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How many medical beds does a country need? An international perspective

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Part of a longer series on hospital bed numbers and occupancy available at
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Abstract

Aims: To investigate acute medical group bed numbers in various countries using a new method for inter- and intra-national bed comparison.
Background: While many methods exist for calculating bed numbers up to the present no method has existed to make more detailed international comparisons. The current international method, namely, beds per 1,000 population is entirely inadequate since it makes no adjustment for population age or the nearness to death effect.
Methods: The number of available (or staffed) medical beds in various (mainly European) countries were obtained from the World Health Organization. These were divided by the number of deaths in each country to give the ratio of beds per 1,000 deaths and this was plotted against the ratio of deaths per 1,000 population (the crude mortality rate) in each country. This was compared to similar data for England over the period 2000/01 to 2018/19 but using occupied rather than available beds.
Results: In England, the medical group of specialties accounts for over 60% of all occupied acute beds. Since 2011 this proportion has risen to over 64%. In 2009, for the 37 countries with data, the ratio of available beds per 1000 deaths had a median value of 198, average 205 and an interquartile range of 158–239. At around 165±5 occupied medical beds per 1000 deaths (at an assumed 95% average occupancy), England has roughly similar medical beds to Albania 178, Italy 177, Israel 173, Turkmenistan and Croatia 167, North Macedonia 161, Estonia 158, Armenia 156, Norway 147, Denmark 145 and Finland 135. The implementation of integrated care in Scotland and Wales since 2009 has led to a 14-unit reduction in the ratio of available medical beds per 1000 deaths up to 2018/2019. The slope of the log relationship between beds per 1,000 deaths and deaths per 1,000 population is relatively low indicating that nearness to death is the major driving force for medical bed requirements.
Conclusions: Both data sets indicate that the approach of death (absolute number of deaths) is the most important variable in forecasting medical group occupied and available bed numbers. Based on the forecast increase in deaths, medical group bed demand in England is anticipated to increase by 39% over the next 40 years.

Key words: Bed planning; Hospital bed numbers; Hospital capacity planning; International comparison; Nearness to death

Introduction

Healthcare budgets around the world are coming under increasing pressure and hospital bed numbers are a perceived avenue of cost reduction (McKee 2004). On the other hand, some countries such as Ireland have recognised that they have too few beds for future requirements (Keegan et al 2019).

The need for medical care in an ageing population appears to be a major driver of acute bed demand and in England the medical group accounts for over 60% of occupied acute beds (NHS Digital 2019). The models used to forecast hospital bed numbers have remained largely unchanged for over 40 years (Ravaghi et al 2020) and are open to manipulation to give whatever answer is 'politically' acceptable (Jones 2010, 2017, 2019a).

However, it has been highlighted that around 55% of a person's lifetime bed utilization occurs in the last year of life (Hanlon et al 1998), and especially so in the last six months of life (Larsson et al 2008, Aaltonen et al 2017). This is reasonably independent of the age at which the person dies (Dixon et al 2004). This is called the nearness to death (NTD) effect, and the importance of NTD regarding costs and activity has been recognised for over 40 years by economists (Payne et al 2007). The role of NTD as a neglected variable in health care capacity planning has been stressed in a recent series of articles in BJHCM (Jones 2017, 2018, 2019a). Indeed, a recent study has demonstrated that NTD is key to understanding future trends in prescription costs (Moore et al 2017).

Based on the key role of NTD it has been proposed that the ratio of beds per 1,000 deaths may be an important parameter in bed modelling (Jones 2018,2019c), and a method has been proposed to compare international bed numbers. This method was developed using total bed numbers which includes acute, mental health and maternity beds (Jones 2019c), and therefore needs to be validated for the medical group.

This study uses data collected by the World Health Organisation (WHO) on the number of *available* medical group beds in 37 mainly European countries in 2009. This data is then compared to *occupied* medical beds in England over the period 2000/01 to 2018/19. Note that medical beds cover both emergency and elective admissions.

