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Does demand for hospital beds depend more on death than demography?

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Part 1 of a 3 part series investigating the factors behind acute hospital size and the trends in bed demand.

Key Words: health service planning, forecasting demand, hospital bed numbers, bed planning, new methods, trends in death, demographics, constant rate fallacy, morbidity and mortality, occupied bed days

Key Points

- Over the past 15 years co-incident trends to lower length of stay and number of deaths per annum in England has created the appearance of the need for fewer hospital beds
- In both England and Australia the number of hospital bed days per death has remained remarkably constant for the past 15 years
- From 2015 onward total deaths per annum in England will begin to increase as the leading edge of the WW II baby boom draws toward the end of life
- Hospitals constructed in the last 10 years are likely to be too small for current and future bed demand
- Investment in community-based end of life care is urgently required to provide bed-equivalent alternatives to an acute admission

Abstract

The leading edge of the post World War II baby boom turned 65 in 2010 and in this respect a person's lifetime utilisation of a hospital bed is concentrated in the last 12 months of life (irrespective of age at death). Studies show that demographic-based forecasts for emergency admission underestimate future demand by over 60% (the underestimation increases in the higher age bands). However, despite large differences in the trends for death over the past 15 years the ratio of bed days per death in both Australia and England has been remarkably stable. A 10% increase in deaths leads to a 9.6% to 11% increase in occupied beds. The current methods used to size acute hospitals require urgent investigation. If the current model of care continues then hospitals constructed in the past 10 years are likely to be too small for both current and future demand given the anticipated increase in total deaths from 2015 onward.

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Introduction

The linkage between death and the requirement for hospital beds has been recently suggested to be a totally neglected aspect of models which forecast future demand for hospital bed numbers (Jones 2010a). Current models for forecasting health care demand rely almost exclusively on the assumption of demographic change or what is called the ageing population (Jones 2001, 2002, 2003, 2010a,b). However, demographic forecasts suffer catastrophically from what is known as the constant rate fallacy (Nicholl 2007), i.e. chronological age is only a crude approximation to the need for medical care in the face of biological age (as opposed to chronological age), multiple risk factors and changing patterns of morbidity and mortality (National Centre for Health Statistics 1965, Busse et al 2002, Rayner et al 2002, Dixon et al 2004, Jemal et al 2005, Walker et al 2005, Donnan et al 2008, Ingarfield et al 2009, Mayor 2009, Horne et al 2009, Atlantis et al 2010, Huzen et al 2010). Hence one study for elderly people in Scotland showed that demography could only explain as little as 10% of the long term growth in hospital admissions (Kendrick & Conway 2003) and another in England suggested that demography could only explain 40% of the all-age growth in emergency admissions (Blunt et al 2010). The study in Scotland demonstrated that the underestimation of future admissions increased with age although in both countries it was the zero and one day stay admissions which accounted for the bulk of growth (Pettinger 2001, Blunt et al 2010).

However, numerous studies have demonstrated that it is the approach of death per se (independent of the age at death) that determines the bulk of both elective and emergency hospital bed usage, especially in the last year and, more so, the last six months of life (Seshamani et al 2003, Round et al 2004, Dixon et al 2004, Karamanidis et al 2007, Pot et al 2009, Blunt et al 2010). Within this general situation it would appear that the healthy elderly have around one year of poor health at the end of life while those with chronic conditions tend to experience around three years of poor health (Mayhew 2001) and those who die aged over 50 may experience total bed usage which is proportional to the number of years lived (Busse et al 2002).

In England some 58% of people die in hospital (Balance of Care Group 2008, Department of Health 2008) and in recent years the need for end-of-life care has become a major health policy and social issue (Currow et al 2008, Kings Fund 2009, Bardsley et al 2010, Leadbeater & Garber 2010). In view of the above we need to ask; why does demography and not death feature exclusively in current models for hospital bed numbers? The answer to this question lies partly in that the models were developed at a time when rapidly reducing length of stay dominated the issue of hospital size (Jones 2002, 2003, 2010a,b) and partly because the continued use of these models give conveniently low

estimates of size and thus a perception of reducing capital and staff costs (Jones 2010a, Pollock et al 2002).

