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Public hospital spending in England: evidence from National Health Service administrative records

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Abstract

Health spending per capita in England has more than doubled since 1997, yet relatively little is known about how that spending is distributed across the population. This paper uses administrative National Health Service (NHS) hospital records to examine key features of public hospital spending in England. We describe how costs vary across the lifecycle, and the concentration of spending among people and over time. We find that costs per person start to increase after age 50 and escalate after age 70. Spending is highly concentrated in a small section of the population: with 32% of all hospital spending accounted for by 1% of the general population, and 18% of spending by 1% of all patients. There is persistence in spending over time with patients with high spending more likely to have spending in subsequent years, and those with zero expenditures more likely to remain out of hospital.

Keywords: health; public spending; hospitals
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1 Introduction

Medical spending per capita in England doubled in real terms between 1997 and 2010, however very little is known about the distribution of this spending across the population, either in cross-section or over time. In this paper, we use National Health Service (NHS) administrative inpatient and outpatient hospital data to examine how publicly funded hospital spending varies across the lifecycle, the concentration among particular groups and the persistence of spending over time.

In an international context, England is an interesting case to study as: (i) health spending as a percentage of GDP is close to the OECD average, but a higher share of spending is publicly financed (83% compared to an OECD average of 73% in 2013, (OECD, 2015)); and (ii) almost all hospital care is provided by state and run owned hospitals. This may lead to important differences in the distribution of spending across the population relative to countries where private financing and provision of health care is more common, such as the United States. Understanding these differences could help provide an insight into differences in clinical outcomes across countries and institutional systems.

In a domestic context, analyses of the distribution of spending are particularly timely given the unprecedented slowdown in the growth of NHS funding since 2010, which has led to a gap developing between what the NHS receives and what it is predicted to spend based on patient need. It has been estimated that productivity gains of between 3 and 6% per annum would be required to ensure that the NHS can meet demand, in terms of both quality and activity (Appleby et al., 2014) . Understanding where costs arise could therefore help identify where there might be large gains in improving performance. Moreover, with the population aged 65 expected to grow by 22% over the next decade, ascertaining the relationship between costs and age is essential for predicting and potentially controlling the growth of future health expenditure. All costs and spending in this paper are given in 2014 US dollars, to allow direct comparisons to other papers in this volume.

The existing literature on per person hospital spending in England is very limited, as payments for care provided (Payment by Results) were only introduced in 2003 and did not become fully operational until 2008 (Department of Health, 2012). Work to date has focused on measures of access and contacts with health services, typically with reference to capturing inequities in use (Morris et al., 2005; Judge et al., 2010). This paper, together with Aragon et al. (2015), therefore represent the first systematic attempt to investigate patterns of patient level expenditure.

Our principal findings are four-fold. First, medical spending varies significantly across the lifecycle. Spending increases after age 50 and escalates after age 70. Average hospital spending for an 89 year old man is around three times higher than the average spending for a 70 year old, and almost nine times more than a 50 year old. Spending is higher for women during childbearing years, but this pattern is reversed at older ages, with average spending higher for men at all ages beyond 55. On average, the costs associated with men aged 65 plus are equivalent to the costs of treating a women three to five years older.

Second, average spending per person is higher in more deprived areas, with differences increasing slightly with age. For those under 25, the ratio of average spending per person in the most deprived quintile of local areas to average spending in the least deprived quintile of local area is 1.10, rising to 1.12 for those aged 25-64 and 1.18 for those aged 65 and over. However, this does not control for differences in underlying medical needs. Given the existing literature on the positive relationship between deprivation and need, it is likely that this gradient would reduce, or even reverse, if underlying medical needs were taken into account (Judge et al., 2010; Smith, 1999; Banks et al., 2006).

Third, hospital spending is highly concentrated in a small fraction of the population. Cross-sectional concentration is highest at younger ages. The top 1% of spenders account for a third of hospital spending in the population of the under 25s. The corresponding figure falls to 22% among those aged 65 plus. The concentration is lower when the sample is restricted to *patients* who have positive expenditures. For the under 25s, 1% of patients account for 20% of spending, while 1% of patients over 65 account for 13% of spending, within their respective age groups. These concentrations fall when averaging over multiple years as a larger proportion of the total population have some positive hospital spending over an extended period.