Methods

Data Sources

The number of *available* medical beds in various (mainly European) countries for 2009 was obtained from the World Health Organisation (WHO 2020a). The crude mortality rate and total population for countries was obtained from the World Bank (World Bank 2020a,b). Hospital Episode Statistics (HES) data by specialty from 1998/99 to 2018/19 was obtained from NHS Digital (NHS Digital 2020). Monthly deaths in England were obtained from the Office for National Statistics (ONS 2020b). Available medical beds in Scotland was from ISD Scotland (2019) and in Wales was from StatsWales (2019).

The Medical Group in England

The medical group of specialties for England in this study includes all medical and clinical specialties (general and elderly medicine, cardiology, gastroenterology, respiratory, rheumatology, nephrology, oncology, haematology, pain management, palliative, rehabilitation, inpatient emergency medical assessment, etc). It excludes all paediatric activity. Surgical specialties, trauma and orthopaedics, plastic surgery, paediatrics, gynaecology and obstetrics are all excluded as is mental health and learning disability. The full list of medical specialties is available on request from the author.

Data Manipulation

All data was manipulated using Microsoft Excel.

Where data on medical beds numbers was not available in 2009 for the WHO data set, data ending 2007 or 2008 was extrapolated to 2009 using a polynomial fit to the time series. Monthly deaths in England were summed to give financial year totals. HES data for the medical group includes both elective and emergency admission types, with both overnight and same day stay admissions. Medical group beds were summed using the selection of specialties in a Pivot table.

Day time *occupied* beds were calculated as midnight occupied beds plus 3.5% to convert from midnight to daytime bed occupancy. To this was added the total number of same-day-stay admissions times 0.35 for an assumed approximate 8-hour average stay.

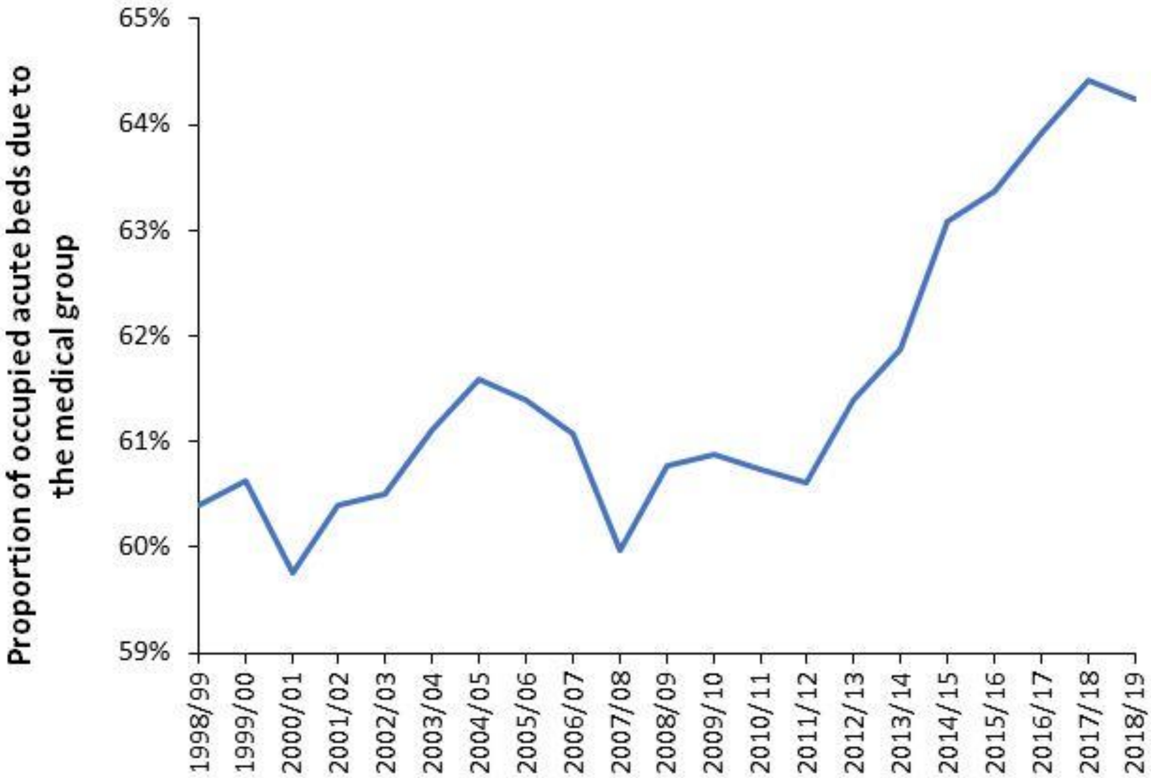
The number of deaths in each country was calculated by multiplying the crude mortality rate times the total population. Available medical beds per 1,000 deaths is the total number of available beds divided by deaths (thousands) for that country.