Elective versus Emergency

While numerous studies indicate that the highest proportion of lifetime bed usage occurs in the last year of life how does this concur with our perception that elective patients are generally younger? In 2008 the most common age for death in England and Wales was 87 while the average was 76 years. As long as the average age for a hospital admission is closer to the average age for death than it is to birth, then death becomes an excellent proxy for both elective and emergency demand. Some 75% and 50% of elective and emergency occupied bed days in England occur for diagnoses with an average age above 48 and 61 years respectively and admissions to diagnoses where the average age is below 30 years only account for 5% of total bed days. In this respect Table 1 gives the average age for any type of admission (elective + emergency) to a variety of specialties during 2008/09 in England while Figure 1 shows the role that age plays in the average length of stay (LOS) for those admissions. As can be observed the most common age for death (87 years) coincides with the point of maximum length of stay.

Hence, while it may be argued that demographic factors will play a role in fine tuning the calculated future bed demand it is clear that the approach of death (i.e. admission in the last quarter to half of the life span) is a very good proxy for a large proportion of the bed demand. Indeed, the demographic contribution may be largely restricted to the role which age *per se* plays upon the overall average LOS (Fig. 1). In this respect it should be noted that the considerably lower LOS associated with admissions for those aged 90+ (comprising 17% of deaths in 2008) will be largely due to the fact that for this group the admissions will be associated with death in hospital and this will act to truncate the LOS (Knaus et al 1991).

To summarise, actual admission data contains the suggestion that bed demand may be strongly linked to the approach of death rather than demography and does not conflict with the record linkage studies which have linked admissions relative to the point of death. The bulk of admissions and especially bed days occur toward the later part of life and hence trends in death become the primary factor determining bed demand.

The Trends

Is it possible to demonstrate a time-series to show that the number of deaths per annum should be an intrinsic part of the planning for future health care costs and hospital size? Figure 2 shows the trends in deaths and occupied beds in England over the period 1979 to 2010. Several features are relevant to understand the issues involved.

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1. The gap between the two lines is an approximate measure of the LOS, hence, between the two arrows the average length of stay underwent a period of rapid reduction. This rapid reduction mirrored international trends in LOS for this period of time (Jones 2002, 2003, 2010a, Wier et al 2010).
2. Prior to December 2000 seasonal influenza epidemics lead to an enhanced degree of saw-tooth behaviour in the deaths data and we can once again expect to see this behaviour from late 2009 onward. The saw-tooth behaviour arises as the influenza epidemic causes excess mortality in susceptible individuals leading to fewer deaths in the following summer and vice versa (Stafoggia et al 2009).

The nature of the linkage between deaths and beds is best illustrated during the two periods when length of stay was relatively constant and this is explored in Figure 3 where it can be observed that after discounting the effects of major influenza epidemics (years when deaths are very high) there is a strong degree of parallel behaviour between the two trends. It would seem that the excess deaths due to influenza are not fully reflected in bed usage. Obviously some additional bed utilization will occur during such epidemics but this is relatively moderate in relation to the whole year bed utilisation, i.e. some events leading to death have an attenuated effect on hospital bed utilisation. As a general comment the deaths trend downward only slightly faster than occupied beds and an approximate linear relationship of a 9.6% increase in occupied beds for a 10% increase in deaths can be derived from the data in Figure 3 (via linear regression).

