Cycles in Emergency Admissions: Supplement

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Each section relates to a section heading in the main article.

Series abstract

Part one of this series discussed how the more widely recognised factors such as an ageing population and re-admissions 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 4–6 years in medicine, and even longer cycles in surgical and trauma admissions. Part three investigates the implications for bed planning. The current methods for estimating the size of hospitals and bed pools are shown to be inappropriate to the needs of acute emergency care.

Natural cycles

If we accept that there may be a strong link between the weather/environment and emergency admissions, it may be useful to observe the degree of complexity shown by some natural cycles in order to consider that such complexity may be present in emergency admissions. For example, what is commonly regarded as 'the lunar cycle' is in fact a very complex series of cycles in different dimensions. The tidal force of the moon on the earth depends on its distance from earth (apogee/perigee), not its phase (the synodic cycle of full moon/new moon). While the synodic period is (on average) 29.53 days, it takes 27.5 days for the moon to move in its elliptical orbit from perigee to perigee. Perigee (moon closest to earth) can occur at any point in the synodic cycle (Walker, 1997). For example, nearest to the earth apogee and full moon showed their closest match in July 2000 and then again in July 2009. The synodic period is itself cyclic and there is a pattern that repeats every 14 lunations (412 days), which is nested within a repeating pattern of 70 lunations (5.64 years) (Bromberg, 2008). Reflected in nature are further 9.3-year lunar cycles nested into 90- and 180-year patterns, which reflect long-term cycles in weather, geologic observations and crop yields (Cycles Research Institute, 2008). The effects of these cycles will interact with an 11-year cycle in sunspot activity, which itself is within a longer 85-year cycle. Sunspot activity should once again reach a maximum duration in the early 2020s (Geerts and Linacre, 1997).

While there appears to be little evidence for the 'full moon' effect on the majority of conditions, it would appear that lunar cycles may exert some influence on emergency admissions for conditions relating to the heart and urinary tract (Payne et al, 1989; Alves et al, 2003; Zimecki; 2006; Quazi et al. 2007). The synodic cycle may have other effects and a study by BT on mobile phone usage demonstrated a clear cycle with increased phone calls in the days leading up to the full moon (Kelly, 2000). The point of greater interest is, however, with the much longer cycles, rather than the short-term synodic or apogee cycle, and the complexity behind what at first appear to be simple cycles.

What is commonly called 'global warming' is also part of a longer time series with a periodic cycle in average temperature. There was a local minimum in 1881 followed by a broad increase, which peaked in 1938–1942, and then another minimum in 1964 followed by another increase, etc (Goddard Institute for Space Studies, 2000; Global Weather Oscillations, 2008). The spell of very cold weather seen in the UK during January and February 2009 is simply part of the fluctuations around the long-term cycles.

The climatologist David Dilley (2008) discovered a series of Primary Forcing Mechanisms in the global warming and cooling cycle and the interaction with the weather. There is a long-term master cycle of 116 000 years, a shorter term master cycle of 925 years, and sub-cycles of 231 years. Dilley predicted a period of relative global cooling beginning around 2008–2009 and leading to lower temperatures by 2023.

Hopefully you will now appreciate the complexity of natural cycles and that emergency admissions are in fact part of a much bigger picture that transcends the span of the NHS and the even smaller span of government policy initiatives. In fact, electronic records of inpatient admissions via Hospital Episode Statistics (HES) for England are only available from 1989 (i.e. only about one and a half sunspot cycles or two turns of a 9.3 year lunar cycle), while the more comprehensive record-linked Scottish data only goes back to around 1981. Hence, in the larger scheme of things, there is only a small data set available to understand the full impact on emergency care.

Step changes

Analysis by the author of a time series of daily medical admissions at the Royal Berkshire Hospital in Reading show changes in the slope of a cu-sum plot in or around March 1993, December 1996, December 2002 and August 2007—i.e. there is no immediately apparent seasonal basis and the broader national trends are reflected (in a more focused form) at a local level.

