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# Does the ageing population correctly predict the need for medical beds,

# Part 1: Fundamental principles

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**Key Points**

- A new method for forecasting medical bed demand suggests high growth in demand due to death of the World War II birth cohort over the next 30 years.
- Age-based forecasting is highly unreliable and always underestimates future demand.
- The nearness to death (NTD) effect must be incorporated in demand forecasts.
- The absolute number of deaths not only reflects the NTD effect but also reflects a component of non-end-of-life acute admission for the wider morbidity due to environmental challenges, i.e., Covid-19, which also cause death.

**Abstract**

The World War II baby boom coupled with increasing life expectancy implies that a surge in deaths will continue for the next 40 years. The last year of life represents a high intensity part of lifetime use of a hospital bed with up to 55% of lifetime occupancy. This is called the nearness to death (NTD) effect. However, the NTD effect has been completely ignored in NHS capacity planning which largely relies on age-based forecasting - the so-called ageing population. In certain locations deaths are forecast to rise far more rapidly than the national average of 1% per annum growth. These locations are highly susceptible to capacity pressures emanating from the NTD effect. The NHS in England is sleep walking into a capacity catastrophe which has been largely fuelled by a misplaced Whitehall policy to build smaller and smaller hospitals.

Key Words: Hospital Bed Numbers, Demand Forecasting, Age-based forecasting, Nearness to Death

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**Introduction**

A recent paper investigating future medical bed demand (Jones 2020a) has raised serious concerns regarding medical bed provision in the English NHS. This study identified that deaths (all-cause mortality) seemed to be the major driver for trends in medical bed demand, which appears to contradict the currently accepted age-based view of rising demand. This document aims to give greater insight into the wider implications of that study and suggest better ways to approach bed modelling. This study builds on previous work revealing serious methodological flaws in the current bed models (Jones 2001, 2010a, 2017, 2019c, Beeknoo and Jones 2017).

Analysis will begin with the unfortunate impact of the out-of-context use of the 1950s Roemer's Law study on the policy to reduce hospital bed numbers. Next the origins of age-based forecasting and its major flaws. Then important role of the nearness to death (NTD) effect, how this relates to medical bed demand, and why deaths are rising. Part 2 will conclude with suggested alternative methods for forecasting demand which include both age and the NTD effect, and the implications to the NHS funding formula.

**Roemer's Law and misconceptions about bed demand**

In its simplest form Roemer's law stated that "in an insured population, a hospital bed built is a filled bed**"** (Shain and Roemer 1959). This study was completely taken out of context and truncated to **"**a hospital bed built is a filled bed**".** Roemer's law only applies to the US health insurance system at a time, i.e., the 1950s and 60s, when it was in the financial interest of doctors and hospitals to admit as many insured patients as possible. The out of context truncated version of Roemer's law then became the mantra of policy makers around the world as to why fewer and fewer hospital beds are needed. The analysis behind Roemer's law was itself flawed and the study of Rohrer (1990) stated that "use of hospital utilization data which are not derived from actual population experience reveals a relationship which is a statistical artifact. The data also reveal that suburban counties have higher utilization rates than either rural or urban counties". Recent analysis of beds in US states show that bed numbers follow wealth rather than need (Jones 2020b), and as such the bed data from the USA is subject to perverse incentives and disincentives.

However, the damage was done, and this erroneous view still holds sway some 60 years later. An additional complication due to long-terms trends in length of stay (LOS) will be discussed below. We need to move past a myopic Roemer's law view of beds as an (un)necessary evil to realize that they are a tool to deliver optimum patient flow. Too few beds result in every conceivable source of inefficiency, cancelled operations, hidden queues, organisational chaos, patient harm, never-events, hospital acquired infection, staff stress, and increased costs (Beeknoo and Jones 2016).

No one is suggesting that all beds should be staffed, but rather that beds should be flexibly staffed as suited to the natural weekly and seasonal cycles and occasional peaks due to infectious agents and catastrophic events (DeLia 2006, Jones 2011, Beeknoo and Jones 2016).

**The origins of age-based forecasting**

Age-based forecasting of bed numbers has been used for many years. Admissions are forecast using age-based forecasts, this is then multiplied by the anticipated future average LOS and an occupancy margin applied. However, in nearly three decades of demand forecasting I have ***never*** found an age-based forecast that was reliable, simply because multiple other mechanisms are involved in growth (Jones 1997, 2009). Without exception age-based forecasting grossly underestimates future

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admissions, especially in the medical group of specialties (Jones 2009, 2021a, Beeknoo and Jones 2017).

Age-based forecasting originated out of the age-standardisation methods employed in Public Health to compare mortality and morbidity rates in populations with different age profiles. Ahmad et al (2001) discuss the history of age standardisation. However, while this is a perfectly valid public health tool, it works very poorly as a forecasting tool. This is because it suffers from the constant risk fallacy (Nicholl 2007), where age is used as a proxy for other risk factors such as co-morbidities and NTD.