Fourth, spending is relatively persistent over time, particularly at the top of spending distribution, with more than 60% of the top 20% of spenders within the population in any given year still in the top 20% of spenders in the following year. Persistence is lower among the older age group, although this almost certainly reflects a higher death rate among this population that is not captured by administrative hospital data.

The remainder of this paper is structured as follows. In Section 2, we set out recent trends in aggregate health spending and the institutional background for public health care in England. Section 3 describes the data and our method of calculating individual hospital costs. Section 4 examines how spending varies over the lifecycle and across the distribution of local area deprivation, while Section 5 examines the concentration of spending across individuals and over time. Section 6 concludes.

2 Public Health Care in England

2.1 UK health expenditure

As in many developed countries levels of health expenditure in England have risen over time. Figure 1 shows the share of health spending in national income and health spending per capita in the UK between 1997/98-2013/14[1]. Average spending per capita doubled between 1997/98 and

[1] Aggregate figures are only available for the United Kingdom as a whole. However, funding allocations mean that patterns for England are very similar to those for the whole of the UK.

2009/10, increasing from $1,700 to $3,400, while health care spending as a share of GDP rose from 5.0 to 7.8%. After 2010/11, growth in both series was halted as public spending restraints were put in place following the great recession. Health spending as a share of public spending rose throughout the period, as other areas of public spending shrunk after 2010/11. In 2013/14, health constituted 17.9% of all public spending and 31.5% of all public service spending.

The UK is close to the OECD average in terms of levels of health spending as a share of GDP, but a higher than average proportion of spending arises from public sources. In 2013, the UK government accounted for 83.3% of total health spending, compared to 48.2% in the US and 76.3% in Germany (OECD, 2015). A small private sector accounts for remaining health expenditures. In 1990, around two thirds of this spending came from out-of-pocket payments by individuals, with the rest covered by private insurance companies. By 2013, each source accounted for roughly half of private expenditures. Unfortunately detailed data are not available for private health spending. As a result, the remainder of this paper focuses upon spending from government sources.

2.2 Institutional background: the English National Health Service

This paper focuses on publicly funded health care in England. Health care in England is primarily funded through general taxation, and provided free at the point of use to all residents (subject to some requirements on the duration of residency) through the National Health Service (NHS).[2]

Primary care within the NHS is principally provided by General Practitioners (GPs), who treat patients for conditions and illnesses that do not require specialist care or refer patients for specialist secondary care where necessary. GPs act as 'gatekeepers' for elective secondary care, as NHS patients cannot self-refer. As NHS patients face no prices for secondary care, services are rationed by need and waiting lists.

Secondary or hospital care is typically provided by publicly owned NHS hospitals. In 2012/13, NHS hospitals accounted for 44% of all NHS spending (Lafond et al., 2014).[3] Following referral from their GP, patients attend an outpatient consultation. Patients may then be discharged without further treatment, receive further outpatient care (e.g. physiotherapy) or be admitted to hospital to receive further treatment as an inpatient. Emergency care that cannot be provided by a GP is available via accident and emergency (A&E) departments, which are almost exclusively based at NHS hospitals. Patients are then admitted for inpatient treatment or referred for outpatient care where necessary. Due to data constraints set out below, this paper focuses exclusively on inpatient and outpatient care.

One important institutional feature of the NHS is the way in which hospitals are compensated

[2]There are limited co-payments for prescriptions, optical and dental care. The majority of fees are waived for individuals: aged under 16; aged over 60; who receive treatment for a chronic condition; or who receive certain income-tested benefits.

[3]A limited amount of publicly funded care is provided by non-NHS providers. In 2012/13 this accounted for 4% of the total cost of hospital treatment (Nuffield Trust, 2014). These episodes are excluded from our analysis.

for providing treatment. An 'internal market' operates within the NHS, with buyers (commissioners) separated from suppliers (hospitals). Commissioning groups manage regional budgets and fund care for the population resident within their boundaries. Suppliers are hospitals, or groups of hospitals, known as NHS Acute trusts. Suppliers are paid by commissioners for providing secondary or hospital care services to the local population.

