ANALYSIS OF TRENDS IN EMERGENCY AND ELECTIVE HOSPITAL ADMISSIONS AND HOSPITAL BED DAYS:
1997/98 TO 2014/15

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ANALYSIS OF TRENDS IN EMERGENCY AND ELECTIVE HOSPITAL ADMISSIONS AND HOSPITAL BED DAYS 1997/98 TO 2014/15

Summary

NHS England commissioned the Centre for Health Services Economics and Organisation (CHSEO), University of Oxford, to examine how far the trends in emergency and elective hospital admissions and bed days in England over the last 17 years can be explained by: the effects of the age distribution of the population, together with rising numbers of older people; cohort effects, that is effects due to differing admission rates of people born in different years (different birth cohorts); period effects, that is admissions effects relating to a specific year which cannot be explained by age or cohort effects. The aim is to generate improved understanding of the trends in elective and emergency hospital care over recent years.

The overall number of emergency admissions rose by around 52% over the period 1997/98 to 2014/15 (but the data for 2014/15 are provisional). This comprises a rise of 134% for short duration (0 to 1 day) emergency hospital stays but only 15% for long duration (2 to 365) emergency stays. The number of bed days of these emergency hospital stays fell by 0.4% over this period, due to shortening average length of stay. The emergency admission rate per head of population rose by 37% but the bed day rate fell by 11% between 1997/98 to 2014/15.

The number of elective admissions (including day cases) rose by around 63% over the period 1997/98 to 2014/15. Within this total the number of day cases rose by 115%, a rise from 60% of all elective admissions in 1997/98 to 79% in 2014/15. The number of bed days of these elective hospital stays, however, fell by 39% over this period. The elective admission rate per head of population rose over this period by 46% and the bed day rate fell by 45% between 1997/98 and 2014/15.

The age effect findings show that the emergency admission rate and emergency bed day rate for adults fall from age 20 to around age 40 and then rise with age, after controlling for cohort and period effects. The minimum rate is at around age 30 for males and age 45 for females. There is little difference in age effect by duration of emergency hospital stay.

The cohort effect findings are that each successive cohort from that born in 1964 onward has experienced a lower emergency admission rate at a given age after controlling for period effects, but that the rate rose for each successive cohort born between 1948 and 1964. Each successive cohort from that born in 1920 to that born in 2003/04 has experienced a lower emergency bed day rate after controlling for the other effects. There is little difference in the cohort effect by gender. While the cohort effect has been downward
for both short and long duration stays since 1970, from 1930 to 1970 the cohort effect was upward for short duration stays but downward for long duration stays.

The period effect for emergency admissions rose almost every year from 1997/98 to 2014/15, after controlling for age and cohort effects, with especially large rises between 2002/03 and 2005/06, between 2007/08 and 2010/11 and in 2014/15. There was little difference in period effects by gender, but the period effect was substantially greater for short than for long duration stays. The period effect for emergency bed days rose most years from 1997/98 to 2003/04, then fell to 2007/08, and then fluctuated, ending in 2014/15 at a similar level to 2000/01.

The age effect findings for electives show that, after controlling for cohort and period effects, the elective admission rate and the elective bed day rate among adults rise with age to age 78 and then fall.

The cohort effect findings are that almost each successive cohort from that born in 1946 onward has experienced a lower elective admission rate after controlling for the other effects. Each successive cohort up to that born in 1988/89 has experienced a lower elective bed day rate after controlling for the other effects. Since 1988/89, the rate fluctuated, fell to a low in 2001/02 and then rose to 2014/15.

The period effect for elective admissions rose every year from 1997/98 to 2014/15, except for 2002/03 and 2004/05, after controlling for the other effects. The period effect for elective bed days peaked in 2002/03, since when it has fallen each year.

A key difference between trends in elective and emergency admissions for the years 1997/98 to 2014/15 relates to the period effects. While the aging 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). It may be that the high period effect for electives reflects rising opportunities for elective interventions to improve patients’ quality of life.

Elective bed days and emergency bed days followed markedly different trends. While the number of emergency bed days hardly changed, 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. The reason is likely to be the large shift from elective admissions of one or more days to elective day cases, which do not contribute to bed day numbers.
ANALYSIS OF TRENDS IN EMERGENCY AND ELECTIVE HOSPITAL ADMISSIONS AND HOSPITAL BED DAYS 1997/98 TO 2014/15

Introduction

NHS England commissioned the Centre for Health Services Economics and Organisation (CHSEO), University of Oxford, to examine how far the trends in emergency and elective hospital admissions and bed days in England over the last 17 years can be explained by: the effects of the age distribution of the population, together with rising numbers of older people; cohort effects, that is effects due to differing admission rates of people born in different years (different birth cohorts); period effects, that is admissions effects relating to a specific year which cannot be explained by either age or cohort effects. The aim is to generate an improved understanding of the trends in elective and emergency hospital admissions and bed days in England over recent years.

The analysis covers the 17 year period 1997/98 to 2014/15. Over this period, the total number of emergency admissions in England rose from 3.70 million in 1997/98 to 5.61 million in 2014/15, but the total number of emergency bed days fell from 31.73 million in 1997/98 to 31.59 million in 2014/15. This is an increase of 51.5% in emergency admissions and a decrease of 0.04% in bed days over the 17 year period. The total number of elective admissions rose over this period from 5.07 million in 1997/98 to 8.26 million in 2014/15, but the total number of elective bed days fell from 11.02 million in 1997/98 to 6.71 million in 2014/15. This is an increase of 62.8% in elective admissions and a decrease of 39.1% in bed days over the 17 year period.

The analysis reported here builds on an earlier substantial study on understanding trends in emergency admissions for older people (Wittenberg et al 2014). The earlier study investigated in detail trends in emergency admissions of older people and bed days of those admissions and examined demand, supply and policy factors that may have impacted on those trends. It included an age, period, cohort (APC) analysis. This divides the increase in emergency admissions between factors associated with the patient’s age (age effect), factors associated with the patient’s year of birth (cohort effect) and factors associated with the year of the patient’s admission (period effect).
Previous study

The earlier study, reported in Wittenberg et al (2014), found that:

- Admission rates fall with age to about age 30 and then rise monotonically with age from around age 40 upward.
- Each cohort from those born around 1912 onwards have experienced lower emergency admission rates after standardising for age and period effects.
- Period effects have been increasing over the period since 1999. They rose especially sharply between around 2002 and 2005 and have continued to rise to the final period of the previous analysis, 2012/13.

