The calendar year fallacy: The danger of reliance on calendar year data in end-of-life capacity and financial planning

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Abstract

Planners, actuaries and others involved in forecasting capacity and costs must manipulate historical data. Data from calendar/financial year totals has been assumed to be adequate and reliable. This relies on the assumption that year-to-year differences do not arise from patterns concealed in the data. While the seasonal cycle is widely recognised, longer term patterns such as disease outbreaks will act to modify annual demand and costs. Monthly data relating to deaths in local government areas in England and Wales is used to demonstrate curious semi-permanent bursts of “high” behaviour. There is no seasonal pattern for the start of these events and the sudden switch to high deaths can occur at any time, even in immediately adjacent areas. Higher deaths, and related demand and costs, endure for around 12-months before they suddenly revert to the former level where they stay until the next of these curious “high” events. In England and Wales (and many other countries), a period of unexplained higher deaths, reduced life expectancy and health care and life insurance costs since 2011 appears to be coming to an end, and looks to have arisen from a coincidence of these events at sub-national level.

Key Words: Forecasting demand, end-of-life, death, sudden shifts

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1 Introduction

Actuaries and others involved in forecasting future costs must manipulate historical data. Up to the present, data derived from calendar or financial year totals has been assumed to be both adequate and reliable. However, this relies on the hidden assumption that the differences from one year to the next do not arise from patterns hidden within the data.
Indeed, the whole process of age standardization, as in mortality and hospital admission rates is known to involve the constant risk fallacy [1], i.e. the risk associated with age is not constant over time.

Studies of the year-to-year volatility (not arising from underlying growth) in deaths at local authority level in England and Wales have shown that the volatility is very high, implying high risk for any industry whose marginal costs rely on death or nearness to death, i.e. various forms of healthcare activities plus health and life insurance [2]. In addition the year-to-year variation was also shown to be location specific [2]. Location-specific volatility is also seen in cancer and other healthcare costs [3-6].

The link between death and healthcare costs arises from the nearness to death effect, where it is observed that around half of a person’s lifetime hospital admissions and bed occupancy occurs in the last year of life [7-14], and more specifically in the last six months [15-16]. Indeed, an admission to hospital for medical care (at any age) is associated with a far higher risk of death within one year [17]. Indicators of frailty in animals and humans only decline with nearness to death rather than age [17-19], cognitive decline in humans largely occurs as a function of nearness to death [20], and a composite biochemical score showed only moderate decline with age but underwent a large deterioration in the months preceding death [21].

Up to the present everyone had assumed that the high year-to-year volatility in deaths was due to variable excess winter mortality, howsoever caused [22,23], and especially due to the timing and magnitude of influenza outbreaks. The winter preference for many infections arises from seasonal forcing, such as a rapid drop in temperature [24,25], and the seasonal expression of genes [26]. However, could it be possible that even more subtle patterns lie hidden in the data which do not necessarily conform to a seasonal pattern?

This study explores the possibility that hidden patterns lie within the trends in death which may act as a confounding factor in the use of calendar/financial year-based data.

2 Methods

A monthly count of deaths in local government areas throughout England and Wales (2001-2019) was obtained from the Office for National Statistics [27]. Monthly counts were summed into rolling 12-month totals using Microsoft Excel. Analysis and charts were conducted using Microsoft Excel.

3 Results

Figure 1 shows typical trends in death constructed using a rolling 12-month total. As can be seen total deaths generally decline from 2001 through to 2010 to 2014. However, the trend for each location shows a series of curious undulations which do not necessarily line up with calendar year totals (at the vertical lines). The undulations before 2010 are concealed by the downward trend in deaths before 2010 but can be more readily seen in the data for Worcestershire where deaths do not show the decline prior to 2010. It is also clear that the trend for England is a composite picture of smaller areas. Seemingly all larger regions reach a minimum in both 2012 and 2014, show an increase after 2014, with the possibility of a
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return to lower total deaths after 2018. Note the two broad shoulders commencing around 2001 and 2007 overlaid on the downward trend before 2010. These will be specifically discussed later regarding their effects on hospital costs.

