

Financial risk in health and social care budgets

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Abstract

With around half of a person's lifetime health and social care costs occurring in the last year of life it is the variation in the absolute number of deaths, not the age-standardized mortality, which drives the marginal variation in budgetary pressure. The year-to-year variation in the deaths in 397 English and Welsh local government areas were investigated over an 18-year period. Because of size, smaller government areas experience higher volatility than larger ones, however, some locations appear to show higher intrinsic volatility in deaths than others. A method is presented to calculate the financial risk reserve which must be deducted from each year's budget to cover for higher than expected variation – somewhat like an insurance premium. While variation is important, deaths have grown far faster in some locations than others, and this will place greater pressure on the budget against funds allocated via a formula which ignores the effects of the absolute number of deaths on costs.

Key Words: Financial risk; variation; volatility; health and social care; budgets; risk reserve

Introduction

The founder of Statistical Process Control (SPC), W. Edwards Deming, insightfully declared that 'variation is the voice of the process' (Wheeler and Chambers 2010). Clearly the average is important but higher variation indicates that the process is 'out of control'. The ability to exert budgetary management disintegrates as variation increases.

So how do the principles of SPC have any bearing on budgetary risk in health and social care? All health and social care purchasers receive their (fixed) annual funding via some form of capitation funding formula. However, the omission of deaths as an explanatory variable for costs may represent a fatal flaw in these models (Jones and Kellet 2018).

In this respect, around half of a person's lifetime health and social care costs occur as death approaches, i.e. the nearness to death effect – which has been well-documented in many countries during the past four decades, and is irrespective of the age at death (Henderson et

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al 1990, Hanlon et al 1998, Zweifel et al 1999, Busse et al 2002, Payne et al 2007, Aaltonen et al 2017, Moore et al 2017, Howdon and Rice 2018).

Unfortunately, much of the discussion around pressures on health and social care budgets revolves around the ageing population, with little recognition of the magnitude of the nearness to death effect. The correct forecasting of demand therefore relies on models which incorporate both effects (Howdon and Rice 2018). Hence, demand based on age for conditions relating to 'wear and tear' and the occasional acute exacerbation plus a component based on nearness to death. Such a two-compartment model has been successfully used to model prescription costs (Moore et al 2017). Age alone is entirely insufficient, and misleading.

The absolute importance of the magnitude of the nearness to death component can be illustrated by a study into the decline in cognitive ability with age. In a 20-year longitudinal study it was found that, after excluding persons near to death, cognitive ability only declined very slightly with age. The rapid decline was only seen in the near-to-death group (Rabbitt et al 2008). The authors concluded that omission of the nearness to death effect led to an over-estimation of the real decline in cognitive ability due exclusively to age. This same over-estimation of the effect of age has occurred regarding health and social care costs.

Hence, since around half of demand occurs in the last year of life it is volatility in the absolute number of deaths which drives the marginal variation in costs, not the age-standardized mortality rate.

Data and Methods

Data on monthly deaths in 397 English and Welsh government areas and regions (January 2001 to July 2018) is from the Office for National Statistics (2018a). The analysis commences with the absolute difference in deaths for the 12-months ending December 2002 versus the 12-months ending December 2001. Move forward one month and repeat the calculation, i.e. a rolling or moving 12-month comparison. The average for each area is therefore made up from over 180 paired differences. To avoid distortion due to trends in death over time the analysis converts the absolute difference in deaths into standard deviation equivalents by dividing by the square root of the average deaths over the two years. The data is then transformed back into a percentage using the most recent 12-month total deaths for each location, namely, August 2017 to July 2018.