Hospitals are compensated by commissioners for providing care in two ways.[4] First, hospitals receive payments per patient for the care they provide, under the 'Payment by Results' (PbR) framework (Department of Health, 2012). These types of payments accounted for 58% of hospital income in 2012-13 (Lafond et al., 2014). The payments hospitals receive depend on three factors:

1. The type of care provided. Healthcare Resource Groups (HRGs) are used to group together procedures that use similar levels of NHS resources.[5] National tariffs or prices are set for each HRGs in each year, and aim to reflect the average cost of providing a particular bundle of care. The number of HRGs has increased over time, but by 2014/15 there were over 1,200. To give an example of how prices vary across HRGs, in 2014/15 the tariff for the HRG corresponding to an elective coronary artery bypass graft (heart surgery) was $11,470, while the tariff for an HRG to cover migraine and headaches without other complications was $935.

2. Length of stay. Hospital receive additional per diem payments if patients stay longer than the threshold specified in each HRG. For example, the threshold for an ordinary stay for an elective coronary artery bypass graft is 14 days, after which hospitals receive an additional $330 per day.

3. Adjustment for local differences in cost. A 'Market Forces Factor' (MFF) multiplier is applied to the tariff to adjust for unavoidable variation in the cost of providing care across hospitals.[6]

The total payment received by a hospital under Payment by Results is thus given by the national tariff for the HRG plus adjustments for length of stay, multiplied by the market forces factor.

Second, hospitals also receive income from locally negotiated contracts. This is known as 'non-tariff income' and covers services for which no national prices are agreed, including specialist drugs and services. The lack of national prices for such services makes it extremely difficult to accurately cost these treatments, or assign expenditure to individual patients. As a result, we restrict our individual medical spending estimates to treatments covered by the framework of national tariffs.

[4] In 2009-10, hospitals received 80% of income through these methods. They also received central funding from the Department of Health for general hospital running costs (7% of their budget) and education and training (7%, in addition to clinical income from other sources including private patients (6%) (Department of Health, 2012)

[5] HRGs are similar to the Diagnostic Resource Groups (DRGs) that are used in the US.

[6] For example, the MFF Guy's and St Thomas' in London in 2014/15 was 1.277, compared to 1.046 for Leeds Teaching Hospital. This reflects the unavoidable higher costs associated with providing care in central London, as compared to Leeds (a smaller city in Northern England)

3 Data

The Hospital Episode Statistics (HES) are administrative data, and contain the universe of all publicly funded inpatient and outpatient hospital care in England. HES records treatment at the episode level, with an episode defined as a period of treatment under the care of a single consultant. These data contain basic patient characteristics, such as their age and sex and local area of residence, hospital, dates of admission and discharge, and information on the treatments provided including the associated HRG code. Patients can be followed over time using the pseudo-anonymized identifier provided.

Our main focus is publicly funded individual level doctor-led hospital spending. This includes all inpatient and outpatient treatment which can be costed using the framework of national tariffs outlined in the previous section.[7] Treatments without a national tariff are excluded from the analysis. This includes non-consultant led outpatient episodes, including some common treatments such as physiotherapy. In total, approximately 10% of inpatient episodes and 25% of outpatient episodes are excluded from the analysis[8]. Similarly, accident and emergency attendances which do not result in a subsequent inpatient admission are also excluded from the cost estimates.

We estimate the cost of each episode by combining episode-specific HRGs and provider codes in the following way. First, we match the episode-specific HRG to the appropriate annual national tariff. Second, we adjust costs for cases in which patients have an unusually long length of stay. Finally, we use unique hospital codes to apply the provider-specific market forces factor to account for regional variation in costs.

We aggregate the data using anonymized individual identifiers to produce annual estimates of hospital spending for each individual. This yields a dataset with 39.4 million individuals and 93.6 million individual-financial year observations between 2010/11 and 2014/15. HES data only include individuals who received hospital treatment in a particular year. This means that the remainder of the population, who have zero hospital expenditure by definition, are excluded from the data. We therefore augment HES with age and gender specific estimates of the national population from the Office of National Statistics (ONS) to account for individuals with zero expenditure.[9] All monetary figures are given in 2014 US$.[10]

[7]Our cost estimates represent the payments received by hospitals to reimburse them for carrying out these procedures. These costs are approximations of the average cost faced by the hospital when providing these treatments. However, they do not exactly reflect the average cost due to the time required to analyze cost data and decide upon an appropriate tariff. For example, 2014/15 tariff prices were set using cost data from 2010/11 (Monitor & England, 2014). These costs do not capture payments received by hospitals to finance the general running of the hospital (e.g. fixed costs relating to property etc).