Cycles in health

A study of monthly sickness absence in England over 1971–1984 showed an overall minima of absence (relative to the general longer term downward trend) during 1971, 1977 and 1983 (Barmby et al, 1997). A link between sickness absence and emergency medical admissions is likely since the annual pattern of monthly absence roughly follows that seen for emergency medical admissions. Therefore, for whatever reason, the general seasonal pattern of absence was less pronounced (especially in January/February) during these three years, giving a lower total absence for the year as a whole. A similar effect can be seen for emergency admissions in what would be commonly called a 'mild' winter. Given the association between sickness absence and the annual seasonal cycle, longer term changes in the weather and environment could have a knock-on effect to sickness absence rates. In this regard, the level of sickness absence has been observed to follow long-term cycles which may be partly related to the economic cycle, but may also include aspects of the medical cycle (Lusinyan and Bonato, 2007).

The next intriguing, but more obtuse, piece of evidence comes from the USA, where the pattern of total health expenditure (after adjustment for cost inflation) appeared to show a 6-year cyclical pattern for 32 years from 1960, with minima in 1966/1967, 1971/1972, 1978, 1986; however, the expected minimum in 1992 was delayed to 1994 and the trend then disappeared for six years to 2000, when an increase began again in 2001 (Gabel et el, 1991; Born and Santerre, 2005). The point of increase in 2001 was also reflected in a marked increase in A&E attendances (Spade, 2005). It is unknown what caused this cycle as total expenditure will include ambulatory as well as inpatient care, and will include case-mix and volume considerations; however, the point of interest is that it existed.

Step changes

The concept of step changes is not at variance with cycles as an 'imperfect square wave' can be the result of anything with greater than a fifth harmonic oscillation (Wikipedia 2009). The interaction of solar and lunar cycles on top of the cycles around the long-term global warming and cooling cycle with weather patterns could produce such complex effects. The pause in the US cycle seen in the interval 1994–2000 may be an example of an imperfect square wave type effect.

Shifts in disease patterns

Specific diagnoses showing a change associated with the 2002 trigger event included (ICD-10 code in brackets): unknown causes of morbidity (R69), observation (Z04), COPD (J44), abdominal pain (R10), urinary disorders (N39), respiratory infections (J06, J22), syncope and collapse (R55), asthma (J45), dorsalgia (M54), abnormal breathing (R06), cognitive symptoms (R41), headache (R51) and cellulitis (L03). Many of these diagnoses match with those given in *Table 1* of the main text. There may have been effects related to complications during pregnancy and in the newborn associated with the 2007 trigger event, but these were borderline and would require further investigation.

Confounding factors

The national studies concerning the 1993 trigger event could be interpreted to show that there was considerable regional variation in both the onset and the extent of the response to the factor leading to the increase (Jones, 1996b). Data across the South Central region for the

2007 event shows similar variation around the timing and extent of response. An attempt by the author to analyse national HES data over the period 1989 to 2006 using high level postcode district (RG, GU, OX, etc) encountered the same issues. By way of comparison, even influenza pandemics are known to show marked regional variation (Viboud et al, 2006).

Studies by the author show that data obtained from three hospitals based in Camberley, Reading and Slough show similar patterns of emergency admission over the past 12 years, with clearly defined transitions at similar times and to a similar extent. All three hospitals are within 25 km of each other, but service very different population groups (i.e. the effect is not some artefact of demography). However, the HES data extract at high level postcode district for GU, RG and SL (where these hospitals are located) presents an inconsistent picture.

Similar high-level geographic inconsistency can be seen in the University of Oxford's *Geographic Atlas of Hospital Admission Rates*, which presents rates of disease (using ICD diagnosis codes) at local authority level and using HES data sets for the period 1998/99–2002/03 and 2002/03–2004/05 (UHCE, 2007). No matter what the disease/diagnosis, there is always huge variation in apparent admission rates using data aggregated at local authority level.

A study conducted across the former Thames Valley SHA may have clarified some of the reasons for this mismatch between the hospital-based and geographic-based views. This study used the minimum distance to the nearest acute site to aggregate small area geographic data into a larger hospital catchment area, rather than arbitrary local authority, PCT or postcode district boundaries. It was discovered that each hospital interacted in a unique way with its catchment population; hence each hospital had a unique distance-related pattern for the decline in rate of emergency admissions commonly seen with increasing distance around acute sites (Jones, 2006). Each acute site also appeared to have a unique 'threshold' for different types of emergency admission and how these were coded. Therefore, it would seem that any attempt to investigate this phenomenon may need to use hospital-based data sets as a proxy for the response seen in the catchment population.