Results and Discussion

Trend in deaths

Hospital mortality rates in the surgical specialties are low (around 5 per 1,000 admissions) (Ramsay et al 2019), and hence most hospital admissions ending in death are in the medical group of specialties, i.e. these specialties have a greater focus on end of life care. In England, the medical group accounts for over 60% of occupied acute beds and the trend in this proportion is shown in Figure 1. As can be seen the proportion occupied by the medical group has risen since 2011/12.

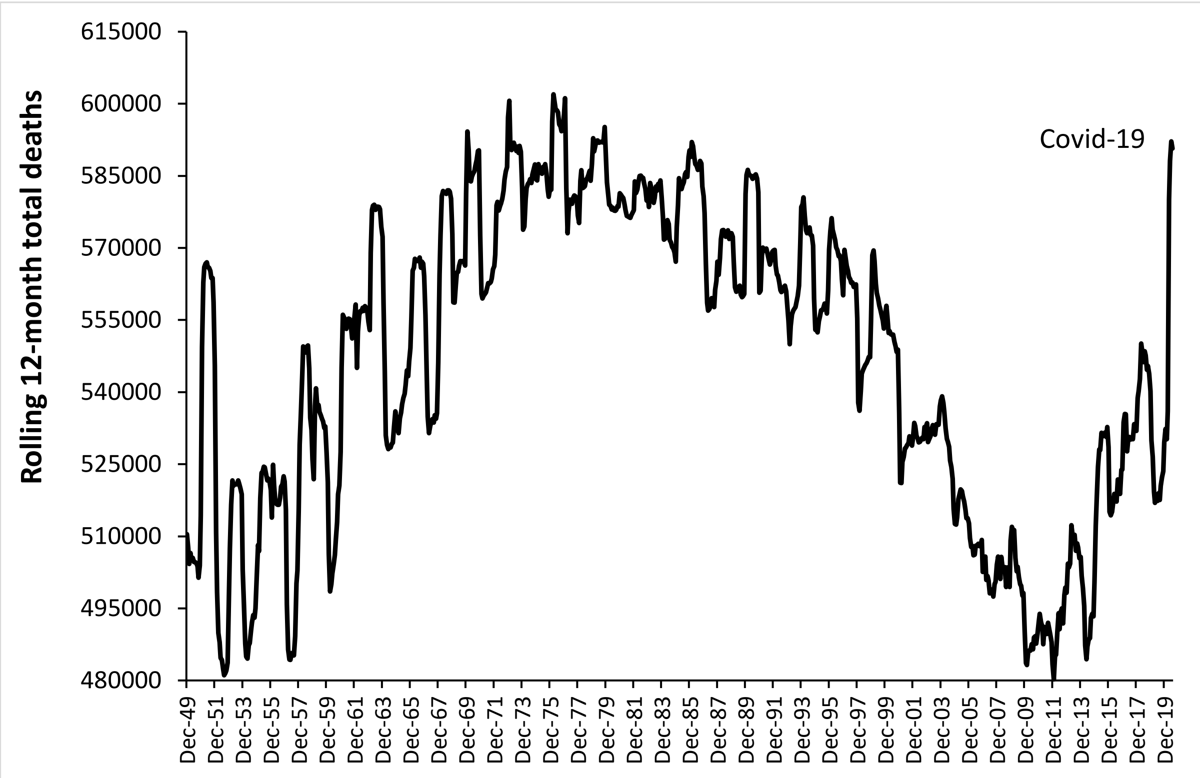
Figure 1. Trend in the proportion of daytime occupied acute beds by patients in the medical group of specialties in hospitals in England



In England, the year 2011/12 is somewhat critical regarding the role of the NTD effect on bed pressures. Few will be aware that total deaths in England have been falling since the early 1970’s but showed a dramatic increase since 2011/12. This trend is shown in Figure 2.