The risk of death from Covid-19 is an excellent example of the constant risk fallacy. A large international study has established that the risk of death rises logarithmically with age (Levin et al 2020). However, the fatality rate between different locations within a country or between countries varies around the trend line indicating that age is also acting as a proxy for other risk factors such as co-morbidities, ethnicity, and poverty.

Despite these serious limitations age-based forecasting is still widely used in health services around the world (Ravaghi et al 2020). Indeed, NHS England in their May 2016 submission to the Health Select Committee calculated that age-based pressures would increase acute activity by 1.5% per annum in 2019/20 falling to 1.4% per annum in 2020/21. They estimated that non-demographic factors contribute a further 1% per annum to the growth in activity (NHS England 2016). Non-demographic factors will include medical technology, social changes such as the elderly living alone, misplaced expectations about what acute care can achieve at the end of life, plus the effects of NTD on medical admissions.

**Length of stay (LOS) is no longer rapidly declining**

One of the misconceptions regarding the perceived need for fewer beds is that LOS is supposedly rapidly declining. Many people forget that advances in medical care with increasing recognition of the need to mobilise people rather than let them convalesce (NHS Improvement 2018) led to a very rapid reductions in overnight average LOS during the 1970s through to the 1990s (Witsberger and Kominski 1990, Kominski and Witsberger 1994, OECD 2020). Such rapid reductions hid the fundamental flaws in the simple age-based bed models during this time.

However, rapid reduction in LOS cannot continue ad infinitum and so the rate of LOS reduction declined during the 1990s. LOS in the NHS showed a brief period of faster reduction in the early 2000s (see Figure 1). Figure 1 shows the trend in the real overnight average LOS (persons who stay one or more nights) for the NHS in England after removing all types of same day stay admissions from the denominator and is for both elective plus emergency admissions. Data is from NHS Digital (2020). The method takes occupied bed days and divides this by the number of admissions less all types of same day stay admissions, hence it gives the real average LOS for 'overnight' patients who stay for one or more days. As can be seen following a dramatic decline through to 2007/08 overnight LOS in obstetrics has been slowly rising since 2010/11 due to increasingly older mothers, has been slightly rising for the surgical group of specialties since 2013/14, is only very slowly declining in paediatrics and seems to have reached another plateau for the medical group since 2018/19. Forecasting future LOS is a highly perilous endeavour. As always, note the fluctuations in the trends. Future LOS is a frequency distribution set by the fluctuation in the trends not a single value, hence the need for an adequate occupancy margin.

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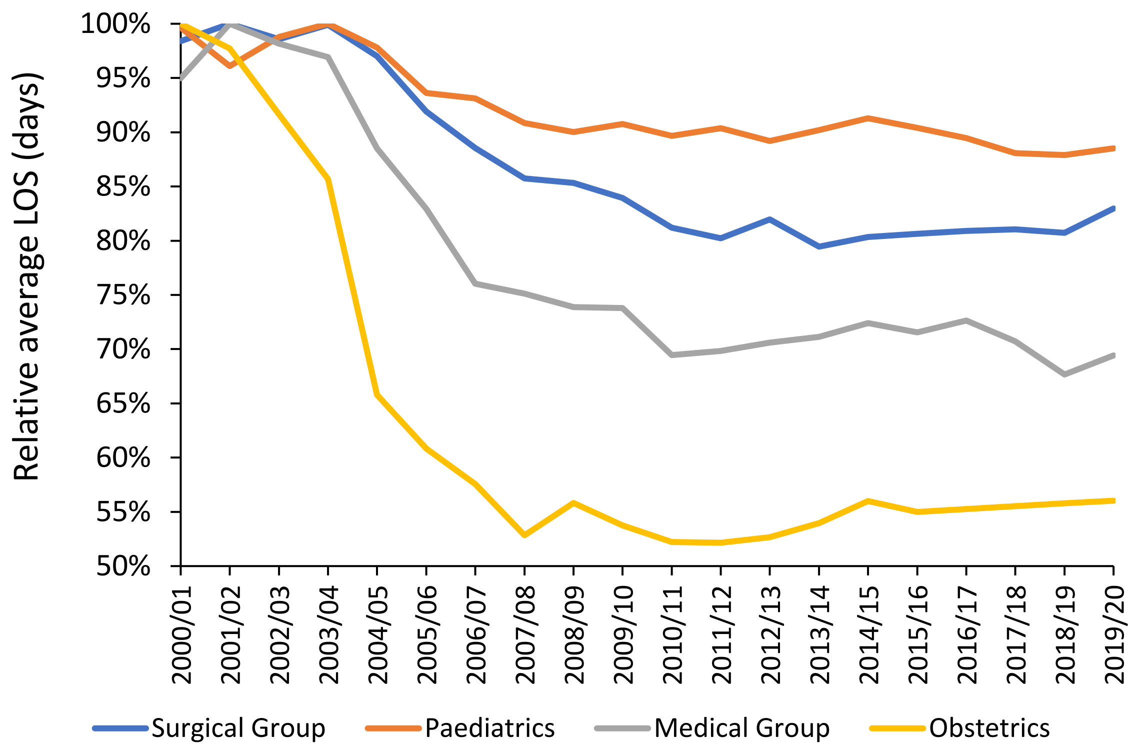
Hence simplistic assumptions regarding overnight-stay LOS as an ever-declining modelling parameter are creating entirely unrealistic bed modelling outputs (Jones 2019c). No model is ever better than its (hidden) assumptions.

