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Have doctors and the public been misled regarding hospital bed requirements?

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Abstract

Since 1998/1999, the number of daytime occupied beds in England has declined by around 0.08% per annum, an almost negligible reduction. However, the number of available beds has declined by over 21% leading to unsustainable increases in average occupancy. In January and February of 2018, hospitals were instructed to stop all non-urgent elective surgery because of winter bed pressures. This article discusses how pressures to contain costs have led to a mismatch between occupied and available beds.

Key words

forecasting, hospital bed numbers, hospital bed occupancy, length of stay, models, public consultation, trends

Introduction

The National Health Service (NHS) in the UK is publicly funded and must achieve break-even within the financial envelope dictated by parliament. While politicians make optimistic statements about access to services and patient safety, it is accepted by NHS managers that break even represents their number one priority.

Doctors and the public will be aware that bed availability is declining, despite management assurances that 'robust' modelling of bed demand, often by external Management Consultants, indicates that this is entirely justified.

In this context, my own experience relating to hospital bed modelling began in the early 1990's when I was asked to forecast bed numbers for a new hospital in Reading, Berkshire, UK. The Director of Strategy was aware that the bed models were sadly lacking in rigor and asked me to investigate if better methods could be developed. A forecast was prepared and duly challenged by the Local Health Authority who claimed that schemes were in hand to considerably reduce bed demand and that the hospital would need 100 fewer beds than my forecast. The managers at the hospital wisely left

space for the 100 beds in the center of the new build site. Chronic bed shortages then necessitated a second business case to build the 100 beds.

This tendency to underestimate future bed demand is somewhat endemic in the UK and the introduction of the Private Finance Initiative (PFI) in the UK in the early 1990's led to considerable 'political' pressure to underestimate future demand and to build smaller 'affordable' hospitals within the severe limitations of far higher PFI costs (Dunnigan and Pollock 2003, Hellowell and Pollock 2010). This is a classic case of the unintended consequences of policy (Merton 1936).

Evidence that the UK now has too few beds comes from the fact that acute (midnight) bed occupancy in England (excluding pediatric and specialist mainly elective hospitals) hit an average of 95.8% (median 96.6%, upper quartile 99.0%) on Wednesday the 3rd of January 2018 (NHS England 2018a) – despite hospitals being instructed to cancel routine elective surgery (Royal College of Surgeons 2018).

This paper does not discuss Paediatric and Obstetric bed requirements since both are largely driven by trends in the number of births.

Modeling Bed Demand

The modeling of hospital bed numbers relies on methods which have not changed for many decades (Farmer and Emami 1990, Seematter-Bagnoud et al 2015). Future bed demand is said to be predicted by the multiplication of future admissions times future average length of stay (LOS) times an occupancy margin. In earlier years the occupancy margin was modeled as the turn-over-interval (TOI) or the average time a bed stayed empty between patients (Jones 2001). This was erroneously assumed to be a measure of efficiency. It is now widely recognized that the occupancy margin is set by the volatility in admissions (Jones 2011b), which can largely be approximated by queuing theory and the Erlang equations (Bain et al 2010).

The seminal paper of Farmer and Emami (1990) documents the practical and theoretical errors in bed forecasting relating to admissions and LOS. A series of ~~more~~ pragmatic studies were also published in the early 2000's which discussed common errors prevalent in NHS bed planning (Jones 2001, 2003). The NHS in England is a top-down policy-driven organization where policy-based evidence, rather than evidence-based policy abounds (Marmot 2004). The earlier studies were completely ignored due to the overwhelming policy pressure to contain healthcare costs and to build smaller 'affordable' hospitals consistent with very high PFI costs (Dunnigan and Pollock 2003, Hellowell and Pollock 2010). PFI was terminated in 2018 on the basis that it posed 'a fiscal risk to the government' (HM Treasury 2018).

This paper will discuss the limitations in the methods for forecasting admissions and average length of stay (LOS), and will investigate alternative methods based on the trends

in occupied beds or the novel observation that medical beds can be approximately forecast based on trends in deaths as a proxy for end-of-life care.

Population Factors Behind Hospital Bed Demand

Health service planning in the UK, and many other countries, relies on the assumption that the admission rate in each age band stays constant and growth arises due to population increase, especially in the older ages. This is called demographic forecasting (Charlton 1981). This assumption is fundamentally flawed and has been called the constant risk fallacy (Nicholl 2007). According to this view of the world, a period of higher than expected deaths will have no impact whatsoever on occupied beds, since it is claimed that admissions are driven almost exclusively by age.

While an ageing population would logically indicate a greater need for healthcare services, there are far more subtle determinants of hospital bed demand. Interestingly, around 55% of a person's entire lifetime utilization of a hospital bed occurs in the last year of life, ***irrespective of age at death***, and more specifically in the last six months (Hanlon et al 1998, Aaltonen et al 2017). This is called the proximity to death effect and has been demonstrated to occur across multiple countries and over many years (Zweifel et al 1999, Busse et al 2002, Payne et al 2007, Moore et al 2017, Howdon and Rice 2018). This fact has been known since the early 1980's (Henderson et al 1990). Indeed, the risk of death for any person, young or old, admitted as an acute medical emergency is far higher than the general population of the same age (Flojstrup et al 2017), i.e. admission to hospital is an indicator of potential imminence to death and of morbidity. Despite this long-standing knowledge this has never been incorporated into bed models. Hence, models are lacking a component of demand which is related to the absolute number of deaths rather than age-standardized mortality.