[8]Examples of inpatient treatment costs that are not included are: certain high cost drugs (e.g, AIDS/HIV antiretrovirals); certain high cost devices (e.g, bone anchored hearing aids); and certain specialist procedures (e.g, cleft lip and palate and IVF). Outpatient care that is excluded includes family planning clinics and dental care.

[9]Population data are available on the ONS website: http://www.ons.gov.uk/ons/taxonomy/index.html?nscl=Population+Esti

[10]We calculate spending in nominal GBP and convert to 2014 GBP using the ONS household total expenditure implied price deflator. Figures are converted to 2014 USD using an exchange rate of 1.58. Annual exchange rates are available from the IRS website: http://www.irs.gov/Individuals/International-Taxpayers/Yearly-Average-

4 Variation in hospital spending

In this Section, we examine how average medical spending varies across individuals of different ages and with different characteristics. Understanding how costs vary over the lifecycle is important in understanding the impact of a growing and ageing population. Similarly, examining how costs vary across individuals gives an insight into who benefits from health spending, and how the demands on the system are likely to develop as the population changes.

4.1 Hospital population

Figure 2 shows the proportion of individuals at each age who receive NHS inpatient or outpatient care, for which we can estimate costs, in 2010/11 and 2014/15. There are two key points of note. First, the proportion of the population who use any hospital services increases with age. For example, 64% of 80 year old individuals received hospital care in 2010/11. This compares to only 30% of 40 year olds. Second, the proportion of the population using hospital services at all age over 40 is greater in 2014/15 than 2010/11. This may be explained by two factor. First, a genuine increase in hospital activity. Second, an increase in the number of HRGs for which national tariffs (from 1,074 to 1,236), which allows a larger proportion of treatment to be costed.

In the subsequent analysis, we present two types of statistics. First, using gender-age specific weights, we account for individuals with zero medical expenditure in a given year. This analysis therefore examines the distribution and persistence of medical spending across the entire national population. In the second set of statistics, we exclude individuals with zero expenditures. This analysis therefore examines the distribution and persistence of spending across the patient population (i.e. only those who use hospital services and therefore appear in HES).

4.2 Medical spending over the life cycle

Figure 3 examines average spending between 2010/11 and 2014/15 by age and gender. There are four main points of note. First, there are substantial costs associated with children under the age of one. All newborn children in NHS hospitals are recorded as inpatients, and account for approximately 8% of inpatients in a given year. Second, average spending is higher for females during childbearing years, with the average spending for a 30 year old female three times more than average spending for a male of the same age. Third, average spending increases for both genders after the age of 50, with particularly sharp growth after the age of 70. For example, average spending for an 89 year old man is $6,442, almost three times more than an average 70 year old male ($2,273), and almost nine times more than an average 50 year old male ($751). Finally, the age gradient is steeper for males beyond age 55. However, the magnitude of this difference is

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relatively small, with the average spending on males approximately equal to spending on a female aged three to five years older.

4.3 Distribution by local area deprivation

Understanding the distribution of medical spending by income is important for the incidence of a very large component of public spending. There are two potential sources of variation in medical spending by income. The first is differences in underlying medical need by income group. As rates of morbidity decrease typically decrease with income, this would suggest a negative relationship between income and need (Judge et al., 2010; Banks et al., 2006; Hernández-Quevedo et al., 2006; Smith, 1999; Deaton, 2003). The second, and often offsetting source of variation, is differences in access to and the use of health care for a given medical condition or level of morbidity.

HES data has two limitations in assessing the relationship between income and medical spending. The first, as noted above, is that HES data do not contain information on the income of patients. We therefore proxy individual income through the deprivation of their local area of residence, as measured by the Index of Multiple Deprivation (IMD)[11]. To test the assumption that IMD does proxy for income and wealth, we considered the correlation between local area IMD and measures of income and wealth contained in the English Longitudinal Study of Ageing (ELSA) in 2006 and found the expected strong, negative relationships between income, wealth and local area deprivation.[12] The second is that HES data do not contain enough information to capture need, either for patients contained within the data, or for individuals who have zero expense (and therefore not included in the data) but who potentially should be receiving hospital treatment. The relationship between hospital spending and income will therefore reflect a combination of potential differences in need and access conditional on need.[13]

Table 1 shows average hospital spending by IMD quintile, gender and age category for NHS patients.[14] The first panel shows spending for individuals under 25, the second between 25 and 64

[11]IMD scores provide an index of nine dimensions of deprivation, including income, education and the health care access of the local population. We use the income dimension only to avoid double-counting the impact of local health provision, and use the version produced in 2004. We verify the suitability of this proxy below by comparing deprivation levels to survey data on income.

