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# Is the weekend mortality effect real?

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## Weekend mortality, same day emergency admissions and other awkward issues

### Introduction

Based on analysis by Freemantle et al (2015) the Secretary of State for Health (England) declared that implementing 7-day working would save 11,000 of avoidable deaths each year (Telegraph 2015). He then introduced new working arrangements for junior doctors as the first step in achieving this worthy goal. Since that point there has been disquiet as to whether the weekend effect may be an artefact. Are there pitfalls into which even eminent academics can tumble? Whilst doing my PhD, nearly 40 years ago, I can still vividly remember Dr E.T. White impressing on our young minds regarding the pitfalls of statistical theory when confronted with real world data, and the general untrustworthiness of mathematical models – especially when they contain hidden assumptions.

### How to model acuity

The so-called weekend mortality effect for hospital admissions contains both of the above ingredients in abundance. Firstly, all current models naively assume (hidden assumption) that diagnosis is predictive of acuity. Talk to any doctor and they will unanimously agree that diagnosis is an extremely poor predictor of acuity, and that length of stay is probably a far better predictor. Hence while advising a hospital on matters relating to hospital mortality I constructed a model to predict mortality rates using only admission type (elective versus emergency), age in single year increments, gender and length of stay. The model worked very nicely with same day stay admissions having very low rates of mortality, with mortality increasing in 1 day increments up to 14 days, beyond which there was no further increase.

The key point being that a dodgy assumption (diagnosis) will cause statistical theory to generate spurious correlations. The current models indicating a weekend effect all contain additional assumptions which have been discussed elsewhere (Jones 2015, Jones et al 2016).

### Selection bias

In David Becker's seminal review of weekend mortality published in 2008 (Becker 2008) it was pointed out that conditions having the greatest excess of weekend mortality also had the greatest reduction in weekend admission rates. This incisive review, and its summation of traps for the unwary has been seemingly overlooked by most recent studies on the topic.

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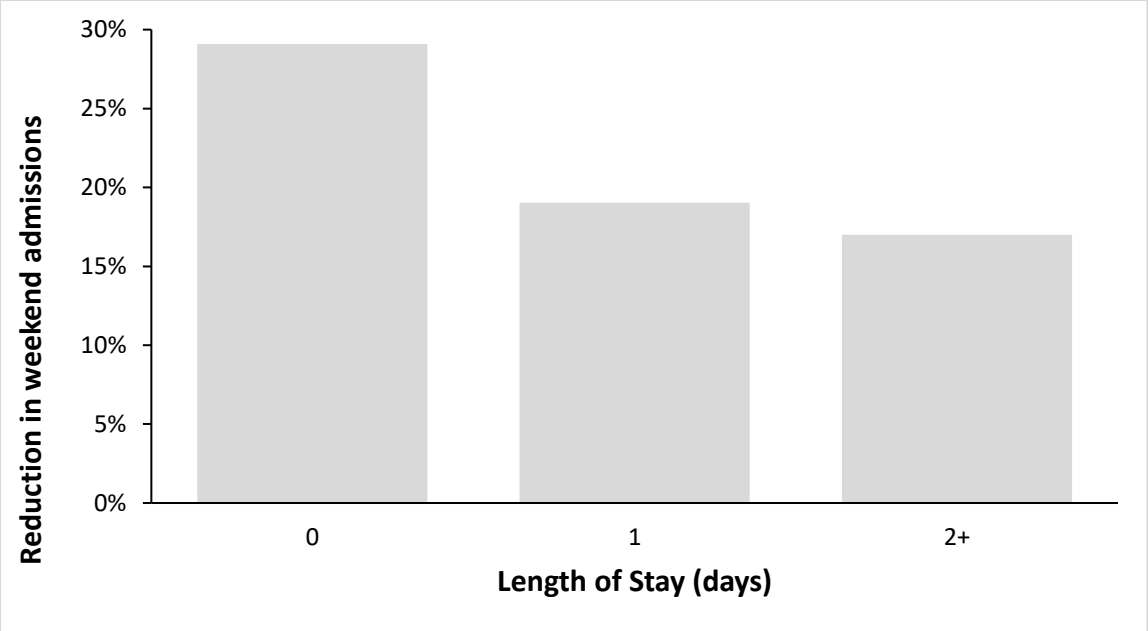
This difference in admission rates, seemingly due to greater acuity/severity, is perhaps an excellent example of the constant risk fallacy (Nicholl 2007), where rates are assumed to be constant when they are not.

Two recent studies have confirmed earlier findings. Earlier this year Meacock et al (2016) published a study which demonstrated that there are similar attendances across the week in A&E and there is no weekend effect for deaths among A&E attenders. However, fewer people are admitted from A&E at the weekend and it is in this group that weekend mortality appears higher. Later in the year, CHKS (a provider of hospital benchmarking services) (Raspin and Bassi 2016) analysed 25 million emergency admissions in England over a five-year period and demonstrated that for the majority of conditions the weekend drop in admissions correlated with the weekend rise in mortality. Intercranial injury was an outlier probably due to alcohol-related weekend admissions. This is an example of selection bias, where a 'sicker' cohort are admitted on the weekend.