Especially relevant is the period between 2000/01 and 2003/04 where the generally reducing trend in deaths and occupied beds was interrupted by a short period of upward trajectory where a modest increase in deaths is magnified into a larger increase in occupied beds. In this period a 10% increase in deaths led to an 11% increase in occupied beds, i.e. total bed days prior to death has increased by 10%. Such a localised increase is set against the ongoing general reduction in length of stay although for particular diagnoses individual lengths of stay may have changed. It has already been pointed out that this unique period was characterised by a totally unexpected and unexplained increase in hospital admissions characterised by diagnoses related to accidents and injuries (Jones 2009d), i.e. unexpected trends in bed demand do occur where events leading to death have a magnified effect on hospital bed occupancy. On this occasion “accidents and injury” could be interpreted in the context of increased frailty. Indeed my own (unpublished) research into this curious relationship shows that the increase in occupied beds during this time was generally reflected in any diagnosis where the average age at admission was higher than 60, i.e. the association between deaths and occupied beds is highly plausible. After this unexpected event both bed demand and deaths then

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abate and this leads to the question as to how many of these unexpected trends will arise in the future?

International Comparisons

Having investigated the possibility that death may be a better indicator of future bed demand it is useful to apply this method to explore the trend in bed days per death in both Australia and England over the past 15 years (see Figure 4). As can be seen there is remarkable constancy in the number of bed days per death over time despite considerable changes in population size and age structure, government health policies, funding and medical technology. Indeed the greatest difference lies in the fact that over the 15 years deaths in Australia rose by 19% while those in England fell by 13% and yet the bed days per death in both countries remained relatively constant (subject to the exceptions discussed in relation to Figure 3). This observation confirms the fundamental integrity of death as a predictor of future bed requirements.

Given the known role of mental health in contact with the health services (Keene & Rodriguez 2007) and the fact that up to 40% of people who commit suicide make contact with accident and emergency (A&E) in the year before death (Gairin et al 2003) it is suggested that the proposed method also applies to aspects of mental health as indicated by the high average age in Table 1.

As detailed in the footnote to Figure 4, a figure of 45 bed days per death has been added to the data from England to facilitate comparison. After accounting for the various sources of undercounting in the English data this still leaves a gap of around 10 to 15 bed days per death between the two countries. In the area of mental health it is well recognised that the requirement for hospital beds can be increased or decreased by the quality of care delivered in the community (Davis et al 1998, Davis & Lowell 1999). The boundary between acute, community and social care can be equally influential in determining acute hospital utilisation particularly toward the end of life (Phelps & Shepperdson 1998, Jarman et al 2004, Bardsley et al 2010). Understanding the gap between the two countries may therefore give additional insight into the absolute requirement for hospital beds under the more challenging conditions afforded by the lower population density and harsher environmental conditions encountered in Australia.

What of the future? A recent review of the trends in place of death over the period 1974 to 2003 in England has noted two vital points (Gomes & Higginson 2008). Firstly while deaths fell by 8% between 1974 and 2003 they are expected to rise by 17% between 2012 and 2030 and at the same time home deaths are projected to fall from around 31% to 18%. The authors conclude that ‘either inpatient facilities must increase substantially, or many more people will need community end of life care from 2012 onward’.

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Implications

The balance between acute and community-based bed equivalents is a choice or outcome from how the totality of health care is delivered. Total bed or bed equivalent demand is going to increase and if the status quo is maintained the bulk of this increase will arise in the acute bed pool. Based on the analysis presented in this article acute costs will increase in direct proportion to future numbers of deaths per annum unless a shift to community or home-based equivalents is commenced.

Health care policy relies on the availability of fundamentally sound models to assist in the tactical implementation of such policies. The tendency of current bed models to grossly underestimate future acute demand is a major concern since it has the potential to mislead health care commissioners regarding the absolute imperative for investment in end of life care. Anecdotal evidence is that fledgling GP commissioning groups are investing in schemes to reduce GP referral and elective surgery which have a minimal impact upon bed demand. Hopefully investment in end of life care is also being considered.

While effective alternatives to acute based care at the end of life will reduce acute costs the difficulty arises in estimating the size of the potential shift. Based on a 20 year career in health care the authors experience is an almost universal predisposition of health care planners to overestimate of the impact of such changes, which in itself, leads to perverse increases in acute demand due to a revolving door effect similar to that seen in mental health (Davis et al 1998, Davis & Lowell 1999).