[12]For example, in ELSA wave 3 (2006) mean total net (non-pension) wealth and mean total net financial wealth both decrease monotonically with local area deprivation. On the total net non-pension wealth measure, mean wealth is 4.5 greater in the least deprived quintile than the most deprived quintile; on the total net financial wealth measure, mean wealth is 5.3 times higher in the least deprived quintile relative to the most deprived quintile.

[13]A large literature using survey data documents differences in health care utilization conditional on need, see amongst others: Wagstaff et al. (1989); Wagstaff and van Doorslaer (2000); van Doorslaer et al. (2002); van Doorslaer, Koolman, and Jones (2004); Doorslaer and Koolman (2004, 2004); Bago d'Uva et al. (2009); van Doorslaer, Masseria, and et al. (2004)

[14]Population data are unavilable at the MSOA level for much of our period of interest. As a result, our analysis is constrained to look across the IMD distribution for patients only. If detailed population data were available, the inclusion of individuals with zero expenditures could have two potential impacts. First, if need for healthcare is greater in more deprived areas, leading to greater use of hospitals in these areas, we would expect to see a larger difference between spending in the most and least deprived areas. On the other hand, if access to hospital care is better in less deprived areas, leading to fewer individuals with no hospital use, then the difference would be smaller

and the final panel for individuals aged 65 and over. The table provides three points of note. First, for all age groups and both genders average hospital spending increases with local area deprivation. Second, the gradient becomes somewhat steeper for older age groups: for the under 25s, the ratio of average spending of those living in the most deprived quintile to those in the least deprived quintile is 1.10, compared to 1.12 for those aged 25-65, and 1.18 for those aged 65 plus. Third, the relative steepness of the gradient by gender varies by age. For those under 25, the gradient is much steeper for women: the ratio of average spending in the most to least deprived quintile is 1.44 for females but just 1.08 for men. Among those 25-64, the gradient is similar for men and women (with ratios of 1.12 for men and 1.11 for women). Similarly, for the over 65s the gradients by IMD are similar with those in the most deprived quintile spending around a fifth more than those in the least deprived quintile.

Taken together, these results suggest that those in the most deprived area consume more hospital resources than those in the least deprived areas. However, it is important to again emphasize that these calculations do not take account for need. Given the large literature that shows a positive relationship between deprivation and need, it is likely that the gradients we estimate will be ameliorated or reversed once need is taken into account.

5 The concentration and persistence of medical spending

5.1 Cross-section concentration

We expect hospital spending to be concentrated in a relatively small share of the population, as a large fraction of the population have no hospital spending at all in a given year, and some conditions are much more costly to treat than others. The concentration of health care spending will in large part reflect the concentration of medical need, and indeed, the potential to incur large costs is why health care is typically financed through the state or through private insurance. However, understanding the degree of concentration is important for at least three reasons. First, establishing how much spending is concentrated at the top of the distribution could help guide cost reduction exercises, or help predict a large part of future spending. Second, large differences in the concentration of spending across countries may indicate variation in costs or the quality of treatment provided, which could explain differences in spending or clinical outcomes. Third, the concentration of hospital spending in England shows the distribution of more than $150 billion of public spending. This may be entirely consistent with the distribution of need, but does show the degree of insurance against large medical costs provided by the state provision of health care.

Table 2 shows mean medical spending for each age category, by gender and population spending quintile. As shown in Figure 2, the share of the population with positive hospital spending is below half for those under 65. This results in zero entries for the first three quintile for the under 25 age

or in fact reversed.

group, and two empty quintiles and a very small value for quintile three for the 25-64 age group. For the over 65 population there is positive spending in the highest three quintiles only. For both men and women aged under 25 or 25-64, the ratio of the average spending of the top quintile to the average spending across the population is approximately 5. For those aged 65 and over, a woman in the top spending quintile spends 8 times the average women, while a man in the top quintile spends just under 5 times the average man.