**Figure 1: Trend in the real overnight average LOS after removing same day stay admissions. All lines are relative to the maximum LOS which can occur up to 2003/04.**




**Nearness to death (NTD) and bed demand**

As explained in the earlier study on medical bed demand, nearness to death (NTD) has a profound effect on hospital bed utilization. Up to 55% of lifetime bed occupancy (acute plus mental health) occurs in the last year of life (Hanlon et al 1998). In 2010 this author pointed out that the models used to forecast future bed numbers needed to be revised to incorporate the nearness to death (NTD) effect (Jones 2010a). This has been ignored, perhaps because most government health agencies see fewer beds as a route to cost savings.

A recent review suggested that the average number of bed days in the last year of life has not greatly changed in the past 30 years with somewhere around 25 cumulative days stay for both elective and emergency admissions (equivalent to 69 occupied beds per 1,000 deaths) mostly in the last 6-months of life (Jones 2021d). Hence each extra death adds around 25 bed days of demand into the NHS.

**Who is in the last year of life?**

The NHS will be seeking to move a significant proportion of NTD based bed demand into non-acute settings (Public Health England 2020). But who is in the last year of life? Alas, to a large extent those in the last year of life are only known in retrospect. Combined models are available to predict individual mortality, however the C-statistic (is typically around 0.78 (Torisson et al 2017). A C-statistic value of 0.5 indicates the model is no better than chance, above 0.7 is considered good, while above 0.8 is considered excellent, while 1.0 represents perfect prediction. The implication is that current models are not able to be used to 100% avoid (largely futile) acute admission in the last year of life (Chin-Yee et al 2017). It has been suggested that retrospective funding for this portion of demand is necessary (Jones and Kellett 2018). This will be discussed in more detail in Part 2.

However, the observation made in the medical beds paper was that the method was working over and above just the 25 days directly attributed to the last year of life (Jones 2020a). Deaths were also serving as a proxy for wider morbidity.

**Death as a proxy for wider morbidity**

It should be self-evident that anything which can kill people (temperature extremes, infectious outbreaks, spikes in air pollution, etc) will lead to acute exacerbations of existing (often hidden) conditions.

**Table 1: Admissions per death in England for persons aged 65+, 75+ and 85+ in 2019**

| ICD-10 | Primary diagnosis of the admission | 65+ | 75+ | 85+ |
|---|---|---|---|---|
| A41 | Other septicaemia | 58.2 | 52.6 | 48.1 |
| L03 | Cellulitis | 39.5 | 33.4 | 27.7 |
| N39 | Other disorders of urinary system | 26.9 | 24.7 | 21.5 |
| I63 | Cerebral infarction | 22.2 | 20.5 | 18.1 |
| K92 | Other diseases of digestive system | 31.7 | 25.1 | 17.6 |
| D46 | Myelodysplastic syndromes | 26.1 | 21.3 | 12.5 |
| I50 | Heart failure | 16.7 | 15.0 | 11.7 |
| J69 | Pneumonitis due to solids and liquids | 12.8 | 11.6 | 9.8 |
| K57 | Diverticular disease of intestine | 33.0 | 20.8 | 9.3 |
| J22 | Acute lower respiratory infection, unspecified | 13.1 | 11.0 | 8.3 |
| C90 | Multiple myeloma and plasma cell neoplasms | 22.4 | 16.1 | 8.0 |
| I26 | Pulmonary embolism | 10.0 | 8.6 | 7.0 |
| J18 | Pneumonia, organism unspecified | 9.6 | 8.5 | 6.8 |
| I80 | Phlebitis and thrombophlebitis | 6.4 | 6.2 | 6.6 |
| | **All causes** | **19.4** | **14.7** | **9.4** |
| K56 | Paralytic ileus and obstruction w/o hernia | 8.9 | 7.0 | 5.2 |
| J45 | Asthma | 10.4 | 7.0 | 4.1 |
| K70 | Alcoholic liver disease | 3.8 | 3.4 | 4.0 |
| C92 | Myeloid leukaemia | 8.4 | 6.6 | 3.4 |
| I48 | Atrial fibrillation and flutter | 8.5 | 5.8 | 3.2 |
| C67 | Malignant neoplasm of bladder | 6.8 | 5.4 | 3.0 |
| C91 | Lymphoid leukaemia | 10.7 | 6.9 | 2.9 |
| I21 | Acute myocardial infarction | 3.5 | 3.0 | 2.7 |
| C43 | Malignant melanoma of skin | 4.3 | 3.4 | 2.6 |
| J44 | Other chronic obstructive pulmonary disease | 4.0 | 3.4 | 2.5 |
| I62 | Other nontraumatic intracranial haemorrhage | 2.4 | 2.3 | 2.2 |

Hence, each death is a proxy for far wider numbers of non-end-of-life admissions. For example, analysis of data from US states reveals that at the peak for each state, for each Covid-19 death, there were approximately 20 to 45 persons occupying a hospital bed due to Covid-19 (The Covid Tracking Project 2020). In England, this ratio was between 13 to 28 occupied beds per death in hospital, depending on the region (data from NHS England 2020c,d). Clearly there are different lag times between bed occupancy and deaths, however, wider morbidity in terms of bed occupancy per death is clear.