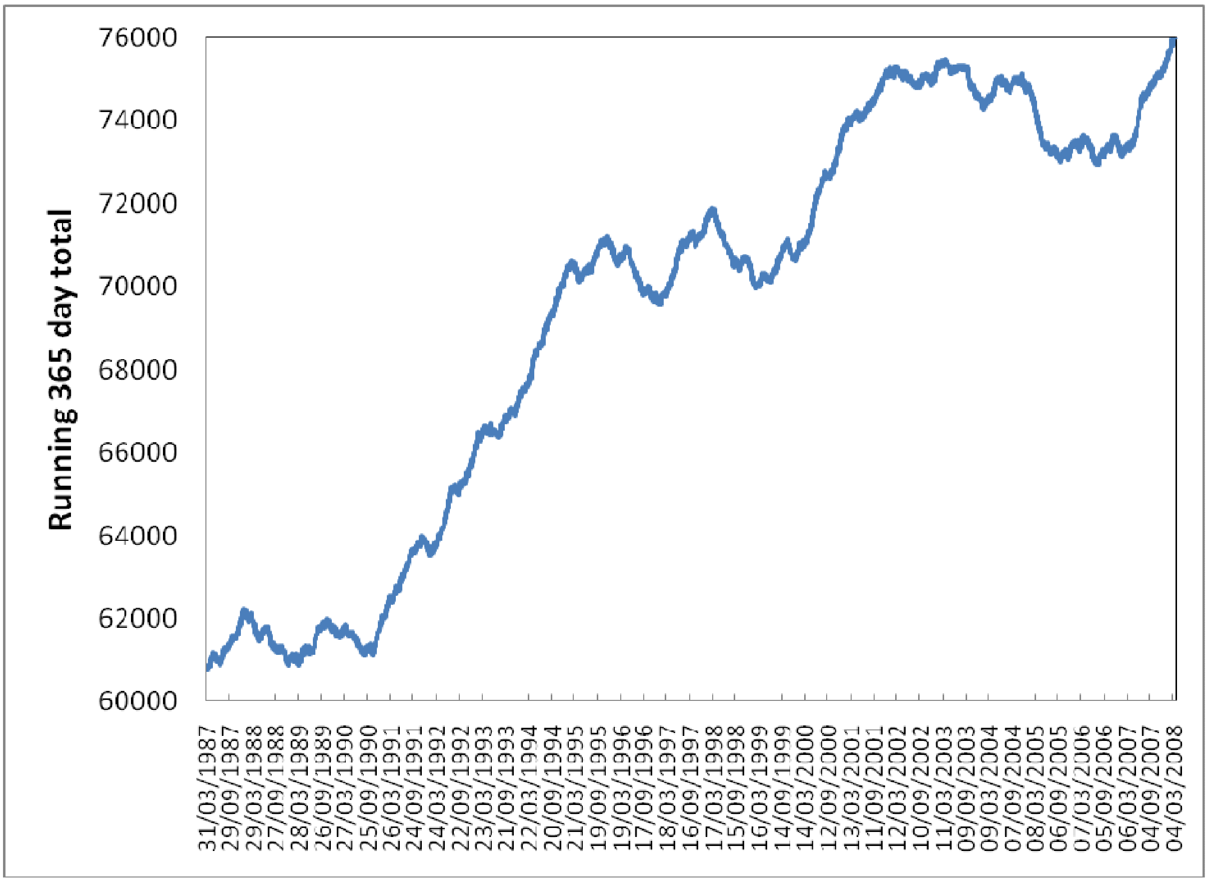
Figure S1 presents data for overnight stay emergency admissions to the medical group of specialties for the whole of Scotland. Similar behaviour to England can be observed; however, the dates for the onset of the progression to a new plateau appear to be slightly different with trigger events around August 1990, May 1993, December 1999, and January 2007. Again, an investigation using trust-based data may be required to determine the specific events happening at local level.

Age standardised rates

The author has not used age standardised rates as the aim is to demonstrate an event which has an effect far greater in magnitude than simple demographic change over a short space of time.

Having demonstrated the effect using this approach, future research can make use of age-specific rates to determine which age groups have been the most effected by each of the trigger events. For example, the effect of influenza is known to show different age-specific patterns depending on the strain and type of the virus (American Lung Association, 2004).

Figure S1: Overnight stay emergency medical group admissions for Scotland.



Data provided by isd Scotland. Zero day stay admissions have been excluded.