Table 3 examines the concentration of medical spending among *patients*, or those with positive expenditure. There are three points of interest. First, as expected, the average spending for those in the top quintile rises with age. Second, spending is highly concentrated in the top quintile in all age groups: the average spending for those in the top quintile (quintile 5) is four times higher the average in quintile 4 for the over 25s, 4.5 times greater for the 25-64 group, and 5.2 times greater for those 65 and over. Finally, although average spending across the whole distribution and within each quintile increases with age, the spending distributions of the three age groups do overlap. The average spending of a patient in the top quintile of the under 25 distribution ($5,949) costs a third of the average patient in the top quintile of the over 65s distribution ($18,257), but significantly more than patients in the next quintile down on of the over 65s distribution ($3,560).

5.2 Concentration over time

In this subsection, we examine the concentration of medical spending over time, by averaging medical spending across multiple years, and by estimating persistence of spending, or how spending this year is related to spending in subsequent years. This analysis will indicate the extent to which high spending reflects the treatment of short term episodes of poor health, relative to long-term conditions that require continuing care. Again, this may be entirely in line with population need, but may have important implications for how we expect future healthcare spending to develop as the population grows and ages.

The major limitation of using our data to undertake analysis over time is that we only observe deaths that occur in hospitals. Zero expenditure in the year that follows treatment may therefore signify either that the patient no longer needs hospital care or that the patient has died. The averaged concentration and persistence parameters therefore represent the lower bound of true levels of persistence. However, Aragon et al. (2015), in this volume, have obtained mortality data linked to HES and do address medical spending around the time of death.

5.2.1 Persistence in the population spending distribution

Table 4 shows correlations, both in levels and logs, between individual hospital spending in one year (t) and spending in the next one (year $t+1$) or two ($t+2$) years, between 2010/11 and 2014/15.[15]

[15] We assign an annual cost of zero for individuals who do not appear in HES in a given year. For example, an individual who appears in HES in 2012, but not in the previous or following years, will have a positive cost estimate

Correlations are shown by gender and age group. The correlation in levels falls over time, and is lower for the over 65s than the younger two age groups. There are no substantial differences between males and females. Correlations in logs are stronger than those in levels and increase with age in $t+1$.

These results suggest that there is some persistence in medical spending. However, the extent of this persistence is likely to vary across the spending distribution, and this would not be captured by the previous correlations. We therefore now examine the persistence of spending among different groups in greater detail.

Table 5 considers simplified transition between zero and positive hospital expenditure over the next one and two years. There is a high degree of persistence in both zero and positive spending. In each age group, the majority of individuals with zero expenditures in year t also have zero expenditures in year $t+1$. This is also true when examining the transition over a two-year period. For the under 25s, 67.1% of those with zero spending in one year also have zero expenditure in the the following year, while 60.8% have zero spending two years later. Theses figures are smaller for the over 65s, but remain high at 60.9% and 53.1% respectively.

A similar pattern exists for those with positive spending (i.e patients). In all age groups, the majority of individuals with positive expenditure in year t will have positive expenditure in the year $t+1$. For the under 25s, of those with zero expenditure in year t, 51.5% have positive expenditure in year $t+1$. This relationship strengthens for the older age groups, with 75.7% (68.5%) of over 65s with positive expenditure in year t remaining in the positive expenditure group in year $t+1$ ($t+2$).

Table 6 examines the persistence of spending for individuals at the top of the medical spending distribution. For all age groups, more than three fifths of patients in the top spending quintile in a given year will remain in the top quintile the following year, with persistence falling slightly with age (67.1% for the under 25s compared to 60.9% for the over 65s. As expected, two-year persistence is lower, and the difference between one and two year persistent is larger for the oldest age group. This is almost certainly attributable to higher out of hospital death rates in this group. We are therefore underestimating the persistence for individuals who are still alive.

in 2012 and zero costs in all other years. There are however two exceptions. First, individuals born in later years in the period are excluded from the preceding years of analysis (e.g. an individual born in 2012 will be excluded from the analysis in 2011). Second, individuals who are recorded as dying in hospital are excluded from the analysis in future years (e.g. an individual who dies in hospital in 2012 will be included in the analysis up to and including 2012, but will be excluded from the 2013 and 2014 analysis). As noted above, this may underestimate the true level of persistence if only a small proportion of decedents are captured by the data. Individuals who never appear in HES are assigned a zero cost in all years, using population estimates to calculate the size of this non-patient population in each year. For the natural logirithm of spending, we bottom code individual spending, and set all values which are less than 10% of the annual mean of medical spending to 10% of the mean. We use an identical method for Tables 5 and 6.

