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Cycles in emergency admissions

Dr Rod Jones (ACMA)
Statistical Advisor
Healthcare Analysis & Forecasting,
Camberley, Surrey, UK
hcaf_rod@yahoo.co.uk,
www.hcaf.biz

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Key Points

- For medical admissions, there appears to be an approximate four to six year cycle with a 10% to 13% step-like increase due to a trigger-point.
- This increase in medical admissions appears related to a group of ill-defined and miscellaneous diagnoses and its onset is characterised by a modest increase in excess deaths over a two-month period.
- The increase exhibits considerable regional variability as to the onset and extent of the response.
- GP referral for an outpatient appointment also appears to follow the medical cycle.
- According to this cycle medical emergency admissions in 2009/10 for particular locations should be around 10 to 13% higher than seen in 2007/08 and should continue at this higher level for the next four to six years.
- Emergency admissions to the surgical specialties and trauma admission in Orthopaedics follow different cycles and do not show a trigger-point as in medicine.
- The medical cycle may influence the cycle of surplus and deficit seen in the NHS.
- The three-year lag in the tariff setting process could lead to higher prices in particular years which may exaggerate the cycle of surplus and deficit.

Series Summary

Part one of this series discussed how the more widely recognised factors such as an aging population and re-admissions only contribute to a baseline increase in emergency admissions. Short stay admissions (mainly zero day stay) account for the bulk of the increase. At first glance, most diagnoses appear to show a roughly linear trend over time. However, these are unable to explain the observed cyclical events occurring about every four to six years in medicine and even longer cycles in surgical and trauma admissions. These cycles are discussed here while part three investigates the implications to bed planning. The current methods for estimating the size of hospitals and bed pools are shown to be inappropriate to the needs of emergency care.

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Introduction

While the aging population and re-admissions for patients with long term conditions appear to explain the trends seen in the majority of diagnoses, they do not explain the collective trend seen at speciality level as demonstrated in Figure 1. The trend in Figure 1 (which is illustrative of England in general) does not conform to any of the accepted mechanisms for growth outlined in part one of this series (Jones 2009d). Given the role of weather (temperature, pressure, humidity, etc) and environment (pollution, viruses, etc) in changes in health as seen in the seasonal nature of emergency admissions it is highly likely that long term trends in weather and environment could generate similar longer-term cycles in emergency admissions. In this respect, the potential link between global warming and healthcare has been the subject of several reviews (Hales et al 2000, Haines & Patz 2004, McMichael et al 2006). In this article, the word 'cycle' is used loosely for any recurring event. An alternative description could be waves or 'wavelets' which is the term used in the mathematical analysis of such phenomena.

Given the large number of new concepts to be addressed further discussion on each section can be found in a supplement (http://tinyurl.com/dl56z8).

Natural Cycles

The linkage between the weather and emergency admissions is well established (Jones 2009d). Various natural cycles which may influence the weather or emergency admissions are discussed in the supplement where the complexity behind natural cycles should translate into complex cycles in emergency admissions for particular conditions.

Cycles in Health

Is there any evidence that long term cycles are involved in emergency admissions? The first piece of evidence comes from studies on the incidence of a wide range of diseases and conditions encountered in general practice. These studies use the weekly data returns to the Royal College of GP's Birmingham research unit where a network of 100 general practices spread across England classify all patient attendances (RCGP 2007, 2008). Data extending back to 1967 are analysed and the incidence of over 80 conditions have been shown to follow complex long-term cycles (Fleming et al 1991, RCGP 2007). Observations by the author indicate that there are links with acute care. For instance, demand for elective ENT appears to follow the longer-term incidence of tonsillitis. By implication emergency admissions should also show similar patterns.

The El Nino cycle which influences warming and cooling in the southern hemisphere is known to influence the outbreak of cholera, malaria, hanta virus and even viral pneumonia all of which can lead to emergency admission (Hjelle & Glass 2000, Ebi et al 2001, Kovats et al 2003). See supplement.

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Hence what has been established is that there are patterns which could loosely be termed as cycles which affect health and hospital admissions and that a general pattern can be suspended for periods of time. This leads us to a discussion of step changes and what may be called trigger events.

Step Changes

The concept of a spike increase is easy to understand; however, there is growing evidence to show that medical emergency admissions also experience step-like change, i.e. admissions rise to a peak as in a spike increase but then fail to come down to the former level. The admissions then continue at the higher level. See supplement.

Re-analysis of emergency admissions in England using a mix of paper and electronic records shows evidence for step-like changes around the years 1983-1984, 1988-1989, 1993, 1996, 2003 and 2007 which are about every four to six years.

