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Unanswered questions from the international trends in hospital bed occupancy and its potential impact on hospital planning

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Key Words: Bed occupancy, health care, trends, cycles, increase in medical emergency admissions, NHS, England, Canada, Australia, infectious outbreaks, hospital design, bed planning

Key Points

- The long-term trends in bed demand show considerable deviation from simple demographic-based trajectories
- The behaviour of medical bed pools in particular seem to be subject to long-term cycles
- Unexplained step-changes in bed occupancy seem to arise from what, at first, appear to be meandering trends at diagnosis level
- Research is urgently required to understand these complex patterns.

Abstract

The ongoing rise in medical emergency admissions seen around the world over the past four to five decades has never been fully explained. Long term trends in hospital bed occupancy in England, Canada and Australia are examined to show that a recurring pattern of time-specific increases appears to apply. The possibility of a common infectious source is discussed. Whatever the cause the needs to future-proof acute hospitals against unexpected increases in bed demand is demonstrated to be more important than has hitherto been appreciated.

Introduction

A series of recent articles has been instrumental in highlighting the issue of the hospital bed occupancy required for optimum function and efficiency, and hence the wider issues around planning for adequate hospital size (Bain et al 2010, McCarthy 2010, Keegan 2010, Jones 2009 c-e, 2010n, 2011c-f, Wilson et al 2010). Part of the wider panorama will involve trends in hospital admission and in this respect the unusually high growth in medical admissions has been an enduring international enigma over the past four to five decades (Hobbs 1995, Kendrick 1995, Capewell 1996, Parker et al 1997, NZHTA 1998, Hilder et al 2000, Morgan et al 1999, LAIA 2001, Kendrick & Conway 2003, NSW Health 2007, MacDonald et al 2008, Trotter et al 2008, Roberts et al 2008, Pallin et al

2008, Jones 2009a-d,2010a-b,d,g-h,l-n, Blunt et al 2010). Up to the present these trends have been largely attributed to health care consumerism and failings in the processes and organisation of health and social care. No one seems to have asked the obvious question; could it be that there is a general trend to increasing poor health? Indeed, why have illnesses such as diabetes, allergies, asthma and other immune syndromes apparently increased in parallel with increases in emergency admissions for a wider range of illness (Hyams 1998, Anderson et al 2007, Moorman et al 2007)?

Examination of the long-term trends in medical admissions in the UK, USA, Canada (Jones 1997, Jones 2009a-d, 2010a-n) and in Europe and New Zealand (unpublished analysis) has revealed curious cyclic patterns which are reminiscent of the behaviour that would characterise an infectious disease outbreak. An excellent example of such cyclic behaviour is the observation that the incidence of syphilis (which has an element of acquired immunity) follows an approximate nine year cycle while that for gonorrhoea (no acquired immunity) does not exhibit cyclic behaviour (Grassley et al 2005). All infectious diseases involving acquired immunity have their own unique time cycle (Andersen et al 1984, Flemming et al 1991, Dushoff 1996, Dowell 2001, Koelle & Pascual 2004, Grassley & Fraser 2006). For a comprehensive review see Altizer et al (2006).

Interestingly, the pattern of surplus and deficit, accident and emergency attendance, bed occupancy and the size of the inpatient elective waiting list (a knock on effect from bed occupancy and the cycle in surplus and deficit) also appear to conform to such a cyclic pattern (Jones 2010c,h-j,l-n, 2011a). This paper will examine wider international evidence for patterns in bed occupancy which cannot be explained by demographic changes, funding or wider differences in health care organisation, policy or implementation.

Methods

General & acute available and occupied beds in England were obtained from the Department of Health's Publications & Statistics website: (http://www.dh.gov.uk/en/Publicationsandstatistics/Statistics/Performancedataandstatistics/Beds/DH_083781). Data on available beds in the period 1979 to 1986 was obtained from the Department of Health publication 'NHS Hospital Activity Statistics for England, 1979 – 1990/91'.

Monthly medical and surgical group occupied bed days for emergency admissions in Alberta, Canada was obtained from the Data Integration, Measurement & Reporting Division; Alberta Health Services. Medical group admissions are for general & elderly medicine, cardiology, endocrinology, rheumatology, etc while the surgical group comprises general surgery, urology, ENT, ophthalmology, gynaecology, orthopaedics, etc.