Year-to-Year Variation

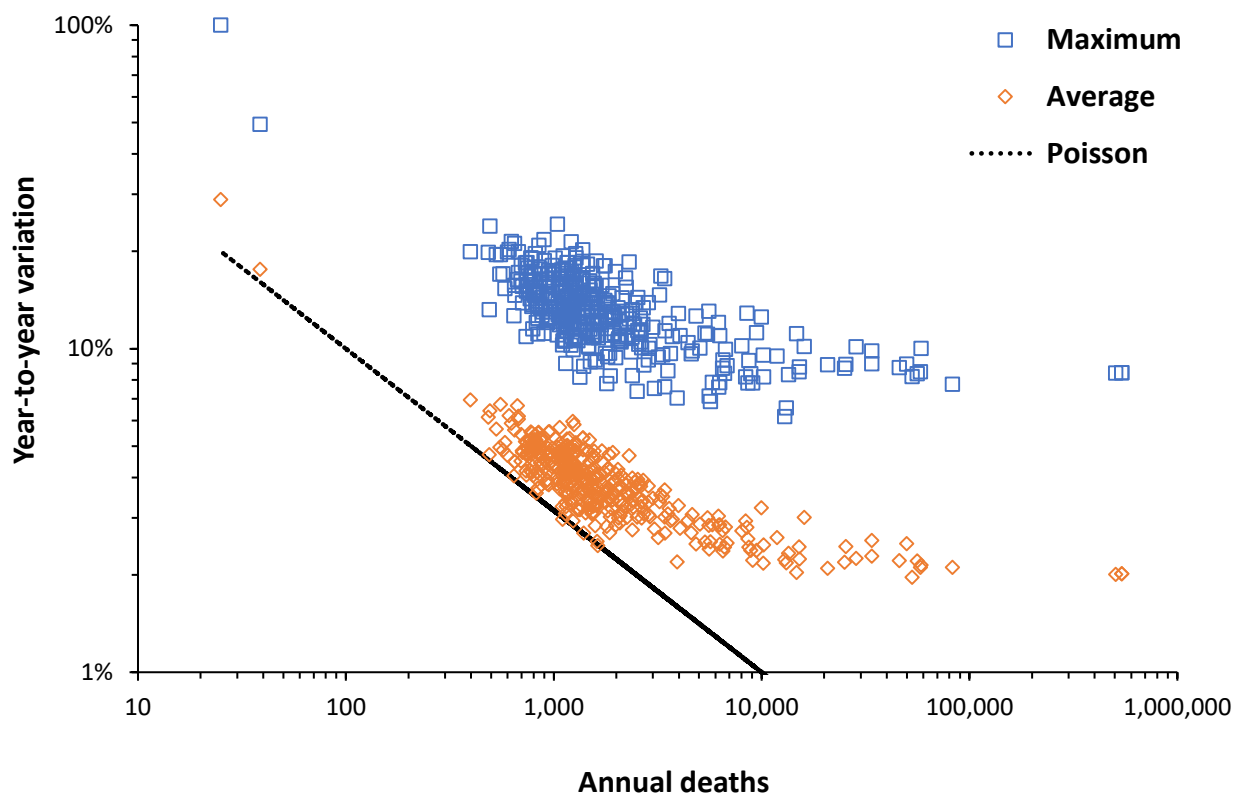
Managers in health and social care organisations need to know how costs will vary from one year to the next. Statisticians would argue that this is implicit in the standard deviation, however, while the two are indeed linked from a pragmatic point of view the analysis in this study will focus on the direct measurement of year-to-year volatility. As mentioned in the methods section the impact of long-term change in the number of deaths over time has been mitigated by averaging the deaths in the year-to-year comparison and converting this into standard deviation equivalents using Poisson statistics, or as a percentage difference relative to the average. Poisson statistics applies to integer events such as deaths. In a

Poisson distribution one standard deviation is equal to the square root of the average (Brooks 2005).

Variability in deaths

In this respect Fig. 1 shows an 18 -year average of a rolling (or moving) 12-month difference in deaths for 397 local government areas throughout England and Wales. Variation is plotted according to size (number of deaths).

Figure 1: The 18-year average and the maximum variation in successive 12-month deaths for English and Welsh local government areas, 2001 to 2018