Fig. 1 illustrates the nature of the data series behind the longer-term trends. As can be seen there is considerable monthly fluctuation which is loosely described by the annual seasonal cycle but the transition to a new and higher rate of emergency admission can also be seen. The onset of the transition tends to be clearer in the running twelve-month chart. This method was also used in part one (Fig. 1) of this series where a running 365-day total was used to illustrate the cumulative effect of the 'trigger event'. Both figures demonstrate that the full effect is usually only discerned in the following financial year due to the nature of the underlying response to the trigger and the fact that the trigger can occur at variable points in a financial year. The duration of the slope connecting the successive plateaux reflects the time taken to reach the new point of equilibrium; hence the response can take around 15 to 18 months for the full effect to be seen in a retrospective twelve months data series. Hence the difficulty of pinpointing the onset of the effect when using a series of financial year data and this by extension explains the nature of the financial pressures experienced by healthcare purchasers and providers alike. The apparent long transition seen in Fig. 1 may be an artefact of local pressures in 2004/05 since the fundamental shift appears to have ceased by around April 2004.

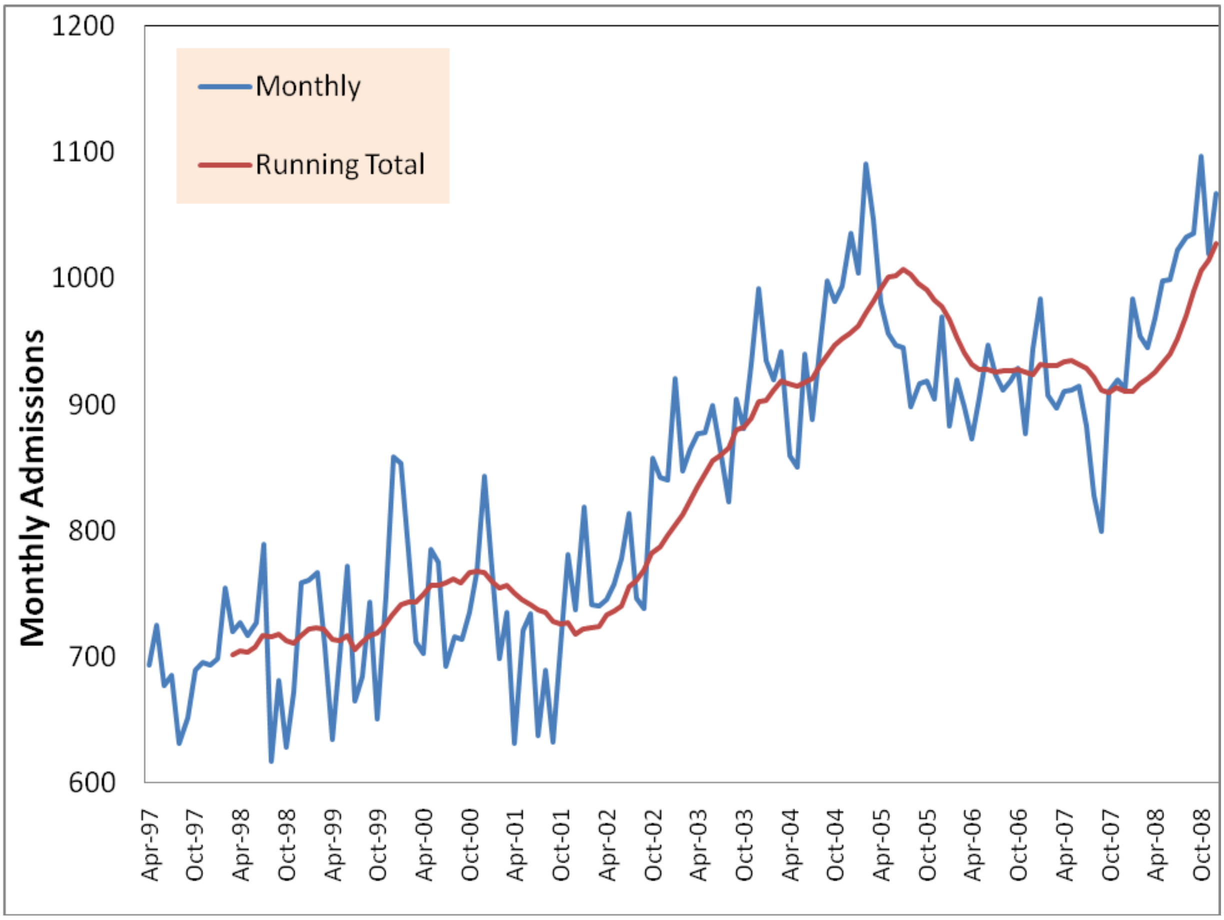
Both the 1998/99 and 1994/95 step changes also coincided with a step change in GP referral for outpatient attendance (DHSSPS 2002, Capewell 1996, Crossen-White et al 1997) and the most recent step change has also led to a large rise in GP referral, howbeit in particular specialties. The 1998/99 step change in Northern Ireland led to a 12% step increase in emergency admissions (DHSSPS 2002) while the step change seen in Reading led to a 13% increase (Jones 1996). A similar increase was observed across England (Hobbs 1995).