A favourable cohort effect (the more recent the cohort, the lower the admission rate given the age) broadly offset the age effect (the older the age group, the higher the admission rate, given the cohort) and the impact of rising numbers of older people. The rate of emergency admissions, averaged across all ages, fell for successive cohorts, after controlling for period effects. While the age and cohort effects are likely to reflect demographic and epidemiological change, the period effects capture admissions that could not have been anticipated given evidence concerning the changing age structure and years of birth of the population: these period effects would reflect both changes in supply-side willingness to admit, perhaps as a result of policy or technological innovations, and any increases to patient emergency admission demand unconnected to age and cohort.

Data and methods

The new analysis uses Hospital Episode Statistics (HES) for England for each year from 1997/98 to 2014/15. The data for 2014/15 are still provisional and are expected to be an under-estimate of the final number of admissions in that year, especially the figure for March 2015. This use of provisional data would have minimal impact on our findings on age and cohort effects and on period effects up to 2013/14, but our estimated period effect for 2014/15 must be regarded as an under-estimate.

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2 The reason is that admissions are not included in the data until the patient is discharged.
The APC analysis is a form of multivariate regression analysis. The dependent variable is emergency admission rates by age and year, using single years and single year age bands\(^3\). The independent variables are dummies for each age, year of birth and year of admission.

In this type of analysis, restrictions have to be imposed, or a reformulation made, to resolve an identification problem. Age, cohort and period form a co-linear set: since everyone born in a given year reaches a given age in the same year, when cohort and age are selected period is pre-determined. Various methods have been suggested for addressing this problem. We have used two different methods, which produced similar findings. The detailed methodology is described in a technical report, at Annex A.

Emergency admissions are discussed in sections 1 to 3, with section 1 considering emergency admissions in total, section 2 emergency admission by gender and section 3 emergency admissions by duration. Section 4 considers elective admissions. Emergency bed days are discussed in sections 5 to 8, with section 5 considering emergency bed days in total, section 6 emergency bed days by gender and section 7 emergency bed days by duration. Section 8 considers elective bed days. A final section concludes.

\(^3\) Except that the highest groups are banded into age 85 and over because more detailed population estimates by single year for those in late old age are not available for years before 2002.
I. Emergency admissions: total

The total number of emergency admissions in England rose from 3.70 million in 1997/98 to 5.61 million in 2014/15 (Figure 1.1). 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 2014/5 (Figure 1.2). The age-standardised rate rose by 30%, from 76.1 in 1997/98 to 99.0 in 2014/15, an annual average increase of 1.56% (Figure 1.4).

The emergency admission rate has risen over this period most rapidly for the 75 and over age group (Figures 1.3 and 1.4). It has risen every year since 1997/98 except for 2007/08. The only other age group for which the rate has risen more rapidly than the overall, all ages average is the 35 to 64 age group. For this group the rate peaked in 2010/11, fell for two years, and then rose again in 2013/14 and 2014/15. For all other age groups the rates peaked in 2009/10 or 2010/11, declined and then rose again in the most recent years.

If admission rates by age band had remained constant at their 1997/98 levels, 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%. Less than one-third of the increase in the number of emergency admissions during the period 1997/98 to 2014/15 is therefore due to increases in the population by age band.

The key objective of this study is, as explained above, to explore through APC analysis how far the trends in emergency admissions over the last 17 years can be explained by: effects of the age distribution of the population, together with rising numbers of older people; effects due to differing admission rates by different birth cohorts; effects relating to a specific year (period) which cannot be explained by either age or cohort effects.

We present the findings of the APC analysis in two ways for each of the three effects. We first describe how the coefficients on the age, period and cohort variables in the regression vary with changes in age, period and cohort respectively. We then present an example of the ratio between the admission rates at different ages holding the cohort and period constant and similarly for the other two effects. This form of presentation is intended to illustrate the varying effects of age, period and cohort in a helpful way but it should be considered illustrative. This is mainly because the ratios vary with the values of the two factors which are held constant (e.g. with the cohort and period in the case of the ratio of admission rates between different ages) since the function is exponential.
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 1.5). 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 (Figure 1.6).

The cohort effect findings are that 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 as well as age effects (Figure 1.7). 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 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 (Figure 1.8).

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 1.9). The emergency admission rate in 2014/15 is around 45% higher than the rate in 1997/98 for the 1970 cohort and age 50 (Figure 1.10).

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 5.61 million in 2014/15 (Figure 1.11). This shows that 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.

**Sensitivity analyses**

We conducted three sensitivity analyses, the results of which are available on request:

1. We ran the APC analysis using higher estimates for the number of emergency admissions in 2014/15 since the provisional data for that year are expected to be under-estimates. More specifically we increased the March 2015 provisional figure by 5% or by 10%. This had little impact on the estimated age and cohort effects or the period effects prior to 2014/15 but increased the period effect for 2014/15.

2. A feature of the APC analysis is that it does not allow interactions between cohort and period effects. Thus, for example, we cannot test whether the cohort effect is greater for adults than for children or for older people than for people of working age. A way to address this is to undertake the analysis for separate age groups. Thus we conducted an APC analysis for people aged 20 and over only. This had minimal impact on the pattern of age,
cohort and period effects for adults.

2. We conducted an analysis for 2002/03 to 2014/15, omitting the first five years. This had minimal impact on the pattern of age, cohort and period effects. The reason we explored this is partly because HES data may have been less reliable in the early years of HES and partly because from 2002/03 onward population data are available for single year age bands up to age 99 rather than just up to age 84.

Figure 1.1: Emergency hospital admissions by broad age band, England, 1997/8 – 2014/5
Figure 1.2: Emergency hospital admission rates by age band, England, 1997/8 – 2014/5

Figure 1.3: Indexed emergency admission rates by age band, England, 1997/8 – 2014/5
Figure 1.4: Age-standardised indexed emergency hospital admission rates by broad age band, England, 1997/8 – 2014/5

Figure 1.5: APC analysis estimated age effect coefficients
Figure 1.6: Emergency admission rates by age, for fixed cohort and period

Figure 1.7: APC analysis estimated cohort effect coefficients
Figure 1.8: Emergency admission rates by cohort, for fixed age and period

Figure 1.9: APC analysis estimated period effect coefficients
Figure 1.10: Emergency admission rates by period, for fixed age and cohort

Figure 1.11: Expected Admissions if Period Effect was Held Constant at 1997/8 Levels
2. Emergency Admissions by Gender

The total number of emergency admissions in England rose from 1.78 million in 1997/98 to 2.68 million in 2014/15 for males and from 1.90 million in 1997/98 to 2.93 million in 2014/15 for females. The average annual rate of increase over this period was 2.44% for males and 2.58% for females.