**Figure 1: Reduction in weekend emergency admissions by length of stay**




*Footnote: Data is for acute hospitals only and therefore excludes mental health and community service providers.*

Based on the policy initiative for a 7-day NHS, NHS Digital was tasked with publishing material supporting the notion of higher weekend mortality (NHS Digital 2016a). Figure 1 takes data from the latest NHS Digital report to show that the reduction in weekend admissions is itself length of stay sensitive, with the greatest reduction among same day stay admissions, although there is still a 17% reduction among those with a stay of two or more days. The weekend reduction is greatest among heart and chest hospitals and women's hospitals, least among children's hospitals, with a weekend increase at oncology hospitals (data not shown). There are clearly additional factors at play.

Given the huge variation in the proportion of same day emergency admissions (range 12% to 40%) among acute hospitals in England (Jones 2016), it is hardly surprising that there is similar variation in the reduction in weekend admissions between English hospitals (data not shown). Hence the strength of the weekend effect may be affected by differential thresholds to 'admission' into various assessment/observation units.

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**Inconsistency in the weekend effect**

If the weekend increase in mortality is such a fundamental property of acute care it would be expected that hospitals should show a degree of consistency in the calculated weekend effect between emergency and total admissions and between years.

**Table 1: $R^2$ values for correlation between the weekend effect for emergency admissions versus all admissions in English hospitals.**

| Year | Unconstrained Intercept | Intercept = 0 |
|---|---|---|
| 2013/14 | 0.04 | -0.998 |
| 2014/15 | 0.62 | 0.48 |
| 2015/16 | 0.55 | 0.47 |

*Footnote:* $R^2 = 1 - \frac{SS_E}{SS_T}$. *This method is used in both Excel and SPSS to calculate $R^2$, hence, under certain conditions (as above) a negative value is possible. It is commonly accepted that a negative value implies the there is no correlation.*

**Table 2: $R^2$ values for correlation between the weekend effect for emergency admissions in English hospitals between different years.**

| Paired Years | Emergency Admission | All admissions |
|---|---|---|
| 2013/14 vs 2014/15 | 0.067 | 0.36 |
| 2014/15 vs 2015/16 | 0.016 | 0.0038 |
| 2013/14 vs 2015/16 | 0.00002 | 0.046 |

Table 1 gives the value of $R^2$ for the correlation in different years of the calculated increase in weekend mortality for emergency versus all admissions. Recall that the bulk of all deaths are from emergency admission and the inclusion of elective deaths in all admissions should make very little difference. However, as can be seen the correlation is very poor, especially when the intercept is constrained to zero – which is the expected situation on this occasion.

This lack of correlation leads to further investigation of the apparent weekend effect for emergency admissions in hospitals over different years. Table 2 therefore presents the $R^2$ for paired correlation in the strength of the weekend effect for English hospitals between different years. This is further illustrated in Figure 2 for 2013/14 versus 2015/16 where there is absolutely no correlation between the two years. Highly concerning since the two should be highly correlated.

The weekend effect appears to have all the substance of a fleeting vapour.

**A biochemical basis for acuity**

Having established that the weekend is almost certainly an artefact of flawed models it is of interest to note that another recent study has suggested that the higher acuity on the weekend can be measured using a composite score derived from common blood biochemical variables (Jones et al 2016). The weekend effect appears to arise from a day-of-week cycle in blood biochemistry which is most pronounced in patients with an acute medical condition. The strength of the day-of-week cycle is lowest in A&E, assessment units and among surgical patients. While not categorically proven that this cycle is associated with

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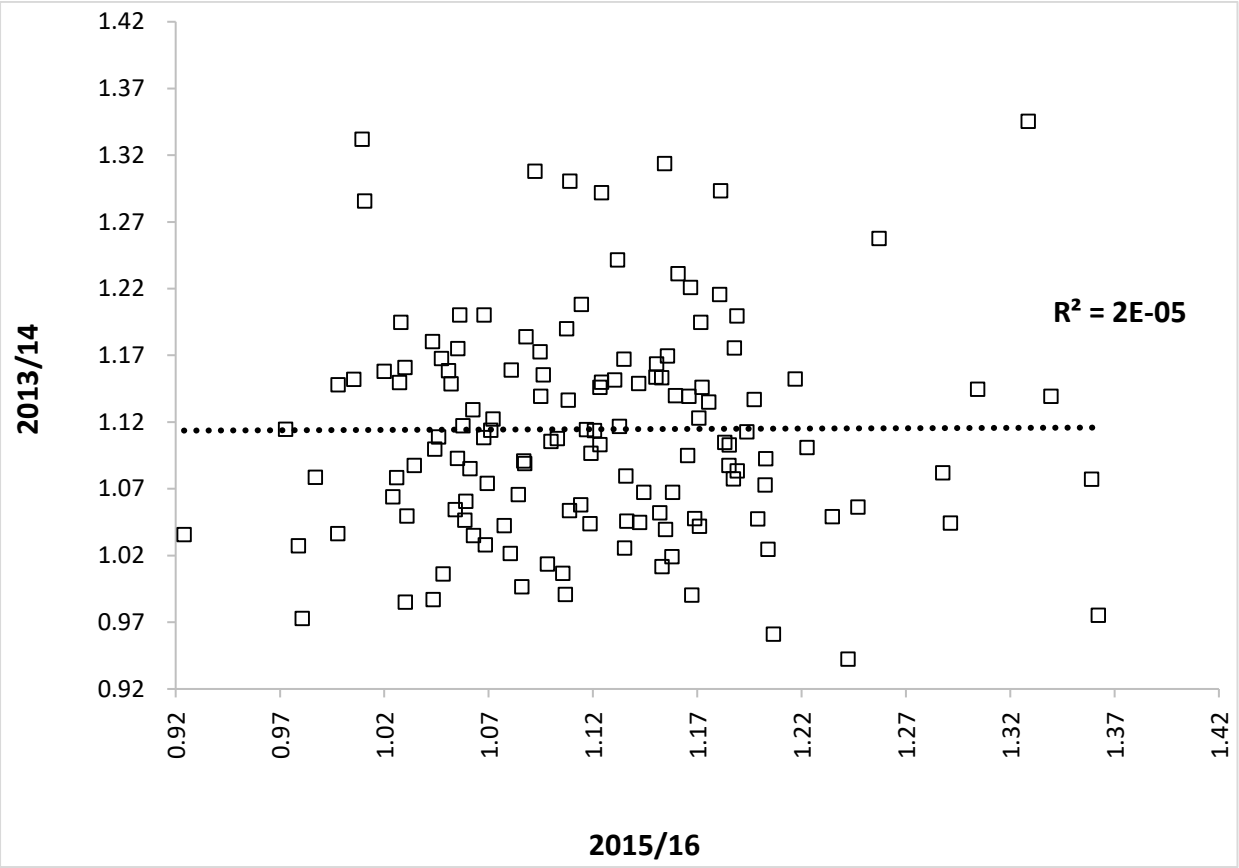
acuity the results were seemingly heading in a promising direction and deserve further study.

**Figure 2: Apparent strength of the weekend increase in mortality for emergency admissions in English hospitals in 2013/14 versus 2015/16**




*Footnote: A value of 1.0 indicates no weekend effect, while less than 1.0 indicates higher deaths for weekday admissions.*

### Same day emergency admissions

It was interesting to note in Figure 1 that same day stay emergency admissions show the highest reduction over the weekend. There is very little Monday surge compared to other week days to indicate that any form of catch-up is involved. The study involving blood biochemistry indicated that acuity in assessment units is low (Jones et al 2016), hence where are all the patients coming from? Dare one suggest from primary care, an assertion supported by the findings of the CHKS study (Raspin and Bassi 2016).

This presents interesting possibilities for the Sustainability and Transformation Planning (STP) process currently underway in England (Kings Fund 2016). Clearly my (unpublished) model based on length of stay, indicated that any emergency admission with a same day stay had a very low likelihood of death, and this was confirmed by the biochemical study (Jones et al 2016). This cohort of 1.7 million same day emergency admissions in 2015/16 NHS Digital 2016b) must therefore be a prime target for admission avoidance and cost reduction. Assuming that 25% are preventable gives somewhere in excess of £80 million of reduced acute costs.

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**Conclusion**

The evidence supporting the weekend effect looks decidedly shaky for the majority of conditions – obvious events such as trauma, etc being exceptions. Somewhat ironically the NHS is about to cut staffing levels in a bid to reduce something close to a £2 billion overspend. Poor staff to patient ratios being one of the best documented factors relating to higher hospital mortality (see references in Jones et al 2016). Seemingly the Secretary of State for Health (England) can justify more weekend staff based on entirely dubious grounds, while on the other hand reducing staff to eliminate a large overspend – a guaranteed way to increase avoidable deaths (Symons et al 2013, Aiken et al 2014). Such is politics.

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**Key Points**

- The weekend mortality effect is largely an artefact of lower weekend admissions
- Studies suggest higher acuity for patients admitted at the weekend
- Data produced by NHS Digital to support 7-day working show poor correlation among parameters which should be highly correlated
- A large decrease in same day stay emergency admissions on the weekend may be due to primary care

**Provenance**

Dr Rodney Jones has over 25-years' experience in health care demand forecasting and capacity planning. He has published over 200 papers in this area including bed planning and the financial risk in health care commissioning.