Table 1: Seasonal adjustment factors by age group for occupied beds in Queensland

Month	Age 16-64	Age 65+
JUL	99.8%	91.0%
AUG	96.4%	88.4%
SEP	99.4%	91.0%
OCT	98.8%	97.6%
NOV	100.2%	101.9%
DEC	105.8%	109.4%
JAN	103.6%	107.9%
FEB	97.4%	102.7%
MAR	98.9%	106.0%
APR	100.1%	107.2%
MAY	99.7%	100.3%
JUN	99.8%	96.3%

Footnote: Occupied beds in each month are multiplied by the adjustment factors to achieve seasonally adjusted bed occupancy. Note that summer occurs in mid-year in the southern hemisphere and the financial year commences in July.

Monthly total occupied bed days for emergency admissions (all acute specialties) in Queensland, Australia for the age bands 16-64 and 65+ were obtained from the Statistics Output Section, Health Statistics Centre; Queensland Health. This monthly data was first divided by days per month to get monthly occupied beds and this was then adjusted for seasonal behaviour. The seasonal adjustment

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was achieved by minimising the sum of absolute differences between successive months over the nine year time series by applying monthly seasonal factors which were determined using the Solver function within Microsoft Excel. The resulting seasonal adjustment factors for the financial year (July through to June) are given in Table 1.

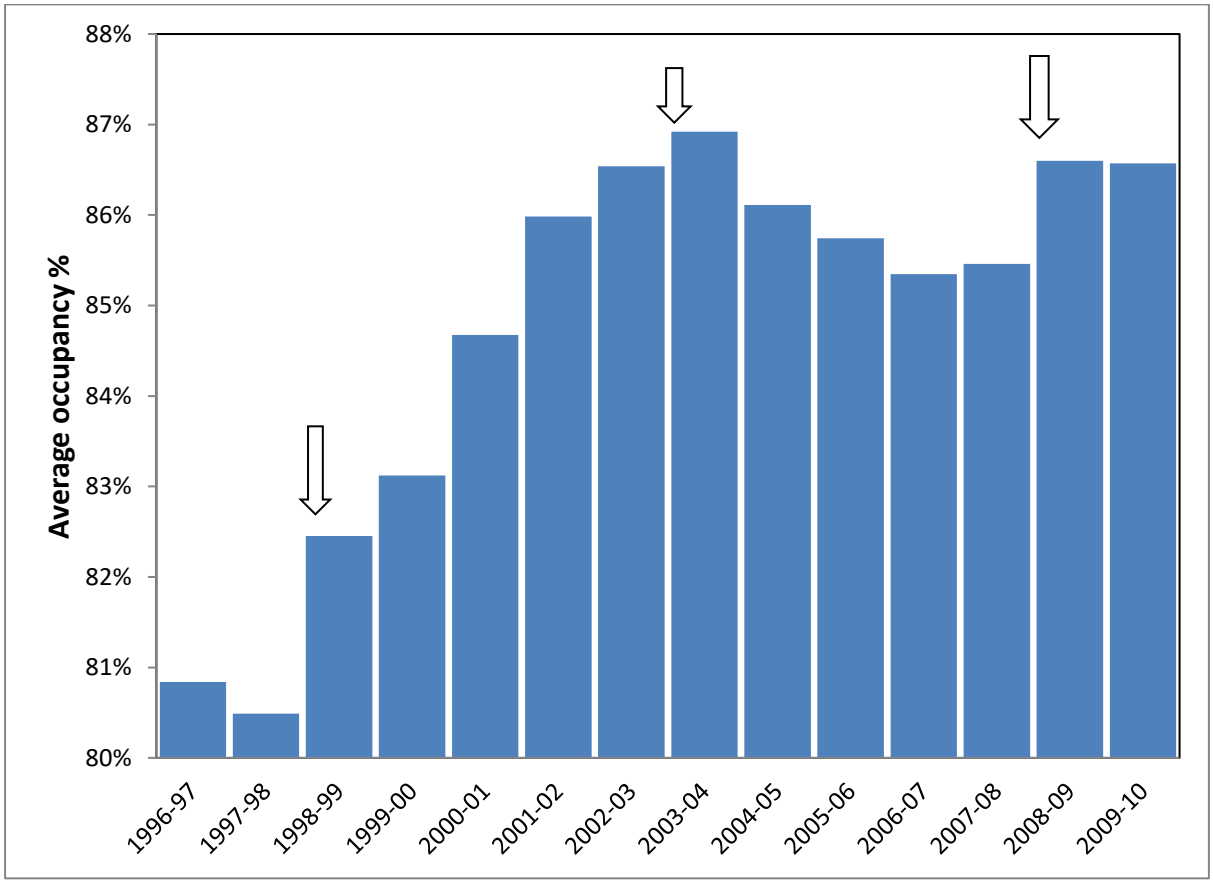
Total occupied bed days (elective and emergency) in Australia from 1993/94 onward were obtained from the Australian Institute of Health & Welfare (AIHW) website in the section relating to 'Principal diagnosis data cubes' (http://www.aihw.gov.au/hospitals/datacubes/datacube_pdx.cfm).