In the UK, issues around the affordability of private finance initiative (PFI) acquired new building stock (Pollock et al 2002) has led to a reduction in the acute bed pool which cannot be justified by the actual trends in occupied bed days (Jones 2009c). The point of relevance is that ‘excess’ acute beds are not the issue. Beds are simply a physical resource needed to allow the delivery of the focussed acute care required to maintain a virtuous downward cycle of lower acute bed days per death. It is for this reason that the poorly understood issues regarding the necessary average occupancy for optimum acute efficiency is discussed in the following article of this series (Jones 2011).

Conclusions

The whole aim of constructing a hospital at the correct size is to achieve optimum efficiency by placing the patient in the correctly resourced specialty bed pool. More beds do not imply more staff (Jones 2001, 2009c-d, 2010a) but simply gives the resource (or physical capacity) into which patients can be admitted into a bed pool with resources dedicated to their reason for admission and in which staff can be flexibly employed to achieve the goal of staffing the patient and not the beds. To build a hospital too small only leads to chaos, inefficiency and increased in-hospital deaths (Jones 2011).

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It should be apparent that the coincident reductions in length of stay and a decline in deaths in England from the 80's to the present acted to mask the catastrophic propensity of demographic-based methods to vastly underestimate future demand. Given the universal use of demography in bed forecasting it is probable that no one was willing to be the odd man out and question the status quo. Departments of Health around the world need to urgently review the basis for bed modelling and invest resources into understanding which aspects of mortality lead to the greatest impacts on bed utilisation. Admission for mental health issues is part of a wider spectrum of inpatient care (Figure 4) and given the somewhat hazy boundary between mental health and acute care it is important to realise that underestimation of the bed requirements in one may cause an knock-on increase in the other.

Demography may well play a role in projecting bed demand for elective interventions and some aspects of emergency care which are not related to end of life. However the key point is that the certainty of ultimate death implies that even if bed utilisation was only concentrated in the last half of life then the number of deaths per annum would still give a good indication of bed requirements, i.e. bed utilisation can occur before death but never after. Allowance needs to be made for unexpected trends to emerge and for other crisis situations and contingencies for the occupancy margin and summer/winter patterns of bed demand (Jones 2009a-b, 2010a). Strategies for end of life care do need to be implemented but cannot be relied upon to completely eradicate the increased bed demand which will arise from 2012 onward in England & Wales. Death in hospital is only one part of the increasing bed demand which occurs during the last 12 months of life and amidst the difficult set of end-of-life decisions it is difficult to actually judge who is or is not in the last 12 months of their life (Emanuel & Scandrett 2010). The apparent increase in bed days per death in Australia relative to England which commenced around 2000/01 requires further investigation to see if it is related to the boundary between health, primary and social care or to other factors.

