ANALYSIS OF TRENDS IN EMERGENCY AND ELECTIVE HOSPITAL ADMISSIONS AND HOSPITAL BED DAYS 1997 TO 2015

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Introduction

There will always be a place for inpatient hospital care in a comprehensive health care system, but hospital care is expensive and the growing demand for hospital care is a key policy issue in England (NHS England 2019). Despite the concerns and efforts of policy makers, it has proved difficult to restrain the growth in hospital admissions. NHS Digital (2019) reported a 25% growth in elective admissions and a 28% growth in emergency admissions from 2008/09 to 2018/19, with the two series increasing to new highs of 8,809,917 and 6,437,959 respectively in 2018/19. The NHS England budget is growing at a similar rate. The Institute for Government (2019) report growth of 19.1% in the ten years to 2018/19, but this increasing expense is putting pressure on the sustainability of the NHS itself and cannot continue at its current rate. Indeed, reducing avoidable A&E attendances, admissions and delayed discharge is a key component of Government policy, with a scheme of financial incentives to reward GPs successful at doing so announced as part of the NHS Long Term Plan (2019).

It has been widely shown that activity in NHS hospital services has been growing rapidly in recent years, both in absolute levels and as a proportion of all NHS activity (see for example Baker 2018; Tallack et al. 2020), and there are several theories about why this growth may be taking place. Demographic factors, such as an ageing population, play a significant role but studies into emergency admissions have found that less than half of the increase is due to an increase in the number of older people. The majority of the increase is due to changes in technology, behaviour of practitioners, patient expectations and policy (see Cowling et al (2014) Jones (2013); Smith et al (2014); Steventon 2018).

Similar issues have a significant role in explaining the growth in elective care. In particular, reforms to the payment system for hospitals (Farrar et al. 2009), opening up the market to allow private providers to perform procedures on NHS patients paid for by the NHS (Naylor and Gregory 2009), and changes to GP contracts (Coast et al. 1998) could have contributed to this growth. Other contributing factors include improving technology (Hobbs 1996) and changes to the clinical threshold used to determine admission (Blunt et al. 2010).

Rice and Aragón (2018) use decomposition methods to study the determinants of health care expenditure growth in NHS hospitals. They report that only a small proportion of the growth in average expenditure between 2007/08 and 2014/15 was due to demographic changes – such as age and gender – in the patients treated, with the rest due to increases in resources used and the costs of services.

In this paper we perform "Age-Period-Cohort" analyses (henceforth APC) to examine trends in emergency and elective hospital admissions and bed days in England from 1997/98 to 2014/15. This period was chosen to cover a time of significant policy upheaval in the NHS. There were two main themes in government policy towards the NHS in England during the period we study. The first was strong growth in real funding of the NHS until 2009/10. This was followed by a halt to such growth from 2010/11 onwards following the beginning of the world financial crisis. The second was a series of measures aimed at improving the efficiency and quality of NHS care such as setting performance targets; reforming the employment contracts for staff; restoring the "internal market" for hospital care; introducing "payment by results" for acute hospital services in England; and attempting to shift care "closer to home".

APC analysis is a form of statistical decomposition that allows the identification of the relative importance of three factors: 1) the effects of the age distribution of the population, together with rising numbers of older people; 2) cohort effects due to differing admission rates of people born in different years (different birth cohorts); and 3) period effects, namely effects relating to a specific year which cannot be explained by either age or cohort effects. The results of this analysis will help to generate an improved understanding of the factors driving trends in elective and emergency hospital admissions and bed days in England over recent years, for patients of all ages.

The coefficients for **age** capture activity changes due to differences in demand of patients at specific ages. For example, more hospital care is consumed by older patients. This is mainly a matter of "need" because the method implicitly assumes a 90 year old born in 1910 will have the same health status in the year 2000 as a 90 year old born in 1920 would have in 2010.

There may be something specific about particular birth **cohorts**. For example, patients born during times of war and/or austerity could have long-term health deficiencies relative to people born in more prosperous times. They may also have different expectations of the levels of care they should receive. This will also manifest itself through higher levels of activity for certain cohorts.

The **period** effects capture any residual trends not caused by cohort or age factors. In the NHS, the period effect is likely to be large, as supply-side factors such as new technologies and changes to the workforce, along with policies to improve waiting times, efficiency measures and the use of financial incentives will play a large role in driving activity.

This paper expands Wittenberg et al (2017), who explore APC effects for emergency admissions of patients over 65. To our knowledge, these methods have not previously been applied to a dataset covering all hospital activity.

The source of growth has important policy consequences. For example, if the increase in admissions is due to the persistent ageing of the English population, then it may be difficult for the Government to influence. However, most impacts from policy or Government intervention will appear in the period effect. If the period effect is large, it may be possible to control increases by implementing new appropriately targeted policies. It may also be possible to identify specific cohorts that are affected by policy decisions, or to impact on certain cohorts with specially designed policy to address issues that arise from the identification of the model parameters.

We find that most of the increase in elective admission rates per 1,000 population is due to a period effect: this is perhaps the result of Government action to increase hospital capacity. Elective bed-days have been decreasing, generally due to a shift towards day-cases. The total amount of emergency bed-days used have remained fairly consistent, with the effects of an ageing population being counteracted by increasingly healthy cohorts.

Section 1 describes our data and methods and section 2 presents results. Section 3 discusses our results with limitations discussed in section 4. Section 5 concludes.

1 Data and methods:

1.1 Data

Our study comprises analyses of inpatient data taken from Hospital Episode Statistics (HES) for England, combined with population estimates from the Office for National Statistics (ONS), covering the time period from 1997/98 to 2014/15. HES is a database which provides information concerning all inpatients and outpatients treated by NHS hospitals in England from 1989/90 onwards, including those resident outside England, private patients treated in NHS hospitals, and care delivered by Treatment Centres for NHS patients (including those in the independent sector). For each patient, clinical information is collected about their condition and any interventions provided, personal information such as age group, gender and ethnicity, administrative information such as admission date, time spent in hospital and discharge date, and geographical information concerning where patients were treated and where they live.

We include in our analysis all admissions in the “Admitted Patient Care” section of HES, including day cases, for patients admitted as emergency or elective. We exclude admissions for maternity-related issues and mental health and learning disabilities admissions. We do not distinguish between the type of care patients receive, whether it is acute, rehabilitation, long-term or palliative care. Our analyses use data on the patient’s age, type of admission (emergency or elective), duration of spell and financial year of admission. The APC analysis, which we describe further in section 1.3 below, cannot include other variables except by running separate analyses for different patient groups.

In order to calculate "rates", we use mid-year population estimates from the ONS. These series are calculated at several geographical levels, by age and sex, and published each year. We use the series for each year of age, aggregated to England.

Hospitals are reimbursed on an activity basis, with a certain tariff paid for each type of treatment. This case-based payment system, called "Payment by Results", is based on groupings known as Health Related Groups, which are similar to the Diagnostic Related Groups used elsewhere in the world. The tariffs used are based on average hospital costs and then informed by "best practice" to ensure efficiency gains can be properly extracted. This approach is common across most types of care.

1.2 Descriptive Statistics

Figure 1, Figure 2 and Figure 3 illustrate the data by year of admission (period), patient age and birth cohort respectively.