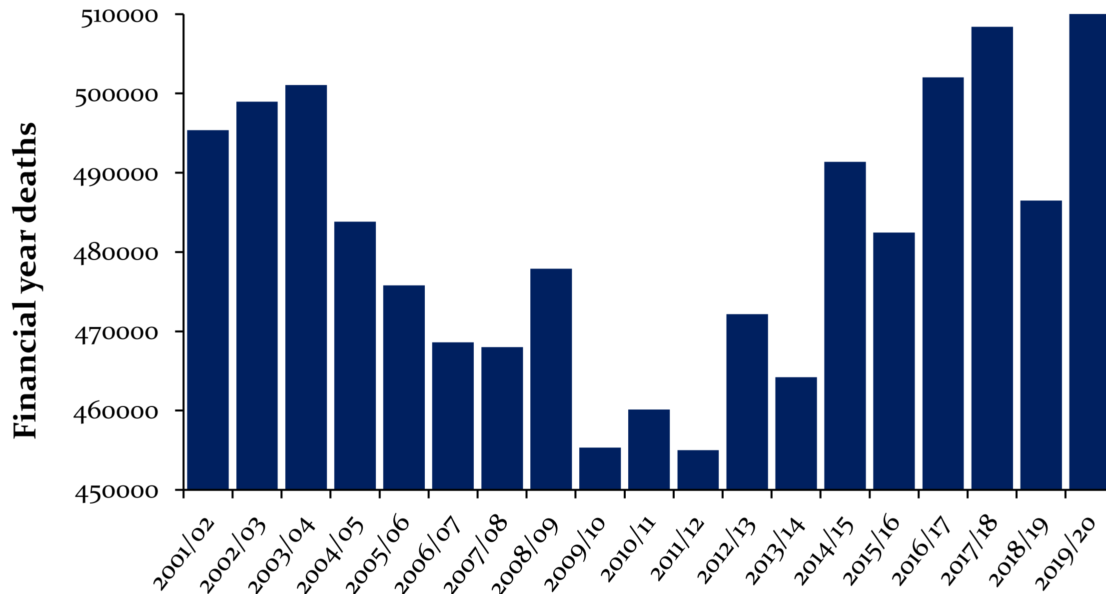
Trend in Deaths

In England and Wales, past trends in births and changes in life expectancy meant that the number of deaths reached a maximum of 598,500 in 1976. Improvements in life expectancy led to a steady decline to a minimum of 484,400 in 2011, a 20% reduction over 35 years. After 2011, deaths showed an inexplicable and large increase culminating in 532,000 deaths in 2017, a 9% increase in just 6 years (Office for National Statistics 2018a). For many years an increase in deaths had been forecast to occur around the mid-2010's, however, the magnitude of the increase defied actuarial forecasts. This led to improvements in life expectancy stalling since 2011 (Hiam et al 2018), and Public Health England (PHE) was eventually commissioned by the government to investigate (PHE 2018).

Since most of the analysis in this study uses NHS financial year data Figure 1 shows the trend in financial year deaths in England between 2001/02 and 2018/19. Data for England is from monthly deaths aggregated into financial year totals (Office for National Statistics 2019). As can be seen deaths prior to 2011/12 were declining, as across the rest of the

UK, and show a rapid rise thereafter. Also note that the year-to-year volatility in deaths is very high, which, implies that the nearness to death effect should impose an increment of volatile bed demand on top of any other trends.

Figure 1: Trend in financial year deaths (all-cause mortality) in England, 2001/02 to 2019/20



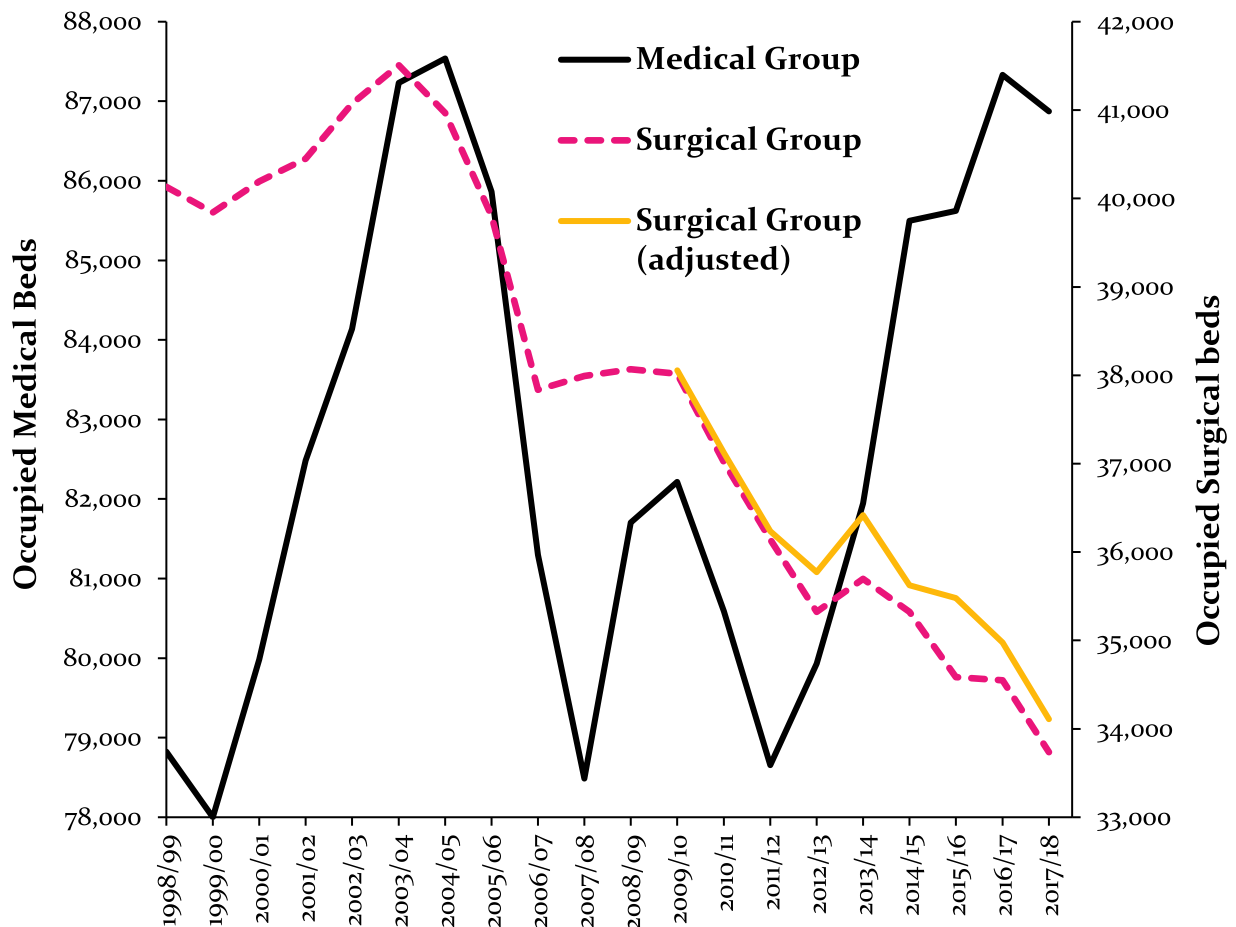
Footnote: 2019/20 deaths are a maximum possible forecast