Mechanisms

At this point the issue regarding a potential mechanism for the step and trigger point changes in past data requires discussion. As a working hypothesis, it must be noted that viruses are the only common infective agents with the ability to permanently infect a host by interfering with the natural immune responses, which in turn can lead to secondary opportunistic infections (Alcami and Koszinowski, 2000; Xu et al, 2001; Baranek and Dalod, 2008; Zuniga et al, 2008).

There are hundreds of viral diseases (and perhaps just as many as yet unidentified) with the ability to cross between species, and are implicated in AIDS, some cancers, arthritis and other inflammatory disease, transplant rejection, and where non-specific symptoms such as those seen in *Table 1* of the main text could be acquired by a susceptible sub-set of the population (Allander et al, 2005; Kumar et al, 2005; Voisset et al, 2008; de Graaf et al, 2008; Wrong Diagnosis, 2009). The issue of host resistance has been suggested as a mechanism in relation to the seasonal cycles and other issues relating to the outbreak and spread of a wide variety of infectious diseases (Dowell, 2001). Modern high-speed air, rail and road travel allows the spread of epidemics both internationally and within the UK in a very short time (Hollingsworth, 2007). The apparent patchy nature of this trigger effect could even implicate that a specific series of viral infections is required or may simply reflect the fact that many infectious diseases exhibit a patchy outbreak pattern (Dowell, 2001; Mullins et al, 2003).

An association between un-seasonal influenza-like illness and the March 1993 step increase in emergency admissions has been noted (Jones, 1996b). The following is from a report regarding an Australian outbreak of a previously unknown virus (MacKenzie, 1999):

'Both workers had an* influenza-like illness *with rash during the pig outbreak, but extensive serologic testing showed no evidence of any alternative cause; therefore, the illness is believed to have been caused by the new virus.'

This is merely to illustrate that a diagnosis of influenza-like illness can be an indicator of wider viral-based illness.

Maternity

The factors regulating the trends in births are notoriously complex; however, the key factor is that the basic fertility rate does show fluctuation over time and there have been pronounced minima in the UK in 1977 and 2001—24 years apart (Smallwood, 2002; Jefferies, 2008).

The menstrual cycle may show some degree of weak phase locking with lunar cycles and fertility may peak in the third lunar quarter, although these are mentioned more to highlight possible links with the much longer lunar cycles than for the short-term immediate effects (Cutler, 1980; Criss and Marcum, 1981). Births do show a seasonal cycle and a study in Senegal revealed fluctuations in births related to rainfall, while another demonstrated a role for temperature and other unexplained environmental factors (Lam and Miron, 1991; Jones, 1996a; Pitt and Sigle, 1997). Socio-demographic factors have also been implicated (Bobak and Gjonca, 2001). Therefore, there is the wider possibility that along with societal trends, additional weather and environmental factors may be involved in longer term birth cycles.