A rolling 12-month total has been used to show that the trend is rather volatile. In addition, a rolling total is a useful visual method to illustrate changes in the cause(s) of death. An influenza epidemic such as the one which commenced in December 1989 creates a table-top feature since the spike in deaths due to influenza enters the rolling total, stays there for 12-months, and then drops out of the total. Influenza-only outbreaks are seemingly less frequent that may be expected and the complex shapes in the rolling total indicate multiple causes for periods of higher deaths.

Figure 2. Rolling 12-month total deaths in England and Wales 1949 to present



However, the key point is that deaths (hence the magnitude of the NTD effect) were falling through to 2011/12 and then underwent a rapid rise which was mirrored in a rapid rise in the proportion of acute beds occupied by medical patients (as in Figure 1).

International Comparison

Having demonstrated that the medical group of specialties represent a significant part of acute bed capacity which is influenced by NTD we can now investigate how medical beds are distributed between different countries.

International data on available medical beds is not widely available, however, the data on the number of available medical group beds for 37 mainly European countries in 2009 (latest WHO data available) is presented in Figure 3. This data has been presented as the ratio of available beds per 1,000 deaths as an indicator of potential interest given the role of NTD in hospital bed demand.

Many countries in the WHO data set had been reducing bed numbers over the interval 2000 to 2009. The median was a -9% change (-1% per annum), the interquartile range was -20% to -1%. For example, France -4%, Austria -8%, Germany -9%, However, some countries did increase medical bed numbers such as Denmark, Belgium +2%, Israel +3%, Finland +4%, Spain +5%. The countries showing the largest reduction were mainly the former members of the USSR.

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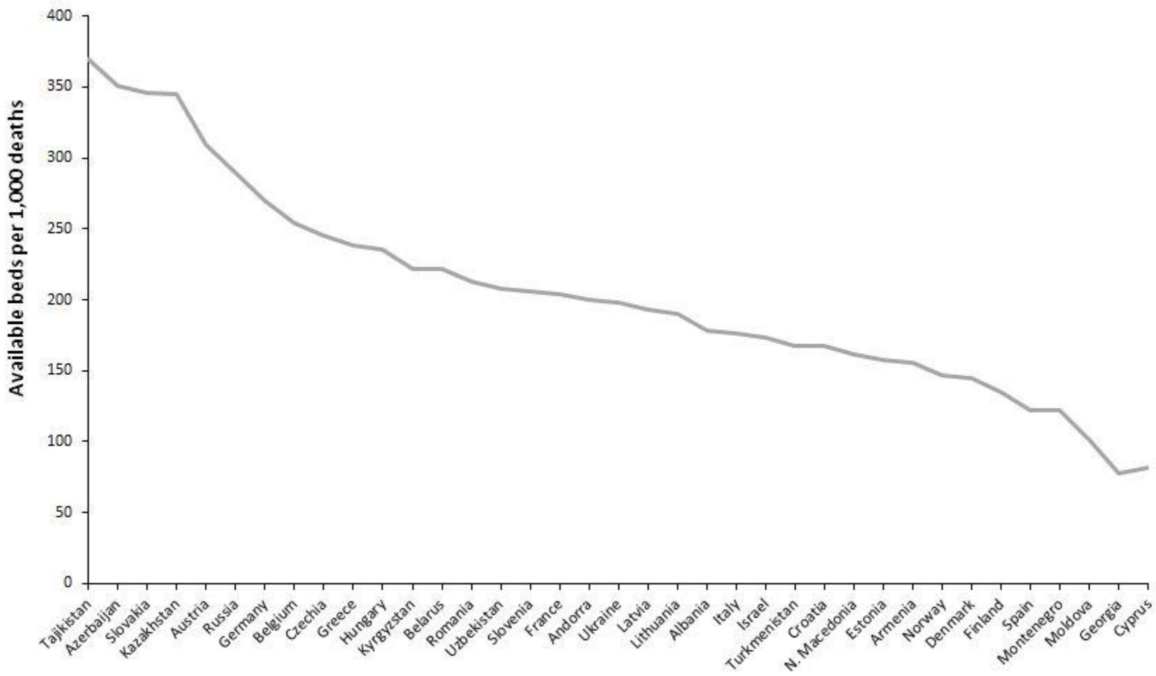
Figure 3. Available medical group beds per 1000 deaths (all-cause mortality) in 2009 for 37 countries.