Hence, since 1976 the demographic component of non-end-of-life care (the ageing population) plus any contribution from healthcare technology have been contributing to increased healthcare demand, but the end-of-life component was reducing up to 2011. Based on the simple fact of 55% of a person’s lifetime bed occupancy occurs in the last year of life (Hanlon et al 1998), these trends must surely have had an impact on bed requirements?

It is likely that the bulk of end-of-life care will occur in the medical specialties and the possibility of different trends between medical and surgical care is explored in Figure 2 where daytime occupied beds for elective and emergency care combined have been calculated for England between 1998/99 and 2017/18. Data for England is from Hospital Episode Statistics (NHS Digital 2018). As can be seen in Figure 2 occupied beds in the medical group of specialties bounces between a minimum of 78,000 to 79,000 in the years 1999/00, 2007/08 and 2011/12 and a maximum of between 82,000 to 87,000 in the years 2004/05, 2009/10 and 2016/17. There is no evidence of any fundamental trend to fewer occupied beds.

In contrast the surgical group of specialties do show a trend to lower numbers of occupied beds over time. There are shoulders in the downward trend around the same time that medical bed occupancy is at a maximum. Due to effective flat lining in real-terms funding for the NHS since the financial crash (Kings Fund 2015) the number of persons waiting has grown by 1.7 million since 2011/12 (NHS England 2019) and hence Figure 2 contains an estimate of the effect of the growing waiting list on bed demand in each year. This adjustment only makes a marginal contribution to the downward trend which from 2003/04 has been around 1.5% per annum fewer daytime occupied beds.

Figure 2: Trend in daytime occupied beds for the medical and surgical groups of specialties in NHS hospitals in England, 1998/99 to 2017/18



Footnote: Daytime occupied beds includes all same day stay admissions with an assumed length of stay of 8 hours. Occupied beds (midnight) has been increased by 3.5% to reflect the underestimation of true length of stay (LOS) due to the use of whole number LOS.

For a large part the downward trend in the surgical specialties is driven by a shift to same day care with only 40% of all admissions (elective + emergency) being same day in 1998/99 but increasing to 65% in 2017/18 (NHS Digital 2018). At the same time the median length of stay (elective + emergency) for the surgical group has dropped from 2.2 days in 1998/99 to 1.7 days in 2017/18. This is partly due to the shift to same day care but also to a reduction in overnight length of stay.

However, changes in the number of admissions between the two groups have been profoundly different. Between 1998/99 and 2017/18 surgical group admissions increased from 5 to 6 million (+20%) while medical group admissions have increased from 3.8 to 7.9 million (+108%), hence, the lack of any reduction in medical occupied beds is largely driven by the very high growth in admissions. By comparison, demographic growth over a 19-year period could be expected to add up to 25% extra admissions (as per the surgical group plus the increase in the waiting list). Note that surgical group activity has effectively flat lined since 2011/12, hence, the growth in the waiting list. See Figure S1 in the Supplementary material. Clearly, attempts to divert emergency activity to more appropriate non-acute settings, which would have been a fundamental part of every PFI business case, have failed to contain rising medical demand.

The situation with available beds is entirely different. Since 1998/99 in England there has been a 30,347 reduction in acute bed numbers (including same day stay beds), a 21% reduction (NHS England 2018b). Unsurprisingly, acute bed occupancy has been rising by 0.52% (percentage points) per annum to an annual average level of 91% for the whole of England in 2017/18 (NHS England 2018b). This is a midnight average occupancy which includes weekends, holiday periods, children's wards, plus several large and mainly elective specialist hospitals but excludes daytime occupancy levels. Adult bed availability became so limiting in the winter of 2017/18 that most routine elective surgery was cancelled during January and February leading to 62,000 fewer surgical cases (Royal College of Surgeons 2018).

As mentioned above, since the end of 2011 the UK has experienced an unprecedented and unexpected increase in total deaths, both in-and out-of-hospital, which has been accompanied by an unexplained increase in mainly medical admissions (Jones 2015, Jones 2018). This is a repeat of similar events in the past. During the period of unexplained rising deaths since 2011 bed closures have continued and some 6,014 acute hospital beds have been closed (5.4%), while since 2012/13 some 2,895 beds were closed (2.8%) (NHS England 2018b). All periods of unexplained higher bed occupancy in Fig. 2 have been accompanied by periods of unexplained higher mortality rates and total numbers of deaths (Jones 2015, 2018).

Figure S2 (see Supplementary material) illustrates the truth that demography, or the ageing population, has had only a modest involvement in the increase in acute admissions since 2011. The increase due to demography comes from official figures used by NHS England (NHS England 2016), which forecasts 1.3% p.a. growth in 2015/16 and 2016/17, 1.5% p.a. in 2017/18 to 2019/20, and 1.4% p.a. in 2020/21. The small changes in growth

due to demography arise from birth cohort effects due to the World War II baby boom and other periods of higher births. It is important to realize that the line labelled 'demography' in Fig. S2 is an overestimate of the contribution due to demography since the end-of-life component has been included in the calculated contribution from 'demography'. Demographic growth only gives continuous time trajectories with only tiny undulations due to birth cohort effects. Factors associated with the mysterious increase in deaths, which causes ***large*** undulations in the number of deaths, are seemingly dominating the trends (Beeknoo and Jones 2017, Jones 2015, 2018). Hence, the real contribution from demography is probably somewhere around 1% per annum.