For males, the age-standardised emergency admission rate per 1,000 population rose from 75.0 in 1997/98 to 88.6 in 2014/15, an annual average increase of 0.98% (Figure 2.1). For females, the age-standardised emergency admission rate per 1,000 population rose from 76.2 in 1997/98 to 96.4 in 2014/15, an annual average increase of 1.39% (Figure 2.2). For both males and females the rate rose over this period most rapidly for the 75 and over age group (Table 2.1). While rates in 2014/15 were higher for males aged 35 and over than for females, rates for females were much higher for the 20 to 34 age group.

Table 2.1: Emergency admission rates per 1,000 population, 2014/15, by age and gender

<table>
<thead>
<tr>
<th>Age band</th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-19</td>
<td>76.0</td>
<td>72.0</td>
</tr>
<tr>
<td>20-34</td>
<td>49.4</td>
<td>80.2</td>
</tr>
<tr>
<td>35-64</td>
<td>76.6</td>
<td>72.6</td>
</tr>
<tr>
<td>65-75</td>
<td>158.8</td>
<td>128.5</td>
</tr>
<tr>
<td>85+</td>
<td>397.3</td>
<td>368.5</td>
</tr>
<tr>
<td>Total</td>
<td>100.0</td>
<td>106.4</td>
</tr>
</tbody>
</table>

If admission rates by age band had remained constant at their 1997/98 levels, the number of emergency admissions would have reached for males 2.13 million in 2014/15 rather than 2.68 million, an increase since 1997/98 of 19.7% instead of 50.6%, and for females 2.11 million in 2014/15 rather than 2.93 million, an increase since 1997/98 of 10.8% instead of 54.1%. Less than 40% of the increase in the number of emergency admissions for males and less than 20% of the corresponding increase for females during the period 1997/98 to 2014/15 was due to increases in the population by age band.

We present the findings of the APC analysis in two ways for each of the three effects. We first describe how the coefficients on the age, period and cohort variables in the regression vary with changes in age, period and cohort respectively. We then present an example of the ratio between the admission rates at different ages holding the cohort and period constant and similarly for the other two effects.

The age effects differ by gender. For male adults the emergency admission rate falls from age 20 to around age 30, and then rises with age, rising at an increasing rate with higher age (Figure 2.3). For female adults, the rate falls from age 20 to around age 45 and then rises with age, again rising at an increasing rate with higher age (Figure 2.4). For boys, the emergency admission rate falls to age 16, and then rises with age to age 20. For girls the rate falls to age 10 and then rises to age 20. This is after controlling for cohort and period effects.
The emergency admission rate for males is around 3.1 times higher at age 75 than at age 45, on the basis of constant 2010 period effect and 1970 cohort effect (Figure 2.5). The rate for females is around 2.7 times higher at age 75 than at age 45, on the basis of constant 2010 period effect and 1970 cohort effect (Figure 2.6).

The cohort effects do not differ much by gender. Each successive cohort of both males and females from the cohort born in 1964 onward has experienced a lower emergency admission rate at a given age after controlling for period as well as age effects. 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 emergency admission rate for males born in 1945 is similar to the rate for those born in 1970, and for females born in 1945 the rate is similar to those born in 1975. The rate for those born in 1985 is around 13% lower for males and 9% lower for females than the rates for those born in 1945, at age 50 and constant 2010 period effect.

The general pattern of period effects does not differ much by gender. For both males and females, 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. The period effect rose more rapidly for females than for males. While for males the emergency admission rate in 2014/15 is around 35% higher than the rate in 1997/98, for females the rate in 2014/15 is around 45% higher than the rate in 1997/98. This is for the 1970 birth cohort and at age 50.

If there had been no period effect the number of emergency admissions would have risen for males from 1.78 million in 1997/98 to only around 1.94 million in 2014/15 instead of 2.68 million in 2014/15 (Figure 2.7); and for females, from 1.90 million in 1997/98 to only around 1.96 million in 2014/15 instead of 2.93 million in 2014/15 (Figure 2.8). This shows that for males the cohort effect offset most (over 80%) of the positive effect of age on admissions and rising number of older people during the period 1997/98 to 2014/15. For females the cohort effect is even stronger, and almost completely offset the positive effect of age on admissions and rising number of older people during this period.
Figure 2.1: Indexed age-standardised male emergency hospital admission rates by broad age band, England, 1997/8 – 2014/5

Figure 2.2: Indexed age-standardised female emergency hospital admission rates by broad age band, England, 1997/8 – 2014/5
Figure 2.3: APC analysis for males: estimated age effect coefficients

Figure 2.4: APC analysis for females: estimated age effect coefficients
Figure 2.5: Male emergency admission rates by age, for fixed cohort and period

Figure 2.6: Female emergency admission rates by age, for fixed cohort and period
Figure 2.7: Male Expected Admissions if Period Effect was Held Constant at 1997/8 Levels

Figure 2.8: Female Expected Admissions if Period Effect was Held Constant at 1997/8 Levels
3. Emergency Stays by Duration of Stay

Analyses by duration of emergency hospital stay need to be conducted in terms of discharges rather than admissions. This is because duration is recorded at discharge. The number of discharges following emergency admission in 1997/8 was slightly higher than the number of emergency admissions: 3.78 million discharges in comparison with 3.68 million admissions. The number of discharges in 2014/15 was rather higher than the number of emergency admissions: 5.86 million discharges in comparison with 5.63 million admissions. Reasons for this difference include data quality and timing of data recording: as explained above, the data for 2014/15 are provisional and are inevitably an under-estimate of admissions for the latter part of 2014/15 but they are not likely to be an equivalent under-estimate of discharges. For simplicity the rest of this section of the report 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% (Figure 3.1). 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% (Figure 3.2). 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.

The analysis for short duration stays is presented first and then the analysis for long stay duration stays. The two analyses are then compared.

Short duration stays

The short duration emergency rate per 1,000 population more than doubled between 1997/98 and 2014/15, rising from 25.8 in 1997/98 to 54.1 in 2014/15 (Figure 3.3). The number of short duration emergency stays rose for every age group (Figure 2). The rate rose especially sharply for the 75 and over age group, more than trebling from 37.1 in 1997/98 to 126.8 in 2014/15 (Figures 3.4 and 3.5). The rate also rose sharply for the 65 to 74 age group, almost trebling from 20.8 in 1997/98 to 59.8 in 2014/15.

If rates by age band had remained constant at their 1997/98 levels, the number of emergency short duration stays would have reached 1.39 million in 2014/15 rather than

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4 Since bed days of emergency stays have been falling, discharges would be expected to exceed admissions in any given year. But the large difference in 2014/15 is at least partly due to the provisional nature of the data for that year: because of the timing of recording of admissions and discharges, admissions in March, for example, are more likely to be missing from provisional data than discharges in March. Data quality is also likely to be responsible for part of the difference, especially since the payments system gives NHS providers greater incentive to record discharges accurately than admissions.
2.94 million, an increase since 1997/98 of 10.4% instead of 134.0%. Less than 10% of the increase in the number of these stays during the period 1997/98 to 2014/15 was due to increases in the population by age band.