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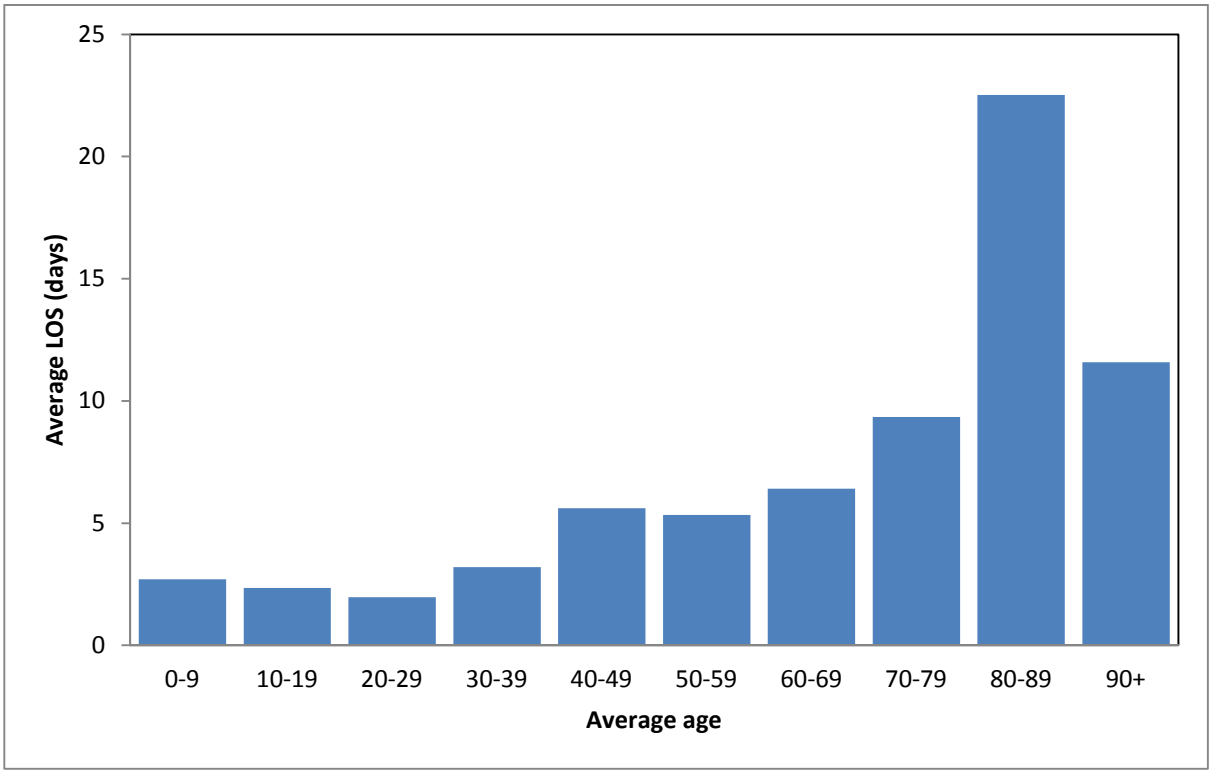
Table 1: Average age at admission

Specialty	Average age	Proportion of beds
Geriatric Medicine	78	15%
Ophthalmology	69	0.2%
Rehabilitation	68	1%
Cardiology	65	2%
General Medicine	64	23%
Urology	62	2%
Thoracic Medicine	62	1%
Cardiothoracic Surgery	59	1%
General Surgery	55	9%
Trauma & Orthopaedics	53	9%
Adult Mental Illness	50	16%

Footnote: Hospital admissions in England during 2008/09. From www.hesonline.nhs.uk

Figure 1: Average length of stay and age



Footnote: Admissions and occupied bed days for each diagnosis (3 digit ICD-10 code) for the eleven year period 1998/99 to 2008/09 were grouped by average age into ten year age bands. The sum of bed days was divided by the sum of admissions to get average length of stay. Data from www.hesonline.nhs.uk