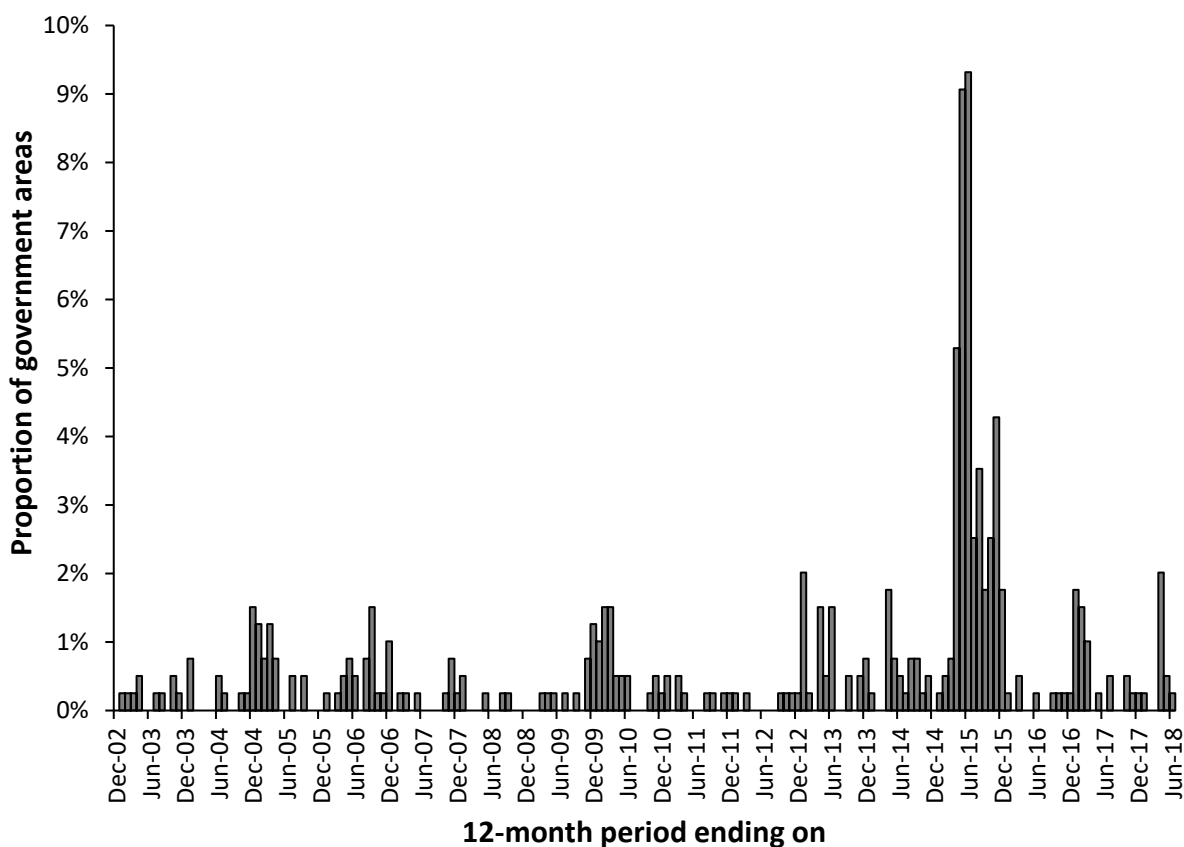
The line marked 'Poisson' shows one standard deviation equivalent of variation expressed as a percentage. This line will apply to locations where the effect of the variable external environment (weather, pollution, infections) only plays a minor role in the variability in deaths (Jones 2012). Only a handful of local authorities show little effect from the variable external environment. Most local authorities have around 1,000 deaths per annum and above 1,000 deaths the observed year-to-year variation deviates further away from simple Poisson randomness. The deviation becomes greater as size (number of deaths) increases because the variation is the composite of increasingly diverse social and ethnic groups, and their associated health and social care behaviours, interacting with the environment in different geographic areas (Jones 2015a,b, 2017c,d).

Average year-to-year variation for the whole of England is a manageable $\pm 2\%$ with a maximum difference of $+8.4\%$ for the 12-months ending June 2015 compared to the 12-months ending June 2014. Hence, Whitehall perceives a stable (in-control) system while the

average local government area (with 1,000 average deaths) see a chaotic world with around $\pm 3\%$ to $\pm 6\%$ average or $\pm 9\%$ to $\pm 24\%$ maximum variation, depending on location. The two smallest local authorities, City of London and Isles of Scilly, experience over 20% average and 50% maximum volatility. This represents totally uncontrollable variation due to variability in the environment, i.e. how volatile is local temperature, etc (Jones 2012).

The 2015 calendar year showed the greatest year-on-year increase in deaths in England and Wales in 50 years (ONS 2016). However, Fig. 2 shows that maximum year-on-year increases occur in different locations at markedly different times. Such periods of maximum increase are clustered in time (Jones 2012, 2015a,b, 2016, 2017b-d). The level of synchrony between different locations then acts to determine the magnitude of the increase observed at regional and national level. The year ending 2012 saw the fewest number of maximum amplitude events, however, high synchrony led to a national increase in deaths (Jones 2015b). Each of these curious events appears to initiate a step-increase in deaths which lasts for around 12 months (Jones 2015b, 2016). The 12-month period may well be set by loss of living independence, functional and health decline occurring most rapidly in the last 12 months of life (Kalbarczyk-Steclik and Nicinska 2015, Aaltonen et al 2017), i.e. the events trigger the pathways of rapid decline leading to eventual death in susceptible individuals.