Trigger Events

The issue of trigger events is worthy of further consideration. For example, the end of the year 2000 saw an abrupt decline in the incidence of influenza to levels far below anything seen in the previous 33 years, i.e. eight consecutive years of unexplained very low incidence (RCGP 2007). Another example is that of infectious intestinal disease which showed a sudden step increase in incidence at the end of 1968 from around 20 up to 80 per 100,000 population. It then declined to a minimum of 40 in the interval 1983 to1986, rose back to a maximum of 80 around 1992 and then declined progressively to return to the pre-1968 level by around 2007 (RCGP 2007).

The increase in emergency medical admissions seen toward the start of the 1993/94 financial year was a national phenomenon. Acute Trusts were accused of conspiring to admit more emergency admissions to inflate their income. Indeed the ‘unexplained’ increase led to a host of national studies and reports. I was assistant director of information at the Royal Berkshire hospital at the time of this increase and conducted an internal investigation. No changes in admission practice or process had occurred but what appeared to be a step increase in medical admissions had occurred during March 1993 (Jones 1996b). This step increase coincided with an un-seasonal spike in what GP practices across England identified as ‘influenza-like’ illness (Jones 1996a,b).

Figure 1: Overnight stay emergency admissions to the medical group of specialties.



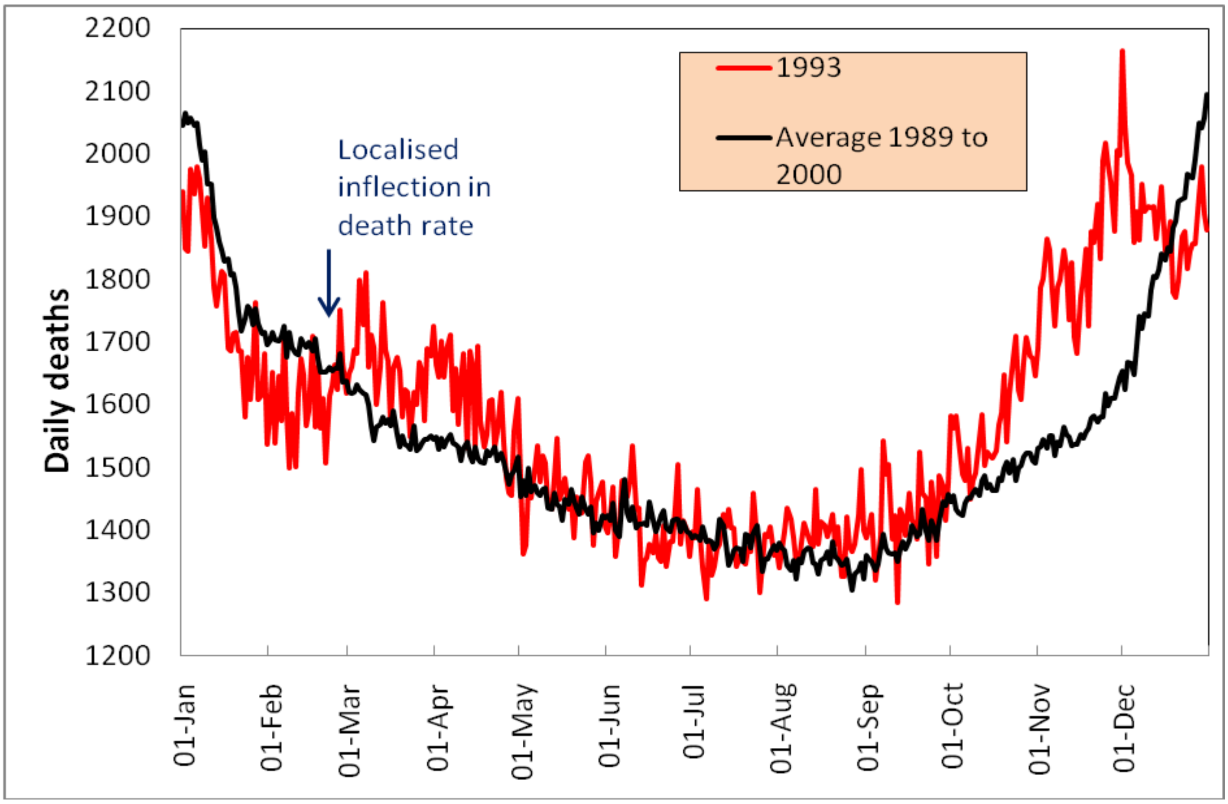
Footnote: Data excludes zero day stay admissions. The running twelve-month total has been divided by twelve to bring it back to a monthly scale. With permission of the Heatherwood & Wexham Park Hospitals NHS Foundation Trust. A running total has been used to smooth out the annual seasonal cycle. Note that the start of the trigger event will coincide with a change in the slope of the running total but the running total will then lag behind during the transition period.