We present the findings of the APC analysis in two ways for each of the three effects. We first describe how the coefficients on the age, period and cohort variables in the regression vary with changes in age, period and cohort respectively. We then present an example of the ratio between the admission rates at different ages holding the cohort and period constant and similarly for the other two effects. This form of presentation is intended to illustrate the varying effects of age, period and cohort in a helpful way but it should be considered illustrative. This is mainly because the ratios vary with the values of the two factors which are held constant (e.g. with the cohort and period in the case of the ratio of admission rates between different ages).

The age effect findings 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 3.6). 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 (Figure 3.7).

The cohort effect findings are that each successive cohort from the cohort born in 1970 onward, except for a few blips, has experienced a lower short stay rate at a given age after controlling for period as well as age effects (Figure 3.8). 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. In both cases these are estimated for age 50 and 2010 period effect (Figure 3.9).

The period effect has risen each year from 1997/98 to 2014/15 except in 2011/12 (Figure 3.10). The rate in 2014/15 is over twice as high as the rate in 1997/98, for the 1970 cohort and age 50 (Figure 3.11).

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 (Figure 3.12). This shows that during the period 1997/98 to 2014/15 the cohort effect offset around two-thirds of the positive effect on short duration emergency stays of age and rising numbers of older people.

**Long duration stays**

The number of long duration stays fell over the period 1997/98 to 2014/15 for those aged under 35 and rose for those aged 35 and over (Figure 3.13). For the older groups there was,
however, a dip in 2006/07 and 2008/09, especially for the 65 to 74 age group. The overall long duration emergency rate per 1,000 population rose slightly from 52.0 in 1997/98 to 53.8 in 2014/15 (Figures 3.14 and 3.15), but the age-standardised rate fell slightly over this period (Figure 3.16). The rate fell for all groups under 75 years. It rose only for the 75 and over age group, and even for this group it first rose from 1997/98 and then fell again from 2003/04 and then rose significantly only from 2007/08.

It is important to note that, not only did the rate of long duration emergency stays per 1,000 population fall over the 17 year period 1997/98 to 2014/15, but the average length of these stays also fell (Figure 3.17). It first rose from 12.2 days in 1997/98 to 13.3 days in 2002/03 and then fell to 10.4 days in 2014/15.

If rates by age band had remained constant at their 1997/98 level, the number of emergency long duration stays would have reached 2.96 million in 2014/15 rather than 2.92 million, an increase since 1997/98 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 increases in the population by age band.

The age effect findings show that, after controlling for cohort and period effects, the long emergency stay rate of among adults falls with age to around 40 and then rises (Figure 3.18). 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 (Figure 3.19).

The cohort effect findings are that each successive cohort from the cohort born in 1930 onward, except for a few blips, has experienced a lower long stay rate at a given age after controlling for period as well as age effects (Figure 3.20). 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 (Figure 3.21).

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 3.22). The rate in 2014/15 is around 10% higher than the rate in 1997/98, for the 1970 cohort and age 50 (Figure 3.23).

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 in 2014/15 (Figure 24). 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.
Comparison between short and long duration emergency stays

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 the population change.

For both short and long stays, hospital stay rates per 1,000 population fell between ages 20 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: each successive cohort from those born in 1970 onward has experienced lower emergency rates than the previous cohort, with just a few blips. For the period from 1930 to 1970, the cohort effect was upward for short duration stays but downward for long duration stays. The overall effect is that the downward cohort effect offset around two-thirds of the ageing rising population effect for both short duration stays and long duration stays over the 17 year period 1997/8 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 2003/4, 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.
Figure 3.1: Emergency hospital discharges by duration, England, 1997/98 – 2014/15

Figure 3.2: Short-stay emergency hospital stays by broad age band, England, 1997/98 – 2014/15
Figure 3.3: Short-stay emergency hospital rates by age band, England, 1997/98 – 2014/15

Figure 3.4: Indexed short-stay emergency rates by age band, England, 1997/98 – 2014/15
Figure 3.5: Indexed age-standardised short-stay emergency hospital rates by broad age band, England, 1997/98 – 2014/15

Figure 3.6: APC analysis estimated age effect coefficients: short duration emergency stays
Figure 3.7: Emergency short duration stay rates by age, for fixed cohort and period

Figure 3.8: APC analysis estimated cohort effect coefficients: short emergency stays
Figure 3.9: Short duration emergency stay rates by cohort, for fixed age and period

Figure 3.10: APC analysis estimated period effect coefficients: short emergency stays
Figure 3.11: Short duration emergency stay rates by period, for fixed age and cohort

Figure 3.12: Expected short stays if period effect was held constant at 1997/98 Levels
Figure 3.13: Long duration emergency stays by broad age band, England, 1997/98 – 2014/15

Figure 3.14: Long duration stay rates by age band, England, 1997/98 – 2014/15
Figure 3.15: Indexed long emergency stay rates by age band, England, 1997/98 – 2014/15

Figure 3.16: Indexed age-standardised long duration emergency stay rates by broad age band, England, 1997/98 – 2014/15
Figure 3.17: Average lengths of stay of emergency hospital stays of 2-364 days, England, 1997/98 to 2014/15

Figure 3.18: APC analysis estimated age effect coefficients: long duration emergency stays
Figure 3.19: Long duration emergency stay rates by age, for fixed cohort and period

Figure 3.20: APC analysis estimated cohort effect coefficients: Long duration stays
Figure 3.21: Long duration emergency stay rates by cohort, for fixed age and period

Figure 3.22: APC analysis estimated period effect coefficients: long duration stays
Figure 3.23: Long duration stay rates by period, for fixed age and cohort

Figure 3.24: Expected long duration stays if period effect held constant at 1997/98 level
4. 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 (Figure 4.1). 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%. It rose from 104.2 in 1997/98 to 152.0 in 2014/15 (Figure 4.2). The age-standardised rate rose from 104.2 in 1997/98 to 146.3 in 2014/15, an annual average increase of 2.02% (Figure 4.1). This compares with an annual average increase, on the same basis, of 1.56% for emergency admissions.