1.2.1 Emergency admissions

The total number of emergency admissions in England rose from 3.70 million in 1997/98 to 5.61 million in 2014/15. This is an increase of 51.5% over the full 17-year period and an average annual increase of 2.5%.

The overall emergency admission rate per 1,000 population rose by 37% between 1997/98 and 2014/15, an average annual increase of 1.87%. It rose from 76.1 in 1997/98 to 104.2 in 2014/15. The emergency admission rate has risen over this period most rapidly for the 75 and over age group.

Less than one-third of the overall increase in the number of emergency admissions during the period 1997/98 to 2014/15 is due to increases in the population by age band.

1.2.2 Emergency Discharges by Duration of Stay

Analyses by duration of emergency hospital stay are conducted in terms of discharges rather than admissions because duration data is recorded in HES at discharge. The number of discharges following emergency admission in 1997/98 was slightly higher than the number of emergency admissions: 3.78 million discharges in comparison with 3.68 million admissions. By 2014/15, the corresponding figures were 5.86 million discharges and 5.63 million admissions. For simplicity the rest of this paper refers to emergency hospital stays rather than discharges following emergency admission.

The number of short duration (0 to 1 day) emergency hospital stays in England rose from 1.25 million in 1997/98 to 2.94 million in 2014/15, an increase of 134.0%. The number of long duration (2 to 365) emergency hospital stays rose from 2.53 million in 1997/98 to 2.92 million in 2014/15, an increase of only 15.4%. The average annual rate of change over this period is a rise of 5.13% for short duration stays and of 0.85% for long duration stays.

It is important to note that, not only did the rate of long duration emergency stays per 1,000 population fall, but the average length of these stays also fell. After a small increase from 12.2 days in 1997/98 to 13.3 days in 2002/03, there was a steady decline to 10.4 days in 2014/15.

If rates by age band had remained constant at their 1997/98 levels, the number of emergency long duration stays would have reached 2.96 million in 2014/15 rather than 2.92 million, an increase of 16.9% instead of 15.4%. The number of long emergency stays, therefore, rose slightly more slowly during the period 1997/98 to 2014/15 than would be expected from the observed increases in the population by age band.

1.2.3 Elective admissions

The total number of elective admissions (including day cases) in England rose from 5.07 million in 1997/98 to 8.26 million in 2014/15. This is an increase of 62.8% over the full 17-year period and an average annual increase of 2.9%. This compares with an annual average increase of 2.5% for emergency admissions.

The overall elective admission rate per 1,000 population rose by 45.8% between 1997/98 and 2014/15, an average annual increase of 2.2%. The elective admission rate has risen over this period most rapidly for the 75 and over age group and almost as rapidly for the 65 to 74 age group. If elective admission rates by age band had remained constant at their 1997/98 levels, the number of elective admissions would have reached 5.84 million in 2014/15 rather than 8.26 million, an increase since 1997/98 of 15% instead of 63%. Less than one-quarter of the increase in the number of elective admissions during the period 1997/98 to 2014/15 is therefore due to increases in the population by age band. This is even lower than the equivalent for emergency admissions: less than one-third of the increase in the number of emergency admissions during the period 1997/98 to 2014/15 is due to increases in the population by age band.

1.2.4 Emergency bed-days: total

The total number of emergency bed days in England fell marginally from 31.73 million in 1997/98 to 31.59 million in 2014/15. The overall emergency bed day rate per 1,000 population rose from 652.0 in 1997/98 to 704.7 in 2003/04 and then fell to 581.5 in 2014/15. If bed day rates by age band had remained constant at their 1997/98 levels, the number of emergency bed days would have reached 37.67 million in 2014/15 rather than 31.59 million, an increase since 1997/98 of 18.7% instead of a decrease of 2.3%. This shows that the impact of the increasing population and rising proportion of older people within the population has been more than offset by other factors.

1.2.5 Emergency Bed Days by Duration of Hospital Stay

The number of short duration (0 or 1 day) emergency admissions rose far faster than the number of long duration (2 or 365 days) emergency admissions over the period 1997/98 to 2014/15. It is therefore not surprising that the proportion of total emergency bed days accounted for by short hospital stays rose from 2.4% in 1997/98 to 4.1% in 2014/15.

The analysis reported here concentrates on bed days of long duration emergency hospital stays. This is partly because they account for the great majority of emergency bed days and partly because an analysis of bed days of short duration hospital stays – of either 0 or 1 day by definition – is unlikely to differ greatly from the analysis of short duration admissions reported in section 1.2.2.

The number of bed days consumed by stays of 2 to 365 days fell from 30.98 million in 1997/98 to 30.29 million in 2014/15. This is a decrease of 2.21% over the 17-year period and an average annual decrease of 0.13%. This compares with an annual decrease of total emergency bed days of 0.03%.

If the emergency bed day rates by age band for stays of 2 to 365 days had remained constant at their 1997/98 levels, the number of these bed days would have reached 36.83 million in 2014/15 rather than 30.29 million, an increase since 1997/98 of 18.9% instead of a decrease of 2.2%. This means that the impact of the increasing population and rising proportion of older people within it has been more than offset by other factors.

1.2.6 Elective bed days

The total number of elective bed days in England fell from 11.02 million in 1997/98 to 6.71 million in 2014/15. This is a decrease of 39.1% over the full 17-year period and an average annual decrease of 2.88%. This compares with an annual average decrease of 0.03% for emergency bed days.

The age-standardised rate fell from 226.5 in 1997/98 to 116.2 in 2014/15, an annual average decrease of 3.85%. This compares with an annual average decrease, on the same basis, of 1.16% for emergency bed days.

As for emergency bed days, the impact of the increasing population and rising proportion of older people within the population has been more than offset by other factors.

1.3 Method

We use a regression-based methodology to identify the effects of age, period and cohort (APC) on the trends of emergency and elective hospital admissions. The APC methodology (Yang and Land 2004) provides a framework to analyse time series count data for a population, such as births, deaths, disease incidence etc. It attempts to attribute the changes in an outcome to three factors:

- Age effects. These show how the age of an individual impacts the likelihood that they will experience an outcome.

- Cohort effects. These show the combined impact of all factors that affected a common birth cohort. They can be seen as a generational effect – capturing differences accrued both at time of birth and during peoples' formative years.

- Period effects. These show the impact of contemporaneous factors that impact upon all age groups.

APC analysis is a form of multivariate regression analysis. The dependent variable is "counts" by age and year of the variable to be analysed, or those "counts" by age and year expressed as rates e.g. per 1,000 population. The models we estimate in this paper all have dependent variables which are rates. The independent variables are dummy variables for each age, year of birth and year to which the observation relates. The APC model therefore has three time scales: age *i*, period *j* and cohort *k*. The data are arrays of responses and doses indexed by two of the three time scales. The statistical model is a generalized linear model with a predictor of the form:

$$Y_{ik} = A_i + P_j + C_k + e$$

Where A = age; P = period and C = cohort.

A problem arises when attempting to apply the APC method econometrically, in that age, period and cohort are a perfectly multi-collinear set (period = cohort + age). To obtain consistent coefficient estimates it is necessary to impose constraints on any APC regression.