The US Centers for Disease Control and Prevention (CDC) estimates that, depending on the influenza season, for every influenza death there are between 8 to 13 influenza hospitalisations (CDC 2020). Depending on the diagnosis the length of stay for influenza/pneumonia in England is between 5 to 10 days (NHS Digital 2020) giving 40 to 80 occupied beds per death. Among soldiers there are around 140 heat related hospitalizations per death (Carter et al 2005). For every cancer death there are multiple inpatient/outpatient admissions/attendances among the survivors plus additional palliative care among those who die (Jones 2012a).

To illustrate further Table 1 gives the ratio of admissions (primary diagnosis for the admission) per death (primary cause of death) in England in 2019 for persons aged 65+. Admissions were from Hospital Episide Statistics (NHS Digital 2020) while cause of death was from the Office for National Statistics (2020a). The diagnoses with the 20 highest ratio of admissions per death are listed. This ratio was determined for diagnoses having more than 1,000 deaths in 2019. The rules for coding morbidity and mortality are slightly different and hence while cause of death may be listed as “dementia” the admissions may be coded as pneumonia or heart disease, etc. Table 1 illustrates how extra deaths arising from common causes of death can indeed be the source of higher admissions and occupied beds. Table 1 is not a direct link but rather illustrates the principle that whatever environmental factors precipitate deaths coded to an underlying cause are also capable of precipitating far more admissions.

Note how the admissions per death decrease as the age range is truncated, i.e., 85+ includes far more persons about to die. Extrapolating the “All causes” data gives 5 admissions per death for age 95+ which will be mostly associated with NTD.

A recent study has estimated that a maximum possible number of 50 bed days per death are contingent upon NTD *plus* wider morbidity not related to NTD (Jones 2021f). Is the estimate of 50 bed days per death realistic? To reach a conclusion Figure 2 shows the trend in occupied beds (elective and emergency) per death (all causes) in England for the medical group of specialties since 2001/02. The data in Figure 2 is occupied bed days in the medical group of specialties from NHS Digital divided by the number of deaths in England from the ONS. The exact method is detailed in a recent study (Jones 2021a). As can be seen in Figure 2 occupied medical beds had an average of 157 ± 4 occupied beds per 1,000 deaths (equivalent to 57 bed days per death).

The data point for 2019/20 in Figure 2 has been adjusted for the impact of Covid-19. Covid-19 almost certainly came to the UK in before January 2020. Lockdown began on the 23rd March. Hence the 2019/20 financial year will contain some contribution from Covid-19 irrespective of whether it was diagnosed or not. However, during March of 2020 NHS hospitals were preparing for the alarming rise in Covid-19 admissions and measure were taken to release beds. Some 230 occupied beds have been added to the medical group total to account for reduced medical admissions arising from these measures, although this makes negligible effect. The long-term average remains at 157 ± 4 occupied