Next, we come to the two more recent increases in emergency admissions the last of which became acute toward the winter of 2008/09. Fig. 1 reveals that an abrupt step change is not implicated but some sort of trigger event can be seen in or after the interval July to September (Q2) of both 2001/02 and 2007/08 with step-like consequences. In 2001 this particular trigger event led to a month on month increase in emergency admissions over four successive quarters after Q2 of 2001/02, while the event in 2007 has led to an increase for at least four successive quarters beyond Q2 in 2007/08, although ongoing analysis will be required during 2009. The cumulative effect of the latter increase led to the national emergency admission crisis late in 2008 and early 2009. At the hospital in Slough on both of these occasions the trigger for the increase was heralded by a preceding quarter of very low emergency admissions.

Excess Deaths

The analysis of death rates is an accepted method for characterising the progress of an emerging infectious disease. For example, the outbreak of SARS in Hong Kong in 2003 occurred over a 116-day period with the majority of deaths occurring in the middle 60 days (Chan & Tong 2004). In this instance, we have no positive identification of the cause but can follow the progress of excess to expected deaths as a proxy.

Figure 2: Daily deaths during 1993 in the UK



Footnote: Data covering the period 1989 to 2000 is for deaths from all causes and was obtained from the UK Office of National Statistics. Over the period 1989 to 1999 the number of deaths per annum remained roughly constant, hence, the use of an eleven year average is a valid approach with this data set.

Fig. 2 demonstrates that the 1993 trigger-event was also associated with an inflection in the rate of decease during early March. This localised higher rate of decease (excess deaths) continued during March and April after which the level of decease returned to the 11-year average. The level of decease during this period were the highest seen in the 11-year time series from 1989 to 2000. The second peak in excess deaths during October and November of 1993 was due to an unrelated influenza epidemic (Fleming 1996). Fig. 2 illustrates the possibility that the level of excess deaths associated with the trigger event (initiating the transition to a higher level of medical emergency admissions) appears to be relatively modest compared to that seen for something like an influenza outbreak and if such an event were to occur in winter it may be otherwise overlooked.

Analysis by the author of the Dec-96 trigger event shows a similar elevation in national deaths between 12th December 1996 to 15th February 1997 with daily excess deaths at their highest (for the 11-year period) between 7th and 28th January 1997. The levels of influenza-like illness over this period were not sufficiently high to evoke such a response. Using a less precise monthly (rather than daily) data set for deaths in England and Wales over the period 1982 to 2007 gives possible dates for earlier trigger events around March to May 1984 and February to April 1988. This monthly data set also shows elevated levels of death in April through to November of 2003 with a peak in August while in 2007 there are elevated deaths between May and October with a peak also around August. It would appear that the point of onset for the increase in emergency admissions is marked by a temporary elevation in excess deaths which could be the result of an infectious agent. Obviously, there are many causes for excess deaths and this analysis is presented only as a pointer to future more detailed research.

Shifts in Disease Patterns

A study of the rates of admission for a basket of respiratory infections and lung diseases showed little effect of the 1993 step change on the majority of conditions except for COPD and Fibrosing alveolitis (ICD-10 J40-44, J47 and J84.1 respectively) both of which went from very low growth in emergency admissions in the years prior to 1993 to a high growth situation in the ensuing years (Lung & Asthma Information Agency 2001).

In Scotland, the 1993 event led to a step change in the admission rates for all ages above 65 years. This step lasted until 1999 and in 2000 the rates of admission dropped back to the underlying trend line (Kendrick & Conway 2003).

Re-analysis of data of Morgan et al (1999) which looked at emergency admissions in the former Avon health authority in the nine years between 1989/90 to 1997/98 showed that the number of individuals (with one or more emergency admissions) showed a distinct jump in 1994/95 and 1995/96, i.e. in the years following the March 1993 trigger event. Admissions in 1996/97 and 1997/98 still remained higher than the trend line described by the 1989/90 to 1993/94 data, i.e. the trigger event was sufficient to increase both short-term excess deaths and a longer-term increase in the persons requiring emergency admission for at least four to five years after the initial trigger event.

Similar re-analysis of data of Pettinger (2001) from Scotland shows that the trend line for emergency admissions with a zero or one day length of stay shows an inflection to a higher slope around 1993 and again at the end of 1996. Both are years associated with the trigger event for General Medicine identified in this work.

Table 1: Diagnoses showing a significant change for the 2007 trigger-event

Diagnosis	**Average admissions per quarter**	**Change in slope as a proportion of average admissions**	**Index of Variation**
Miscellaneous and ill-defined diagnoses	2,479	14%	16.2
Viral infection	1,059	13%	3.5
Syncope	1,176	6%	2.1
Other perinatal conditions	1,207	5%	3.7
Urinary tract infections	1,793	3%	3.6
Skin and subcutaneous tissue infections	1,656	3%	4.0
Pancreatic disorders (not diabetes)	366	8%	1.9
Conditions associated with dizziness or vertigo	287	8%	2.5
Other aftercare	131	17%	2.7
Asthma	1,016	2%	4.6
Spontaneous abortion	627	3%	1.9
Other nervous system disorders	543	3%	2.1
Acute and chronic tonsillitis	627	3%	3.3
Inflammatory diseases of female pelvic organs	200	9%	1.5
Retinal detachments, defects, occlusion, retinopathy	111	18%	2.8
All the above	**13,277**	**9%**	**12.5**
Data covers residents of the South Central region in England and is by kind permission of the South Central SHA. Data was extracted using the Dr Foster Performance Monitor software and the diagnostic groups are those assigned by Dr Foster.			