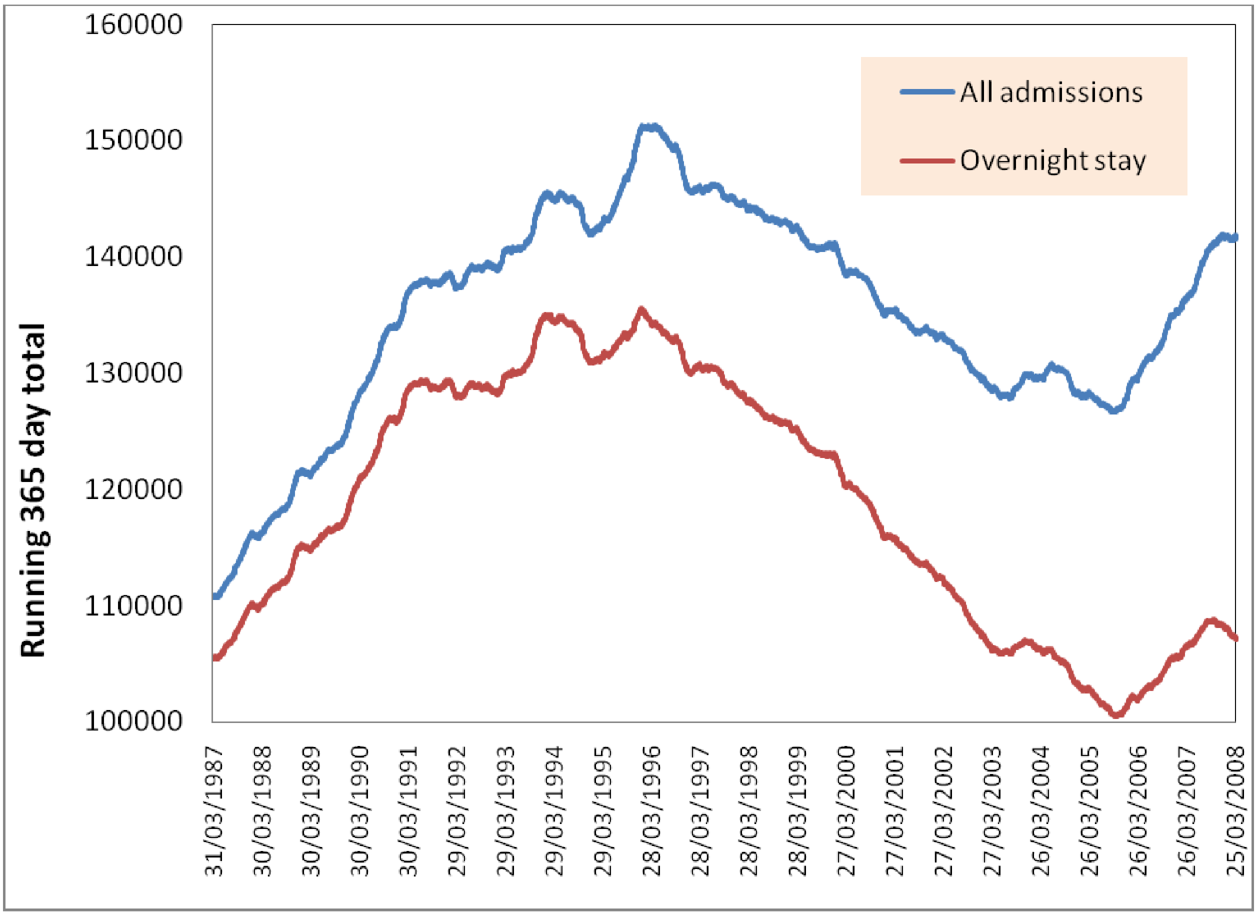
GP referral

The March 1993 trigger was also associated with an increase in GP referral to outpatients. Analysis of attendance for first outpatient appointment in the South Central region during 2007/08 shows a step-like increase at some point in or after quarter two (July to September) with widespread increases in GP referral across many specialties; however, there was no apparent change in referral to any of the paediatric surgical sub-specialties: clinical genetics, nephrology, or plastic surgery. This more diffuse increase in GP referral requires further investigation to see if the incremental additional referrals are of a more medical nature. Even ophthalmology showed a 10% increase (after allowing for demographic growth) and in this respect the bulk of outpatient attendances are of a medical nature, as opposed to its surgical inpatient functions. It would seem that the theme of a general feeling of 'unwellness', or of the knock-on exacerbation of existing but latent conditions, appear to be implicated, as noted for the particular diagnoses associated with the change in medical emergency admissions.

Other specialties

Figure S2 shows emergency admissions to the specialty trauma and orthopaedics for the whole of Scotland. There is evidence for what may be a very long-term cycle, or at the very least what is highly non-linear behaviour with changes in slope, which are not consistent with demographic change. Note the increasing divergence between the two trend lines due to increasing numbers of zero day stay 'admissions'. The issue of zero day stay emergency 'admissions' was discussed in part one of this series (Jones, 2009).

Figure S2: Orthopaedic trauma (emergency) admissions for Scotland



Data provided by isd Scotland. Data for overnight stay excludes zero day stay admissions.