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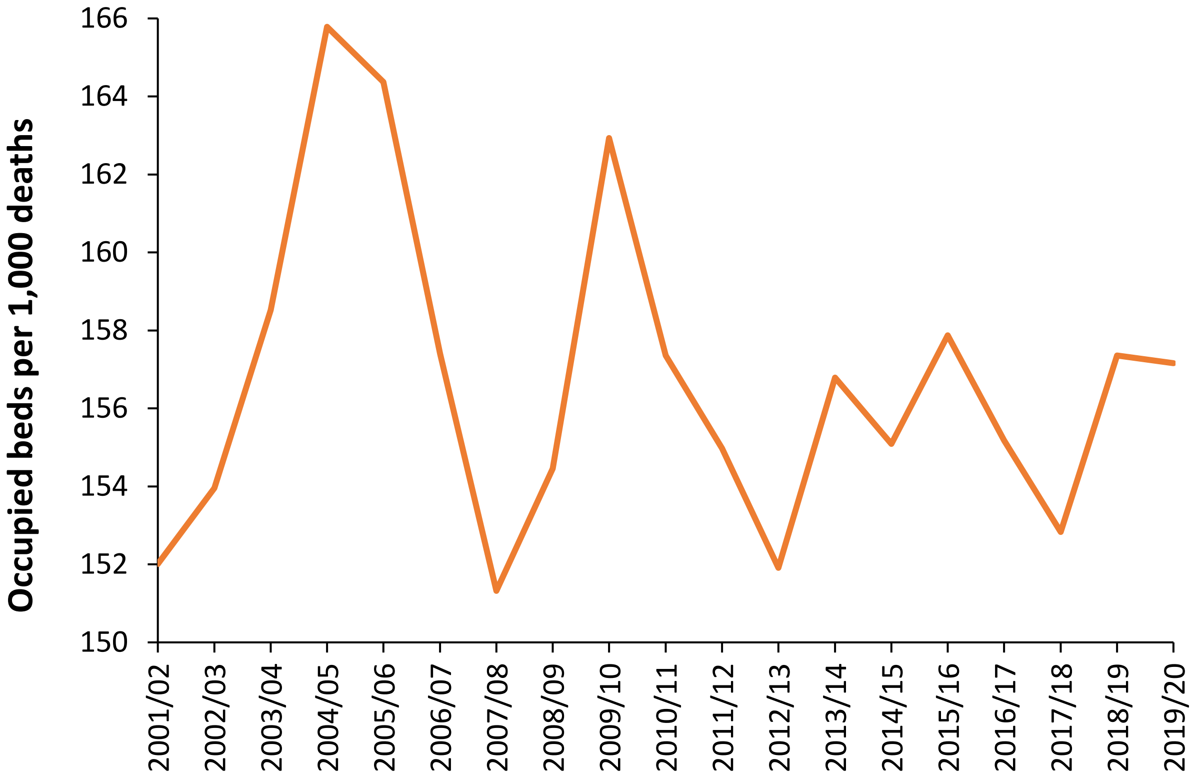
beds per 1,000 deaths irrespective of the inclusion or exclusion of 2019/20. The average and median (middle value) are both 157. Further data will be required to see if Covid-19 made at material impact on the ratio of occupied beds per 1,000 deaths in 2020/21 – beyond the upper limit shown in Figure 2 in 2004/05.

**Figure 2: Ratio of occupied medical group beds per 1,000 deaths (all-cause mortality), 2001/02 to 2019/20 (NHS Digital 2020, Office for National Statistics 2020b)**




In Figure 2 the upper number of 166 occupied beds per 1,000 deaths is equivalent to 61 bed days per death while the lower number of 152 occupied beds per 1,000 deaths is equivalent to 56 bed days per death. Clearly admissions in the last year of life are spread across both elective and emergency admission types and include both mental health and acute hospital admissions. The upper estimate of 50 bed days per death (equivalent to 137 occupied beds per 1,000 deaths) seems to be believable. Hence from Figure 2 the upper limit of 50 bed days per death would probably apply at the peak around 2004/05 while a much lower number would apply at the trough in 2007/08. It has been suggested that this variation around the median and average is due to the timing and mix of pathogens to which the population is exposed in different years (Jones 2021c,d).

This a particularly important finding because it implies that around half of total occupied bed days (across all specialties) may be related to NTD *plus* the wider impact of non-end-of-life morbidity triggered by the agents leading to final demise.

The standard assumption is that under conditions when age-standardized mortality is falling, then age-based forecasting is supposed to over-estimate demand. However, age-standardized mortality is a single measure of more complex shifts in the age-at-death profile (Basellini and Camarda 2019). The standard assumption also depends on whether admission (or disability) rates are constant, rising or falling (Whittenberg et al 2018). See section in Part 2 dealing with "Alternative models for bed demand". Also, the very fact that far more acute demand than thought possible depends on the trends in deaths, i.e., deaths as a proxy for wider demand, introduces an entirely new dynamic into the situation.