Analysis of the 1993 trigger event showed that some conditions such as stroke, trauma and respiratory were unaffected while somewhat more ill-defined conditions such as ‘other groups’ and ‘general symptoms’ showed a large increase. This step change was also reflected in a corresponding step increase in GP referral for outpatient attendance (Jones 1996b).

Table 1 summarises the specific conditions which appear to be associated with the 2007 trigger event. To be included in this table the index of variation (a measure of variation relative to simple statistical randomness) had to be high and the slope of the trend in admissions had to show a positive inflection around the trigger point. As can be seen a set of vague diagnoses, viral infections, tonsillitis, dizziness, etc characterise the trigger point.

Similar analysis of the 2002 trigger event using national HES data showed a 14% increase (2003/04 vs. 2002/03) for a basket of diagnoses accounting for 22% of all emergency admissions (HES Online 2009). Many of these match with diagnoses in Table 1. While such conditions may have shown a change, they do not explain the full extent of the trend seen in Fig. 1 which is for the medical group of specialties, i.e. the effects are more widespread and can best be described as a general increase in poor health, i.e. this is a collective effect with possible knock-on effects which exacerbate existing conditions.

Confounding Factors

Why has it taken so long to identify this cycle? Firstly, very few were looking since everyone ‘knew’ that it was all simply related to an ageing population, rising expectations and more conservative GP behaviour. Secondly almost all studies, other than those related to seasonality, look at trends using annual totals and therefore missed the opportunity to see the mid-year step or step-like changes. My research following the March 1993 step change had accumulated sufficient evidence to publish the findings but I felt that the message was somewhat ‘before its time’ (Jones 1996c). Since that time, the excellent work of Dr William Bird at the MET Office Health Forecasting Unit has made the link between weather, infectious diseases and emergency admissions a more acceptable message (MET Office 2001, Hughes et al 2004).

We also need to understand why the trigger event in or after Q2 of 2001/02 (full effect seen in 2003/04) received such scant attention. The effect was noted and the Department of Health (DH) did informally ask Strategic Health Authorities to investigate. Unfortunately, the increase was clouded by the rapid rise in zero day stay emergency admissions arising from the focus on the target to achieve a maximum wait of four hours in A&E. In addition, the NHS was undergoing a period of massive increase in funding which was typically 9% per annum in real terms from 2003/04 through to 2007/08. In 2003/04 Payment by Results (PbR) was still in policy stage and so PCTs were still free to negotiate marginal rates for the additional emergency admissions. Hence the financial pressures experienced from 2003/04 onward due to the rise in medical emergency admissions were overshadowed by the larger year on year increase in funding. Indeed, the curious possibility exists that the 2002 trigger event may have also acted to fuel the rise in zero day stay emergency admissions as particular A&E departments became more pressured due to the overall rise in medical demand. See supplement for a discussion of the geographic nature of the trigger events. The specific issue of ill-defined diagnoses will now be discussed.

Ill-defined Diagnoses

In part one of this series, it was established that the majority of diagnoses appeared at first glance to follow roughly linear trends which appears at variance to the cyclic behaviour observed at specialty level. This apparent discontinuity is however resolved if it can be demonstrated that a group of diagnoses exist whose behaviour is non-linear and possibly U-shaped. The group of ill-defined and miscellaneous diagnoses does appear to show such complex behaviour. In Scotland over the period 1981 to 2001 the diagnosis ‘signs & symptoms’ showed the highest overall growth (Kendrick & Conway 2003). Highly non-linear growth has been demonstrated for the wider group of signs, symptoms and ill-defined conditions over the period 1995 to 2003 (Walsh et al 2008). Growth in the period 1995 to 1997 was particularly high, perhaps due the earlier 1993 trigger event.

Using more recent data covering the South Central Region of England reveals that only three diagnostic groups appear to show what may be called U-shaped behaviour (Fig. 3). Of these only the ill-defined group has sufficient admissions to go toward explaining the behaviour seen in the medical admissions group as a whole, however, even this group falls short of explaining the 10% to 15% step change seen in almost all repeats of the cycle.