In an act of supreme circular thinking the three periods of higher occupied beds (Fig. 2) were ignored because the bed models predicted that they should not exist, and policy demanded lower costs! Rather than challenging the adequacy of the models, the models were simply assumed to transcend reality. All three peaks are indeed associated with periods of unexpected higher deaths, and the small rise in 1998/99 seen in Fig. 1 points to earlier peaks in bed occupancy (Jones 2015, 2018). The 2003/04 and 2009/10 peaks in occupancy accounted for around £100 million (in today's terms) of extra inpatient costs (reviewed in Jones 2015), and unexplained increases in outpatient referral (reviewed in Jones 2015). Once again, inconvenient truths which have been largely ignored due to the pressures to contain costs.

The simple fact is that the trends in death at local level are far more volatile than current actuarial models would allow (Fig. 1). Extended periods of higher death are common, and some locations show higher volatility than others, presumable due to the role of environment (weather, pollution and infectious outbreaks) in the expression of local deaths (Jones 2012). Such intrinsic volatility in deaths implies that reserve capacity will always be required, and this is supported by local and international trends in occupied beds (Jones 2011b).

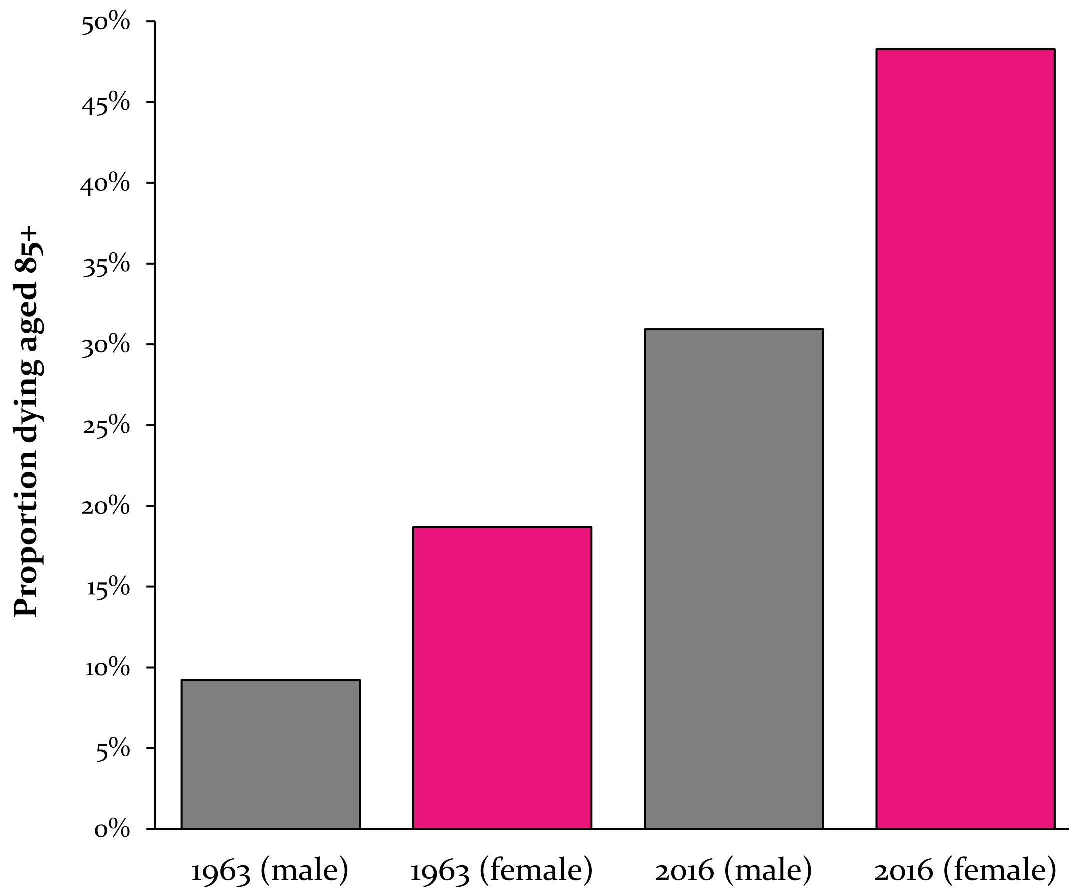
In summary, bed models need to be split into two components. In the first, is the more usual demographic component which accounts for population growth and an ageing population. In the second, is a component of bed demand relating to the last year of life, which can be approximated by a count of total deaths. Such a two-part approach has recently been successfully applied to modeling prescription costs (Moore et al 2017). The intrinsic high volatility in deaths also requires the provision of reserve or surge capacity.

Perceptions Regarding Age

Judging from the National Press and politicians anyone would conclude that the 'elderly' are clogging up hospital beds. As discussed previously while people are indeed living longer, this does not necessarily mean vastly more healthcare demand (Zweifel et al 1999, Busse et al 2002, Payne et al 2007, Moore et al 2017, Howdon and Rice 2018). For those aged over 60, increasing life expectancy simply shifts the age at first admission to a higher age (Karampampa et al 2013).

However, the ageing population has indirectly created a perception that hospitals are full of old people. This is illustrated in Fig. 3 where data on the age of death in England and Wales has been compared between 1963 and 2016. In 1963 the most common age to die was 74 in men and 82 in women, while in 2016 this had shifted to 82 in men and 89 in women. At the same time the shape of the profile of deaths with age has shifted to become more tightly clustered around the mode. It is this shift which has generated the change in the proportion of those over 85 illustrated in Fig. 3.

Figure 3: Proportion of 'old' people (arbitrarily defined as aged 85+) who may be occupying a hospital bed as part of the end-of-life process



Footnote: Data is from the Office for National Statistics (2018a)

Given the fact that around 55% of lifetime bed occupancy occurs in the last year of life, walking into a hospital in 1963 would show a far more youthful set of patients in the beds than in 2016. While the age has changed the fact remains that a large part of the demand is driven by nearness to death and not by age per se.

Several studies have investigated the implications of these trends. Firstly, in 2013 compared to 1998 for persons dying at the age of 70 or older in Finland there was a five-percentage point reduction in the number living at home until their last months of life, and a six-percentage point increase in persons utilizing high intensity care services in the last months of life. Persons with dementia, multimorbidity, women and the oldest old were overrepresented in this latter group (Aaltonen et al 2017). By implication the demand for high intensity out-of-hospital nursing care is increasing.

The rising need for high-intensity nursing care has been emphasized in a UK study where it was noted that by 2040 there will be a 108% increase in deaths in care/nursing homes and an 89% increase in deaths supported at home. If care home beds do not increase to match this demand additional deaths will occur in hospital and the percentage of deaths occurring in hospital will start increasing by 2023 – as opposed to the current downward trend of 1% per annum (Bone et al 2018).

Clearly one set of beds are going to be replaced by another, and any scheme claiming to reduce acute beds needs to demonstrate increases in care/nursing home beds or at-home supported care bed-equivalents.

Given the magnitude of the suggested increases it is strongly recommended that combined demographic and end-of-life models be developed to better estimate likely bed requirements. It goes without saying that changes in how end-of-life care is delivered will play a role in mitigating the suggested increases in occupied beds, however, such schemes need to be real and not merely concocted to justify fewer acute beds.

Length of Stay

The change in occupied beds in Fig. 2 arises from simultaneous changes in admissions and LOS.

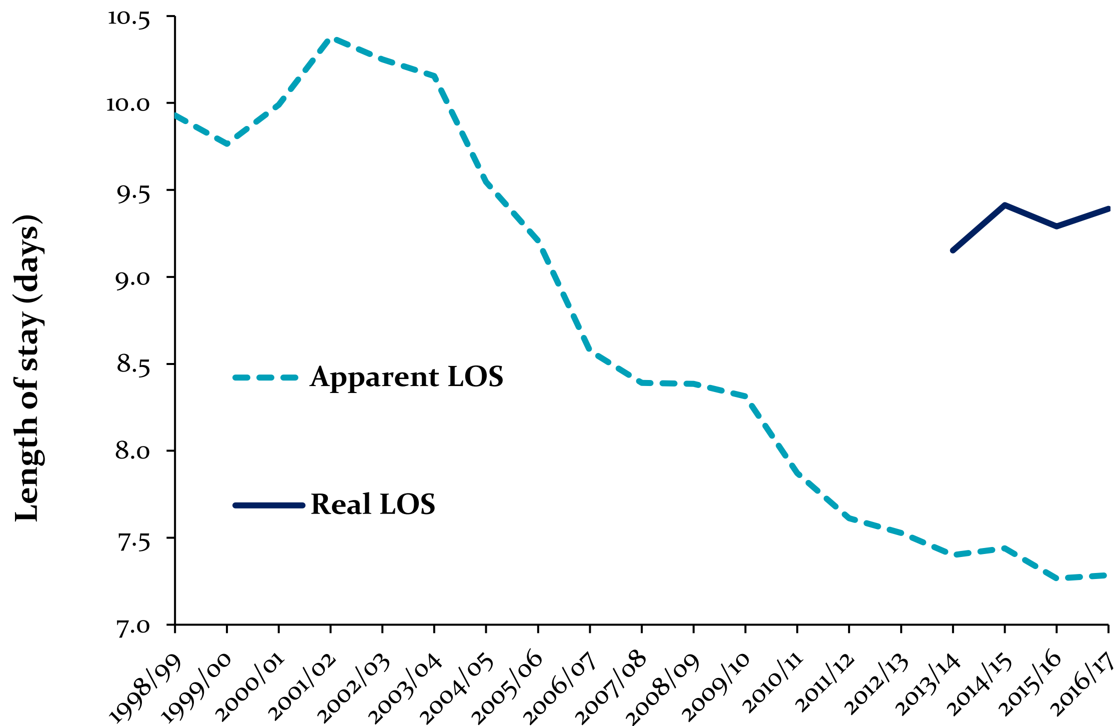
Trends in LOS are the result of complex interactions between many variables. Hence, the application of simple regression methods to predict future LOS trends involves a low Durbin Watson (DW) statistic which indicates the presence of autocorrelation in the residuals, i.e. that there is systematic information which is not accounted for by the regression (Farmer and Emami 1990). See further discussion of this point below relating to Fig. 4.

While linear regression is seldom used to forecast future LOS, given the ‘political’ and PFI-based pressure to contain costs the temptation is to postulate schemes which will reduce LOS (as noted in the introduction) to achieve a hypothetical financial objective.

The calculation of LOS is subject to several sources of inherent bias to underestimate the real value. Firstly, LOS is usually calculated in terms of the number of times a patient is in a bed at midnight, hence, a 2-day stay means 2 midnight stays and any time spent in a bed outside this criterion is omitted from the calculated LOS. A real stay of 3.9 days gets

truncated to 3 days using this method with considerable scope to underestimate the real average LOS. The gold standard for calculating the real LOS is to use days, hours and minutes and studies show that midnight stays underestimates real average LOS by up to 12% (Tierney and Conroy 2014). Hence real bed demand is already underestimated due to inherent bias in the method used to measure LOS.

Figure 4: Trend in apparent and real overnight average length of stay for the medical group of specialties.



Footnote: Hospital Episode Statistics (HES) data for admissions is from NHS Digital (2018)

A further complicating factor regarding the apparent trends in LOS in England has been the inclusion of same day stay admissions (other than day case) into the count of ‘overnight’ admissions. These same day admissions are imputed a 0-day (midnight) LOS. In England, these same day admissions showed huge growth after 2002, and in 2016/17 there were 2.3 million same day admissions to acute hospitals (NHS Digital 2017).

A count of same day admissions has been available in the Hospital Episode Statistics (HES) data since 2013/14 financial year and Fig. 4 illustrates the trends in apparent LOS for the medical group of specialties which includes general and elderly medicine, all other medical sub-specialties, clinical specialties, oncology and haematology.

As can be seen in Fig. 4 the trend in LOS is subject to unexplained periods of higher LOS (as in Fig. 2) and that the real LOS (after excluding same day 'overnight' admissions from the denominator) is far higher than 'official' statistics suggest. The reduction in real LOS since 1998/99 is likely to be far lower than previously thought (or has been incorporated into bed calculations), and in recent years the real LOS appears to be increasing rather than decreasing.

Therefore, the politically correct view of LOS as an ever-decreasing indicator of increasing efficiency is flawed. Indeed, during a previous period of unexplained higher deaths medical LOS was shown to increase (reviewed in Jones 2015) presumably reflecting higher patient acuity.

The available evidence suggests that LOS across many specialties is indeed starting to rise. There are several good reasons why future overnight stay LOS should increase, namely:

- In the surgical specialties, continued extraction of elective overnight activity into day case implies that the remaining case mix becomes increasingly complex, i.e. leaves higher LOS patients in the overnight stay pool
- LOS increases with age due to a reduction in the speed of the natural healing process, and an ageing population along with increasingly older end-of-life deaths imply upward pressure on future LOS

Table S2 shows the per annum growth (as percentage increase per annum) in real LOS for a range of adult specialties. Percentage growth per annum is the slope of the trend in real LOS between 2012/13 and 2017/18. As can be seen growth is widespread across multiple specialties.

The Occupancy Margin

Hospital beds are a key asset which allow for delay-free flow of patients into the correct specialty bed pool. Very few realize that the 85% occupancy margin typically recommended for acute hospitals has no theoretical basis but is simply a very approximate rule of thumb (Philip et al 1984, Bain et al 2010). The optimum occupancy for a delay-free hospital is actually less than 80% (Bain et al 2010, Jones 2011), while it is even lower in the critical care unit (Lamiell 1995, Tierney and Conroy 2014). Very high occupancy in UK hospitals implies that significant numbers of extra beds are required simply to restore delay-free flow.

Staffing and beds

It is often claimed that beds are expensive, however, what this actually means is that fully staffed beds are expensive. The generous occupancy margin implied for a delay-free hospital implies that beds are not fully staffed, but that the patients in a bed set the staffing level. While safe staffing levels may be desirable in the UK staffing is also set by

the need for a hospital to break-even, which is eventually determined by how the government sets NHS funding. It is the lesser of two evils to have too few staff rather than too few beds, or indeed too few of both!

Anticipated Trends

In the current absence of two compartment models to forecast future bed demand Figure S3 (Supplementary material) presents an approximate method for the medical group of specialties. The majority of end-of-life care will occur in the medical group (See Table S1 in the Supplementary material) and Figure S3 gives the ratio of occupied medical beds per 1,000 deaths in England since 2001/02. Given the huge changes in medical technology, age structure and deaths (Fig 1) which have occurred in this time period the ratio of occupied beds per 1,000 deaths is surprisingly constant. The undulations correspond to the unexplained peaks and troughs in Figure 2. Given that deaths are expected to rise for many years to come (Office for National Statistics 2018) the need for more medical beds will increase.

Surgical bed demand will probably continue to decline although the current rate of reduction of 1.5% per annum may not be sustainable. The pressing need is for more surgical beds to restore a delay-free occupancy margin and to reduce the size of the waiting list.

Conclusions

Doctors and the public must rely in good faith on the advice of so-called bed forecasting experts. This trust has been abused. All too often government agencies put pressure on managers to rework the figures to obtain a more 'affordable' answer. This is a highly simplistic view where fewer beds are deemed to equate to lower costs. The existence of highly unusual trends in admissions and LOS have been ignored. As an observation, every trick in the book was employed during the PFI era to convince the public that fewer beds were needed in all new hospitals built since the 1990's.

However, put simply, too few beds creates every conceivable type of inefficiency, risk, stress, increased in-hospital mortality, an increasing waiting list, missed waiting time targets and increased costs (reviewed in Beeknoo and Jones 2016). Beds themselves are not expensive, it is the staff which cost the money. Methods are available to flex staff to match the seasonal profiles of bed demand (Beeknoo and Jones 2016). Additional beds are required to restore average occupancy to a safe and operationally effective level, allow for decontamination of whole wards following infectious outbreaks and for emergency planning, i.e. surge capacity.

Surgical occupied beds are currently declining at 1.5% per annum, although this rate of decrease will decline with time. There is currently no evidence that medical occupied beds are declining over time, while the unexplained surges in bed demand in Figure 2 continue to reoccur, seemingly at times of unexplained higher deaths. Despite huge

changes in technology, population age structure and the number of deaths for the past 16 years medical group occupied beds have stayed in the range 168 to 182 occupied beds per 1,000 deaths (Figure S3 in the Supplementary material). Continued growth in deaths for many years to come (Office for National Statistics 2018b) suggests that medical bed demand will continue to rise.

This article has presented the evidence that current models for forecasting demand require modification to include the far higher utilization of resources in the last year of life. This fact has been well known and researched since the 1980's yet has never been incorporated into current models, omission of this vital component of demand leads to gross underestimation of future bed demand. Deluding the public that fewer beds are needed, when this is clearly not the case, is not a wise policy. There are profound implications of these findings to health care policy.

Footnote

An extended series of papers (containing references to other studies) relating to demand forecasting and bed modelling is available at http://www.hcaf.biz/2010/Publications_Full.pdf

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Supplementary Material

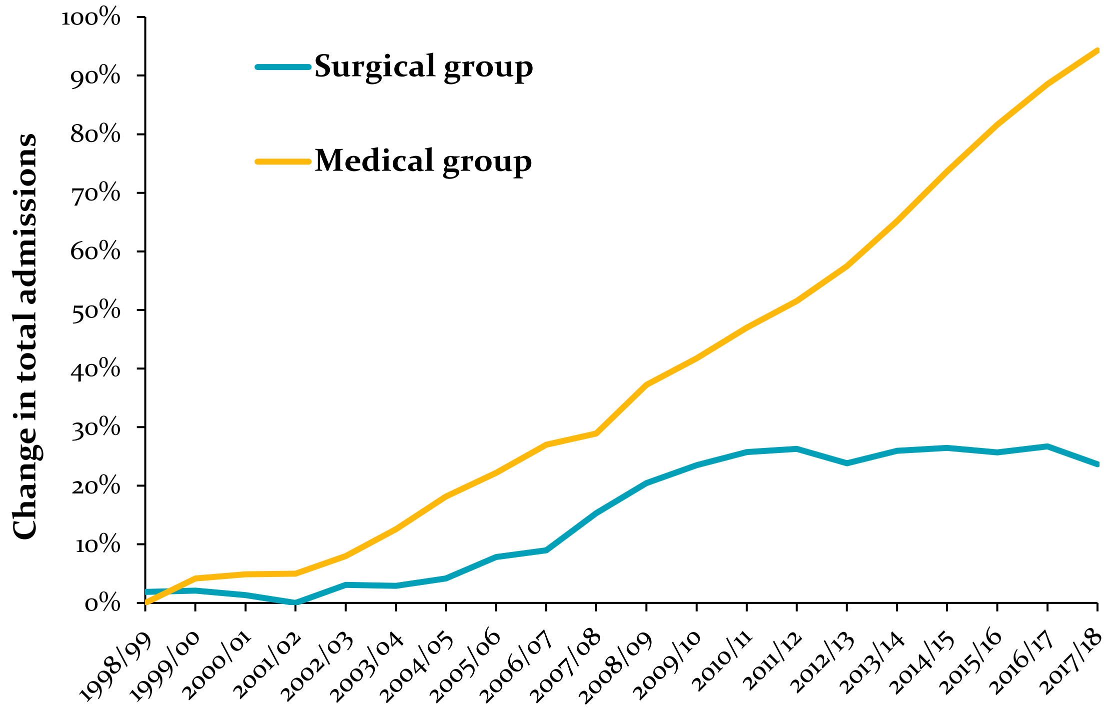
Table S1: Occupied beds in 2017/18 for the various specialties in the Medical Group

Specialty	Occupied Bed-days	Occupied Beds
General medicine	8,526,382	23,360
Geriatric medicine	6,490,267	17,782
Respiratory Medicine (Thoracic Medicine)	2,175,000	5,959
Cardiology	1,811,865	4,964
Gastroenterology	1,771,473	4,853
Clinical Haematology	821,418	2,250
Rehabilitation	801,147	2,195
Nephrology	700,663	1,920
Endocrinology	660,934	1,811
Neurology	618,356	1,694
Accident & Emergency (Assessment & Observation)	528,530	1,448
General Medical Practice	448,573	1,229
Clinical Oncology (previously Radiotherapy)	420,519	1,152
Medical oncology	395,482	1,084
Not known	315,621	865
Nursing episode	288,115	789
Rheumatology	244,592	670
Anaesthetics	212,812	583
Acute Internal Medicine	206,974	567
Infectious diseases	187,259	513
Critical Care Medicine	154,185	422
Palliative Medicine	133,809	367
Allied Health Professional Episode	98,139	269
Community medicine	94,667	259
Haematology	78,299	215
Dermatology	74,700	205
Radiology	36,435	100
Clinical Pharmacology	26,977	74
Clinical Immunology & Allergy	12,775	35
Genitourinary medicine	7,537	21
Tropical Medicine	3,587	10
Medical Microbiology & Virology	3,289	9
Clinical Neuro-physiology	2,467	7
Medical Microbiology (Microbiology &	1,635	4
Immunopathology	1,310	4
Nuclear medicine	1,151	3
Chemical pathology	925	3
Clinical Genetics	360	1
General Pathology	330	1
Histopathology	306	1

Table S2: Growth in real LOS per annum (percent growth per annum for combined elective and emergency LOS) for a range of acute, mental health and community specialties, 2012/13 to 2017/18

