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

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Key Words: health service planning, bed numbers, bed planning, Erlang equation, occupancy level, adverse outcomes, staff stress, optimum efficiency, excess deaths, hospital acquired infection (HAI), Private finance initiative, NHS, England

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.

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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.

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.

Article continues.....

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Other Factors

Case Study

Conclusions

Conflict of Interest

References

- Appleby J (2008) Ask a sensible question... *Brit Jnl Healthc Manage* 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
- 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 initiatives 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

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.

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

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. *Br Jnl Healthcare Manage* 15: 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

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.

Marjot D (1987) Estimating hospital bed numbers. *Bulletin of the Royal College of Psychiatrists* 11: 432-434.

McCarthy 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

Sprivilis 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