Figure 2: Date of the maximum amplitude year-on-year increase in deaths in each of 397 local government areas in England and Wales



Public Health England attempted to claim that the large 2015 national increase was largely due to an influenza outbreak in January of 2015 (Newton et al 2016), however, the fact that

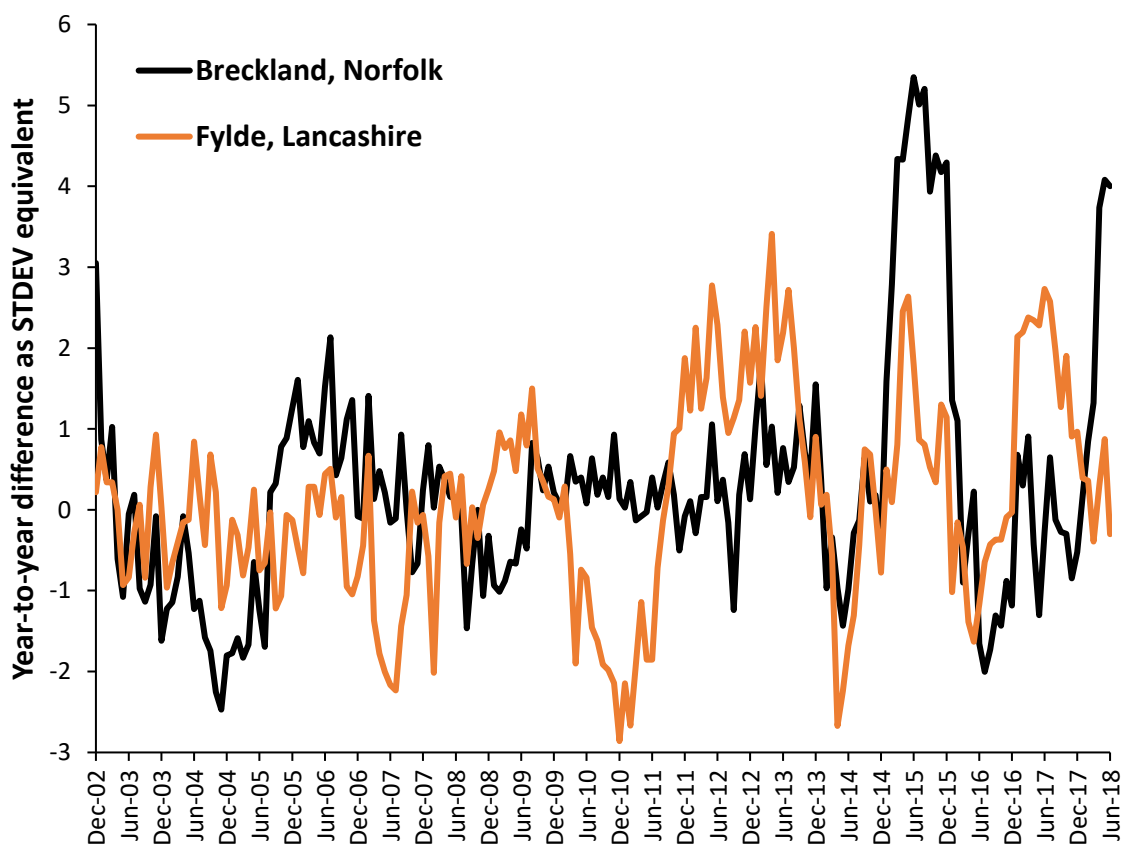
many local government areas showed their greatest increase for the 12-months ending June 2015 (Fig. 2), i.e. a very large step increase in deaths initiated in July 2014, tends to completely argue against this proposal. The actual agent responsible for the increase showed spatial spread, hence, the cluster of dates in the histogram (Jones 2015b, 2016, 2017a-d).

How stable is the average?

The average variation is calculated as part of a distribution of values. Fig. 1 showed the maximum for each area. The maximum year-to-year variation is typically 3.4-times the average (range 2.2- to 5.5-times). This difference increases as size increases, i.e. ratio of maximum to average = $2.3 + 0.15 \times \ln(n)$, where n = number of deaths. The distribution of this ratio around the trend line shows skew to higher values.