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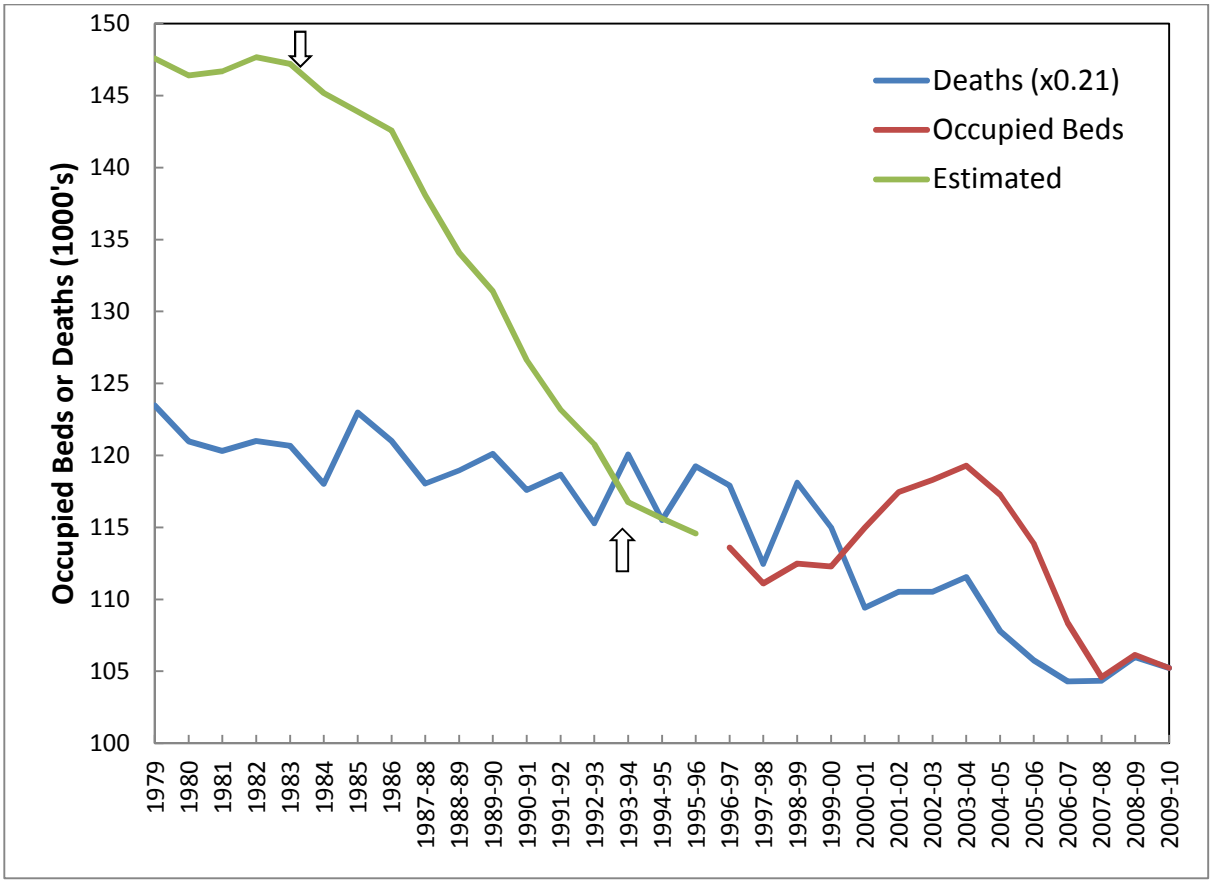
Figure 2: Trends in deaths and acute bed occupancy for England



Footnote: See appendix.