5.2.2 Persistence in the patient spending distribution

The high persistence found in Table 6 for spending across the entire population is not surprising given that ill health exhibits strong state dependence (Contoyannis et al., 2004). In Tables 7 and 8 we examine the evolution of spending for *patients*, or individuals who have positive expenditure in any given year. Table 7 shows the transition from patients in positive spending quintiles in year t, to positive spending quintiles and a zero expenditure group in year $t+1$. Table 8 presents the same information for year $t+2$.[16]

Tables 7 and 8 reveal three main points of interest. First, persistence in spending remains at the top of the expenditure distribution. Conditional on positive spending in the following year, individuals in the top quintile in year t are very likely to appear in the top quintile in years $t+1$ and $t+2$. However, as expected, this persistence is substantially lower than that found when examining the spending distribution of the entire population. For the population aged 65 plus, 30.2% of individuals in the top positive spending quintile in year t remain in the top quintile in year $t+1$, while 22.0% remain in year $t+2$. This compares to 60.7% and 49.5%, respectively, when examining the entire population. Second, regardless of their spending quintile in year t, all individuals aged below 65 are most likely to appear in the zero expenditure group in year $t+1$ (and $t+2$). Finally, in all age groups individuals who appear in the bottom quintile in year t are most likely to appear in the zero expenditure group in year $t+1$ and $t+2$, while individuals in the top quintile are least likely to appear in the zero expenditure group.

A comparison of Tables 5 and 7 also indicates that among the over 65s, even a small amount of medical spending in one year substantially decreases the probability of having zero expenditure in the following year. In Table 5, individuals aged 65 and over with zero expenditure had a 60.9% probability of having zero expenditure in the following year (top left hand number of over 65 panel). By contrast, Table 7 shows that individuals in the bottom positive quintile in year t - who had a mean spend of less than \$200 - had a 33.1% chance of having zero expenditure in year $t+1$ (top right hand figure in over 65 panel) . This compares to the under 25s, where the probability of zero expenditure in year $t+1$ is similar for the bottom spenders (59.4% in Table 7) and those with zero expenditure (67.1% in Table 5) in year t.

Table 9 shows further measures of the concentration of medical spending across the entire population by age. This shows, for each age group, the gini coefficient and the percentage of total age-specific spending accounted for by 1% and 10% of the population. The Table illustrates that spending is highly concentrated among a small share of individuals at all ages, but that there are significant differences across age groups, with spending least concentrated among the over 65s. Just over a fifth (21.9%) of all spending among the over 65s is accounted for by 1% of the population, compared to 32.9% for the under 25s and 31.5% for those aged 25-64. Spending

[16] Individuals who die in hospitals in year t are excluded from the analysis. It should again be noted that zero expenditure in years t+1 and t+2 may be due to the death of the individual in a previous year. As a result, the probability of transition from positive to zero expenditure group over the time may be overestimated.

becomes significantly less concentrated for all ages groups when averaging over more years. For example, when averaging over 3 years, 10% of the under 25 population accounted for 40.0% of spending, less than half the percentage accounted for by 10% when averaging over only one year. Similar results are found when looking at the older populations and the gini coefficients show a similar trend.

Table 10 shows the same measures for the patient distribution. There are three points of note. First, in all cases, spending is less concentrated among patients than the entire population. Second, these differences in figures become much smaller when averaging over three years. This reflects the fact that the size of the patient population is much closer to the entire population when averaging over a number of years. Finally, the share of spending accounted for by 1% of the population is highest for the under 25s. However, a larger share of spending is accounted for by 10% of the population in the over 65 population (56.1%) than in the under 25s (52.4%). This is reflected in the higher gini coefficient for older age groups.