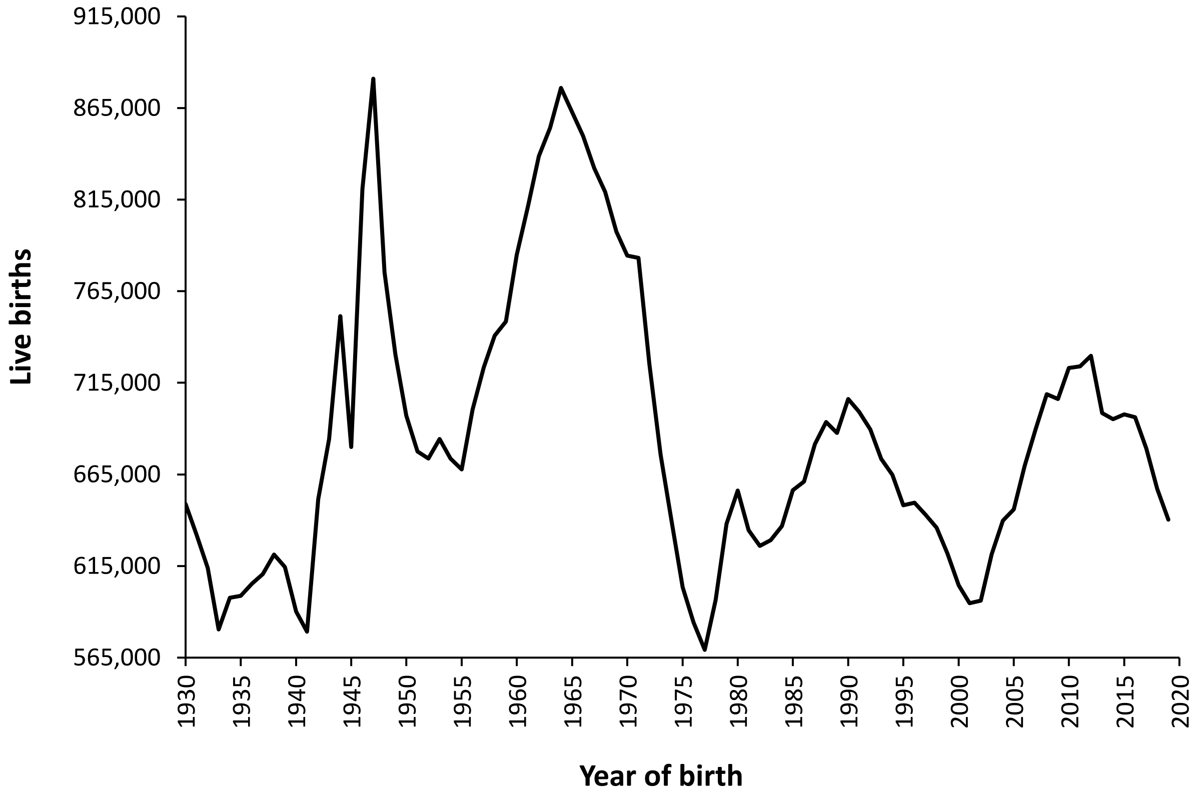
As a final comment, Figure 2 appears to show a reduction in the variation in occupied beds per death over time. This is simply because the NHS has closed so many beds that bed occupancy is constrained to a maximum occupancy set by bed numbers. The gap is simply showing up in the ballooning size of the elective waiting list. The NHS is in a perilous state of self-inflicted bed shortages with associated hidden queues and inefficiency.

Hence, the key point is that f***uture medical bed demand does indeed seem to largely depend on the trend in total deaths.*** If this is so what are the trends in future deaths?

### Trends in deaths

The baby boom emanating out of World War II set in motion events which are of particular importance to the issue of medical bed demand. As Figure 3 demonstrates between 1942 and 1952 some 8 million babies were born in England and Wales (ONS 2015, 2020c). Due to the rapid development in antibiotic therapy after the release of penicillin in 1942 (Powers 2004), many of these babies have lived long lives and are only now nearing the end of their lives.

**Figure 3: Births in England and Wales, 1930 to 2019.**




The 1952 cohort are now 68 while the 1942 cohort are 78. Some have died before 2020, however, additional waves of inward immigration have added to the number of survivors such that in 2019 in England alone there were 5.5 million persons aged 68 to 78 (ONS 2020b). All of these will die in the

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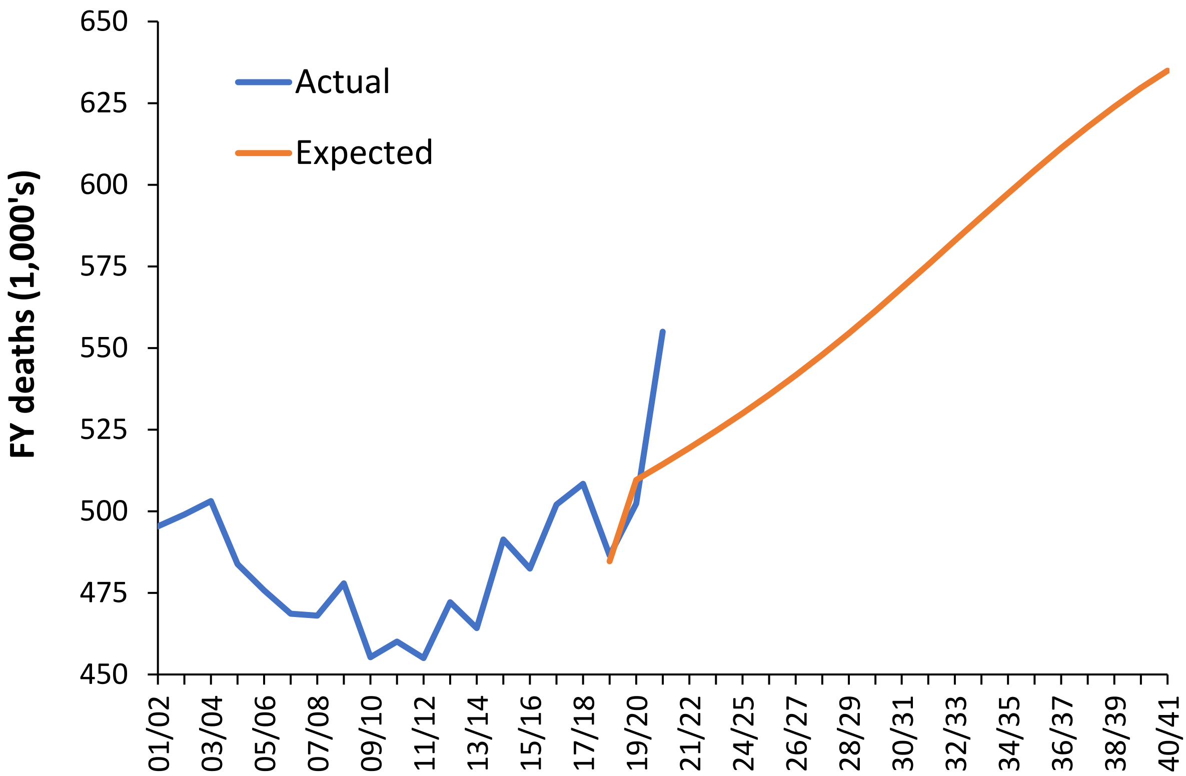
next 40 years plus additional deaths from persons born after 1952, especially those born in the second peak in births between 1955 and 1973 which arises from the WW II boom. Essentially the WWII babies all grow up and have a second generation of babies at roughly the same time, etc, etc. The ONS estimates that in England some 14.4 million people will die in the 24 years 2019 to 2043 (ONS 2020c). This total includes deaths among those born in the 1956 to 1972 'boom', plus a smaller contribution from the 1985 to 200 and the 2005 to 2020 minibooms. These cause a ripple effect in the numbers of deaths over time.