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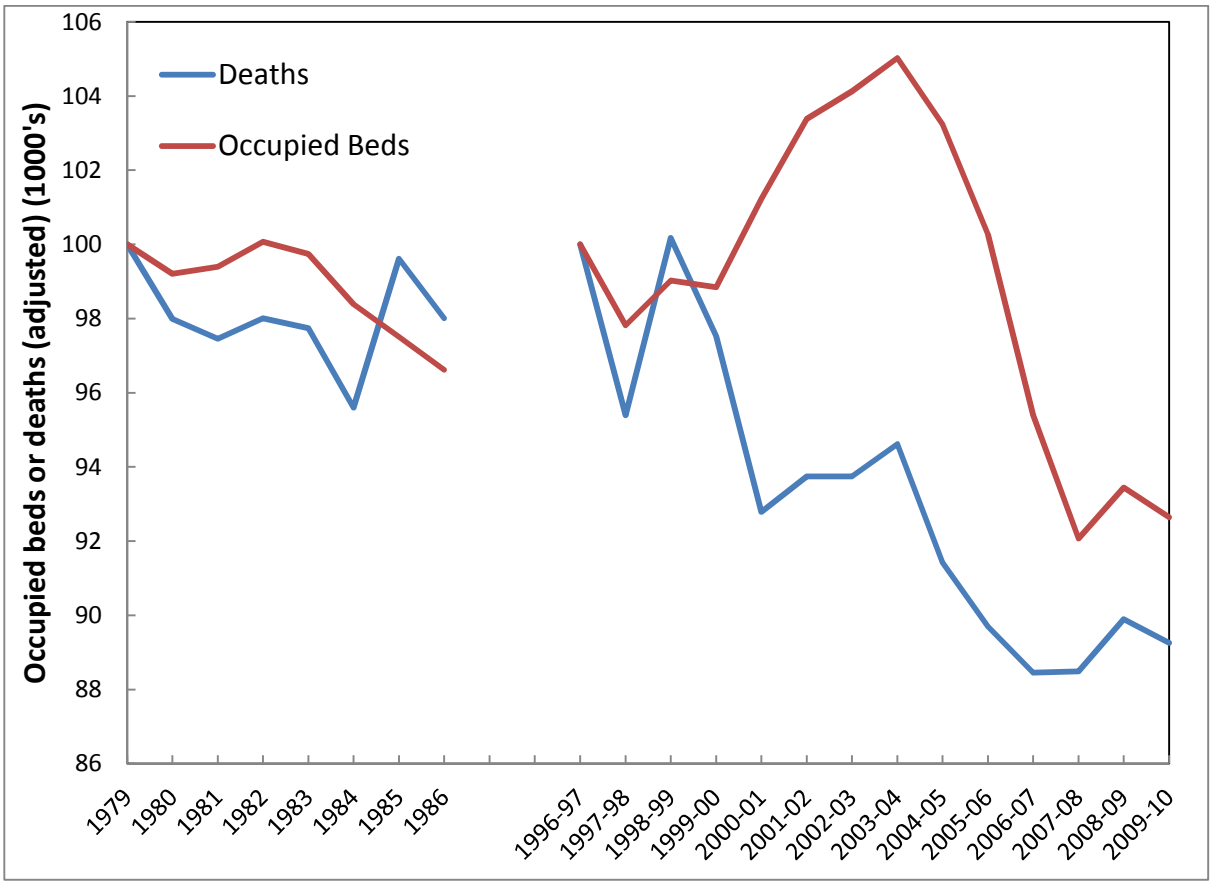
Figure 3: Deaths and occupied beds when length of stay is not undergoing rapid change



Footnote: Data sources as per appendix. Both deaths and occupied beds have been adjusted to 100 at the start of each time series. This adjustment brings the two lines into reasonably close proximity for the purpose of visual inspection.