We have adopted the Intrinsic Estimator (IE) approach, developed and discussed by Yang et al. (2004, 2008) and Fu et al. (2011), to address the multicollinearity issue. This approach avoids the need to impose potentially arbitrary constraints on parameters. Rather than imposing a constraint directly on the regression coefficients, it restricts the impact of the design matrix on the coefficient estimates. In practice, this implies that the constraint is determined by the number of age and period groups modelled. Yang et al. (2008) found that the IE is unbiased, relatively efficient and asymptotically consistent.

Yang et al. (2008) state in their conclusions that: "the IE has passed both empirical and simulation tests of validity and can be used to test theoretically motivated hypotheses and to incorporate and test side information from other studies. The IE therefore may provide a useful tool for the accumulation of scientific knowledge about the distinct effects of age, period, and cohort categories in social research".

We calculated rates per 1000 population of elective and emergency admissions, and associated bed-days, for each single year of age for each year of admission from 1997/98 to 2014/15, and estimate APC models for these series using patients' age, year of birth and year of admission as the independent variables. We used Stata version 12.

2 Results:

2.1 Emergency admissions: total

The key objective of this study is to explore through APC analysis how far trends in several measures of hospital utilisation over the last 17 years can be explained by:

1. effects of the age distribution of the population, together with rising numbers of older people;
2. effects due to differing admission rates by different birth cohorts;
3. effects relating to a specific year (period) which cannot be explained by either age or cohort effects.

To facilitate comparison across the series we study in this paper, the coefficients from each estimation are presented in charts, with each chart plotting the coefficients relating to one factor (age, period and cohort) of each estimation.

We begin by showing the results from estimation of the emergency admission rate. The age effect findings show that the emergency admission rate among adults falls from age 20 to around age 40 and then rises with age (Figure 4). For children and young people the rate falls until age 10 and then rises. This is after controlling for cohort and period effects. The emergency admission rate is around 2.4 times higher at age 85 than at age 75 and around 7.0 times higher at age 85 than at age 45, on the basis of constant 2010 period effect and 1970 cohort effect.

Each successive cohort from the cohort born in 1964 onward has experienced a lower emergency admission rate at a given age after controlling for period and age effects (Figure 5). Prior to 1964, cohorts born from 1929 to 1948 had successively lower admission rates, but the rates then rose for cohorts born between 1948 and 1964, the generation who make up the post-World War 2 ”baby boom”. The emergency admission rate for those born in 1985 for example is around 10% lower than the rate for those born in 1945 at age 50 and constant 2010 period effect.

The period effect rose every year from 1997/98 to 2014/15, except for 2011/12, after controlling for age and cohort effects. There were especially large rises between 2002/03 and 2005/06 and between 2007/08 and 2010/11 and then again in 2014/15 (Figure 6). The emergency admission rate in 2014/15 is around 45% higher than the rate in 1997/98 for the 1970 cohort and age 50.

If there had been no period effect the number of emergency admissions would have risen from 3.70 million in 1997/98 to only around 3.89 million in 2014/15 instead of the observed value of 5.61 million in 2014/15. This shows that the cohort effect almost fully offset the upward-pressure on admissions caused by age and the rising number of older people during the period 1997/98 to 2014/15.

2.2 Emergency Discharges by Duration of Stay

2.2.1 Short duration stays

The APC analyses show that, after controlling for cohort and period effects, the short emergency stay rate of among adults falls with age to around 45 and then rises (Figure 4). For children and young people the rate falls until age 12 and then rises. The rate is around 1.7 times higher at age 75 than at age 65 and around 2.7 times higher at age 75 than at age 45, on the basis of constant 2010 period effect and 1970 cohort effect.

In general, later cohorts have experienced a lower short-stay rate at a given age after controlling for period as well as age effects (Figure 5). In contrast, for the period before 1970, each successive cohort from the cohort born in 1915 onward, except for a few blips, has experienced a lower short stay rate at a given age. The rate for those born in 1985 is around

20% lower than the rate for those born in 1965, but similar to the rate for those born in 1945, holding constant the age effect (at 50) and the period effect (at the 2010 level).

The period effect has risen each year from 1997/98 to 2014/15 except in 2011/12 (**Error! Reference source not found.**). The rate in 2014/15 is more than twice as high as the rate in 1997/98, for the 1970 cohort and age 50.

If there had been no period effect, the number of short emergency stays would have risen from 1.25 million in 1997/98 to only around 1.30 million in 2014/15, instead of the actual figure of 2.94 million in 2014/15. This shows that during the period 1997/98 to 2014/15, the cohort effect offset around two-thirds of the increases in short duration emergency stays that were due to age and rising numbers of older people.

2.2.2 Long duration stays

After controlling for cohort and period effects, the long emergency stay rate of adults falls with age to around 40 and then rises (Figure 4). For children and young people the rate falls until age 9 and then rises. The rate is around 1.8 times higher at age 75 than at age 65 and around 3.6 times higher at age 75 than at age 45, on the basis of constant 2010 period effect and 1970 cohort effect.

Each successive cohort, from the cohort born in 1930 onward, has generally experienced a lower long stay rate at a given age after controlling for period and age effects (Figure 5). The rate for those born in 1985 is around 30% lower than the rate for those born in 1945, at age 50 and constant 2010 period effect.

The period effect has risen and fallen over the earlier years of the period from 1997/98 but has risen in most years since 2007/08 (Figure 6). The rate in 2014/15 is around 10% higher than the rate in 1997/98, for the 1970 cohort and age 50.

If there had been no period effect, the number of long duration emergency stays would have risen from 2.53 million in 1997/98 to only around 2.66 million in 2014/15, instead of the actual figure of 2.92 million. This shows that during the period 1997/98 to 2014/15 the cohort effect offset around two-thirds of the positive effect on long duration emergency stays of age and rising numbers of older people.

2.3 Elective Admissions

The APC analysis show that after controlling for cohort and period effects, the elective admission rate among adults rises with age to age 78 and then falls (Figure 4). For children and young people the rate fluctuates to age 4, falls until age 11 and then rises. The elective admission rate is around 1.4 times higher at age 75 than at age 65 and around 2.7 times higher at age 75 than at age 45, on the basis of constant 2010 period effect and 1970 cohort effect.

Each successive cohort from the cohort born in 1946 onward, with one exception in 2010, has experienced a lower elective admission rate at a given age after controlling for period and age effects (Figure 5). The rate rose for cohorts born between 1920 and 1945. The elective admission rate for those born in 1985 for example is around 40% lower than the rate for those born in 1945 at age 50 and constant 2010 period effect. This estimate of around 40% is much higher than the equivalent estimate of around 40% for emergency admissions, but this is due to the age and time period selected for this illustrative example. As discussed below, overall cohort effects do not differ significantly between elective and emergency hospital care.

The period effect rose every year from 1997/98 to 2014/15, except for 2002/03 and 2004/05. There were especially large rises between 2004/05 and 2008/09 and between 2012/13 and 2014/15 (Figure 6). While the former period coincides with the introduction of 'Choice' and higher funding, it is less clear why elective care has surged between 2012/13 and 2014/15. The elective admission rate in 2014/15 is around 41% higher than the rate in 1997/98, for the 1970 cohort and age 50. As discussed below, the period effect has been considerably higher for elective than for emergency hospital admissions.