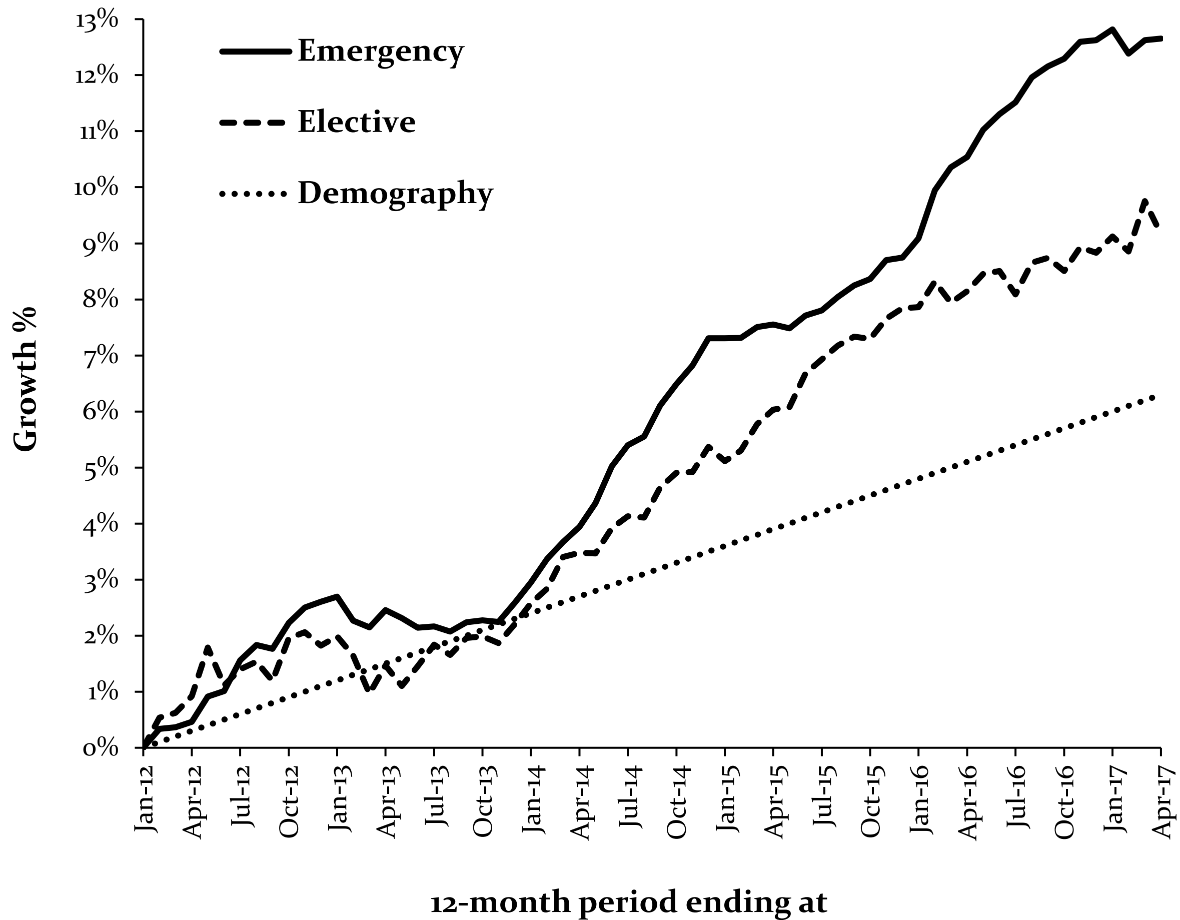
Specialty	Average real LOS in 2017/18	Growth per annum
Tropical Medicine	18.3	18.1%
Genitourinary medicine	38.8	13.7%
Dermatology	9.4	12.4%
Allied Health Professional Episode	26.6	11.0%
Nephrology	11.0	8.9%
Community medicine	41.8	8.2%
Anaesthetics	15.3	6.8%
Ophthalmology	3.8	6.7%
Clinical neurophysiology	3.0	6.6%
Gastroenterology	12.3	5.8%
Radiology	3.4	5.5%
General Medical Practice	27.6	5.2%
Rheumatology	8.2	5.1%
Clinical oncology (radiotherapy)	8.4	4.1%
Mental handicap	41.6	3.7%
Nursing	22.6	3.0%
Haematology	15.2	2.6%
Palliative medicine	22.5	2.5%
Old age psychiatry	94.1	2.4%
Oral & Maxillo Facial Surgery	3.3	2.1%
Ear, nose & throat (ENT)	2.5	2.0%
Medical oncology	7.6	1.9%
Midwifery	1.9	1.8%
Neurosurgery	9.2	1.3%
Accident & emergency	1.3	1.3%
Oral surgery	3.1	0.9%
Endocrinology	9.2	0.9%
Trauma & orthopaedics	6.6	0.4%
Obstetrics	2.7	0.4%
Cardiology	9.0	0.3%
Acute Internal Medicine	2.8	0.2%
Nuclear medicine	2.0	0.2%
Plastic surgery	4.2	0.0%
Thoracic medicine	10.6	0.0%
Infectious diseases	10.6	0.0%

Figure S1: Growth in total admissions to the surgical and medical groups between 1998/99 and 2017/18 in England



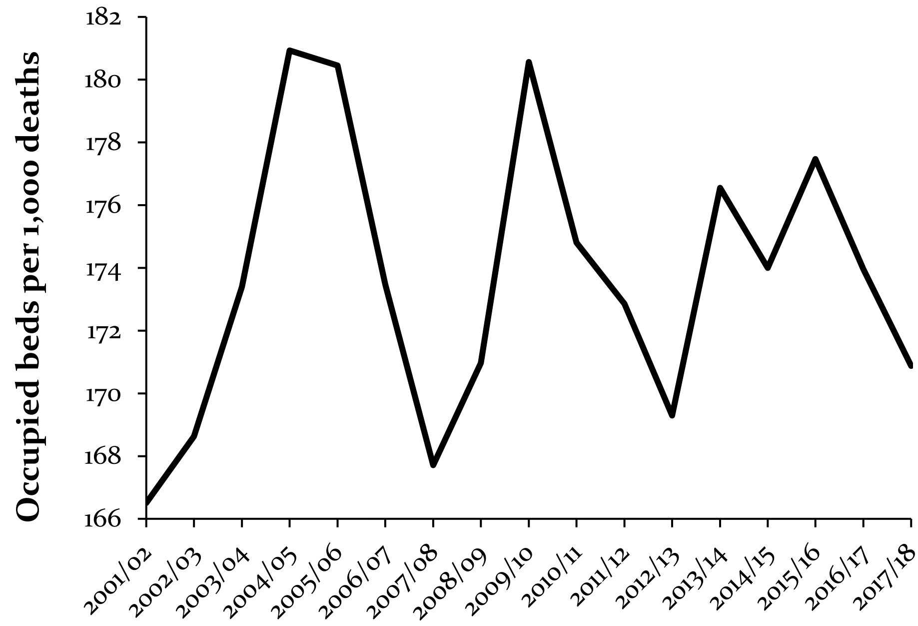
Footnote: Data is from Hospital Episode Statistics (NHS Digital 2018)

Figure S2: Moving (rolling) 12-month growth in emergency and elective admissions relative to the 12-month period ending January 2012. The line labelled 'demography' is an overestimate since the calculation includes the contribution from end-of-life



Footnote: Monthly data on hospital admissions is from NHS Digital (2018) https://digital.nhs.uk/data-and-information/publications/statistical/hospital-episode-statistics-for-admitted-patient-care-outpatient-and-accident-and-emergency-data/provisional-monthly-hospital-episode-statistics-for-admitted-patient-care-outpatients-and-accident-and-emergency-data---april-2017-to-february-2018 while demography comes from NHS England (2016) England.nhs.uk/wp-content/uploads/2016/05/fyfv-tech-note-090516.pdf.

Figure S3: Trend in occupied medical group beds per death in England, 2001/02 to 2017/18



Footnote: See Table S1 in the Supplementary material for a breakdown of the medical group of specialties.