To understand these factors Fig. 3 shows the distribution of paired differences over time for two local authorities, namely Breckland in Norfolk and Fylde in Lancashire. This distribution is not a typical 'normal' shape but is characterized by extreme positive deviations from the average, i.e. large cost shocks which are poorly compensated for by periods of lower than average variation. This highly skewed behaviour is typical of an extreme value distribution. Extreme value distributions are observed for metrological events such as rainfall or epidemics and is important from an insurance perspective (Gilli and Kellezi 2006).

Figure 3: Year-to-year difference in deaths shown as standard deviation (STDEV) equivalents in two different local authority areas

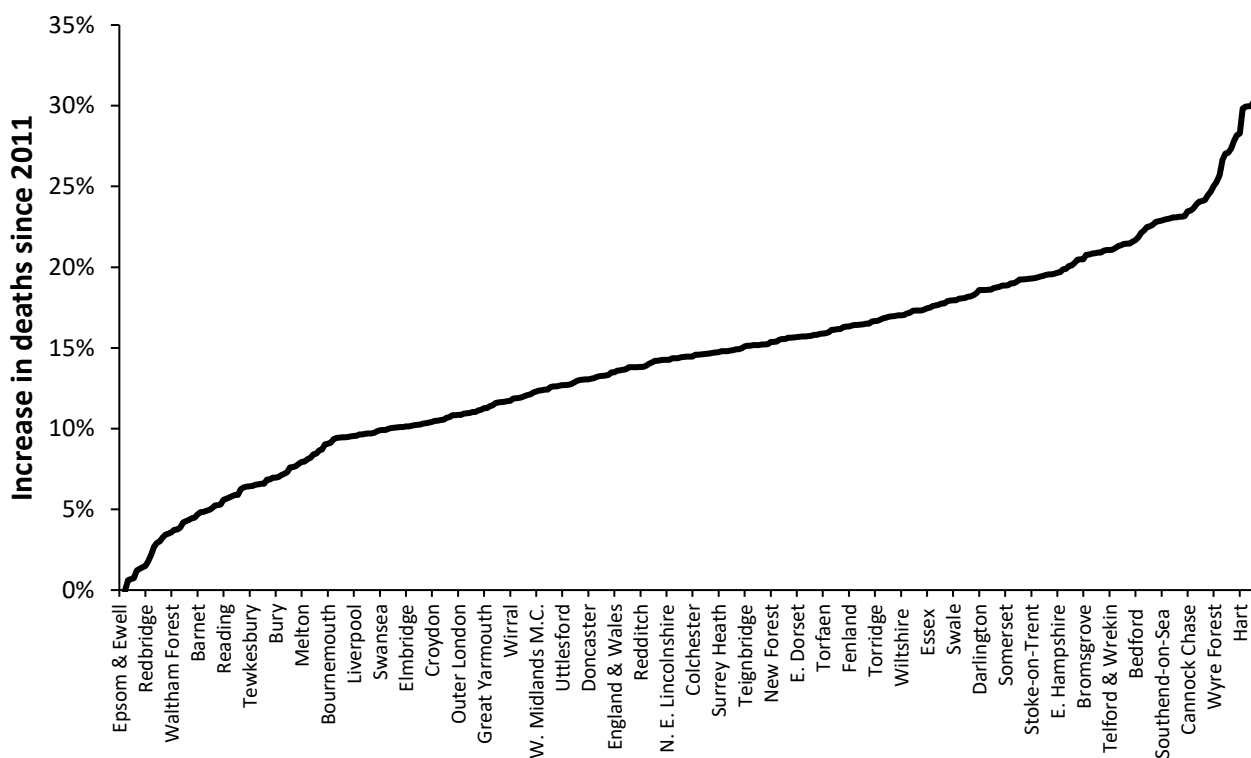


The average year-to-year variation reported here typically experiences a range in which one standard deviation is equal to 74% of the average (range 56% to 112%), hence, the average variation only applies for very long-term financial planning, i.e. if you wish to plan over an n-year horizon, then you need to keep one standard deviation divided by the square root of n as a financial risk reserve. This comes from a formula describing the standard error of the mean (McHugh 2008). For example, Breckland in Norfolk (approximately 1,600 deaths per annum) has a low 2.5% average variation but a high 112% standard deviation. Were the Breckland local authority to make a 4-year plan they must therefore keep a reserve of 56% ($112\% \div \sqrt{4}$) of 2.5% = 1.4% of each year's budget to cope with the potential adverse effects of above average variation over the term of the 4-year plan.