Results

Examples of long-term trends in bed demand (as occupied bed days or percentage occupancy) are given in Figures 1 to 4 and the key features to note in all cases are as follows:

- Non-linear trends over time which defy explanation
- Relatively rapid shifts which cannot be explained by demography
- Evidence for long-term cyclic behaviour

Figure 1: Average percentage occupancy in English hospitals



Footnote: *Average occupancy for general and acute beds, i.e. excluding maternity and mental health*

The first examples are from England where the trends in annual average bed occupancy (Figure 1) are given for what are called general and acute admissions, i.e. a combination of both elective and emergency admissions for all acute specialties excluding obstetrics and mental health. It is immediately apparent that the long-term trends are complex. The arrows indicate the point where step-like increases in medical emergency admissions have been proposed to occur. These correspond with changes in percentage bed occupancy. Occupied bed data is not available prior to

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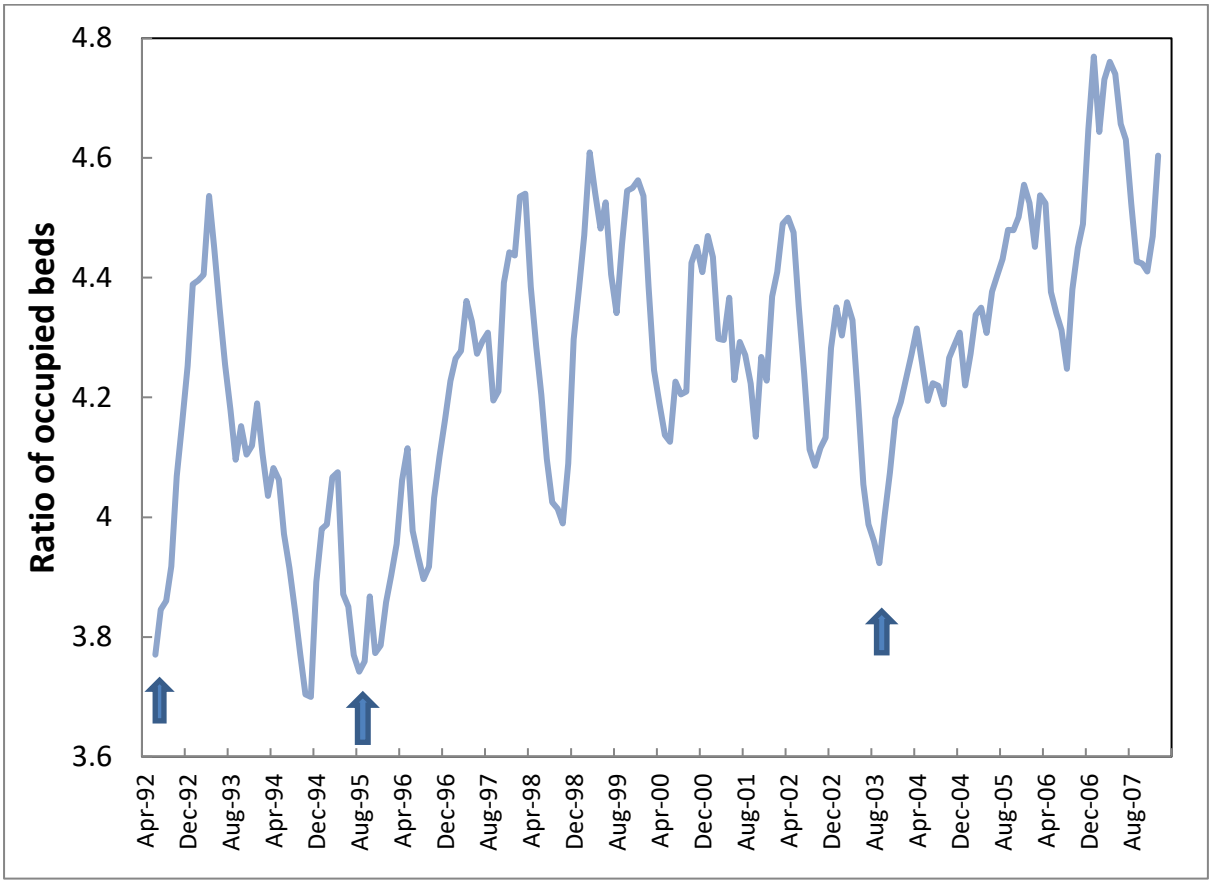
1996 although the data for total available beds in this period does show inflection points which correspond to presumed similar events (unpublished observations).