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 (Figures 4.3 and 4.4). For these two older age groups it has risen every year since 1997/98 apart from slight dips in 2001/02 and 2003/04. For the 35 to 64 age group the rate dipped more markedly in those two years, but has subsequently risen every year from 2003/04. For the 20 to 34 and 0 to 19 age groups the rates fell in the earlier years of the 17 year period since 1997/98 and then rose again, reaching a slightly higher level in 2014/15 than in 1997/98. The increase in the elective admission rate, therefore, relates mainly to people aged 35 and over and especially to those aged 65 and over. Interestingly, the tendency for admission rates to increase at a faster pace as age rises, is therefore not merely applicable to those over 65, but also from the age of young adults.

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.

We again present the findings of the APC analysis in two ways for each of the three effects. We first describe how the coefficients on the age, period and cohort variables in the regression vary with changes in age, period and cohort respectively. We then present an example of the ratio between the admission rates at different ages holding the cohort and period constant and similarly for the other two effects. This form of presentation is intended to illustrate the varying effects of age, period and cohort in a helpful way but it should be considered illustrative. This is mainly because the ratios vary with the values of the two
factors which are held constant (e.g. with the cohort and period in the case of the ratio of admission rates between different ages).

The age effect findings 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 4.5). 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 (Figure 4.6).

The cohort effect findings are that each successive cohort from the cohort born in 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 (Figure 4.7). Prior to 1946, 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 (Figure 4.8). 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 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, after controlling for age and cohort effects. There were especially large rises between 2004/05 and 2008/09 and between 2012/3 and 2014/15 (Figure 4.9). While the former period coincides with the introduction of ‘Choice’ and higher funding, it is less clear why elective care has surged between 2012/3 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 (Figure 4.10). This estimate of around 40% is similar to the equivalent estimate of around 45% for emergency admissions, but again this is due to the age and cohort selected for this illustrative example. 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 (Figure 4.11). 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.

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 4.1). While the aging 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.

Table 4.1: Comparison of trends in elective and emergency admissions, 1997/98 to 2014/15

<table>
<thead>
<tr>
<th></th>
<th>Emergencies</th>
<th>Electives</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997/8 actual level</td>
<td>3.7</td>
<td>5.07</td>
</tr>
<tr>
<td>2014/5 actual level</td>
<td>5.61</td>
<td>8.26</td>
</tr>
<tr>
<td>2014/5, constant 1997/8 rates</td>
<td>4.26</td>
<td>5.84</td>
</tr>
<tr>
<td>2014/5, no period effects</td>
<td>3.89</td>
<td>5.33</td>
</tr>
<tr>
<td>Decomposition of the % rise in levels, 1997/8-2014/5: Impact of ageing</td>
<td>15%</td>
<td>15%</td>
</tr>
<tr>
<td>Impact of cohort effect</td>
<td>-9%</td>
<td>-9%</td>
</tr>
<tr>
<td>Impact of period effect</td>
<td>44%</td>
<td>55%</td>
</tr>
<tr>
<td>Total admissions increase, 1997/98-2014/15</td>
<td>52%</td>
<td>63%</td>
</tr>
</tbody>
</table>
Figure 4.1: Elective hospital admissions by broad age band, England, 1997/8 – 2014/5

Figure 4.2: Elective hospital admission rates by age band, England, 1997/8 – 2014/5
Figure 4.3: Indexed Elective admission rates by age band, England, 1997/8 – 2014/5

Figure 4.4: Indexed age-standardised Elective hospital admission rates by broad age band, England, 1997/98 – 2014/15
Figure 4.5: APC analysis estimated age effect coefficients

Figure 4.6: Elective admission rates by age, for fixed cohort and period
Figure 4.7: APC analysis estimated cohort effect coefficients

Figure 4.8: Elective admission rates by cohort, for fixed age and period
Figure 4.9: APC analysis of Elective Care: estimated period effect coefficients

Figure 4.10: Elective admission rates by period, for fixed age and cohort
Figure 4.11: Expected elective admissions if period effect is held constant at 1997/8 Levels
5. Emergency bed days: total

The total number of emergency bed days in England fell from 31.73 million in 1997/98 to 31.59 million in 2014/15 (Figure 5.1). This is a decrease of 0.4% over the full 17 year period and an average annual decrease of 0.03%. The number first rose from 1997/98, peaked in 2003/04, fell between 2003/04 and 2007/08 and then fluctuated to 2014/15.

The overall emergency bed day rate per 1,000 population first rose from 652.0 in 1997/98 to 704.7 in 2003/04 and then fell to 581.5 in 2014/15 (Figure 5.2). Over the whole 17 year period between 1997/98 and 2014/15 the rate fell by 10.8%, an average annual decrease of 0.67%. The age-standardised rate fell more rapidly, by 18.0%, from 652.0 in 1997/98 to 534.6 in 2014/15, an annual average decrease of 1.16% (Figure 5.4). The emergency bed day rate has fallen least rapidly over this period for the 75 and over age group and most rapidly for the 20 to 34 age group (Figures 5.3 and 5.4). That the rate has fallen least for the 75 and over group is not surprising since the average age of people in this group has risen.

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 0.4%. This means that the impact of the increasing population and rising proportion of older people within the population has been more than offset by other factors.

The key objective of this study is to explore through APC analysis how far the trends in admissions and bed days over the last 17 years can be explained by: effects of the age distribution of the population, together with rising numbers of older people; effects due to differing admission rates by different birth cohorts; effects relating to a specific year (period) which cannot be explained by either age or cohort effects.

We present the findings of the APC analysis in two ways for each of the three effects. We first describe how the coefficients on the age, period and cohort variables in the regression vary with changes in age, period and cohort respectively. We then present an example of the ratio between the admission rates at different ages holding the cohort and period constant and similarly for the other two effects. This form of presentation is intended to illustrate the varying effects of age, period and cohort in a helpful way but it should be considered illustrative. This is mainly because the ratios vary with the values of the two factors which are held constant (e.g. with the cohort and period in the case of the ratio of admission rates between different ages) since the function is exponential.

The age effect findings show that the emergency bed day rate among adults falls from age 20 to age 37 and then rises with age (Figure 5.5). For 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 over twelve times higher at age 85 than at age 45, on the basis of constant 2010 period effect and 1970 cohort effect (Figure 5.6).

The cohort effect findings are that 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 coefficients from the statistical analysis are set out in Figure 5.7 and an interpretation of them is illustrated in Figure 5.8. 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, which is 20% 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 2000/01 (Figure 5.9). 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 (Figure 5.10).

