may well be an underlying cause for the general low staff satisfaction in English hospitals (Appleby 2008).

This entirely unsatisfactory situation places nursing staff in an ethical dilemma which is only compounded by the generally lower than required ratio of nurses to patients (Clements et al 2008).

Conclusions

Queuing theory is a useful tool for explaining why size and occupancy are directly linked. The question is not about what average whole hospital occupancy should we use, but rather, what occupancy is appropriate to a bed pool of this particular size and function? The challenge then becomes how to staff the patients rather than the beds and what supporting tools are required to achieve this goal (Jones et al 2002, Jones 2009a,b, 2010). Attempts to save both capital (and implied staff) costs can then be seen in their true light and the full extent of the unanticipated consequences for staff and patients can be appreciated. Whole-hospital annual average bed occupancy from the USA has been included as a benchmark and the excess deaths at the South Staffordshire hospital in England can be seen to have been partly aided by excess average occupancy.

As a final comment, high bed occupancy is universally recognised as a source of hospital acquired infection(s) (HAI). HAI is a major contributing cause to higher whole hospital average length of stay (Dulworth & Pyenson 2004) and can treble the cost of care for those infected (Plowman et al 1999). A recent PhD thesis on the topic of infection control has concluded that HAI increases significantly above 82% average occupancy, however, the evidence regarding single room accommodation as a way of preventing hospital acquired infection is weak (Gidney 2008). Obviously as the levels of HAI increase there is a greater perceived need for single room accommodation to isolate infected patients. Hence average occupancy in the 82% to 85% range should be regarded as entering into the danger zone and thus from the infection control perspective no hospital should ideally be allowed to operate above 85% average occupancy (even during the winter).

This issue is directly relevant to the situation in the UK where levels of hospital occupancy are so high. To move the average occupancy back into the recommended 82% to 85% range should therefore make a significant impact on the levels of HAI and hence on the perceived need for single room accommodation. Indeed the excessive levels of occupancy may well prove to be the single most important factor blocking the progression to lower length of stay that is required to reduce inpatient costs.

Hopefully this article has provided the conceptual framework within which managers and planners can appreciate the wider implications of hospital occupancy and how too high occupancy may be preventing the efficient operation of acute hospitals to which we all aspire.

Conflict of Interest

The author provides consultancy to health care organisations.

References

Appleby J (2008) Ask a sensible question… BJHCM 14(5): 182

Bagust A, Place M, Posnett J (1999) Dynamics of bed use in accommodating emergency admissions: stochastic simulation model. BMJ 319: 155-158.

Baillie H, Wright W, McLeod A, Craig N, Leyland A, et al (1997) Bed occupancy and bed management. Report of SCO Project K/OPR/2/2/D248. www.sphsu.mrc.ac.uk/files/File/library/otherreports/BedOccupancy.pdf

Bain C, Taylor P, McDonnell G, Georgiou A (2010) Myths of ideal hospital occupancy. Med J Aust 192: 42-43

An edited version of this article has been published as: Jones R (2011) Hospital bed occupancy demystified. ***British Journal of Healthcare Management*** 17(6): 242-248. Please use this to cite.

Borg M (2003) Bed occupancy and overcrowding as determinant factors in the incidence of MRSA infections in general ward settings. Journal of Hospital Infection 54(4):316-318

Borg M, Suda D, Scicluna E (2008) Time-series analysis of impact of bed occupancy rates on the incidence of meticillin-resistant Staphylococcus aureus infection in overcrowded general wards. Infect Control Hosp Epidemiol 29: 496-502

BorgM, Cookson B, Rasslan O, Gur D, Ben Redjeb S, Benbachir M, et al (2009) Correlation between meticillin-resistant Staphylococcus aureus prevalence and infection control iniatives within southern and eastern Mediterranean hospitals. Journal of Hospital Infection 71(1): 36-42

Brockmeyer E, Halstrom H, Jensen A (2004) The life and work of A.K. Erlang. Danish Academy of Technical Sciences. http://oldwww.com/teletraffic/Erlang.htm

Clements A, Halton K, Graves N, Pettitt A, Morton P, et al (2008) Overcrowding and understaffing in modern health-care systems: key determinants in meticillin-resistant Staphylococcus aureus transmission. Lancet Infectious Diseases 8(7): 427-434

Cunningham J, Kernohan W, Sowney R (2005) Bed occupancy and turnover intervals as determinant factors in MRSA infections in acute settings in Northern Ireland. J Hosp Infect 61(3): 189-193

Cunningham J, Kernohan W, Rush T (2006) Bed occupancy, turnover intervals and MRSA rates in English hospitals. Br J Nursing 15(12): 656-660

Department of Health (2001) Shaping the future NHS: Long Term Planning for Hospitals and Related Services Response to the Consultation Exercise on the Findings of The National Beds Inquiry. 15th February 2001; http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_4009394

Department of Health (2009a) The operating framework for the NHS in England 2010/11. Dec 2009. http://www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/@dh/@en/@ps/@sta/@perf/documents/digitalasset/dh_110159.pdf

Department of Health (2009b) NHS 2010-2015 from good to great. Preventative, people-centred, productive. Dec 2009. http://www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/@dh/@en/@ps/@sta/@perf/documents/digitalasset/dh_109887.pdf

Dulworth S, Pyenson B (2004) Healthcare-associated infections and length of hospital stay in Medicare population. American Journal of Medical Quality 19(3): 121-127.

Forster A, Tugwell P, Van Walraven C (2000) An hypothesis paper on practice environment and the provision of health care: Could hospital occupancy rates effect quality. Journal of Quality in Clinical Practice 20: 69-74.

Gidney G (2008) Infection control: A tool for sustainable hospital design. University of Cambridge IDBE 12 Thesis. www.idbe.org/uploads/Gidney%Thesis%FINAL.pdf

Healthcare Commission (2009) Investigation into Mid Staffordshire NHS Foundation Trust. March 2009. http://www.cqc.org.uk/_db/_documents/Investigation_into_Mid_Staffordshire_NHS_Foundation_Trust.pdf

Hillier D, Parry G, Shannon M, Stack A (2009) The effect of hospital bed occupancy on throughput in the pediatric emergency department. Ann Emerg Med 53(6): 767:776

Jones R (2002a) Hospital bed occupancy – don't take it lying down. Health Service Journal 112(3456): 23-24.

Jones R (2002b) New approaches to bed utilisation – making queuing theory practical. Healthcare Analysis & Forecasting, Camberley, UK. http://www.hcaf.biz/Recent/Microsoft%20Word%20-%20New%20approaches%20to%20bed%20utilisation%20_2_.pdf

An edited version of this article has been published as: Jones R (2011) Hospital bed occupancy demystified. ***British Journal of Healthcare Management*** 17(6): 242-248. Please use this to cite.

Jones R (2002c) Principles for effective bed planning and management. Healthcare Analysis & Forecasting, Camberley, UK. http://www.docstoc.com/docs/61300810/Principles-for-effective-bed-planning
Jones R (2002d) Seasonal bed requirements in Paediatrics. Healthcare Analysis & Forecasting, Camberley, UK. http://www.hcaf.biz/Hospital%20Beds/Microsoft%20Word%20-%20Paediatric%20summer%20bed%20closures.pdf
Jones R (2003) Bed Management -Tools to aid the correct allocation of beds. Healthcare Analysis & Forecasting, Camberley, UK. http://www.hcaf.biz/Hospital%20Beds/Microsoft%20Word%20-%20Bed%20planning%20HMC.pdf
Jones R (2009a) Trends in emergency admissions. BJHCM 15: 188-196.
Jones R (2009b) Emergency admissions and hospital beds. BJHCM 15: 289-296.
Jones R (2009c) E-plus for beds. Healthcare Analysis & Forecasting, Camberley, U.K. http://www.hcaf.biz/Hospital%20Beds/Microsoft%20Word%20-%20E-Plus%20for%20Beds.pdf
Jones R (2009d) Building smaller hospitals. BJHCM15: 511-512
Jones R (2010a) Allocation of beds within the NHS. Healthcare Analysis & Forecasting, Camberley, UK. http://www.hcaf.biz/Hospital%20Beds/Allocation_of_Beds.pdf
Jones R (2010b) Myths of ideal hospital size. Med J Aust 193(5): 298-300
Jones R (2011) Gender factors influencing same sex accommodation. Br Jnl Healthcare Manage 17: confirm page nos (suggested money matters article).
Jones S, Joy M, Pearson J (2002) Forecasting demand of emergency care. Health Care Management Science 5(4): 297-305
Keegan A (2010) Hospital bed occupancy: more than queuing for a bed. Med J Aust 193: 291-293
Marjot D (1987) Estimating hospital bed numbers. Bulletin of the Royal College of Psychiatrists 11: 432-434.
Mc Carthy S (2010) Hospital capacity: what is measured and what is the goal? Med J Aust 193: 252-253.
Plowman R, Graves N, Griffin M, Roberts J et al (1999) The socio-economic burden of hospital acquired infection. Health Protection Agency, 1st April 1999 http://www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/@dh/@en/documents/digitalasset/dh_4089725.pdf
Pollock A, Shaoul J, Vickers N (2002) Private finance and “value for money” in NHS hospitals: a policy in search of a rationale? BMJ 324(7347): 1205-1209
Raspin C (2009) What makes ward staffing costs vary? Health Service Journal, 19th March, p15
Schilling P, Campbell D, Englesbe M, Davis M (2010) A comparison of in-hospital mortality risk conferred by high hospital occupancy, differences in nurse staffing levels, weekend admission, and seasonal influenza. Medical Care 48(3): 224-232
Sprivulis P, Da Silva J-A, Jacobs I, Frazer A, Jelinek G (2006) The association between hospital overcrowding and mortality among patients admitted via Western Australia emergency departments. Medical Journal of Australia 184(5): 208-212
Virtanen M, Pentti J, Vahtera J, Ferries J, Stansfield S et al (2008). Overcrowding in hospital wards as a predictor of antidepressant treatment among hospital staff. Am J Psychiatry 165: 1482-1486.
Wilson A, FitzGerald G, Mahon S (2010) Hospital beds: a primer for counting and comparing. Med J Aust 193: 302-304