The curious trend upward commencing around 2000/01 appears to be related to an additional unexplained increase in both admissions and bed occupancy relating to accidents and injury (Jones 2009g) and is linked to a short period of increasing deaths set against a general backdrop of an otherwise reducing trend to lower deaths per annum (Jones 2011c). This anomaly in itself requires further investigation but, none the less, confirms the suspicion that increasing bed usage in the last months of life has a far greater influence on bed demand than has been hitherto appreciated (Jones 2011c-d).

Figure 2: Ratio of medical to surgical emergency bed occupancy, Alberta Canada



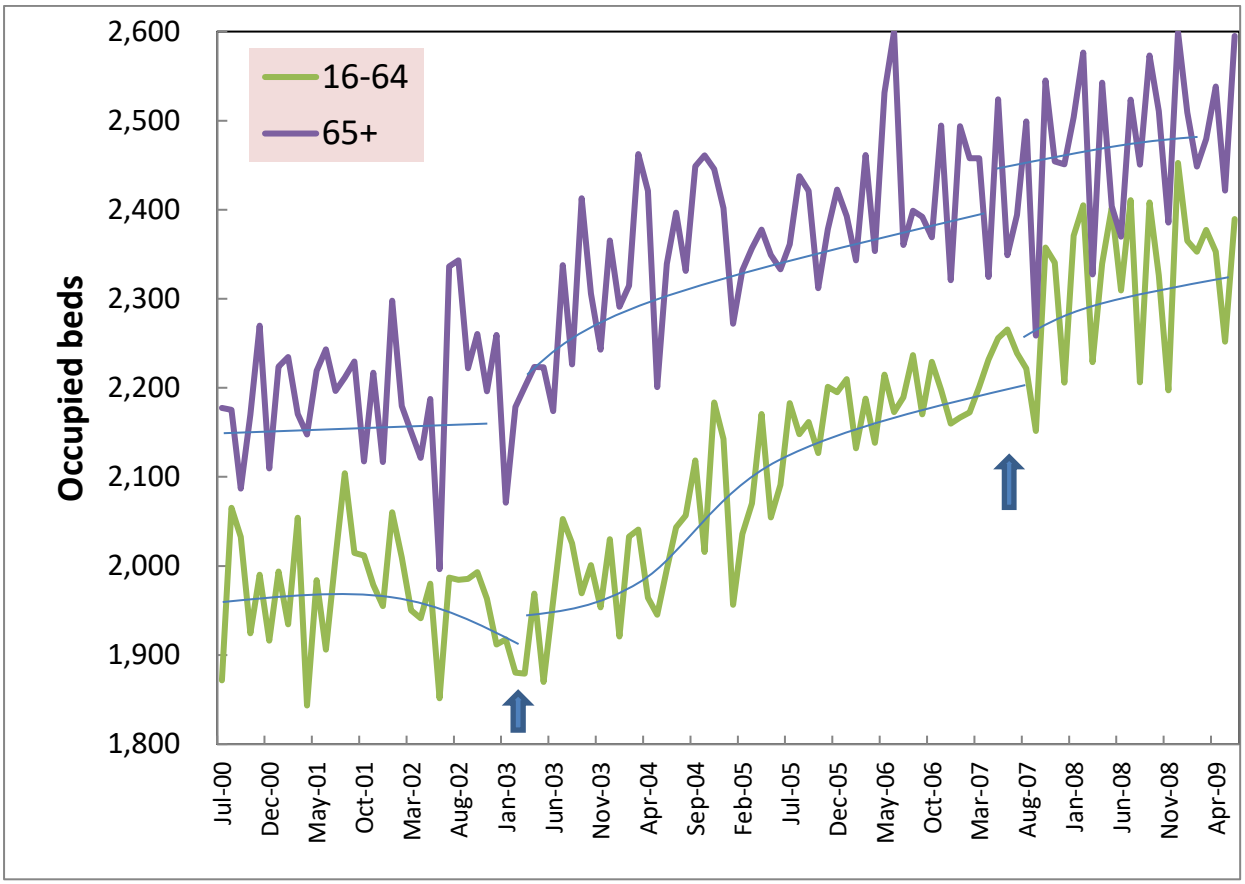
Footnote: The trend is a running five-month average centred on the third (middle) month