On/Off Switching and Risk

In a running or moving 12-month comparison, as in Fig. 3, switch on/off behaviour shows up as saw-tooth features in the trend. In a running 12-month total the effects of seasonality are effectively removed from the trend and a sudden step-like increase in deaths (switch-on) shows as the foot of a large peak. The full extent of the step-increase is revealed 12-months later, i.e. a full 12-month total of the step change is revealed. This switch on/off behaviour arises at very small-area level, also affects hospital medical admissions and staff sickness absence, with males and females seemingly respond in slightly different ways to each event (reviewed in Jones 2015b). At local government area level, the shape of the 12-month running trend is therefore a composite picture of male/female behaviour across all small-areas (Jones 2016).

Figure 4: Change in the number of deaths in English and Welsh local government areas between 2011 and 2018



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Up to the present no one had thought that such on/off behaviour was possible, however, it has now been extensively documented in UK local government areas (Jones 2017b), across Europe and in other Western countries (Jones 2015a,b) and is a fundamental source of both high volatility and financial risk. This is illustrated in the online supplementary material using data from Australia. The data from Australia shows slightly higher scatter than that in this study simply because only 10 years data was analysed compared to 18 years in this study – hence the scatter could be expected to be around 30% greater due to the smaller sample size. The key point is that all countries so far studied show the same intrinsic behaviour.

Areas with high growth in deaths

While health and social care budgets have had to cope with high volatility in end-of-life costs there has been an additional increase in the number of deaths (and associated costs) since 2011 (Jones 2017a). Some have claimed that this increase may be due to government austerity, however, this has been disputed (Jones 2017c,d). Fig. 4 shows the magnitude of the increase in deaths between 2011 and 2018.

As can be seen in Fig. 4 some locations, with mainly younger residents, have seen almost no change through to a 33% increase in Huntingdonshire. The omission of deaths from the funding formula implies that such increases are mostly unfunded (Jones & Kellet 2018).

Conclusions

In conclusion, end-of-life health and social care costs are subject to the natural variability in the absolute number of deaths which is subject to the statistics of extreme values. This uncontrollable variation is markedly different between locations due to both size and the external environment. The average local government area experiences such high year-to-year variation that managing budgets becomes close to impossible. The focus on calendar year deaths by both government agencies and the actuarial industry has obscured the fundamental on/off switching in deaths that dominates the overall variation. At local area level maximum amplitude events occur in clusters over time and are not restricted to 2015, hence, very large budgetary shocks can occur at any time. Government agencies seemingly omit to publish analysis which suggests that highly unusual things have been happening for many years. Deaths in 2015 happened to show higher synchrony than usual, although the prevailing spatiotemporal effects show as clustered small-area infectious-like events (Jones 2015b, 2017a-d).

Given this high intrinsic volatility both NHS and local government funding needs to have a retrospective component based on the actual number of deaths rather some formula estimate. While the population is ageing these only places a minor increase in genuine age-related 'wear and tear' and acute exacerbation (not related to end-of-life) costs. The local trends in both forecast and actual deaths then becomes a far more important variable. Deaths are forecast to rise across the UK over the next 25 years mainly due to the World War II baby boomers reaching end-of-life in increasing numbers (Office for National Statistics 2018b). It is not the age of the population, per se, which is the problem, rather the rising number of deaths and concentrated workload and costs in the last year of life.