Footnote: Counting of medical beds is variable. Some countries include mental health beds while others may omit some medical specialties. The data for Georgia and Cyprus appears to omit certain types of available beds.

As can be seen this ratio varies from greater than 290 for some former Soviet Union countries and the Russian Federation through to around 80 in Georgia and Cyprus (see later comments). France had 204, Germany 270 and Austria 309. In 2009 Scotland had a ratio of 183 while Wales had 167. Some caution is required in that the counting of 'medical' beds can vary with some countries including mental health beds, while other countries may omit some specialties. For example, the data for Cyprus omits cardiology due to issues around counting critical care beds.

Data issues aside, the ratio of available beds per 1,000 deaths had a median value of 198 - the median is called a robust average, i.e. is less sensitive to extreme values (Statistics How To 2020), an average of 205 and an interquartile range of 158 to 239.

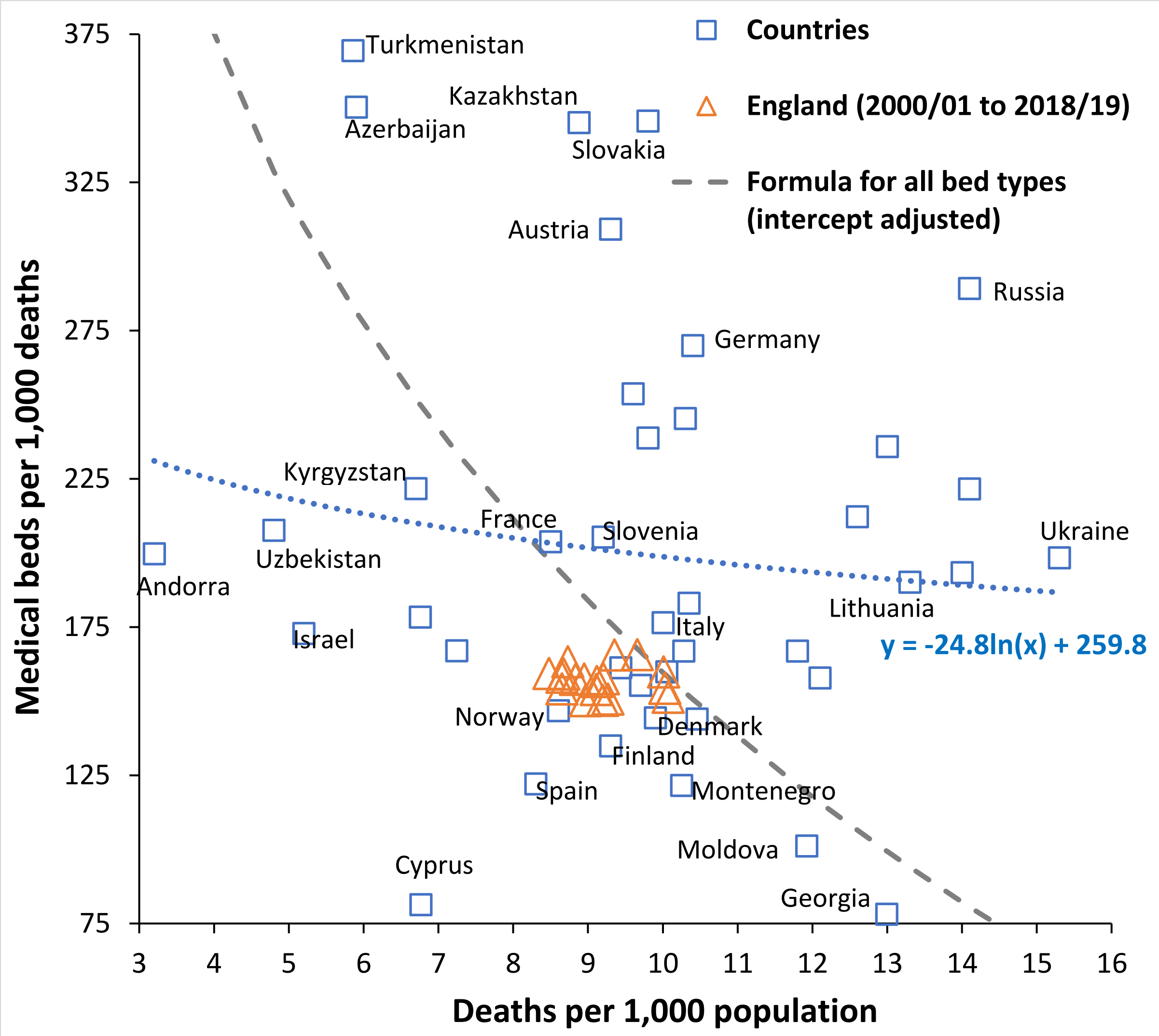
The Scandinavian countries Norway, Finland and Denmark all have a similar ratio around 135 to 147 (see later regarding long term investment in integrated care).