Finally, by controlling for the period effect, we assess the comparative importance in explaining emergency bed-days of aging and the birth-cohort effect. If there had been no period effect, 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 (Figure 5.11). 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 5.1). 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 higher (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, as discussed in section 3, and short duration admissions have less impact on bed days than longer duration admissions.
Table 5.1: Comparison of trends in emergency admissions and emergency bed days, 1997/98 to 2014/15

<table>
<thead>
<tr>
<th></th>
<th>Admissions Emergencies</th>
<th>Bed days Emergencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997/8 actual</td>
<td>3.70</td>
<td>31.73</td>
</tr>
<tr>
<td>2014/5 actual</td>
<td>5.61</td>
<td>31.59</td>
</tr>
<tr>
<td>2014/5, constant 1997/8 rates</td>
<td>4.26</td>
<td>37.67</td>
</tr>
<tr>
<td>2014/5, no period effects</td>
<td>3.89</td>
<td>30.26</td>
</tr>
</tbody>
</table>

**Decomposition of the % rise in levels, 1997/8-2014/5:**

- Impact of ageing: 15% (19%)
- Impact of cohort effect: -9% (-20%)
- Impact of period effect: 44% (4%)
- Total increase over 17 years: 52% (0%)

Figure 5.1: Emergency bed days by broad age band, England, 1997/98 – 2014/15
Figure 5.2: Emergency bed day rates by age band, England, 1997/98 – 2014/15

Figure 5.3: Age-standardised indexed emergency bed day rates by broad age band, England, 1997/98 – 2014/15
Figure 5.4: Indexed emergency bed day rates by age band, England, 1997/98 – 2014/15

Figure 5.5: APC analysis estimated emergency bed day age effect coefficients
Figure 5.6: Predicted emergency bed days by age, for fixed cohort and period

Figure 5.7: APC analysis estimated emergency bed day cohort effect coefficients
Figure 5.8: Predicted emergency bed days by cohort, for fixed age and period

Figure 5.9: APC analysis emergency bed day estimated period effect coefficients
Figure 5.10: Predicted emergency bed days by period, for fixed age and cohort

Figure 5.11: Expected Emergency Bed days if Period Effect was Held Constant at 1997/98 Levels
6. Emergency Bed Days by Gender

The total number of emergency bed days in England rose for males from 13.95 million in 1997/98 to 14.83 million in 2014/15 but fell for females from 17.50 million in 1997/98 to 16.74 million in 2014/15. The average annual rate of increase over this period for males was 0.36% and the average annual decrease for females was 0.26%. This contrasts with average annual increases in emergency admissions of 2.44% for males and 2.58% for females.

For males, the age-standardised emergency bed day rate per 1,000 population fell from 588.6 in 1997/98 to 554.1 in 2014/15, an annual average decrease of 0.36% (Figure 6.1). For females, the age-standardised emergency bed day rate per 1,000 population fell from 701.3 in 1997/98 to 607.9 in 2014/15, an annual average decrease of 0.84% (Figure 6.2).

For both males and females the rate fell least rapidly over this period for the 75 and over age group and most rapidly for the 20 to 34 and 65 to 74 age groups (Figures 6.1 and 6.2). While rates in 2014/15 were higher for males than for females for age groups 35 and over, rates for females were higher for the 0 to 19 and 20 to 34 age groups (Table 6.1).

<table>
<thead>
<tr>
<th>Age band</th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-19</td>
<td>116.7</td>
<td>118.1</td>
</tr>
<tr>
<td>20-34</td>
<td>172.7</td>
<td>191.8</td>
</tr>
<tr>
<td>35-64</td>
<td>366.3</td>
<td>319.7</td>
</tr>
<tr>
<td>65-75</td>
<td>1,078.70</td>
<td>893.4</td>
</tr>
<tr>
<td>75-84</td>
<td>2,738.90</td>
<td>2,483.40</td>
</tr>
<tr>
<td>85+</td>
<td>6,527.70</td>
<td>5,883.90</td>
</tr>
<tr>
<td>Total</td>
<td>554.10</td>
<td>607.9</td>
</tr>
</tbody>
</table>

If emergency bed day rates by age band had remained constant at their 1997/98 levels, the number of emergency bed days would have reached for males 17.66 million in 2014/15 rather than 14.83 million, an increase since 1997/98 of 26.3% instead of 6.3%, and for females 19.69 million in 2014/15 rather than 16.74 million, an increase since 1997/98 of 12.50% instead of a decrease of 4.32%. This means that the impact of the increasing population and rising proportion of older people within the population has been more than offset by other factors.

We present the findings of the APC analysis in two ways for each of the three effects. We first describe how the coefficients on the age, period and cohort variables in the regression vary with changes in age, period and cohort respectively. We then present an example of the ratio between the admission rates at different ages holding the cohort and period constant and similarly for the other two effects.

The age effects differ by gender. For male adults the emergency bed day rate falls from age 20 to around age 35, and then rises with age, rising at an increasing rate with higher age
(Figure 6.3). For female adults, the rate falls from age 20 to around age 40 and then rises with age, again rising at an increasing rate with higher age (Figure 6.4). For boys, the emergency bed day rate falls to age 9, and then rises with age to age 20. For girls the rate falls to age 7 and then rises to age 20. This is after controlling for cohort and period effects.

The emergency bed day rate for males is around 4.8 times higher at age 75 than at age 45, on the basis of constant 2010 period effect and 1970 cohort effect (Figure 6.5). The rate for females is around 3.8 times higher at age 75 than at age 45, on the basis of constant 2010 period effect and 1970 cohort effect (Figure 6.6).

The cohort effects do not differ much by gender. Each successive cohort of both males and females from those born in 1915 onward until 2003/04 has experienced a lower bed day rate at a given age after controlling for period as well as age effects. Since 2003/04 the rates have fluctuated, with the rate in 2014/15 similar to the rate for 2001/02 for both males and females. The emergency bed day rate for males born in 1965 is around 10% lower than the rate for males born in 1945, and the rate for females born in 1965 is around 20% lower than the rate for females born in 1945, at age 50 and constant 2010 period effect.

The general pattern of period effects does not differ much by gender. For both males and females, the period effect rose each year from 1997/98 to 2003/04 (with a dip in 1999/00 for males), fell from 2003/04 to 2007/08, rose again to 2009/10, fell to 2011/12 and rose again to 2014/15, after controlling for age and cohort effects. While for males the emergency bed day rate in 2014/15 is little changed from the rate in 1997/98, for females the rate in 2014/15 is similar to the rate in 2000/01 and around 10% higher than the rate in 1997/98. This is for the 1970 birth cohort and at age 50.