To explore the specific issues around medical bed occupancy in more detail Figure 2 presents the ratio of occupied beds for emergency admissions in the medical specialties compared to the surgical specialties in the province of Alberta, Canada. This ratio has been chosen to factor out the long-term trend to lower length of stay which should be occurring at roughly the same pace of change across all specialties. As can be seen this ratio appears to follow three broad cycles which commence at the point where a step-like increase in medical admissions appears to occur (Jones 2010l-m). Within each of the broad cycles there is considerable short-term variation in the ratio of demand for medical relative to surgical beds which is partly due to seasonal influenza epidemics in the period 1992 to 2000 and the less defined summer/winter differences in medical bed occupancy across the whole time period (Jones 2009c, 2010n).

The monthly time series in Queensland, Australia for emergency admission to the acute specialties is equally intriguing (Figure 3) with unexpected growth in bed demand for the younger age group and

two step-like increases in bed occupancy which initiate the onset of two broad cycles in early 2003 and mid-2007.

Figure 3: Trends in occupied beds for emergency admission, Queensland



Footnote: Monthly bed days have been adjusted for days in the month and seasonal factors. Data excludes maternity, newborn and boarders.

The early 2003 date corresponds broadly to that seen in Canada and England as does the 2007 date with England and data for one hospital in the neighbouring state of NSW (unpublished analysis). In addition, bed occupancy appears to enter an unstable state for the 16-64 age group following the 2007 step-like change, i.e. monthly peaks and troughs in bed demand are accentuated even after seasonal adjustment. Recall that Queensland is a large and geographically diverse area and the complex patterns seen in this figure may partly arise from an initial locus followed by wider spread.