**Figure 4: Actual and expected deaths in England between 2001/02 and 2040/41**




To this end Figure 4 shows the actual and expected trends in deaths in England between 2001/02 and 2040/41 (Office for National Statistics 2020b,d). The financial year 2020/21 contains the effects of the Covid-19 epidemic. However, Figure 4 reveals a very disturbing fact, namely, total financial year deaths during the Covid-19 epidemic will be matched in just eight years' time such that in 2028/29 the NHS will be coping with the equivalent to the Covid-19 epidemic – admittedly spread over the entire year, but none the less far higher than anything experienced in the past 20 years.

The key point is that over the past 20 years the NHS has grown accustomed to living with fewer than 500,000 deaths per annum, which from 2019 onward will become a distant memory.

*Indeed, all our age-based capacity planning has achieved is to delude us into believing that demand is going to be far less than it will be.*

A further key point from Figure 4 is the volatility around the underlying trend line. This volatility partly accounts for the peaks and troughs in Figure 2 and from the fact that cause of death is also

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volatile due to the environmental factors responsible for the primary volatility in Figure 4 (Jones 2012c).

### Effect of age-standardized mortality rate (ASMR)

The ASMR and related life expectancy calculation are traditional public health measures. As highlighted in this study it is the absolute number of deaths which drive the demand for medical beds. ASMR and life expectancy have their relevance in the Office for National Statistics forecasts of future numbers of deaths which are subject to some uncertainty. However, in England and Wales in 2018 the most common age to die was 86 in males and 88 in females, these ages slowly increment

**Table 2: Top 40 local authorities for growth in deaths as a proxy for end-of-life costs, 2019 to 2043 (ONS 2020c)**

| Local Authority | Deaths | Births | Population |
|---|---|---|---|
| Tower Hamlets | 76% | 12% | 27% |
| East Northamptonshire | 72% | 15% | 20% |
| South Derbyshire | 66% | 29% | 28% |
| Westminster | 64% | 3% | 16% |
| Camden | 64% | 6% | 18% |
| Newham | 60% | 3% | 11% |
| Shropshire | 60% | 13% | 18% |
| Cotswold | 60% | 27% | 25% |
| Milton Keynes | 60% | 1% | 5% |
| Suffolk Coastal | 59% | 10% | 13% |
| Taunton Deane | 59% | 13% | 20% |
| Uttlesford | 59% | 19% | 20% |
| South Kesteven | 58% | 2% | 9% |
| Harborough | 57% | 25% | 22% |
| West Dorset | 57% | 0% | 12% |
| East Hampshire | 57% | 17% | 11% |
| West Oxfordshire | 57% | 9% | 11% |
| North West Leicestershire | 57% | 36% | 32% |
| Daventry | 56% | 33% | 27% |
| Aylesbury Vale | 56% | 17% | 20% |
| Malvern Hills | 56% | 15% | 18% |
| Hammersmith & Fulham | 55% | 3% | 10% |
| Brent | 55% | 3% | 8% |
| Rutland | 55% | 13% | 16% |
| Wychavon | 55% | 29% | 26% |
| South Norfolk | 54% | 25% | 26% |
| Mid Suffolk | 54% | 9% | 12% |
| Horsham | 54% | 18% | 18% |
| Huntingdonshire | 54% | 7% | 7% |
| Central Bedfordshire | 53% | 9% | 14% |
| Mendip | 53% | 7% | 14% |
| Torridge | 53% | 9% | 15% |
| Selby | 52% | 19% | 16% |
| Hackney | 52% | 12% | 16% |
| Richmondshire | 52% | -3% | -1% |
| Southwark | 52% | 10% | 13% |
| Stratford-on-Avon | 52% | 39% | 27% |
| Hinckley and Bosworth | 52% | 31% | 23% |
| Vale of White Horse | 52% | 23% | 21% |
| Chorley | 52% | 13% | 16% |
| **England** | **34%** | **10%** | **10%** |