If there had been no period effect, the number of elective admissions would have risen from 5.07 million in 1997/98 to only around 5.33 million in 2014/15, instead of the actual figure of 8.26 million in 2014/15.This shows that, as for emergency admissions, the cohort effect almost fully offset the positive effect of age on admissions and rising number of older people during the period 1997/98 to 2014/15.

2.4 Emergency bed days: total

The APC analysis shows that after controlling for cohort and period effects, the emergency bed day rate among adults falls from age 20 to age 37 and then rises with age (Figure 4). For children and young people the rate falls until age 8 and then rises. The emergency bed day rate is almost three times higher at age 85 than at age 75 and over twelve times higher at age 85 than at age 45, on the basis of constant 2010 period effect and 1970 cohort effect.

Each successive cohort from the cohort born in 1920 to the cohort born in 2003/04 has experienced a lower bed day rate at a given age after controlling for period as well as age effects. The emergency bed day rate at age 50, for a common period effect (2010), is around

400 per 1,000 population for those born in 1940 and 320 per 1,000 population for those born in 1960.

The period effect rose in most years from 1997/98 to 2003/04. It then fell from 2003/04 to 2007/08. Since 2007/08 it has fluctuated, ending higher in 2014/15 than in 2007/08 but at a similar level to 2000/01 (Figure 5). The emergency bed day rate in 2014/15 is less than 1% higher than the rate in 1997/98 for the 1970 cohort and age 50.

If there had been no period effect, we estimate that the number of emergency bed days would have fallen from 32.34 million in 1997/98 to around 30.26 million in 2014/15 instead of 31.59 million in 2014/15. This shows that the cohort effect more than offset the positive effect of age and rising number of older people in the period 1997/98 to 2014/15.

A comparison of trends in emergency admissions and emergency bed days over the period 1997/98 to 2014/15 shows that while the admissions rose by 52% the bed days remained almost constant (Table 1). The reason is the sharp decline in average lengths of stay over this 17-year period. The impact of population ageing is slightly higher for bed days than for admissions: since average length of stay is higher in old age, bed days are more heavily concentrated on older people than admissions. The cohort effect is also more strongly negative for bed days than for admissions. The period effect, in contrast, is far higher for admissions than for bed days. This is not surprising since the period effect is greater for short duration than for long duration emergency admissions and short duration admissions have less impact on bed days than longer duration admissions.

2.5 Emergency Bed Days by Duration of Hospital Stay

The age effect findings for long duration stays are much the same as for all emergency bed days (Figure 4). Among adults the rate falls from age 20 to age 37 and then rises with age and among children and young people the rate falls until age 8 and then rises. This is after controlling for cohort and period effects. The emergency bed day rate is almost three times higher at age 85 than at age 75 and thirteen times higher at age 85 than at age 45, at constant 2010 period effect and 1970 cohort effect.

Each successive cohort from the cohort born in 1920 to the cohort born in 2003/04 has experienced a lower bed day rate at a given age after controlling for period as well as age effects. For cohorts born since 2003/04 the rate has fluctuated. The bed day rate at age 50, for a common period effect (2010), is around 400 per 1,000 population for those born in 1940 and 310 per 1,000 population for those born in 1960, which is 23% lower.

The period effect rose most years from 1997/98 to 2003/04. It then fell from 2003/04 to 2007/08. Since 2007/08 it has fluctuated, ending higher in 2014/15 than in 2007/08 but at a similar level to 2006/07 and 1999/2000 (Figure 5). The emergency bed day rate for long duration stays in 2014/15 is around 1% higher than the rate in 1997/98 for the 1970 cohort and age 50, as was also found for the all emergency bed days rate.

Finally, by controlling for the period effect, we assess the comparative importance in explaining emergency bed-days of ageing and the birth-cohort effect. If there had been no period effect, the number of emergency bed days of long duration stays would have fallen from 30.98 million in 1997/98 to around 30.11 million in 2014/15 instead of 30.29 million in

2014/15. This shows that the cohort effect more than offset the positive effect of age and rising number of older people in the period 1997/98 to 2014/15.

2.6 Elective bed days

After controlling for cohort and period effects, the elective admission rate among adults rises with age to age 78 and then falls (Figure 4). For children and young people the rate falls until age 7 and then rises to age 20 with a dip between ages 16 and 18. The elective admission rate is around 25% higher at age 75 than at age 65 and around 60% higher at age 75 than at age 45, on the basis of constant 2010 period effect and 1970 cohort effect. Each successive cohort from 1912 to the cohort born in 1988/89 onward has experienced a lower elective bed day rate at a given age after controlling for period as well as age effects. Since 1988/89, the rate fluctuated, fell to a low in 2001/02 and then rose to 2014/15. The elective bed day rate at age 50, for a common period effect (2010), is around 175 per 1,000 population for those born in 1940 and 125 per 1,000 population for those born in 1960, which is 30% lower. This estimate of around 30% is greater than the equivalent estimate of 20% for emergency bed days.

The period effect from 1997/98 fluctuated and then rose, peaking in 2002/03, since when it has fallen each year (Figure 5). The elective bed day rate in 2014/15 is around 25% lower than the rate in 1997/98, for the 1970 cohort and age 50. This estimate is in contrast with the equivalent estimate for emergency bed days, where there was minimal difference between 1997/98 and 2014/15.

If there had been no period effect, the number of elective bed days would have fallen from 11.02 million in 1997/98 to around 9.04 million in 2014/15, instead of the actual figure of 6.71 million in 2014/15. This shows that, as for emergency bed days, the cohort effect more than offset the positive effect of age and rising number of older people in the period 1997/98 to 2014/15.

3 Discussion

The number of emergency admissions in England rose by around 52% over the period 1997/98 to 2014/15. The number of bed days used per annum in these emergency hospital stays, however, fell by 0.4% over this period. The emergency admission rate per head of population rose by 37% and the bed day rate fell by 11% between 1997/98 to 2014/15.

The number of elective admissions (including day cases) in England rose by around 63% over the period 1997/98 to 2014/15 but the number of bed days of these elective hospital stays fell by 39% over this period. The elective admission rate per head of population rose over this period by 46%, slightly faster than for emergency care; and the bed day rate fell by 45% between 1997/98 and 2014/15.

A key finding of the analysis of emergency admissions is that each successive birth cohort in the years before 1948, and those after 1964, has experienced lower emergency admission rates after controlling for age and period effects. This cohort effect, that places downward pressure on emergency admissions, is sufficiently large almost to offset the effect on admissions of the larger and more aged population - over the period 1997/98 to 2014/15.

The analysis of emergency stays by duration showed that short duration emergency stays rose far more rapidly than long duration emergency stays. While the number of short stays rose far faster than keeping pace with the rising and ageing population, the number of long stays did not even rise sufficiently to keep pace with population change. For both short and long stays, hospital stay rates per 1,000 population fell between ages 20-25 and 40-45, after controlling for cohort and period effects, and then rose from age 40-45 upward. The rate of increase with age was faster for long than for short stays. There was a downward cohort effect in recent decades for both short and long stays but for the period from 1930 to 1970, the cohort effect was upward for short duration stays and downward for long duration stays. The downward cohort effects offset around two-thirds of the ageing rising population effects for both short duration stays and long duration stays over the 17-year period 1997/98 to 2014/15. This very similar cohort effect for what are two quite different types of treatments is consistent with the view that demand side influences, quite probably arising from improved individual health, are most likely underpinning the strength of the common cohort effects.