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References

- Aaltonen M, Forma L, Pulkki J, et al. Changes in older people's care profiles during the last 2 years of life, 1996-1998 and 2011-2013: a retrospective nationwide study in Finland. *BMJ Open* 2017; 7: e015130.
- Brooks B. The Poisson distribution. 2005. <https://www.umass.edu/wsp/resources/poisson/>
- Busse R, Krauth C, Schwartz F. Use of acute hospital beds does not increase as the population ages: results from a seven-year cohort study in Germany. *J Epidemiol Community Health* 2002; 56: 289-293.
- Gilli M, Kellezi E. An application of extreme value theory for measuring financial risk. *Computational Economics* 2006; 27: 207-228. doi: 10.1007/s10614-006-9025-7
- Hanlon P, Walsh D, Whyte B, et al. Hospital use by an ageing cohort: an investigation into the association between biological, behavioural and social risk markers and subsequent hospital utilization. *J Public Health Med* 1998;20(4):467-76.
- Henderson J, Goldacre M, Griffith M. Hospital care for the elderly in the final year of life: a population-based study. *BMJ* 1990; 301: 17-19.
- Howdon D, Rice N. Health care expenditures, age, proximity to death and morbidity: Implications for an ageing population. *J Health Econ* 2018; 57: 60-74. doi: 10.1016/j.jhealeco.2017.11.001.
- Jones R. End of life care and volatility in costs. *BJHCM* 2012; 18(7): 374-381.
- Jones R. Deaths and international health care expenditure. *BJHCM* 2015a; 21(10): 491-493.
- Jones R. Recurring outbreaks of an infection apparently targeting immune function, and consequent unprecedented growth in medical admission and costs in the United Kingdom: A review. *Brit J Med Medical Res* 2015b; 6(8): 735-770. doi: 10.9734/BJMMR/2015/14845
- Jones R. A regular series of unexpected and large increases in total deaths (all-cause mortality) for male and female residents of mid super output areas (MSOA) in England and Wales: How high-level analysis can miss the contribution from complex small-area spatial spread of a presumed infectious agent. *FGNAMB* 2016; 2(2): 1-13. doi: 10.15761/FGNAMB.1000129
- Jones R. What government data on death rates fail to show. *BJHCM* 2017a; 23(8): 572-573.
- Jones R. Outbreaks of a presumed infectious pathogen creating on/off switching in deaths. *SDRP Journal of Infectious Diseases Treatment and Therapy* 2017b; 1(1): 1-6. <http://www.openaccessjournals.siftdesk.org/articles/pdf/Outbreaks-of-a-presumed-infectious-pathogen-creating-on-off-switching-in-deaths20170606102727.pdf>
- Jones R. Role of social group and gender in outbreaks of a novel agent leading to increased deaths, with insights into higher international deaths in 2015. *FGNAMB* 2017c; 3(1): in press. <https://www.oatext.com/role-of-social-group-and-gender-in-outbreaks-of-a-novel-agent-leading-to-increased-deaths-with-insights-into-higher-international-deaths-in-2015.php>
- Jones R. Different patterns of male and female deaths in 2015 in English and Welsh local authorities question the role of austerity as the primary force behind higher deaths. *FGNAMB* 2017d; 3(1): in press. <https://www.oatext.com/different-patterns-of-male-and-female-deaths-in-2015-in-english-and-welsh-local-authorities-question-the-role-of-austerity-as-the-primary-force-behind-higher-deaths.php>
- Jones R, Kellet J. The way healthcare is funded is wrong: it should be linked to deaths as well as age, gender and social deprivation. *Acute Medicine* 2018; 17(4): in press.
- Kalbarczyk-Steclik M, Nicinska A. The last and the previous year of life in Europe: A comparative analysis of care received and daily living limitations. *J Aging Gerontol* 2015; 3: 1-7.
- McHugh M. Standard error: meaning and interpretation. *Biochemia Medica* 2008; 18(1): 7-13. <http://dx.doi.org/10.11613/BM.2008.002>
- Moore P, Bennett K, Normand C. Counting the time lived, the time left or illness? Age, proximity to death, morbidity and prescription expenditures. *Social Sci Med* 2017; 184: 1-14. doi: 10.1016/j.socscimed.2017.04.038
- Newton J, Pebody R, Fitzpatrick J. Peak in deaths in 2015 is not a complete mystery. *BMJ* 2016; 352: i1582. doi: 10.1136/bmj.i1582

Office for National Statistics. Deaths registered in England and Wales: 2015; 2016. <https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/bulletin/s/deathsregistrationsummarytables/2015>

Office for National Statistics. Deaths registered monthly in England and Wales. 2018a. <https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/datasets/monthlyfiguresondeathsregisteredbyareaofusualresidence>

Office for National Statistics. Subnational population projections – deaths, 2018b. <https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationprojections/datasets/deaths4>

Payne G, Laporte A, Deber R, Coyte P. Counting backward to health care's future: using time-to-death modeling to identify changes in end-of-life morbidity and the impact of aging on health care expenditure. *Millbank Q* 2007; 85(2): 213-257.