**Figure 1:** Rolling 12-month total of deaths for England and various larger regions, 12-month total ending December 2001 to March 2019, all relative to the point of minimum deaths

![Figure 1](https://example.com/figure1.png)

**Figure 2:** Rolling 12-month total deaths in West Berkshire in the South of England. Deaths range from 1,043 in Jan-05 to 1,266 in Jan-17.

![Figure 2](https://example.com/figure2.png)
The possibility of a clearer pattern is explored for a single Local Authority (West Berkshire in the South of England) in Figure 2. West Berkshire has a relatively simple population structure with most residents living in Newbury or nearby Thatcham. The area is relatively affluent with an Index of Multiple Deprivation of just 10 (range for English Local Authorities is 5 – least deprived to 42 – more deprived) [28]. As can be seen the undulations are far clearer and resemble a saw-tooth pattern. As in Figure 1, deaths also reach a recent maximum in either the 2017 or 2018 calendar years. The peaks are around 10% to 15% higher than the troughs. While there is a somewhat regular pattern the peaks and troughs can seemingly occur at any point in the calendar year. For example, September 2013 or February 2009, etc.

**Figure 3: Gap between calendar year growth and rolling 12-month totals, 395 local government areas and regions in England and Wales**

The results of Figures 1 and 2 raise the interesting question as to how can growth be measured? Figure 3 shows the potential for different answers by using two different methods. Given that local government areas seem to reach a maximum count of deaths in either 2017 or 2018 and a common minimum during 2014, two measures can be calculated. In the first is the difference between the highest calendar year total in 2017 or 2018 and the calendar year total in 2014; while in the second is the difference between the minimum rolling 12-month total during 2014 and the maximum rolling 12-month total during 2017 and 2018. The second method should return a higher value than the first. A 1:1 relationship occurs along the dotted line, and this nearly occurs in 4 of 395 local government areas, i.e. 1% of areas. The calendar year method shows a reduction in deaths for 7 local authority areas, i.e. 1.8% of areas.
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There is a 6% (percentage point) difference between the two measures for England and a 24% (percentage point) difference for Epping Forest in Essex. The minimum difference is 1% in Gosport and Test Valley both in Hampshire, Amber Valley in Derbyshire, and Tonbridge & Malling in Kent. The median is a 7% difference. Timing differences partly account for this huge range.

**Figure 4:** Role of size (as deaths in 2014) on the difference between the two methods used in Figure 3

**Figure 5:** Date in 2014 at which English and Welsh local government areas reach their minimum rolling 12-month total
Figure 4 explores the possibility that the size of the area may influence the magnitude of the percentage point difference between the two methods used in Figure 3. As can be seen the range in the difference increases rapidly as size (number of deaths) reduces. The two points at the far right are for England plus Wales and England. Both variable timing and size of the local government areas within a region or country combine in the final composite measure. The huge range in the difference at 1,000 deaths (the average size of a local authority) indicates that whatever is happening shows extreme variation in both timing and magnitude across the whole of England and Wales. The 4% difference for Wales (31,430 deaths per annum) is at the lower range for areas of a similar size, i.e. a 7% difference seen in the North East Region of England (26,888 deaths).

Finally, Figure 5 explores the point in time at which local government areas reached their minimum rolling 12-month total of deaths during 2014. As can be seen there is a strong cluster in April/May 2014 with a scattering of other dates in 2014. Of the 23 largest regions with over 10,000 deaths per annum only 3 had a date other than May 2014, namely Tyne & Wear in February, Inner London in July and South Yorkshire in August. Other dates are seemingly randomly distributed with some possible clusters, for example, a December date for both Runnymede and Guildford in Surrey (minimum for Surrey as a whole in May). In the Ceremonial County of Berkshire dates ranged from April in Wokingham and in Windsor, Ascot and Maidenhead, May in Reading, June in Slough, August in West Berkshire and November in Bracknell Forest.