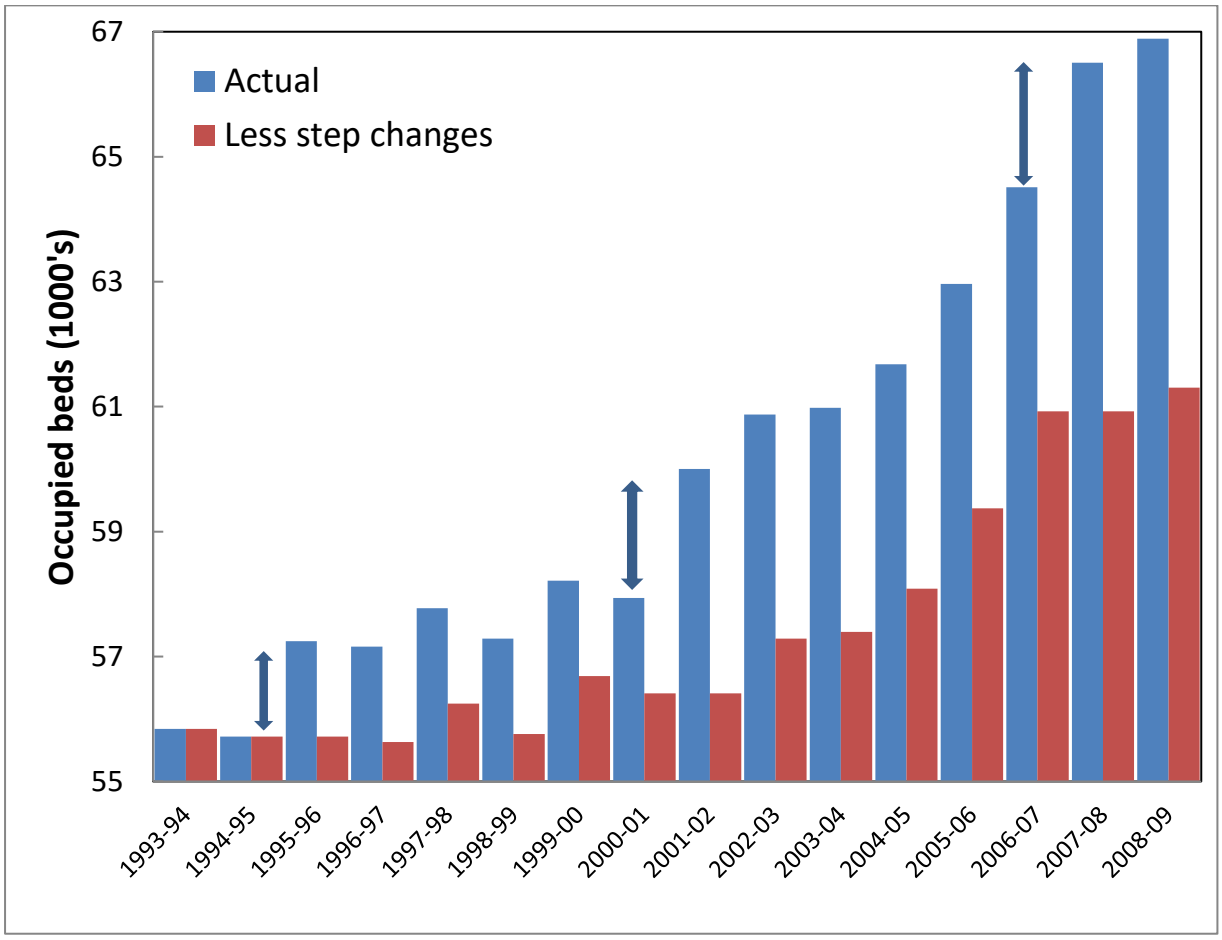
Lastly, the trend in total occupied beds for the whole of Australia is given in Figure 4. This trend includes both mental health and private beds (a far higher proportion of elective work is conducted in the private sector). Several points where a step-change may have occurred appear to exist and stripping out these step-changes in bed demand gives a potential trend with substantially lower present-day bed demand. After stripping out these changes, bed demand could have been said to follow a trajectory expected of demographic change up to around 2002 or 2003 and beyond this point the trends show an unexpected increase which is partly reflected in an increase in the total bed days per death (Jones 2011c).

Discussion

This study is focussed on examination of long-term trends. The highly variable nature of the short-term seasonal trends have been discussed elsewhere (Jones 2009c, 2010n) and it is important to note that the seasonal adjustment factors in Table 1 are different between the two age groups. The

aim here is to stimulate research into the real forces regulating acute bed demand. To achieve this end, trends have been shown which ask more questions than they give answers. Acute bed demand is subject to forces which are poorly understood and hence it has been easier to rely on the existing 'politically correct' methodologies than to ask uncomfortable questions based upon the long term trends or the underlying mechanisms (Bain et al 2010, Jones 2010n).

Figure 4: Total occupied beds in Australia



Footnote: Prior to 1995/96 some 1 million bed days have been added to the AIHW data to account for a deficit in mental health occupied bed days.

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 (Jones 2009e) – apparently irrespective of the consequences (Jones 2011e).

Previously it was stated that bed occupancy is a function of the volatility in demand rather than efficiency (Jones 2010n) and it is of interest to note that the volatility in bed demand observed in Fig. 3 for Queensland (calculated as a five month running average of the absolute difference between successive months divided by the average occupied beds) ranges from 2% in June-06 & February-09 to 9% in May-02 & July-07 for age 65+ and from 1% in Aug-05 to 8% in February-08 for the 16-64 age group.

The patterns over time are complex (data not shown) and this concurs with my own unpublished studies on the volatility associated with bed occupancy using daily data from the UK. It should be clear that bed demand and its associated volatility is an area requiring far greater investigation given its fundamental role in determining the size of the total bed pool. We seem to be building hospitals

based upon a profound ignorance of the fundamental issues regulating the demand for hospital beds (Jones 2009c,h, Jones 2011c-f).