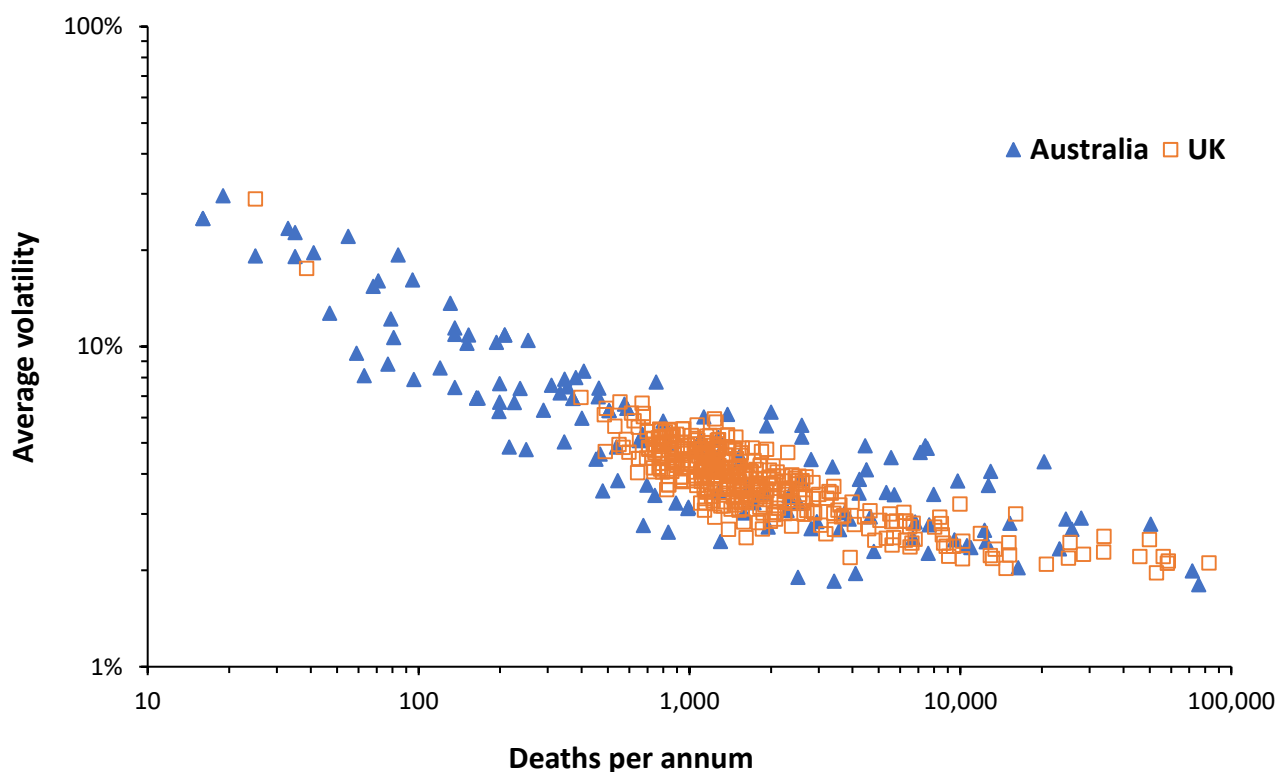
Rabbitt P, Lunn M, Wong D. Death, dropout, and longitudinal measurements of cognitive change in old age. *J Gerontology: Psychological Sciences* 2008; 63B (5): P271-P278.

Wheeler D, Chambers D. Understanding statistical process control. 3rd Ed, 2010. SPC Press Inc, Knoxville, TN.

Zweifel P, Felder S, Meiers M. Ageing of population and health care expenditure: a red herring? *Health Economics* 1999; 8(6): 485-496.

Supplementary Material

Figure S1: Average volatility in Australia versus that in the UK (this study)



Footnote: Data is from the Australian Bureau of Statistics (Statistical report 33020DO001_2013 Deaths, Australia, 2013) and covers the 10 calendar years 2003 to 2013. Data points cover both the whole of Australia (larger number of deaths toward the right-hand side) and the State of New South Wales (smaller number of deaths toward the left-hand side) and are for various age/sex combinations. The method used to analyse the data is identical to that applied to the data from England and Wales except that calendar years are used rather than a running 12-month comparison.