4 Discussion

4.1 Aim of the study

The aim of this study is to get planners and actuaries to question their hidden assumptions around how the trends in death (and associated end-of-life demand and costs) behave over time. A secondary aim is to shed light on the curious international phenomena of unexpected higher deaths and hence stalling improvements in life expectancy observed since 2011 in all high-income countries [29,30]. Of all these countries England appears to have experienced the highest reduction in life expectancy up to 2017 [30]. It has been suggested that this may simply be a blip [31], and the reduction in total deaths in Figure 1 from 2018 appears to support this possibility.

4.2. Saw-tooth behaviour in a rolling 12-month total

In a rolling 12-month total, the seasonal profile of deaths is effectively removed, but sudden semi-permanent increases in deaths will generate the saw-tooth patterns seen in Figures 1 and 2. For example, if deaths are at their usual level the rolling total will continue as a straight line (assuming no growth), however, at the point of a sudden increase there will be 11 months of the original level plus 1 month of the new higher level, move forward 1 month and there are now 10 month of the original level plus 2 months of the higher level. This generates the upward face of the saw-tooth pattern where the apex marks the point where there are 12 months of the new higher level of deaths. If deaths now drop back to the usual lower level the downward face of the saw-tooth will result. A spike event (a single high month) such as an influenza epidemic does not generate a saw-tooth feature.
4.3 International Behaviour

The curious observation is that these saw-tooth features have been identified across the whole of Europe, Australia, New Zealand and in the Counties of Arizona (USA) [32-34], and also simultaneously occurs for the associated medical hospital admissions arising from the nearness to death effect [35-39].

4.4 Financial Implications

Two broad shoulders commencing around 2002 and 2007 were highlighted in Figure 1. For the NHS in England these correspond with two periods of unexplained higher hospital bed occupancy and hospital costs. Hospital bed occupancy was higher than expected during the financial years 2000/01 to 2006/07, also in 2008/09 to 2010/11, and again in 2013/14 to 2016/17 [40]. The two earlier periods were associated with over £700 million of unexplained higher costs (£1 billion in today’s terms) [41]. This national-level cycle has great similarities to the cycle of surplus and deficit called the health Insurance Underwriting Cycle which has been observed over many years in the USA [42].

4.4 Small-area Behaviour

A study using male and female deaths in English small areas about the size of an electoral ward demonstrated that these curious events were constantly commencing in about 1% of all small areas in any given month, and that males and females behaved as if they were separate compartments [43]. The small area behaviour of different commencement dates and magnitudes, along with male/female differences, then aggregates to give the larger area profiles seen in Figures 1, 2 and 5. In another study deaths seemed to behave differently between social groups [44], perhaps via different social group health behaviours. Figure 3 is simply the natural outcome of all these combined effects. Figure 4 then demonstrates that as the area gets larger there is greater opportunity for cancelling out effects between all the smaller areas. Analysis of national or regional calendar year data is then the composite result of myriad of small area effects.

4.5 An infectious agent

All those infectious agents which provoke an immune response are known to have their own unique periodicity, which can interact with health behaviours [45,46]. For example, syphilis has an approximate 8 to 11-year cycle while gonorrhoea, which does not provoke an immune response, does not show cyclic incidence [47]. The agent detected in this study shows cyclic behaviour, especially at small area level, however, does not depend on the usual seasonal triggers.

Single-year-of-age specificity

Of interest to planners and actuaries will be the observation that one of these events occurring in 1993 and another in 2012 (Figure 1 and 2) both showed single-year-of-age specificity [48,49], and that persons suffering from Alzheimer’s and other dementias appear to suffer highest mortality during these events [50,51].

Conclusions
The interesting point of this study is that both Figure 1 and 2 hint that the period of International higher deaths and hence lower life expectancy since 2011 may be coming to an end. The evidence appears to be pointing toward some new type or kind of disease outbreak. This clearly needs to be confirmed. Given the pattern of events in Figures 1 and 2, the clear implication is that national level events as experienced before and after 2011 can happen again. Planners need to be aware that unexplained periods of higher demand and costs will occur, but these will have a local focus. Periods of higher synchrony among the local events will generate national-level events.

Footnote:
For further research go to http://www.hcaf.biz/2010/Publications_Full.pdf

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