If there had been no period effect the number of emergency bed days would have risen for males from 13.95 million in 1997/98 to around 14.89 million in 2014/15 instead of 14.83 million in 2014/15 (Figure 6.7). For females the number of emergency bed days would have fallen from 17.50 million in 1997/98 to around 15.45 million in 2014/15 instead of to 16.74 million in 2014/15 (Figure 6.8). This too shows that for males the period effect was similar at the start and end of the 17 year period and the cohort effect offset only part of the positive effect of age and rising number of older men during the period 1997/98 to 2014/15. It also shows that for females the period effect was higher at the end than at the start of the 17 year period and the cohort effect more than offset the positive effect of age and rising number of women during this period.

A key reason for this difference by gender in the relative impact of the cohort effect in comparison with the ageing and rising population effect is that the number of older men has been rising much faster than the number of older women as the gap between male and female life expectancy diminishes. While the number of women aged 75 and over rose by
11% between 1997/98 and 2014/15, the number of men aged 75 and over rose by 44% over this same period.

Figure 6.1: Indexed male emergency bed day rates per 1,000 male population by age band, England, 1997/98 – 2014/15
Figure 6.2: Indexed female emergency bed day rates per 1,000 female population by age band, England, 1997/8 – 2014/5

Figure 6.3: Male emergency bed days: APC analysis estimated age effect coefficients
Figure 6.4: Female emergency bed days: APC analysis estimated age effect coefficients

Figure 6.5: Predicted male emergency bed day rates by age, for fixed cohort and period
Figure 6.6: Predicted female emergency bed day rates by age, for fixed cohort and period

Figure 6.7: Expected male emergency bed days if period effect was held constant at 1997/98 Levels
Figure 6.8: Expected female emergency bed days if period effect was held constant at 1997/98 Levels
7. 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, as discussed in section 3. 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. This relates to 1 day stays, since 0 day stays do not, by definition, contribute to bed days.

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 is unlikely to differ greatly from the analysis of short duration admissions reported in section 3.

The number of bed days of emergency 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 all emergency bed days of 0.03%.

The overall long duration emergency bed day rate per 1,000 population first rose slightly from 637 in 1997/98 to 687 in 2003/04, and then fell to 558 in 2014/15. The age-standardised rate fell slightly more over this period (Figure 7.1). The rate fell for all groups, least rapidly for the 75 and over age group and mostly rapidly for the 20 to 34 age group.

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.

The age effect findings show that the emergency bed day rate for long duration stays is much the same as for all emergency bed days. 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 (Figure 7.2).

The cohort effect findings are that 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 (Figure 7.3).

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 1999/00. 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 (Figure 7.4), 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 aging 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 (Figure 7.5). 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.

Figure 7.1: Indexed emergency bed day rates by age band for stays of 2 to 365 days, England, 1997/98 – 2014/15
Figure 7.2: Predicted emergency bed day rate for stays of 2-365 days, by age, for fixed cohort and period

Figure 7.3: Predicted emergency bed day rate for stays of 2-365 days, by cohort, for fixed age and period
Figure 7.4: Predicted emergency bed day rate for stays of 2-365 days, by period, for fixed age and cohort

Figure 7.5: Expected emergency bed days for stays of 2-365 days, if period effect was held constant at 1997/98 Levels
8. 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 (Figure 8.1). 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 overall elective bed day rate per 1,000 population fell by 45.4% between 1997/98 and 2014/15, an average annual decrease of 3.50%. It fell from 226.5 in 1997/98 to 123.6 in 2014/5 (Figure 8.2). The annual decline was fairly even over the 17 year period. The age-standardised rate fell from 226.5 in 1997/98 to 116.2 in 2014/15, an annual average decrease of 3.85% (Figure 8.4). This compares with an annual average decrease, on the same basis, of 1.16% for emergency bed days.

The elective bed day rate fell most rapidly over this period for the 75 and over age group and almost as rapidly for the 65 to 74 age group (Figures 8.3 and 8.4). The rate fell least rapidly for the 0 to 19 age group, for which it rose slightly in 2009/10 and has fallen only modestly since 2009/10.

If elective bed day rates by age band had remained constant at their 1997/98 levels, the number of elective bed days would have reached 12.98 million in 2014/15 rather than 6.71 million, an increase since 1997/98 of 17.8% instead of a decrease of 39.1%. This means that 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.

We again present the findings of the APC analysis in two ways for each of the three effects. We first describe how the coefficients on the age, period and cohort variables in the regression vary with changes in age, period and cohort respectively. We then present an example of the ratio between the admission rates at different ages holding the cohort and period constant and similarly for the other two effects. This form of presentation is intended to illustrate the varying effects of age, period and cohort in a helpful way but it should be considered illustrative.

The age effect findings 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 8.5). 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 (Figure 8.6).

The cohort effect findings are that 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 coefficients from the statistical analysis are set out in a figure 8.7 and an interpretation of them is set out in Figure 8.8. 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 8.9). 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 (Figure 8.10). This estimate is in contrast with the equivalent estimate for emergency bed days, where there was minimal difference between 1997/98 and 2014/15.

By controlling for the period effect, we assess the comparative importance in explaining elective bed-days of aging and the birth-cohort effect. 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 (Figure 8.11). 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.

Elective admissions and elective bed days followed very different trends (Table 8.1). 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 case electives and electives involving overnight stays could also explain the large differences in cohort and period effects between elective admissions and elective bed days.

Elective bed days and emergency bed days followed markedly different trends (Table 8.2). While the total number of emergency bed days hardly changed, 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. The reason is again likely to be the large shift from elective admissions of one or more days to elective day cases.
Table 8.1: Comparison of trends in elective admissions and bed days, 1997/98 to 2014/15

<table>
<thead>
<tr>
<th></th>
<th>Admissions</th>
<th>Bed days</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997/8 actual</td>
<td>5.07</td>
<td>11.03</td>
</tr>
<tr>
<td>2014/5 actual</td>
<td>8.26</td>
<td>6.71</td>
</tr>
<tr>
<td>2014/5, constant 1997/8 rates</td>
<td>5.84</td>
<td>12.98</td>
</tr>
<tr>
<td>2014/5, no period effects</td>
<td>5.33</td>
<td>9.04</td>
</tr>
</tbody>
</table>

**Decomposition of the % rise in levels, 1997/98-2014/15:**

<table>
<thead>
<tr>
<th></th>
<th>Electives</th>
<th>Emergencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impact of ageing</td>
<td>15%</td>
<td>18%</td>
</tr>
<tr>
<td>Impact of cohort effect</td>
<td>-9%</td>
<td>-30%</td>
</tr>
<tr>
<td>Impact of period effect</td>
<td>55%</td>
<td>-26%</td>
</tr>
<tr>
<td>Total increase over 17 years</td>
<td>63%</td>
<td>-39%</td>
</tr>
</tbody>
</table>

Table 8.2: Comparison of trends in elective and emergency bed days, 1997/98 to 2014/15