The period effect was variable over time: for both short and long stays it first rose until 2003/04, but then fell to 2007/08 despite strong funding growth, and subsequently rose quite rapidly. Across the whole 17 years from 1997/98, the period effect has been substantially greater for short than for long stays. More considerable changes in technology and/or clinical practice are likely to be prominent reasons for the greater period effects between short duration and long duration stays.

A key finding of the analysis of elective admissions is that each successive birth cohort from 1946 onward, except for a blip in 2010, has experienced a lower elective admission rate at a given age after controlling for period as well as age effects. The rate rose for cohorts born between 1920 and 1945. This cohort effect is, as with emergency admissions, sufficiently large almost to offset the effect on admissions of the larger and more aged population. The implication is that most probably the increases in both types of admission are the consequence of a variety of evolving demand and clinical/hospital side factors that would have occurred even in the absence of a larger and more aged population. Unlike the ageing population, some of these influences are potentially reversible on a three year horizon, and thus the evidence supports the view that carefully constructed policy to ameliorate admissions growth might succeed, and not be overwhelmed by the impact of population ageing.

Whereas actual emergency admissions increased by 51% over the 17-year period and elective admissions by 63%, the effect of the two demographic changes – ageing, and changing hospital admission rate at each age – without period effects would result in an increase in both emergency and elective admissions of only 5.1%. In other words the cohort effect almost cancels out the ageing effect and taken together the age and cohort effects have only a modest impact on emergency admissions amounting to about 10% of the increase in emergency admissions and less than 10% of the increase in elective admissions. This means that the period effect was the main driver of both elective and emergency admissions. This is a crucial result from our analysis because it means we must seek explanations other than population ageing per se to explain rising hospital admissions, since ageing has occurred simultaneously with a lower tendency to admit at any given age. This finding would be unsurprising to those who expect the "compression" of need for health care into the last years of life to continue to hold as the population ages, but it may be more surprising to those who have not considered whether need for inpatient care at a given age might decline over time as life expectancy rises. It may be that there is another reason for this result. Recent technological developments, efficiency improvements driven by policy, or more effective care outside hospital settings (e.g. primary care, social care) are all potential explanations for the large period effect. This result deserves further study to fully identify its cause.

The APC analysis found that the admission rate rose from around age 40 upward for emergency admissions and from age 10 upward (to age 78) for elective admissions. We may ask how the level of admissions would have increased if the population size and age distribution had grown as it did, but without both cohort and period effects. The number of emergency admissions would have reached 4.26 million in 2014/15 rather than 5.61 million, an increase since 1997/98 of 15% instead of 51%. The number of elective admissions would have reached 5.84 million in 2014/15 rather than 8.26 million, an increase since 1997/98 of 15% instead of 63%. By itself, population ageing and growth would have created less than one third of the overall level of emergency admissions growth and less than one quarter of the overall level of elective admission growth since 1997/98, even without allowing for the moderating effect of declining cohort effects.

The key difference between trends in elective and emergency admissions indicated by our age, period, cohort analyses for the years 1997/98 to 2014/15 relates to the period effects (Table 2). While the ageing and cohort effects hardly differ between the two types of admissions, the period effect was 25% higher for electives (55% for elective admissions compared with 44% for emergency admissions). The period effects could be due to a range of factors including supply side changes such as adoption of new technologies. It may be that the high period effect for electives reflects rising opportunities for elective interventions to improve patients' quality of life. In any case, it is for elective care that incremental annual admissions unrelated to the changing age distribution, and the declining cohort effects, have been strongest.

Elective admissions and elective bed days followed very different trends (Table 3). While admissions rose by 63% over the years 1997/98 to 2014/15, bed days fell by 39%. The reason is that a substantial proportion of the rise in number of admissions relates to day cases, which by definition do not involve any bed days. The number of day cases rose from 3.04 million in 1997/98 to 6.54 million in 2014/15, a rise from 59.9% of all elective admissions in 1997/98 to 79.2% of all elective admissions in 2014/15. This degree of "substitution" between day cases and electives involving overnight stays could also explain the large differences in cohort and period effects between elective admissions and elective bed days.

There were also major differences in the bed-day trends for electives and emergencies (Table 4). While the total number of emergency bed days remained fairly constant, the number of elective bed days fell by 39% over the years 1997/98 to 2014/15. Cohort effects were larger (more negative) for elective than for emergency bed days and period effects were strongly negative for elective bed days in contrast to slightly positive for emergency bed days. This is again likely to be due to the large shift from elective admissions involving an overnight stay to elective day cases.

4 Limitations

A general limitation of our work is that APC analyses rely on the use of aggregate data that do not account for the wide variation in patients' socioeconomic characteristics, health conditions and treatment. The analysis uses aggregate hospital activity, and as such does not take account of differences between hospitals and over time in case-mix, quality of care, thresholds used to determine admission (Wyatt 2017), or outcomes for patients.

APC analysis has notable limitations that have been well discussed in the literature, for example Fannon and Nielsen (2019). One specific issue that affects the analysis presented here is that identification of the APC model relies on the assumption that there is no interaction between the age, period and cohort effects. Cohort effects are also explicitly constrained to imparting the same proportionate effect across all age groups, not allowing cohort effects to adjust to new inputs over time. This is a strong limitation in our model, because these variables could be inter-related or there could be other issues – such as gender – which may result in differences for groups of the same age.

A further issue is that the cohorts born at the extremes may be less well represented relative to other cohorts. This leads to larger standard errors for those groups. Hence, some caution is needed when interpreting the coefficients at the extremes of the distributions. In particular, the increases in the coefficients on the cohort variable for the three most recent birth cohorts were unexpected and may be attributed to sparse data for these cohorts.

5 Conclusion

This paper makes a valuable contribution to understanding the sources of growth in English hospital activity using methods that, to our knowledge, have not previously been applied to a dataset concerning all general and acute inpatient hospital activity. Since the first development of APC analysis there has been considerable debate about the methodological issues associated with such modelling. See, e.g Reither et al (2015). However, APC methods have the ability to identify the relative impact of demographic, technological and other factors on changes in hospital admissions, and as such inform policymakers in ways that will help them to design the most appropriate measures to address rapid increases in admissions. We consider that using these techniques can shed important light on a matter of crucial importance to healthcare policymakers and academics studying these issues.

We suggest that there are opportunities to reduce the growth in hospital admissions by targeting certain groups of patients, such as measures to improve primary care for patients with long-term conditions (Deeny et al 2018). However, the results presented here do not allow us to comment on the cost consequences for providers, nor quality or outcome measures for patients associated with the recent trends in hospital activity.

APC analysis could be employed to predict the likely effects of recently introduced policies or those that might be considered in the near future.

In particular, the Government committed to increase funding and pursue structural change via the NHS Long-term plan (Charles et al 2019). Patients are being encouraged to seek care in primary care, with the development of primary care networks a policy focus at present. This may help to reduce the period effect. This is a crucial aim for the NHS which is currently under extreme pressure (eg, Commons Library Briefing 2020), exacerbated by the Covid-19 pandemic, which is likely to shift up the period and age effects significantly. At the same time, significant investment is being made in NHS capital, with a plan to spend £7bn in 2019/20 (The King's Fund 2019), and there is also an emphasis on developing digital services. These two activities should increase capacity and allow the NHS to treat more patients in hospitals as well as other facilities, although as King's Fund state, the growth in funding is unlikely to be enough to revolutionise the system in the way that policymakers aspire to. Further research on these issues could prove illuminating.