Between 2000/01 and 2018/19 England had a ratio for ***occupied*** medical beds per 1,000 deaths of 157 (both mean and median) ± 5 (standard deviation). The range was 166 (2004/05 and 2005/06) to 150 (2007/08 and 2012/13). This number will include beds borrowed from other specialties during the winter peak in demand (Jones 2009). For comparison, the ratio of available medical beds per 1,000 deaths in Scotland was 183 in 2009/10 falling to 160 in 2018/19 while in Wales the ratio was 167 in 2008/09 falling to 144 in 2018/19. The ratio for Wales may not include borrowed beds. Since 2009, both Scotland and Wales have been pursuing a policy of Integrated care (Bruce and Parry 2015, Lewis 2015), and this may explain the 23-unit reduction in both countries up to 2018/19 (see Integrated Care section).

Effect of the crude death rate

This data is re-presented in Figure 4 as the ratio of available beds per 1,000 deaths versus the number of deaths per 1,000 population (the crude death rate).

Figure 4. Available medical beds for 37 countries presented as beds per 1000 deaths vs deaths per 1000 population at 2009 and occupied medical beds in England (2000/01 to 2018/19)



This method of presentation was chosen based on earlier studies of the factors influencing total bed numbers (all hospital bed types not just medical) in world countries (Jones 2019a,b). Also given in Figure 4 is the number of daytime *occupied* medical beds in England from 2000/01 to 2018/19, where each data point is for a single year within that date range. Also shown in Figure 4 is the formula developed in a previous study covering all bed types, i.e. acute + mental health + obstetrics, and the formula shows the line of best fit through the international data covering medical beds.

As can be seen the line of best fit for the international data on medical beds per death has a low slope compared to that developed to cover all bed types. In the formula for all bed types there is a strong dependence on the log of deaths per 1,000 population, which is a proxy for population age profile. This large difference implies that the medical group has little dependence on deaths per 1,000 population, i.e. age structure, but depends far more strongly on the simple ratio of medical beds per death. The inclusion of the surgical specialties, mental health, paediatrics and obstetric/midwife beds in the formula for all bed types should have a greater dependence on age, hence, the higher slope in Figure 4. Indeed, the data for England regarding medical beds per death between 2000/01 and 2018/19 confirms that the ratio of medical beds per death is largely independent of deaths per 1,000 population as a proxy for age structure.

Age as a proxy for NTD

In 2018 in England the most common age to die was 87, with 75% of deaths above age 70, 50% above age 80 and 15% above age 90 (ONS 2020a). Hence specialties serving older patients are more likely to be driven by the NTD effect. This is illustrated in Table 1 where the average age of patients is given for a wide variety of inpatient specialties. As can be seen at the top of the table are Paediatrics, Midwifery, Obstetrics, and Dental specialties which all service younger populations where demand will be driven more by the trends in the number of births rather than deaths, hence by the traditional age-based forecasting. However, all the medical group of specialties lie toward the bottom of Table 1 implying high dependence on the NTD effect.