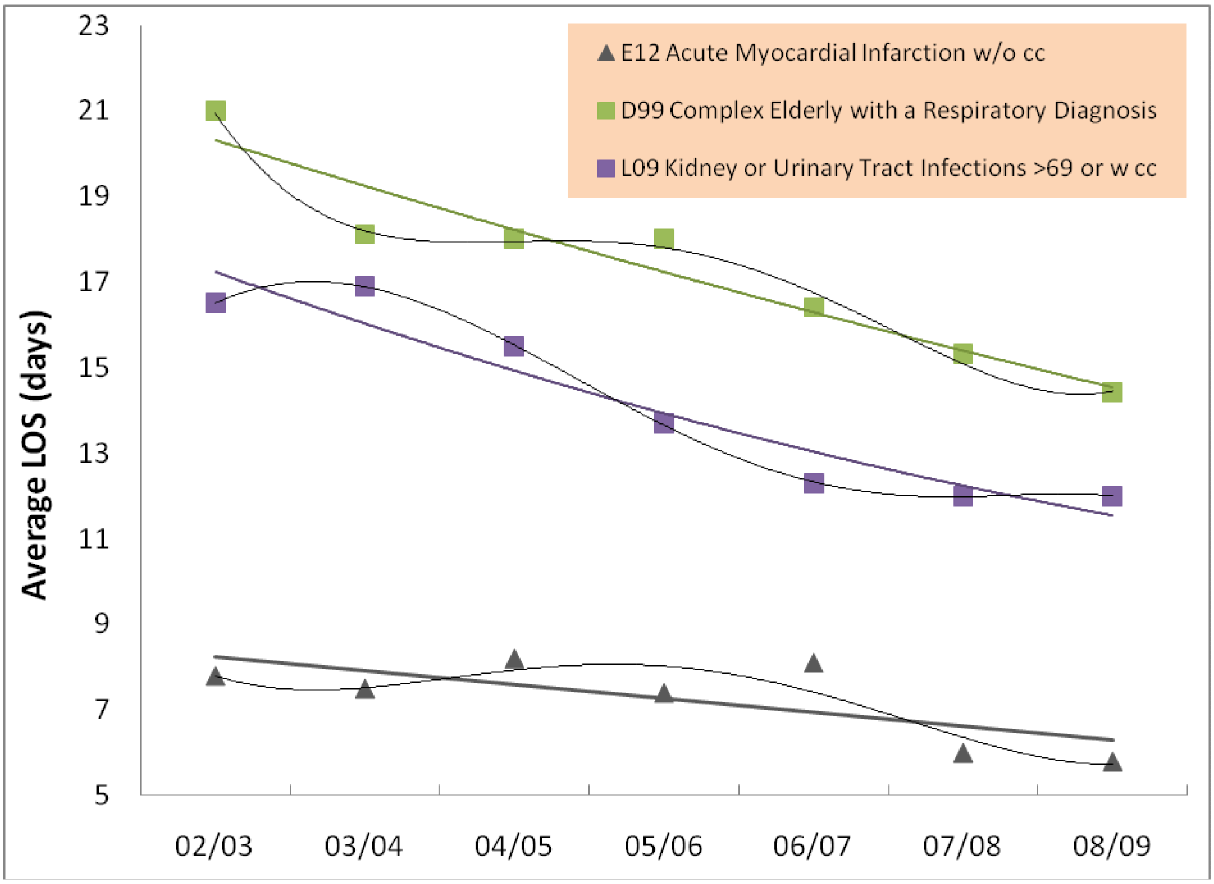
Wider Implications

Figure S3 presents evidence that cyclical behaviour in average length of stay (LOS), and hence cost, can occur and that the application of a specific LOS occurring at mid-points of a cycle to the peak in the cycle will possibly lead to amplification in costs borne out by commissioners in particular years.

The possibility exists that this pattern may depend on regional factors and it remains to be seen whether it is the same in other countries. Is it a coincidence that the 1993/94 year saw a similar step change in emergency medical admissions in New Zealand as in the UK (New Zealand Health Technology Assessment, 1998). In this respect, Dowell (2001) provides an interesting insight into a potential link between host resistance and the initiation of an outbreak of infectious disease.

It is possible that the medical cycle may also affect other trends such as the incidence of road traffic accidents and GP workload, i.e. the knock-on effects of 'unwellness'.

Figure S3: Trends in average length of stay



By permission of the Heatherwood & Wexham Park Hospitals NHS Foundation Trust. Data includes all admissions including those with a zero day stay.

Concluding remarks

The analysis presented here on the cycle seen in medical emergency admissions is an attempt to describe a curious and obviously complex phenomena. No doubt some of the conclusions may be modified or refined as further research is conducted in order to unravel the issues involved. Whatever the ultimate explanation, the observed behaviour does not fit with currently accepted mechanisms for growth and as such, our 'models' to explain growth need to be modified in whatever way is necessary. Irrespective of whether cycles exist or not, the issue with regard to the commissioning of health care is that conventional models based on demographic change only partly work and greater caution is required when attempting to both frame a contract with a purchaser and for long-term planning of services. The issue regarding acute capacity planning also requires thought and for this reason, some of the issues regarding beds and bed pools are explored in part three of this series.

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