Our research shows that a significant amount of the challenges faced in the NHS is due to factors beyond changes in the characteristics of the population and that with appropriately designed policy interventions continuing growth in hospital admissions may not be inevitable.

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Figure 1: Admission and bed-day rates by period

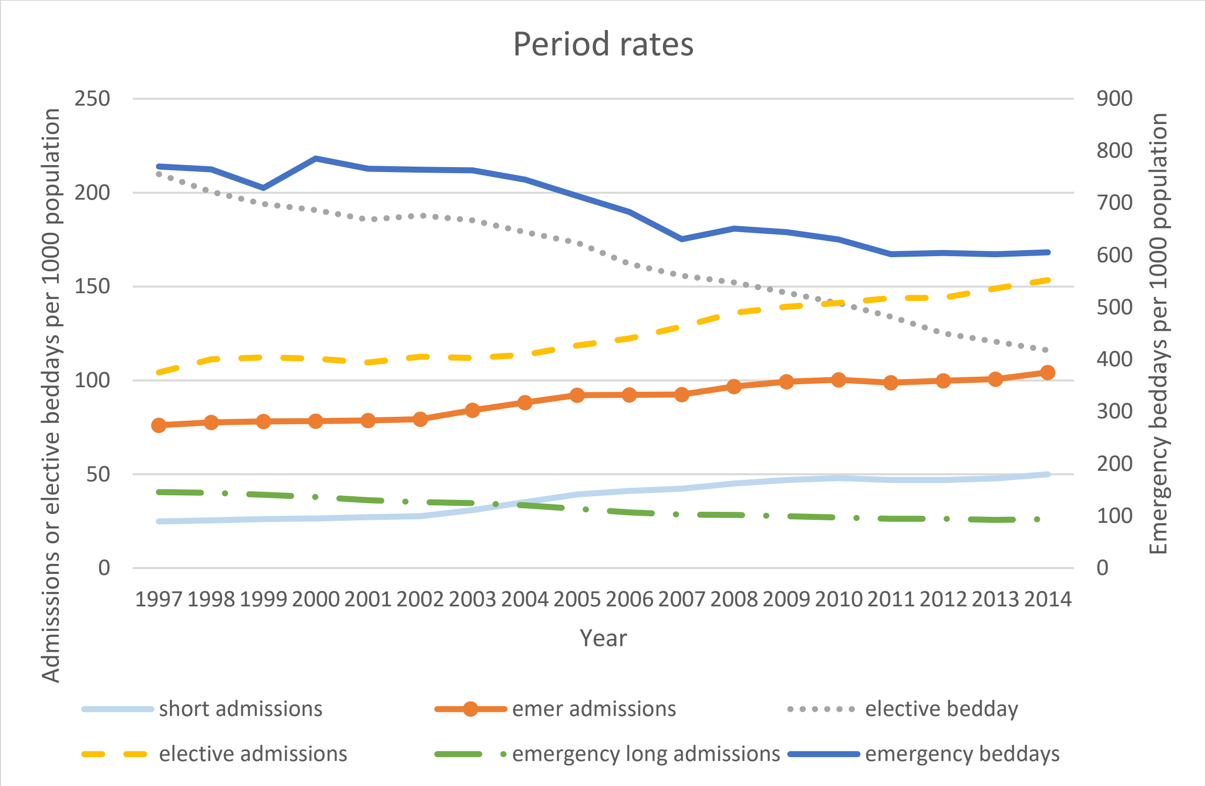

Figure 2: Admission and bed-day rates by patient age

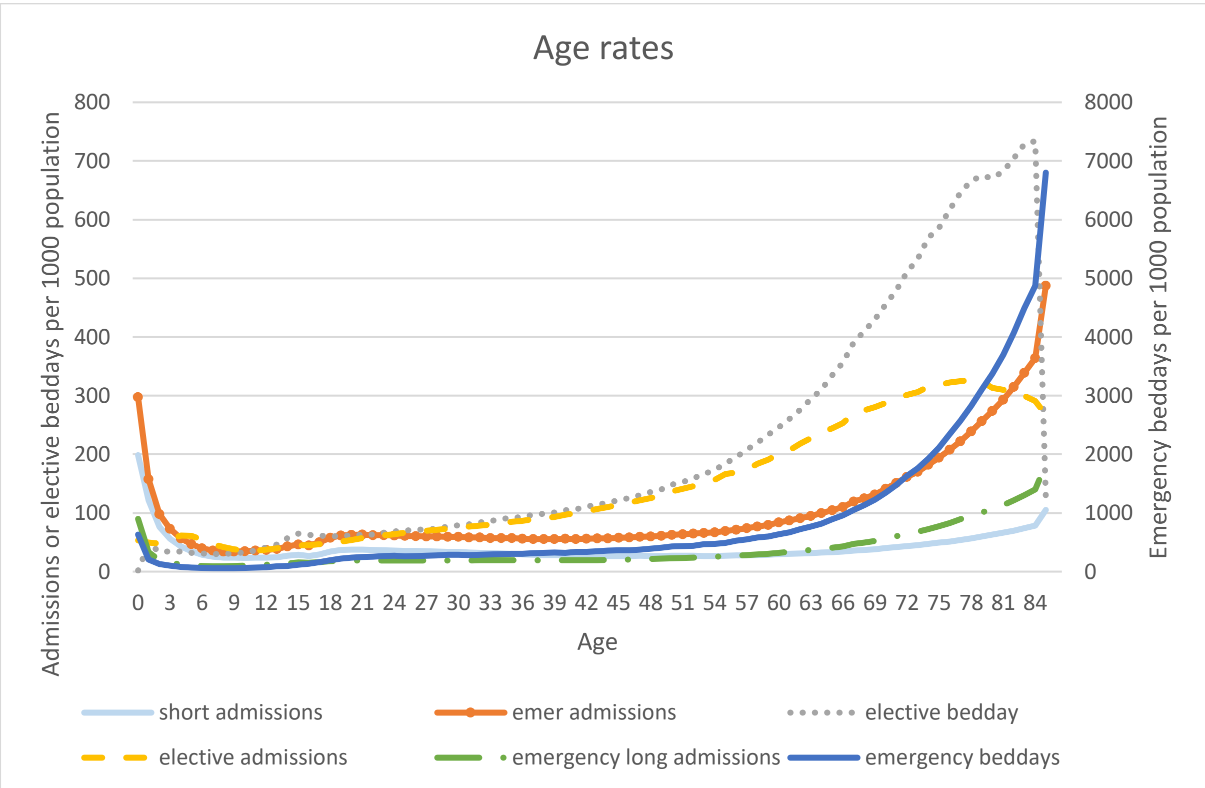

Figure 3: Admission and bed-day rates by birth cohort

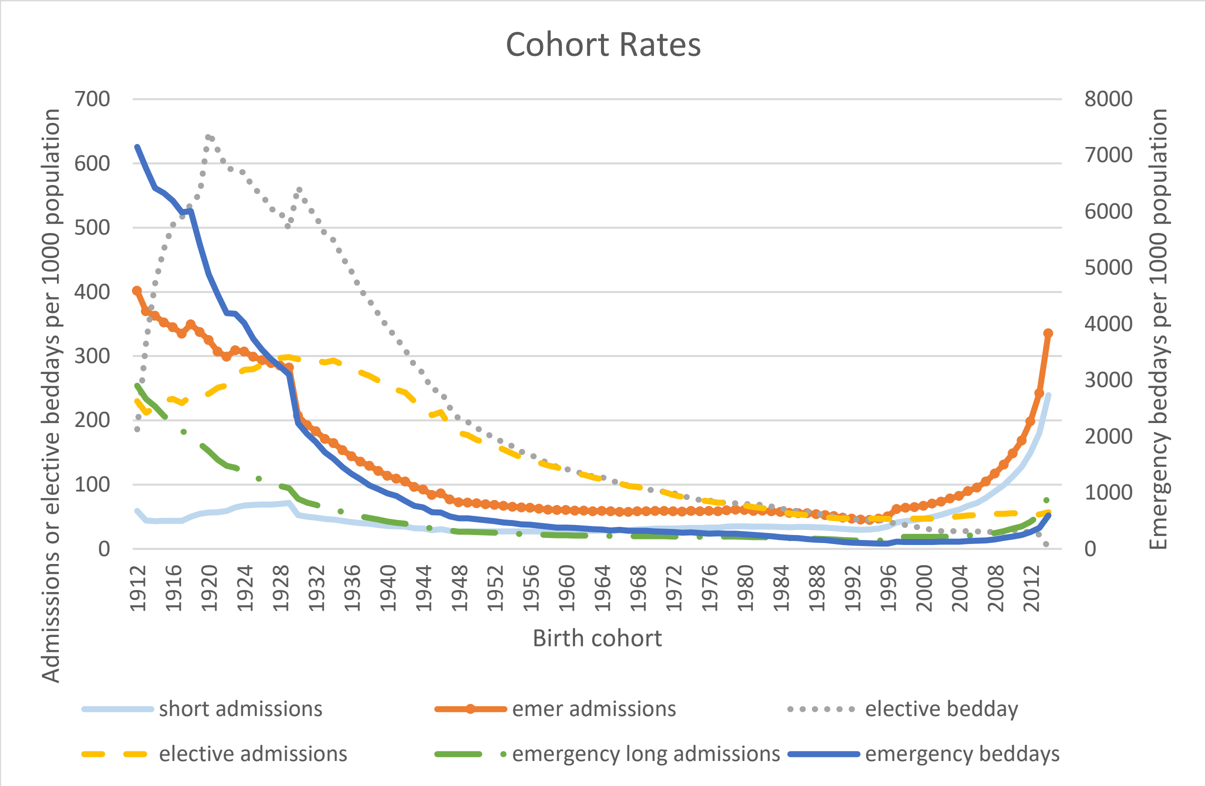

Figure 4: APC analysis estimated age effect coefficients

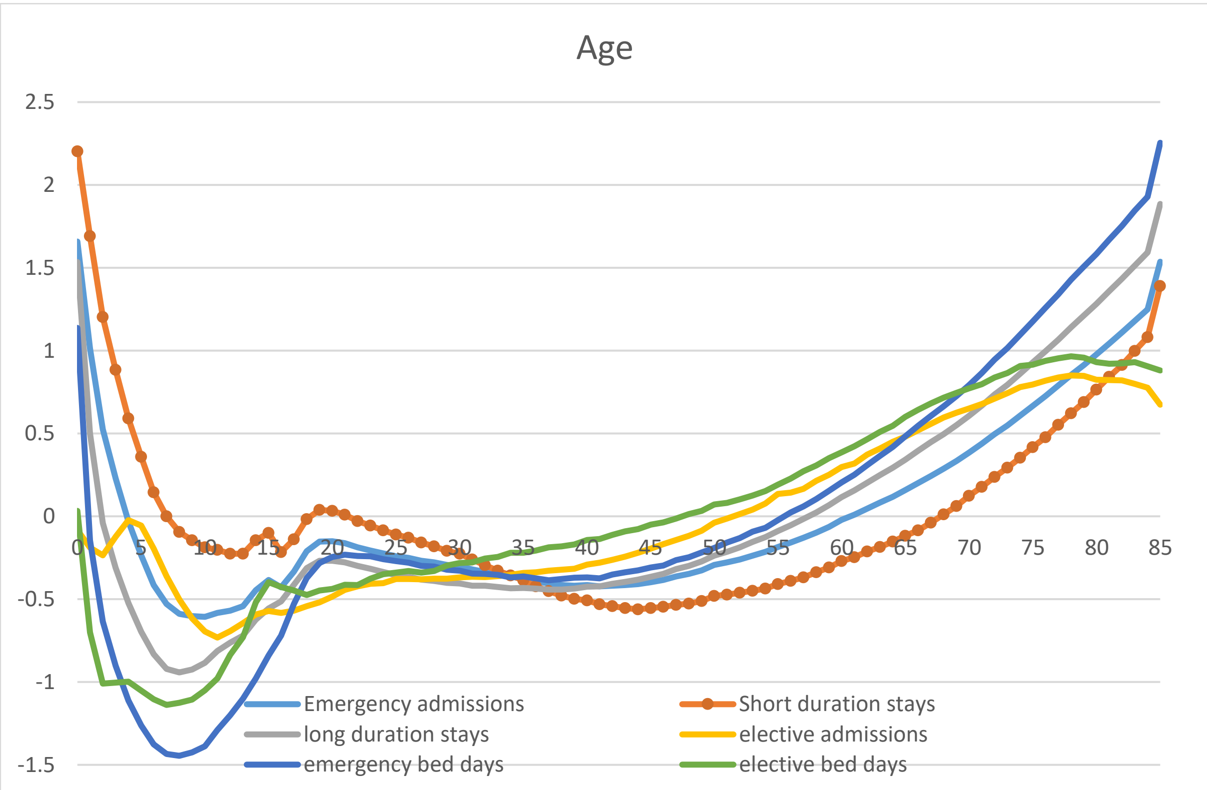

Figure 5: APC analysis estimated cohort effect coefficients

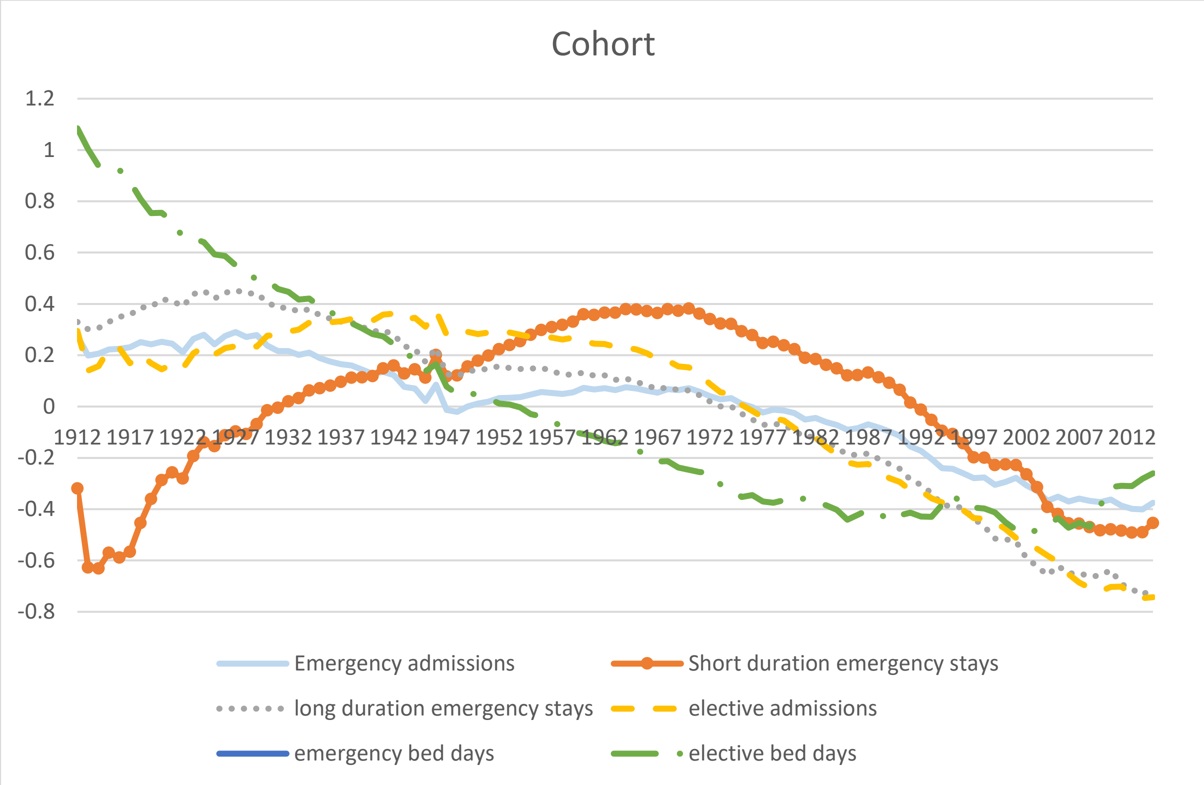

Figure 6: APC analysis estimated period effect coefficients