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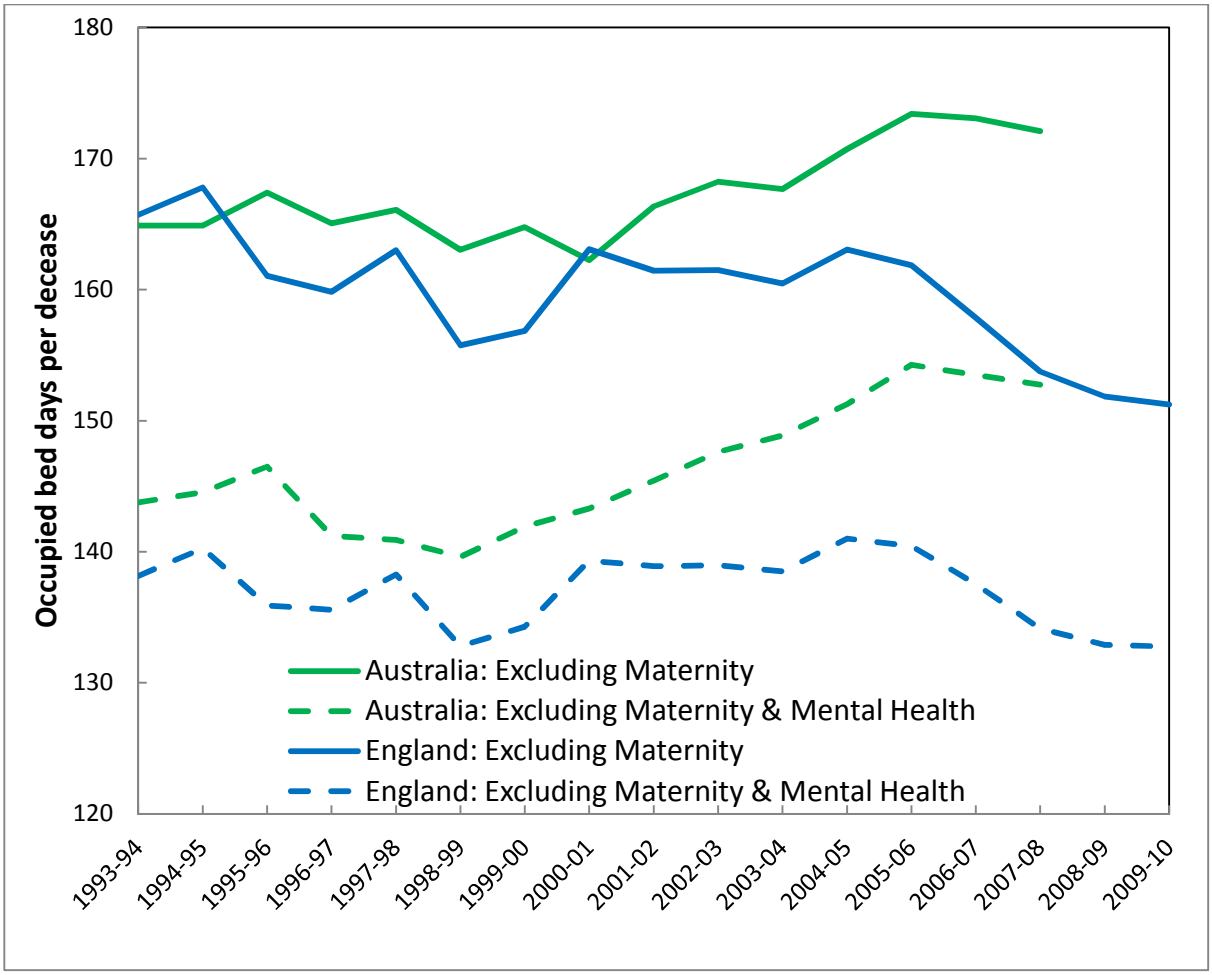
Figure 4: Occupied bed days per death in Australia & England



Footnote: See appendix

Appendix:

For figure 2 data covering deaths in England and Wales was kindly provided by the UK Office of National Statistics. From 1979 to 1986 calendar year data has been used and beyond that monthly data was used to construct the corresponding financial year totals. The financial year runs from April to March in the UK. 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'. General and acute includes all acute specialties but excludes maternity and mental health. Occupied beds prior to 1996/97 were estimated from total available beds under the assumption that bed occupancy had reduced by 0.5% per annum between 1979 and 1995/96. Under this assumption average occupancy in 1979 was estimated to be around 72.3% compared to an actual figure of 86.6% in 2009/10.

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For Figure 4 annual deaths in Australia from 1998 to 2008 were obtained from http://www.abs.gov.au/ausstats/abs@.nsf/Products/768A44A87AE119A9CA2576880020ED54?opendocument – Calendar year data was converted to financial year by averaging between years.

Total occupied bed days for both elective and emergency admission in Australia were obtained from: **http://www.aihw.gov.au/hospitals/datacubes/datacube_pdx.cfm** Data sources for England as per Figure 2. A figure of 45 bed days per death has been added to the total to close the apparent gap between England and Australia. Admissions to private hospitals and an extensive network of charitable funded hospices and community hospital equivalents are not counted in the occupied bed data in England. Discussion with the Kings Fund and others gives a best estimate of between 7 and 12 bed days per death arising from private hospitals and from the charitable sector. Additional comparison between Hospital Episode Statistics (HES) data (http://www.hesonline.nhs.uk/Ease/servlet/ContentServer?siteID=1937&categoryID=207) appears to show that the count of occupied bed days arising from the bed reporting statistics is around 23 bed days per death less than the more comprehensive HES data (after excluding maternity) which includes community hospital admissions. This leaves around 10 to 15 bed days per death which could be attributed to differences in the boundary between health and social care between the two countries.