The existence of a new type of infectious disease has been proposed in an attempt to explain the common cycle-like feature of the international trends. Wider discussion has been given elsewhere (Jones 2009a-d, 2010d-m, 2011a,b) and other explanations may exist, however, further research is needed to understand reality rather than seeking to hide behind the familiar existing explanations relating to the ageing population. The relationship with demography is, of course, partly true in so far as chronological age is a proxy for measures of real biological age, associated co-morbidities and resulting risk scores (Rayner et al 2002, Donnan et al 2008, Horne et al 2009, Mayor 2009, Huzen et al 2010). Hence the application of demography into health planning suffers from what is called the constant rate fallacy (Nicholl 2007).

The curious behaviour seen in Queensland appears to be a repeat of a pattern of increasing bed demand and cost seen around the world and could suggest a common infectious outbreak-like source. Bed occupancy for the over 75's in Australia between 1995/96 to 2001/02 declined by 14% despite a relatively constant admission rate (Gray et al 2004) and hence the proposed step-changes in occupied beds for Australian require further exploration. Is it a co-incidence that step-like increases in the incidence of Herpes zoster in Australia (Nelson et al 2010) appears to follow a similar time-dependant cycle of increase followed by decrease to the one proposed for the UK?

It can be appreciated that attempts to explain these cycles based on common demography or policy would be exceedingly difficult. It is also of interest to note that all three countries cluster in a broadly similar group regarding pharmaceutical usage but differ in the total expenditure on health care (Richards 2010).

The 'old chestnut' of poor data quality has often been used to deflect consideration away from what the trends may actually be trying to say to us. Data quality issues are mainly confined to the clinical coding of diagnosis and procedure and as such do not alter total bed demand per se, i.e. these issues simply move the occupied bed days between diagnostic categories. The trend seen in Figure 2 between 1999/00 and 2002/03 which is partly due to an unexplained increase in admissions for accidents and injuries is one example (Jones 2009g, 2011c). If this were simply due to a change in coding there would be no associated increase in total bed demand.

At this point, the relevance of the apparent step changes in bed occupancy across Australia come into focus. Delving behind the trend in total occupied beds shows that at diagnosis chapter level the apparent meanderings of bed occupancy in each chapter 'conspire' to create the step changes in bed demand. Clearly such regular 'conspiracy' of numbers should not be happening (as seen in Queensland). It was the analysis of such apparently meaningless trends in the UK data which led to the identification of a group of common medical and mental health diagnoses associated with step-changes in admission and bed occupancy (Jones 2010a-n). Interestingly, a remarkably similar group of diagnoses is associated with a similar step-like increase in late 2007 for a hospital in NSW (Jones 2011g). There is far deeper complexity in the medical bed pool than has hitherto been appreciated.

International trends of this order of magnitude demand an explanation. It is of interest that the ubiquitous herpes virus, Cytomegalovirus (CMV) which is capable of infecting almost all organs and tissues, has been increasingly implicated in premature aging, as a risk factor behind many diseases and immune based disorders (Derhovanessian et al 2009, Miller-Kittrell & Sparer 2009, Pawelec et al 2009, Varani et al 2009, Vescovini et al 2010, Varani et al 2010, Van de Berg et al 2010, Wang et al 2010).

Hence the wide spectrum of potential diagnoses arising from the multiple actions of this virus do seem to match the diagnoses which appear to be associated with the agent(s) leading to the curious behaviour in medical admissions and bed occupancy demonstrated here. The unexplained part is the mechanism by which the apparent international 'pandemics' occur over time, however, the well-

known longer term cycles in incidence arising from viral and other diseases (Altizer et al 2006) suggests that CMV may be no exception (Jones 2011b).

Conclusion

While the author has stated that trends in occupied bed days may provide more accurate forecasts of future bed requirements than the current methods based on demographic change (Jones 2010n, 2011c-d), it is obvious that any estimate of future requirements will always be uncertain. Indeed even more so if the mechanisms regulating growth are not understood. The suggested unique behaviour behind certain medical and mental health diagnoses requires considerable research input.

It goes without saying that replacing acute beds with bed equivalents in alternative settings is part of the wider picture, however, attempts to build hospitals which may be too small is likely to lead to considerable waste and inefficiency as 'unexpected' trends start to emerge. Given the uncertain nature of the trends demonstrated here it would be wise to allow a margin of safety to accommodate both the short-term summer/winter annual cycle in bed demand and the longer-term cycles in bed demand and length of stay which still remain poorly understood (Kulinskaya et al 2005, Liu et al 2008, Jones 2009a-d, 2010a-n).

Competing Interests

The author provides consultancy to health care organisations.

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