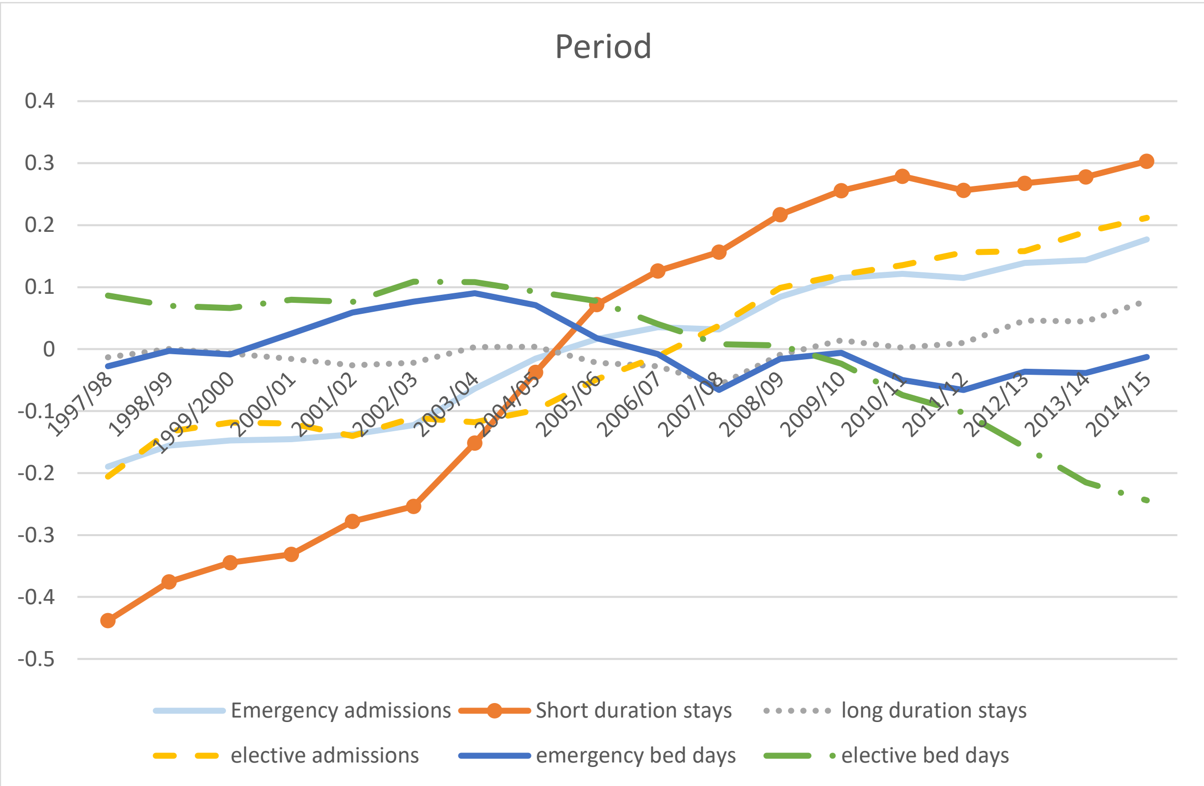

Table 1: Comparison of trends in emergency admissions and emergency bed days, 1997/98 to 2014/15

	Admissions Emergencies	**Bed days Emergencies**
1997/98 actual	3.70	31.73
2014/15 actual	5.61	31.59
2014/15, constant 1997/98 rates	4.26	37.67
2014/15, no period effects	3.89	30.26
Decomposition of the % rise in levels,1997/98-2014/15:		
Impact of ageing	15%	19%
Impact of cohort effect	-9%	-20%
Impact of period effect	44%	4%
Total increase over 17 years	52%	0%

Table 2: Comparison of trends in elective and emergency admissions, 1997/98 to 2014/15

	Emergencies	**Electives**
1997/98 actual level	3.7	5.07
2014/15 actual level	5.61	8.26
2014/15, constant 1997/98 rates	4.26	5.84
2014/15, no period effects	3.89	5.33
Decomposition of the % rise in levels, 1997/98-2014/15: Impact of ageing	15%	15%
Impact of cohort effect	-9%	-9%
Impact of period effect	44%	55%
Total admissions increase, 1997/98-2014/15	52%	63%

Table 3: Comparison of trends in elective admissions and bed days, 1997/98 to 2014/15

	Admissions	**Bed days**
1997/98 actual	5.07	11.03
2014/15 actual	8.26	6.71
2014/15, constant 1997/98 rates	5.84	12.98
2014/15, no period effects	5.33	9.04
Decomposition of the % rise in levels,1997/98-2014/15:		
Impact of ageing	15%	18%
Impact of cohort effect	-9%	-30%
Impact of period effect	55%	-26%
Total increase over 17 years	63%	-39%

Table 4: Comparison of trends in elective and emergency bed days, 1997/98 to 2014/15

	Electives	**Emergencies**
1997/98 actual	11.03	31.73
2014/15 actual	6.71	31.59
2014/5, constant 1997/98 rates	12.98	37.67
2014/15, no period effects	9.04	30.26
Decomposition of the % rise in levels,1997/98-2014/15:		
Impact of ageing	18%	19%
Impact of cohort effect	-30%	-20%
Impact of period effect	-26%	4%
Total increase over 17 years	-39%	0%