<table>
<thead>
<tr>
<th></th>
<th>Electives</th>
<th>Emergencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997/8 actual</td>
<td>11.03</td>
<td>31.73</td>
</tr>
<tr>
<td>2014/5 actual</td>
<td>6.71</td>
<td>31.59</td>
</tr>
<tr>
<td>2014/5, constant 1997/8 rates</td>
<td>12.98</td>
<td>37.67</td>
</tr>
<tr>
<td>2014/5, no period effects</td>
<td>9.04</td>
<td>30.26</td>
</tr>
</tbody>
</table>

**Decomposition of the % rise in levels, 1997/98-2014/15:**

<table>
<thead>
<tr>
<th></th>
<th>Electives</th>
<th>Emergencies</th>
</tr>
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<tbody>
<tr>
<td>Impact of ageing</td>
<td>18%</td>
<td>19%</td>
</tr>
<tr>
<td>Impact of cohort effect</td>
<td>-30%</td>
<td>-20%</td>
</tr>
<tr>
<td>Impact of period effect</td>
<td>-26%</td>
<td>4%</td>
</tr>
<tr>
<td>Total increase over 17 years</td>
<td>-39%</td>
<td>0%</td>
</tr>
</tbody>
</table>
Figure 8.1: Elective bed days by broad age band, England, 1997/98 – 2014/15

Figure 8.2: Elective bed day rates per 1,000 population by age band, England, 1997/98 – 2014/15
Figure 8.3: Age-standardised indexed elective bed day rates by broad age band, England, 1997/98 – 2014/15

Figure 8.4: Indexed elective bed day rates by age band, England, 1997/98 – 2014/15
Figure 8.5: APC analysis estimated elective bed day age effect coefficients

Figure 8.6: Predicted elective bed day rate by age, for fixed cohort and period
Figure 8.7: APC analysis estimated elective bed day cohort effect coefficients

Figure 8.8: Predicted elective bed day rate by cohort, for fixed age and period
Figure 8.9: APC analysis estimated elective bed day period effect coefficients

Figure 8.10: Predicted elective bed day rates by period, for fixed age and cohort
Figure 8.11: Expected elective bed days if period effect was held constant at 1997/8 level
9. Conclusions

The number of emergency admissions in England rose by around 52% over the period 1997/98 to 2014/15 (but the data for 2014/15 are provisional). The number of bed days of 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 data for 2014/15 are provisional). The number of bed days of these elective hospital stays, however, 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.

The questions that we ask in this study include: What were the broad influences behind this? In particular, how important was the separate role of an increasingly aged population? And what role was played by any change over time in the need for emergency and elective hospital inpatient care of a person of a given age as life expectancy rose?

In this report these issues are studied by decomposing the rise in admission rates per head of population and decline in bed day rates into three components: the influence of the changing age distribution of the population; the influence of any change over the years in need for emergency or elective inpatient care at a given age; and the influence of a changing year (or period) effect that remains after the former two effects are estimated.

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 admissions by gender showed that the numbers of admissions and the rates per head of population rose more rapidly for females than for males over the period 1997/98 to 2014/15. Neither cohort nor period effects differed much by gender. The age profile of emergency admission rates and the age effects did differ by age. After controlling for cohort and period effects, the admission rate among adult males starts to rise from age 30 but for adult females from age 45.

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. There was a downward cohort effect during the period since 1970 for both short and long stays; but for the period from 1930 to 1970, the cohort effect was upward for short duration stays but 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 1997/8 to 2014/15. Across these 17 years, the period effect has been substantially greater for short than for long 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. Prior to 1946, 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 rise in both types of admissions are the consequence of a variety of evolving demand and clinical/hospital side factors that would have occurred in the absence of a larger and more aged population. Unlike the aging 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 aging population.

We may illustrate these findings empirically as follows. The roles of i) aging, and ii) changes in admissions at a given age with the passage of time (cohort effect) can be isolated by including these effects in explaining the trend in admissions but holding constant at the base year level the period effects which capture what these two demographic effects cannot explain. The actual and counterfactual levels of admissions are given in Figure 1.11 (emergencies) and Figure 4.11 (electives).

Whereas actual emergency admissions increased by 51% over the 17 year period and elective admissions by 63%, the effect of the two demographic changes – aging, 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 aging effect: the age and cohort effects taken together 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.

The observed rate of emergency hospital admission rose by 37% per head of the population for emergency admissions and 46% for elective admissions over the period 1997/98 to 2014/15; but, in the scenario discussed above of only age and cohort effects, would have fallen by around 5% for emergencies and electives. We must seek explanations other than
population aging per se to explain rising emergency admissions, since aging 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.

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.
ANNEX A: AGE PERIOD COHORT METHODOLOGY

The Age Period Cohort (APC) methodology provides a framework to analyse any sort of 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 actors:

- **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 independent variables are dummy variables for each age, year of birth and year to which the observation relates. The APC model has thus 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 $Y_{ik} = A_i + P_j + C_k + e$

A problem arises however 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. A number of solutions have been proposed to this problem, of which we have adopted two approaches: the Intrinsic Estimator and a method developed by Kuang et al.

The Intrinsic Estimator (IE) developed discussed by Yang et al. (2004, 2008) and Fu et al. (2011) provides one approach we have used. Rather than imposing a constraint directly on the coefficients, this restricts the impact of the design matrix, i.e. the input data, on the coefficient estimates. In practice, this implies that the coefficient estimates are not affected by the number of age and period groups modelled. It has been shown that the Intrinsic Estimator is unbiased, relatively efficient and asymptotically consistent (Yang et al 2008).

An add-on file for calculating the IE in Stata may be obtained by typing `ssc install apc` on the Stata command line on any computer connected to the Internet. It can also be downloaded from the Statistical Software Components archive at http://ideas.repec.org/s/boc/bocode.html. The program uses much the same syntax as Stata’s GLM command for generalized linear models (Yang et al 2008).

A further approach has been developed by Kuang et al (2008) and Nielson et al (2015) which re-parameterizes the model in terms of freely varying parameters. Their approach exploits that the second differences of the time effects are identified and that the predictor itself is also identifiable.
The APC IT package includes functions for age-period-cohort analysis based on the canonical parametrisation of Kuang et al. (2008). The package includes functions for organizing the data, descriptive plots, a deviance table, estimation of (sub-models of) the age-period-cohort model, a plot for specification testing, plots of estimated parameters, and sub-sample analysis (Nielsen 2014).

A limitation common to these APC approaches should be noted. Age, period and cohort effects are not able to interact, and causal factors are unable to have selective impacts. 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 issue can be explored by conducting sensitivity analysis where the analysis is conducted for only some age bands.

References:


