Myths of ideal hospital size

Rodney P Jones

ABSTRACT

- Current methods used to calculate the required size of hospitals are underestimating the true capacity needed for operational efficiency.
- Trends in occupied bed-days (rather than admissions and length of stay) give better estimates of future bed requirements.
- Hospital occupancy rates depend on volatility in demand, not efficiency.
- Larger bed pools and hospitals can operate at higher average occupancy.
- Cost efficiency should be focusing on staffing based on the patients in the beds and not on the available beds.
- Hospitals require supporting climatalogical forecasts to allow for seasonal and other climate-related changes in admissions, if flexible staff deployment is to become a reality.

MJA 2010; 193: 298–300

For editorial comment, see page 252. See also pages 291, 302 and 311.

The physical capacity of a hospital should provide the environment in which patients are efficiently treated in dedicated bed pools (ie, groups of beds that meet the needs of similar patients).[1,2] Recently, there has been a call for an evidence-based debate on hospital occupancy.[3] Since occupancy and size are linked, we must open such debate to the wider issues of hospital size. Trends in occupied bed-days show that hospitals in England needed as many beds in 2007 as in 1998 — despite a large reduction in available beds.[4] Over the same period, there was a 15% increase in occupied beds in Australia (Box 1) and an upward trend in bed demand for emergency admission in Alberta, Canada (Box 2). In the absence of new ways to improve efficiency, these trends will continue. Yet, in the United Kingdom, ageing infrastructure is being replaced with smaller hospitals.[4,5] Does this process have an evidence base?

In the 1960s to the 1990s, average length of stay (LOS) was decreasing and day surgery increasing so rapidly that any attempt to forecast capacity, as long as it was lower than the existing bed allocation, was sufficient to plan the size of a hospital.[2] Indeed, bed demand could have been extrapolated to zero by around 2010. Predictably, however, by the late 1990s the decline in LOS levelled out.[2,6]

How should we "size" a new hospital?

The accepted method for calculating the required size of a new hospital is to forecast annual numbers of admissions and average LOS, multiply the two to calculate occupied bed-days, divide by 365 for the average number of occupied beds, and apply an occupancy margin.[2,7,8] Demographics of the local population are used to forecast admissions, and proposed increases in "efficiency" are used to forecast lower LOS. In the 1990s, I was involved in the planning for a new hospital. After the external demographic-based forecast of admissions at 10 years was surpassed within 2 years, I began a search to understand the real issues behind calculating a hospital size that is conducive to efficient health care.

Experience shows that demographics only give reliable forecasts of admissions for surgical procedures where the intervention rate is stable. Hence, for example, orthopaedic demand has been consistently underestimated as musculoskeletal interventions continue to evolve. Demographics have been seen to give the "right" answer simply because they underestimate future activity,[2,7,8] thereby "affirming" the perceived need to reduce bed numbers.

Emergency admissions are more severely underestimated. In Scotland, demographics explain as little as 10% of the long-term increase in emergency admissions of older people.[9] Long-term trends for admissions in some specialties follow cycles, while medical admissions appear to involve stepwise changes.[10-16] Admissions for "injury" and "infection" exhibit unique patterns.[1,16] Over 58% of emergency diagnoses are subject to a high degree of "special cause" variation.[17] Special cause variation includes all weather and environmental factors (eg, viruses) influencing health, and other sources of non-linear growth, such as changes in the way hospitals count "inpatient" admissions.[17-19] How do we explain such real-world patterns?

The link between health and the environment is widely appreciated. Long-term cycles in human longevity, sex ratio and susceptibility to disease have been linked with the cycle in solar flare intensity.[20-25] Air temperature is fundamental to health, and global warming will affect the incidence of various conditions.[26] Global warming follows a series of short, medium and long-term cycles,[27] and admissions for particular conditions might be expected to exhibit similar behaviour. Infectious diseases are periodic.[28,29] Conditions such as appendicitis show long-term trends that are unrelated to demographics.[30-32]

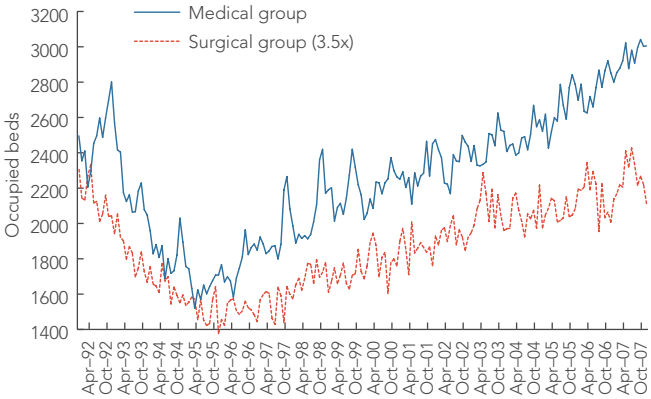
Finally, lifetime hospital bed usage is concentrated in the last year of life, irrespective of age.[33,34] Hence, demographics are only part of a complex equation where the total deaths may be the major driving force. In England, the total number of deaths peaked around 1975 and has declined since; a minimum is anticipated around 2015, followed by a steep increase.[35] We are about to enter a period where death, per se, will assume an increasing contribution to the demand for beds. The real world is not behaving in the simplistic way that our demographic forecasting implies it should

1 Annual average occupied beds in Australia

	Financial year					
	1998–99	2000–01	2002–03	2004–05	2006–07	2007–08
Total for all diagnoses*	61 148	61 559	64 491	65 284	68 286	70 253

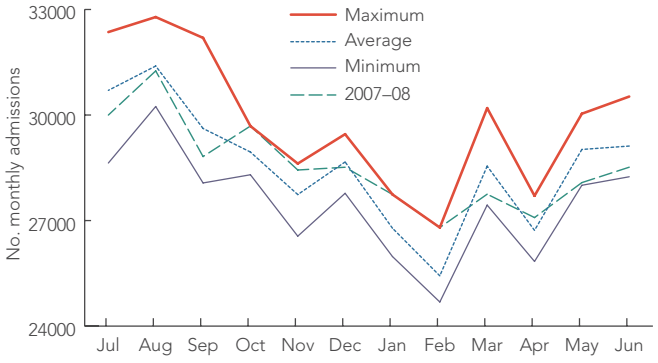
* All diagnoses in chapters I–XIX and XXI of the International Classification of Diseases, 10th edition, Australian modification. Values are total bed-days divided by 365 (days per annum), calculated from Australian Institute of Health and Welfare data available at <http://d01.aihw.gov.au/cognos/cgi-bin/ppdscgi.exe?DC=Q&E=/AHS/pdx0708> ◆

2 Trend in bed demand for emergency admission in Alberta, Canada, 1992–2007*



* Data provided by Alberta Health Services. Medical group excludes mental health, obstetric and paediatric admissions. Surgical group includes trauma and orthopaedic admissions. Influenza activity was virtually absent between Apr 2000 and Dec 2007, hence the absence of large winter peaks in this period. The trend to lower occupied beds between 1992 and 1995 marks the tail end of the period of rapidly declining length of stay. ◆

3 Variation in monthly medical admissions, New Zealand, 1993–94 to 2008–09*



* Data provided by the New Zealand Ministry of Health. Includes all medical diagnosis-related groups but excludes short-stay emergency department activity. All years have been adjusted to give total annual activity equal to that seen in 2008–09. The trend for 2007–08 illustrates how, for a single year, monthly admissions can range across all possible limits and hence the "average" is a poor planning tool. ◆

— although, much like the mythical "85% occupancy" margin, no one appears to have stopped to check why we believe what we believe.[3]

Average LOS is simply occupied bed-days divided by number of admissions.[2,8,36,37] LOS itself follows long-term trends that involve peaks and troughs and other behaviour expected of a complex, environment-sensitive system.[37] A method based on the trends in occupied bed-days has therefore been proposed as a better way to forecast bed demand.[2,7,8] Efficiency programs can be incorporated into such forecasts by moving blocks of bed-days out of the acute care setting. But what occupancy level needs to be applied to the annual average bed demand?

The occupancy margin

The occupancy margin depends on the volatility in admissions and occupied beds and not efficiency (Box 2 and Box 3).[10,13,18,19,38] Queuing theory and the Erlang equation anticipate that the real world is volatile and give insight into the occupancy appropriate to each bed pool.[2,3,39] Smaller bed pools (eg, paediatrics, intensive care) must operate at a lower average occupancy than larger ones. The seasonal component to medical admissions demands different numbers of available beds in summer and winter.[8,13,39] Bed-demand forecasts based on seasonal and climatic conditions are important for enabling hospitals to staff the anticipated number of occupied beds[40-42] (Box 2 and Box 3) rather than merely staffing the available beds or attempting to use an unreliable historical seasonal average (Box 3).

Too few beds and chaotic admission into inappropriate specialty beds result in poor patient care and inefficient LOS. The real issue is not about bed numbers but flexible staffing in the face of uncertain demand.[18,19,42] In the absence of climatalogical forecasts, coupled with too few available beds, health services have no other option but to "staff the beds" (staff being the real cost) without basing staffing on the patients in the beds. Others therefore incorrectly conclude that "beds" are expensive.

To repeat the call already made[3] — can we please have a true evidence-based debate, or will health departments continue to insist on the use of outdated and erroneous models simply because they give the perceived right answer? Both patients and clinical staff deserve to benefit from the tools required to deliver effective and efficient health care.

Competing interests

I am a senior partner and my wife is a partner of Healthcare Analysis and Forecasting.

Author details

Rodney P Jones, BSc(Hons), PhD, ACMA, Statistical Advisor
Healthcare Analysis and Forecasting, Camberley, Surrey, UK.
Correspondence: hcaf_rod@yahoo.co.uk

References

1 Jones R. Crafting efficient bed pools. *Br J Healthc Manag* 2009; 15: 613-616.
2 Jones R. New approaches to bed utilisation — making queuing theory practical. New techniques for health and social care. Harrogate Management Centre Conference; 2001 Sep 27; London. http://www.docstoc.com/docs/11432658/New-Approaches-to-Bed-Utilisation (accessed Jul 2010).
3 Bain C, Taylor P, McDonnell G, Georgiou A. Myths of ideal hospital occupancy. *Med J Aust* 2010; 192: 42-43.
4 Jones R. Building smaller hospitals. *Br J Healthc Manag* 2009; 15: 511-512.
5 Hellowell M, Pollock AM. Do PPPs in social infrastructure enhance the public interest? Evidence from England's National Health Service. *Aust J Public Admin* 2010; 69 (S1): S23-S34.
6 Nataraja S, Fontana E, Kennedy E, Wyche M. Next generation capacity management. Collaborating for clinically appropriate and cost-conscious throughput reform. Washington, DC: The Advisory Board Company, 2009.
7 Jones R. Bed management. Tools to aid the correct allocation of hospital beds. Re-thinking bed management — opportunities and challenges. Harrogate Management Centre Conference; 2003 Jan 27; London. http://www.docstoc.com/docs/5049765/Tools-to-aid-the-correct-allocation-of-hospital-beds (accessed Jul 2010).

8 Jones R. New methods for forecasting bed requirements, admissions, GP referrals and associated growth. Camberley: Healthcare Analysis and Forecasting, 2009 (revised Apr 2010). http://www.docstoc.com/docs/33984420/New-methods-for-forecasting-hospital-bed-requirements (accessed Aug 2010).
9 Kendrick S, Conway M. Increasing emergency admissions among older people in Scotland: a whole system account. NHS Scotland Information and Statistics Division, 2003. http://showcc.nhsscotland.com/isd/files/Whole_System%20_WP1_text.pdf (accessed Jul 2010).
10 Jones R. Trends in emergency admissions. *Br J Healthc Manag* 2009; 15: 188-196.
11 Jones R. Cycles in emergency admissions. *Br J Healthc Manag* 2009; 15: 239-246.
12 Jones R. Cycles in emergency admissions: supplement. Camberley, UK: Healthcare Analysis and Forecasting, 2009. http://www.docstoc.com/docs/5705782/Cycles-in-emergency-admissions-Supplement (accessed Jul 2010).
13 Jones R. Emergency admissions and hospital beds. *Br J Healthc Manag* 2009; 15: 289-296.
14 Jones R. Additional studies on the three to six year pattern in medical emergency admissions. Camberley, UK: Healthcare Analysis and Forecasting, 2009. http://www.hcaf.biz/Recent/Additional_Studies.pdf (accessed Jul 2010).
15 Jones R. Unexpected, periodic and permanent increase in medical inpatient care: man-made or new disease? *Med Hypotheses* 2010; 74: 978-983.
16 Jones R. Can time-related patterns in diagnosis for hospital admission help identify common root causes for disease expression? *Med Hypotheses* 2010; 75: 148-154.
17 Jones R. Emergency admissions and financial risk. *Br J Healthc Manag* 2009; 15: 344-350.
18 Jones R. Financial risk in healthcare provision and contracts. Proceedings of the 2004 Crystal Ball User Conference; 2004 Jun 16–18; Colorado. http://www.docstoc.com/docs/5049810/Financial-Risk-in-Healthcare (accessed Jul 2010).
19 Jones R. Financial and operational risk in healthcare provision and commissioning. Camberley, UK: Healthcare Analysis and Forecasting, 2006. http://www.docstoc.com/docs/3237700/How-statistical-variation-in-demand-affects-all-healthcare-processes (accessed Jul 2010).
20 Davis G, Lowell W. Chaotic solar cycles modulate the incidence and severity of mental illness. *Med Hypotheses* 2004; 62: 207-214.
21 Davis G, Lowell W. The sun determines human longevity: teratogenic effects of solar radiation. *Med Hypotheses* 2004; 63: 574-581.
22 Davis G, Lowell W. Solar cycles and their relationship to human disease and adaptability. *Med Hypotheses* 2006; 67: 447-461.
23 Davis G, Lowell W. The light of life: evidence that the sun modulates human lifespan. *Med Hypotheses* 2008; 70: 501-507.
24 Davis G, Lowell W. Peaks of solar cycles affect the gender ratio. *Med Hypotheses* 2008; 71: 829-838.
25 Davis G, Lowell W. Photons and evolution: quantum mechanical processes modulate sexual differentiation. *Med Hypotheses* 2009; 73: 296-301.
26 Hess J, Heilpern K, Davis T, Frumkin H. Climate change and emergency medicine: impacts and opportunities. *Acad Emerg Med* 2009; 16: 782-794.
27 Dilley DA. Global warming — global cooling: natural cause found. Ocala, Fl: Global Weather Oscillations Inc, 2008. http://www.globalweathercycles.com/GWGCNCF/index1.htm (accessed Jul 2010).
28 Dowell SF. Seasonal variation in host susceptibility and cycles of certain infectious diseases. *Emerg Infect Dis* 2001; 7: 369-374.
29 Anderson R, Grenfell B, May RM. Oscillatory fluctuations in the incidence of infectious disease and the impact of vaccination: time series analysis. *J Hyg (Lond)* 1984; 93: 587-608.
30 Livingston E, Woodward W, Sarosi G, Haley R. Disconnect between incidence of nonperforated and perforated appendicitis. *Ann Surg* 2007; 245: 886-892.
31 Kaplan G, Dixon E, Panaccione A, et al. Effect of ambient air pollution on the incidence of appendicitis. *CMAJ* 2009; 181: 591-597.
32 Alder A, Fomby T, Woodward W, et al. Association of viral infection and appendicitis. *Arch Surg* 2010; 145: 63-71.
33 Dixon T, Shaw M, Frankel S, Ebrahim S. Hospital admission, age and death: retrospective cohort study. *BMJ* 2004; 328: 1288-1290.
34 Karamanidis K, Lim K, DaCunha C, et al. Hospital costs of older people in New South Wales in the last year of life. *Med J Aust* 2007; 187: 383-386.
35 Shaw C. 2000-based national population projections for the United Kingdom and its constituent countries. *Population Trends* 2002; 107: 5-13. http://www.statistics.gov.uk/downloads/theme_population/PT107.pdf (accessed Aug 2010).
36 Jones R. Length of stay efficiency. *Br J Healthc Manag* 2009; 15: 563-564.
37 Jones R. Benchmarking length of stay. *Br J Healthc Manag* 2010; 16: 248-250.
38 Jones R. What next for 18 weeks? *Br J Healthc Manag* 2009; 15: 404-405.
39 Jones R. Bed occupancy: don't take it lying down. *Health Serv J* 2001; 111: 28-31.
40 Baldi M, Salinger J, Dirks K, McGregor G. Winter hospital admissions and weather types in the Auckland region. Australian Government Bureau of Meteorology, 2009. http://www.bom.gov.au/events/9icshmo/manuscripts/M1415_Baldi.pdf (accessed Aug 2010).
41 Hughes S, Bellis M, Bird W, Ashton JR. Weather forecasting as a public health tool. Liverpool, UK: Centre for Public Health, Liverpool John Moores University, 2004. http://www.nwph.net/Regional%20Documents/Weather.pdf (accessed Jul 2010).
42 Jones R. Emergency admissions: admissions of difficulty. *Health Serv J* 1997; 107: 28-31.

(Received 12 Jan 2010, accepted 18 Apr 2010) ❑