Table 1: Average age for patients admitted into various specialties, England 2017/18 and 2018/19

Specialty	Average age
Paediatrics, paediatric surgery, neurology, dentistry and cardiology, audiology, general dentistry	3 to 9
Clinical neurophysiology, child and adolescent psychiatry, special care dentistry	16 to 20
Midwifery, obstetrics, learning disability, orthodontics	24 to 30
Dental medicine specialties, gynaecology, prosthodontics, ENT	32 to 37
Forensic psychiatry, restorative dentistry, adult mental illness	38 to 40
Oral & maxillofacial surgery, sports & exercise medicine, psychotherapy	42 to 45
Surgical dentistry, clinical immunology & allergy, medical ophthalmology	47 to 49
Plastic surgery, neurosurgery	50
Endodontics, genitourinary medicine	51
Medical virology, critical care medicine	52
Tropical medicine, immunopathology	53
Neurology	54
Accident & Emergency (assessment), general surgery, radiology, trauma & orthopaedics	56
Gastroenterology, clinical genetics, chemical and general pathology	58
Anaesthetics, haematology, histopathology, rheumatology, infectious diseases	59
Cardiothoracic surgery	60
Urology, medical oncology, pharmacology, nephrology	61
Clinical haematology	62
Endocrinology, clinical oncology, blood transfusion, clinical physiology	63
Respiratory, general & acute internal medicine, dermatology	65
Occupational medicine, cardiology	67
Medical microbiology	68
Nuclear medicine	69
Ophthalmology	70
Palliative medicine, rehabilitation	72
Old age psychiatry	74
Geriatric medicine	79

Specialties at the bottom of the table will make a disproportionate contribution to overnight bed occupancy.

These factors partly explain why the ratio of occupied medical beds per death in England has remained remarkably constant since 2000/01 (Figure 4), despite the large changes in deaths shown in Figure 2.

In summary, capacity planning for specialties at the top of Table 1 are driven by the usual variables of age as influenced by recent and future trends in births. Following a peak in births in 2012, births have since been declining (ONS 2019). Specialties toward the middle are driven by a mix of age and NTD effects while those at the bottom are principally driven by NTD.

The 2018-based population projections for England (ONS 2019b) shows deaths rising from 510,000 in 2019/20 to 709,000 by 2058/59 (a 39% increase), while births only start to rise again after a minimum of 612,000 in 2027/28 rising to a maximum of 679,000 in 2045/46 (an 11% increase). The large 39% increase in deaths over the next 40 years will therefore drive the NTD component of hospital capacity planning for the medical group of specialties.

Why Include Same Day Stay?

In 2018/19 in England there were 5.2 million same day stays (elective + emergency) in the medical group of specialties which represents 63% of all medical admissions (and growing). While this only accounts for 5,219 of daytime occupied beds (7% of the total assuming 24 hour/365 day equivalent operation) it is still an important part of the totality of bed demand, and recognises that the mode of delivery of medical care is changing over time, i.e. this is double the level since 1998/99 (NHS Digital 2020).

The important point is that capacity planning for same day stay admissions needs to be conducted separate to that for overnight beds. Since 2012/13 medical group same day stay admissions (elective + emergency) have been growing at around 6.5% per annum (NHS Digital 2020). Since 2002/03 same day admissions into medical assessment units have been growing at 20% per annum.

The flow of such increasing large volumes of patients through a small number of beds implies that all same day units, whether elective or emergency, need to be built with excess floor space to cope with the high per annum growth. Unless this occurs, same day admissions will start crowding out the genuine overnight bed pool.

Medical assessment units need to be built to cope with peak winter demand at the peak point in the day – around 2 pm based on this author's unpublished work. Unless this happens, the medical assessment unit will become a source of access block for flow of patients out of the emergency department (Forero et al 2011).