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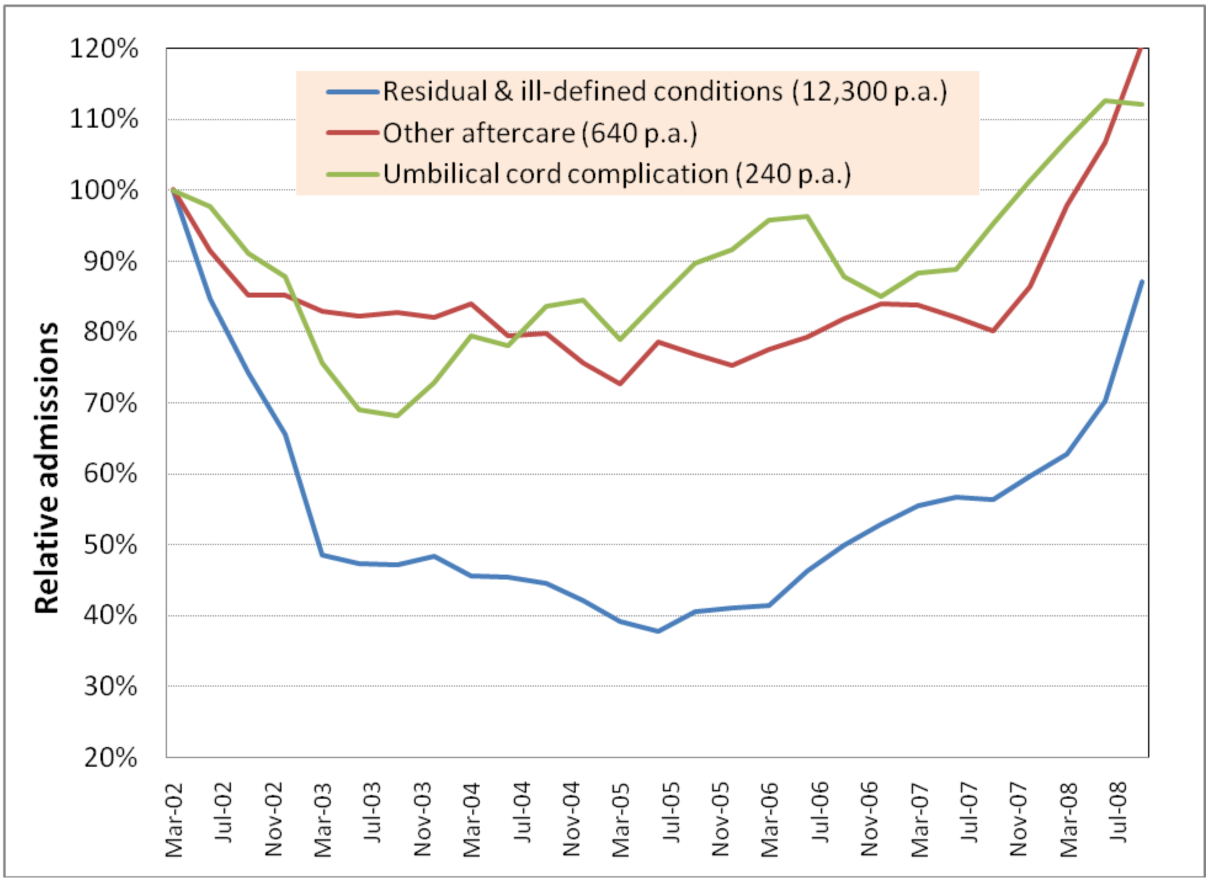
Figure 3: Diagnostic groups showing apparent U-shaped behaviour



Footnote: Quarterly data has been summed using a running annual total and is relative to the 2001/02 financial year. Data for the South Central region of England was extracted using the Dr Foster 'Performance Manager' software and is courtesy of the South Central SHA.

By implication some degree of collective behaviour is being demonstrated in the case mix within the medical group. Hence it would appear that knock-on effects are being seen in other diagnostic groups which are difficult to discern in the smaller numbers associated with each individual diagnosis. While a higher than average baseline of signs, symptoms and ill-defined conditions at specific hospitals is an outcome of a poor coding process it would seem plausible to propose that an overall increase in this group of diagnoses could also arise from the correct coding of genuine non-specific symptoms arising from the trigger-event leading to the rise in medical emergency admissions.

A brief discussion on coding accuracy is probably relevant. The seminal work of Fleming et al (1991) investigating the annual and seasonal variation in the incidence of common diseases encountered criticism from the reviewers around this very point and the Editor's preface by Professor Denis Gray OBE clearly addressed these issues (Gray 1991). In terms of NHS data quality it is clearly evident that there is site-specific counting and coding bias within acute data (Jones 2006a,b), however, this bias is usually consistent over long periods of time and hence the collective behaviour shown in Fig. 1 is a valid measure of a clinically significant mechanism.

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Mechanisms

A recent study investigating factors increasing the risk of emergency admission has shown that previously prescribed analgesics and antimicrobials with a high number of respiratory medications are indicative of increased risk (Donnan et al 2008). This may be symptomatic of a wider group of immune-compromised individuals. The fact that a significant group of admissions receives a diagnosis which is poorly defined should not be interpreted as meaning that they are 'unnecessary' admissions or easily amenable to 'demand management'. The fact remains that this group (acting as a marker to wider effects) led to a permanent shift in the number of emergency admissions as per Fig. 1 and is potentially linked to the modest increase in excess deaths during the onset of the outbreak.

Hence, we have established that medical emergency admissions show step and trigger point changes which appear to be related to an infectious agent which is possibly viral. It remains to be seen if this is a previously undiscovered virus or one of the lesser studied human viruses or a specific series of viral infections. The situation in other specialties can now be considered.

General Surgery

The borderline between surgical and medical admissions is somewhat arbitrary. Re-analysis of the results for a 25 years study (1974 to 1998) of emergency surgical admissions at a hospital based in Exeter appears to show a 12-year cycle in admissions with minima in 1974, 1986 and 1998 (Campbell et al 2002). The index of variation, a measure of actual variation relative to simple random variation for total surgical admissions was 3.2 indicating that variation around the long-term trend line was 3.2-times higher than simple chance variation and this was largely the outcome of the 12-year cycle. It must also be noted that the largest contribution to the cyclic behaviour appeared to arise from the more 'medical' admissions covered by General Surgery.

Other Specialties

Fig. 4 illustrates the nature of some longer-term cycles seen at one hospital for a variety of specialties. As can be seen each specialty has its own specific behaviour and contrary to expectation does not show the upward slope expected of demographic change. In the past such undulating behaviour has been 'explained away' as evidence of poor data quality, however, we must consider the option that longer term cycles do exist as normal behaviour. It would of course be highly surprising if such cycles affected all specialties. Analysis of national data from the UK since 1998 shows that emergency admissions to the specialties Plastic Surgery, Neurosurgery, Ophthalmology, Mental Health, Oncology & Radiology, Palliative Medicine, Oral, Dental & Maxillo-facial Surgery and Anaesthetics all appear to show no immediately apparent cyclic behaviour. Analysis of the 2007/08 trigger point for emergency admissions showed no major change for the above specialties plus Gynaecology, Paediatric Surgery, Paediatric Cardiology and Urology (although specific conditions within these specialties may be effected).

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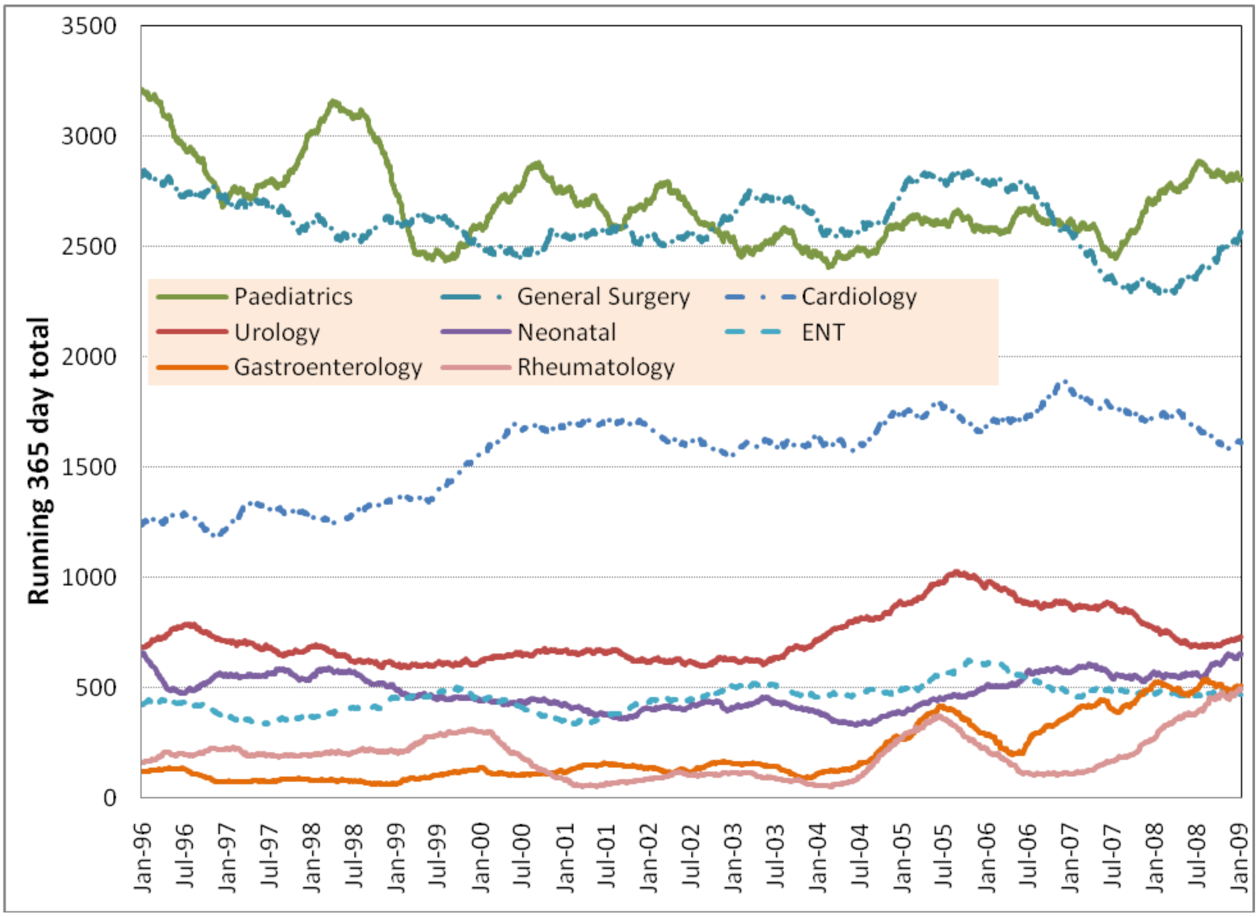
Figure 4: Emergency admissions to a variety of specialty groups



Footnote: Data excludes zero day stay emergency admissions and is a running 365-day total of daily admissions. By permission of the Royal Berkshire Hospital NHS Foundation Trust.

Emergency Trauma admissions seem to follow a more complex cyclic pattern which appears to be related to the weather conditions influencing injury and fractures (Jones 2004, Rising et al 2006). See supplement. Hence it would appear that the longer term cyclic behaviour is not exclusively related to medical conditions, howbeit, with different basic mechanisms.

Wider Implications

In the US, the cyclical nature of costs led to a lagged cycle in insurance premiums and underwriting profit and loss (Gabel et al 1991, Born & Santerre 2005). The implications to the repeating pattern of surplus and deficit seen in the NHS should be obvious. The implementation of ‘Agenda for Change’ in late 2004 and the consequent effect on medical and GP costs will have imposed an additional step change on top of the financial dynamics relating to the underlying pattern of medical emergency admission (DH 2009).

One final factor is that of the HRG tariff which is based on cost data collected three years previously. If something approximating a four to six-year cycle does exist, having costs collected at roughly half the cycle amplitude may not be a good mechanism for setting prices; indeed, it may well lead to overshooting of purchaser costs at particular points in the cycle.

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The additional factor to be born in mind is that the average cost per admission will drop during a period of rapidly rising admissions due to the dilution of fixed costs by higher activity. This has the same net effect as a cycle in LOS and so on both accounts the tariff is likely to amplify financial flows. Some degree of marginal cost adjustment for medical emergency admissions would therefore be prudent for the 2009/10 financial year. Along with its wider specialty-specific deficiencies the HRG tariff is poorly equipped to handle this type of event (Jones 2008a,b, Jones 2009a,b,c). Indeed, in the USA once the underwriting industry became aware of the cycle in healthcare costs steps were taken to mitigate its effects. In effect insurance premiums became more aligned to the here and now rather than the past (Rosenblatt 2004). The HRG tariff may require such modification.

Conclusions

Evidence has been presented to show that medical emergency admissions can show a form of cyclical pattern which is characterised, in part, by a step-like increase or trigger events occurring at around four to six year intervals. The increasing sub-specialisation within the medical group is well known and it is for this reason that long-term analysis such as in Fig. 1 is at medical group level, however, at those hospitals where the sub-specialisation has been relatively constant it is possible to discern different cycles within the medical group (as per Fig. 4). From such analysis, it is possible to conclude that the trigger-point is not primarily to do with the ‘winter’ respiratory peak, i.e. influenza or other common causes.

While it is difficult to prove conclusively it is possible that prior to 1993 the cycle was closer to the regular six-year pattern seen in the total healthcare costs in USA and sickness absence in the UK. The disruption of the cycle around 1993 was also observed in the USA. In the UK the pattern of daily excess deaths during the interval March to December 1993 was 4-times higher than chance and this particular trigger-point appeared to result in a step change (as observed in Reading) rather than the ramp-like increase seen in 1996, 2001 and 2007. There is still much to learn.

Access to a long-time series of data is vital to understanding the nature of these changes and data such as that available from the weekly returns service of the UK Royal College of GPs (which goes back to 1953), the public health laboratory network or the record linked data available in Scotland will be an invaluable resource for future research (RCGP 2008, Health Protection Agency 2009). The possibility of this cycle could have profound implications to healthcare resource planning in terms of hospital beds, PCT and PBC budgets and the scheduling of increases in the level of overall NHS funding (Jones 2004, 2009b,c). Considerable additional research is required to determine cause and affect relationships.

For the other specialties links to weather, sunspot activity, lunar cycles and global warming & cooling require additional research if we are to understand both the wider nature of healthcare costs and possible preventative measures. The key point is that undulating behaviour exists and will have a knock-on effect to purchaser and provider costs.

The final implication of these cycles is that the increase in emergency admissions and GP referrals attributed to more conservative GP behaviour and increased expectations of healthcare may partly be a by-product of the medical cycle and not a cause *per se*. Perhaps rising expectations and GP behaviour make a far lower contribution to the overall increase than has been realised or indeed may have been misattributed to these sources. Hence policy initiatives such a Practice Based Commissioning (PBC) may be based on the flawed assumption that GP's and primary care are the agents capable of reversing the trends in medical emergency admissions. Hopefully this study will encourage further research into this fascinating aspect of emergency admissions.

Conflict of Interests: None

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