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over time (Office for National Statistics 2020e). Hence the 1942 birth cohort will be 87 in 2029 and irrespective of the uncertainty in future longevity the 9-year time frame from 2020 is insufficient to significantly alter the gap between forecast and actual deaths. The full effect of the World War II baby boom is shortly upon us with little time to prepare. While national trends are illuminating it is important to see if there are specific issues at local level.

### Effect of public health measures to increase longevity

It is well recognised that the more deprived die at a younger age that the least deprived (Marmot et al 2020) and there are ongoing measures to reduce this gap. Such measures may reduce present day deaths but only act to increase future deaths. The NTD effect is simply shifted in time.

### High growth locations

Clearly this rise in end-of-life demand is not equally manifested across every part of England and Table 2 therefore shows the top 40 local government areas for the highest forecast growth in deaths between 2019 and 2043. To give a wider context the growth in births and total population has also been added to Table 2. Growth in deaths far exceeds growth in births and population. Tower Hamlets tops the list with a startling 76% forecast growth in deaths. Even the 30th highest, Central Bedfordshire, shows 53% growth.

Especially note the growth in Richmondshire where negative population change will lead age-based models to underestimate future demand.

It can almost confidently be said that none of these locations are prepared for this explosion in end-of-life demand. This is ***on top of*** growth in non-end-of-life admissions arising from simple age-based growth in the population.

Clearly there will be other locations such as Barrow-in-Furness, Bristol, or Kingston-Upon-Hull, etc where growth in deaths is low, and in these locations age-based forecasts may be more applicable. See Appendix 1 for greater detail relevant to London boroughs.

## Conclusions

The absolute number of deaths serves as a dual proxy for both the NTD effect and wider morbidity from infectious outbreaks and other environmental challenges – although with necessary adjustment for cause of death, and higher multi-morbidity in more deprived areas. It is all too common for humans to ignore any evidence which contradicts their firmly held opinions. On this occasion the NHS policy makers and politicians have clung to outmoded philosophies to the detriment of rational planning. Part 2 of this paper will explore the implications of these principles into how to construct models for ‘real’ demand, investigate if integrated care may be able to partly modify the inevitable consequences, and finally look at whether the NHS funding formula has been compromised by these forces.

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**Appendix 1: Change in deaths, births and population for London boroughs and larger regions in England, 2019 to 2043**

| Area | Deaths | Births | Population |
|---|---|---|---|
| Barking and Dagenham | 10% | 5% | 7% |
| Havering | 17% | 13% | 14% |
| City of London | 18% | -23% | 10% |
| Bromley | 20% | 9% | 9% |
| Bexley | 24% | 9% | 10% |
| Sutton | 25% | 3% | 7% |
| Waltham Forest | 25% | 5% | 8% |
| Merton | 29% | 1% | 3% |
| Redbridge | 32% | -1% | 6% |
| Islington | 33% | 12% | 12% |
| Lewisham | 33% | 10% | 12% |
| Harrow | 34% | -1% | 2% |
| Enfield | 35% | -3% | 3% |
| Greenwich | 36% | 11% | 16% |
| Hillingdon | 37% | 3% | 7% |
| Lambeth | 39% | 6% | 8% |
| **London** | **39%** | **5%** | **9%** |
| Croydon | 40% | 3% | 6% |
| Wandsworth | 40% | 6% | 10% |
| Kingston upon Thames | 41% | -2% | 6% |
| Hounslow | 41% | -2% | 3% |
| Ealing | 42% | -3% | -1% |
| Haringey | 46% | 0% | 5% |
| Richmond upon Thames | 46% | 1% | 6% |
| Barnet | 47% | 3% | 12% |
| Kensington and Chelsea | 50% | -5% | 1% |
| Southwark | 52% | 10% | 13% |
| Hackney | 52% | 12% | 16% |
| Brent | 55% | 3% | 8% |
| Hammersmith and Fulham | 55% | 3% | 10% |
| Newham | 60% | 3% | 11% |
| Camden | 64% | 6% | 18% |
| Westminster | 64% | 3% | 16% |
| Tower Hamlets | 76% | 12% | 27% |
| North West | 26% | 10% | 8% |
| North East | 27% | 5% | 4% |
| Yorkshire and The Humber | 29% | 9% | 7% |
| West Midlands | 29% | 17% | 13% |
| **England** | **34%** | **10%** | **10%** |
| East | 36% | 8% | 10% |
| South East | 38% | 8% | 8% |
| London | 39% | 5% | 9% |
| East Midlands | 39% | 14% | 13% |
| South West | 41% | 14% | 13% |