Why does such a simple ratio work?

It is important to realise that death is merely the tip of the mortality/morbidity pyramid. Hence factors increasing death will also increase hospital admissions not immediately associated with death. Both influenza and Covid-19 infections are associated with many more admissions than deaths. An excellent example of the mortality/morbidity pyramid is influenza which since 2010 in the USA is estimated to cause 9 to 43 million illnesses, 140 to 810 thousand hospitalisations and 12 to 61 thousand deaths in a year depending on the severity of the outbreak , i.e. approximately 750:12:1 (Centers for Disease Control and Prevention 2020). Influenza is only one of over 1,400 known species of human pathogens (Woolhouse and Gowtage-Sequeria 2005). Hence infections are a likely source of many of the multiple causes of higher deaths indicated by the unusual patterns in Figure 2.

Role of integrated care

The Scandinavian countries have invested many years of combined policy and implementation into integrated care (Zanon 2015, Buch et al 2018, Ilmo et al 2018). This is reflected in the low ratio of medical beds per death in Finland, Norway and Sweden in Figure 4. The disastrous Health and Social Care Act (2012) implemented in England led to a decade of lost impetus in this area (Timmins 2012, 2018). While NHS England sought to mitigate against the worst impediments of the Act, significant catch up is required especially in the area of targeted policy (Cummings 2011, Timmins 2018).

Substitution for acute medical beds

In England, higher supply of nursing home beds is associated with fewer delayed discharges from an acute hospital (Gaugham et al 2015). In Australia, a hospital in the nursing home programme generated large cost savings as an alternative to acute admission (Fan et al 2018). In New York a hospital at home scheme delivers the equivalent to acute care for geriatric patients in their own home (Monaro et al 2020). In addition, end-of-life hospital admissions involve an estimated 6% to 20% incidence of futile treatments with a mean length of stay of 15 days (Carter et al 2017). Hence, substitution for medical beds is available within a wider context of Integrated care.

Implications to hospital planning

The medical group of specialties has been shown to be highly influenced by the NTD effect. Growth in deaths over the next 40 years implies a 39% increase in medical bed capacity (a mix of overnight and same day stay beds). If England invests heavily in integrated care, there is the possibility to reduce medical bed demand down to the average of the Scandinavian countries of 142 available beds per death – although this figure may exclude same day stay beds.

It is of interest to note that the conclusions of this study are broadly supported in a study of emergency admissions conducted by the Marie Curie organisation (2018). This study shows that in 2016 the average days spent in hospital in the last year of life from an emergency admission was 27.6 days in England, 22.7 days in Scotland and 18.4 days in Wales. Marie Curie estimate that by 2041 an extra 4,300 beds for emergency admissions will be required due to increasing deaths. Note that this study also includes elective medical admissions.

Limitations of the study

Unfortunately, the number of (available) medical group beds is not a widely collected statistic and the WHO data set ends in 2009. Fortunately, the data from England on occupied medical beds covers the period 2000/01 to 2018/19. The average bed occupancy varies considerably between countries and in 2009 the average acute bed occupancy (all acute specialties) for 45 countries had an average of 74.7%, median 75.7%, interquartile range 69.4% to 84.2% (WHO 2020b). Data specific to the medical group is not available.

The data for Georgia may be unreliable as the low number of medical beds conflicts with a reported 36.1% average acute occupancy in this country in 2009 (WHO 2009b).

However, these factors do not alter the key conclusion from Figure 4 that the ratio of beds per 1,000 deaths is relatively insensitive to the ratio of deaths per 1,000 population.

Conclusions

Omission of the NTD effect in hospital capacity planning implies that hospitals built in England based on data collected prior to 2011/12 will be considerably undersized, especially as deaths continue to rise over the next 40 years. This includes all Public Finance Initiative (PFI) hospitals built since 2011/12, since planning calculations will have been performed during the period of falling deaths.

Combined models utilising both age and NTD should be urgently introduced to ensure that the key role of NTD is not omitted from capacity calculations. An excellent example of such a model is for prescription costs in Ireland (Moore et al 2017).

Please note that the final published version contains revised additional material and references.

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