6 Conclusion

This paper has examined the concentration and persistence of public hospital spending in England by age and gender. Our results provide four principal results. First, hospital spending rises steeply at older ages: the mean hospital expenditure for an average 90 year old is three times greater than for an average 70 year old and nine times that of an average 50 year old. Women have higher medical costs during childbearing years, but men more expensive after the age of 55. Second, without correcting for need, those in more deprived areas have modestly higher hospital costs than those in richer areas. However, we re-emphasize that the relationship may look very different if we could control for need. Third, hospital spending is highly concentrated in a small number of patients. For the under 25s, 10% of residents accounted for 81% of hospital spending among this group. This is only slightly lower for the over 65s, at 77.3% The concentration remains high when looking only at *patients* (who have positive spending), 10% of patients accounting for 52.4% of spending in the under 25s and 56% of spending in the over 65s. Finally, individual level health spending is persistent over time, particularly at the top of the distribution, with high spenders in one year much more likely than the rest of the population to be a high spender in subsequent years.

The paper faces two major limitations which must be taken into account when interpreting the results. The first is the very limited information on the underlying health and socioeconomic characteristics of patients. This makes it difficult to provide an accurate measure of the socio-economic gradient in health care use, correcting for need. Such work should be possible using upcoming linkages between HES and survey data such as the English Longitudinal Study of Ageing. Second, we only observe deaths in hospital. This means that we are underestimating persistence, as we anticipate that a high fraction of those who transition from high expenditure to no expenditure will have died, rather than regained their health. Aragon et al. (2015) in this volume, use HES data linked to mortality data in order to capture deaths outside hospital, and are therefore able to provide a more complete picture of medical costs at the end of life.

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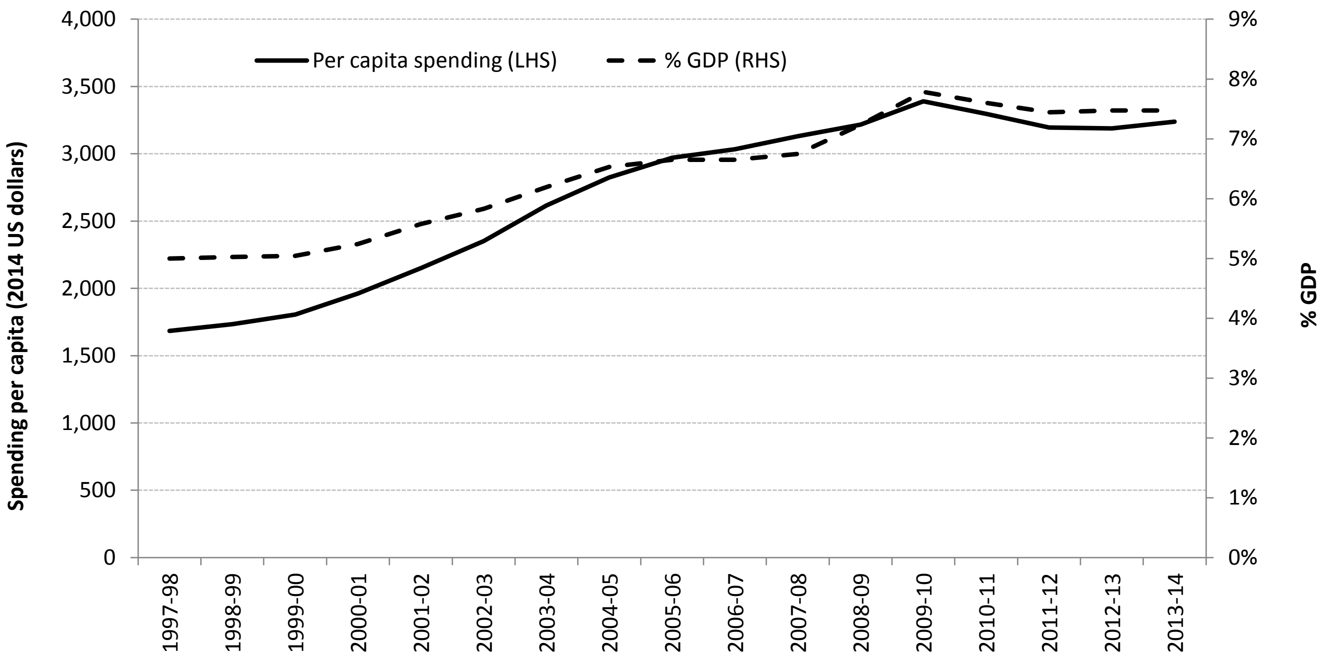
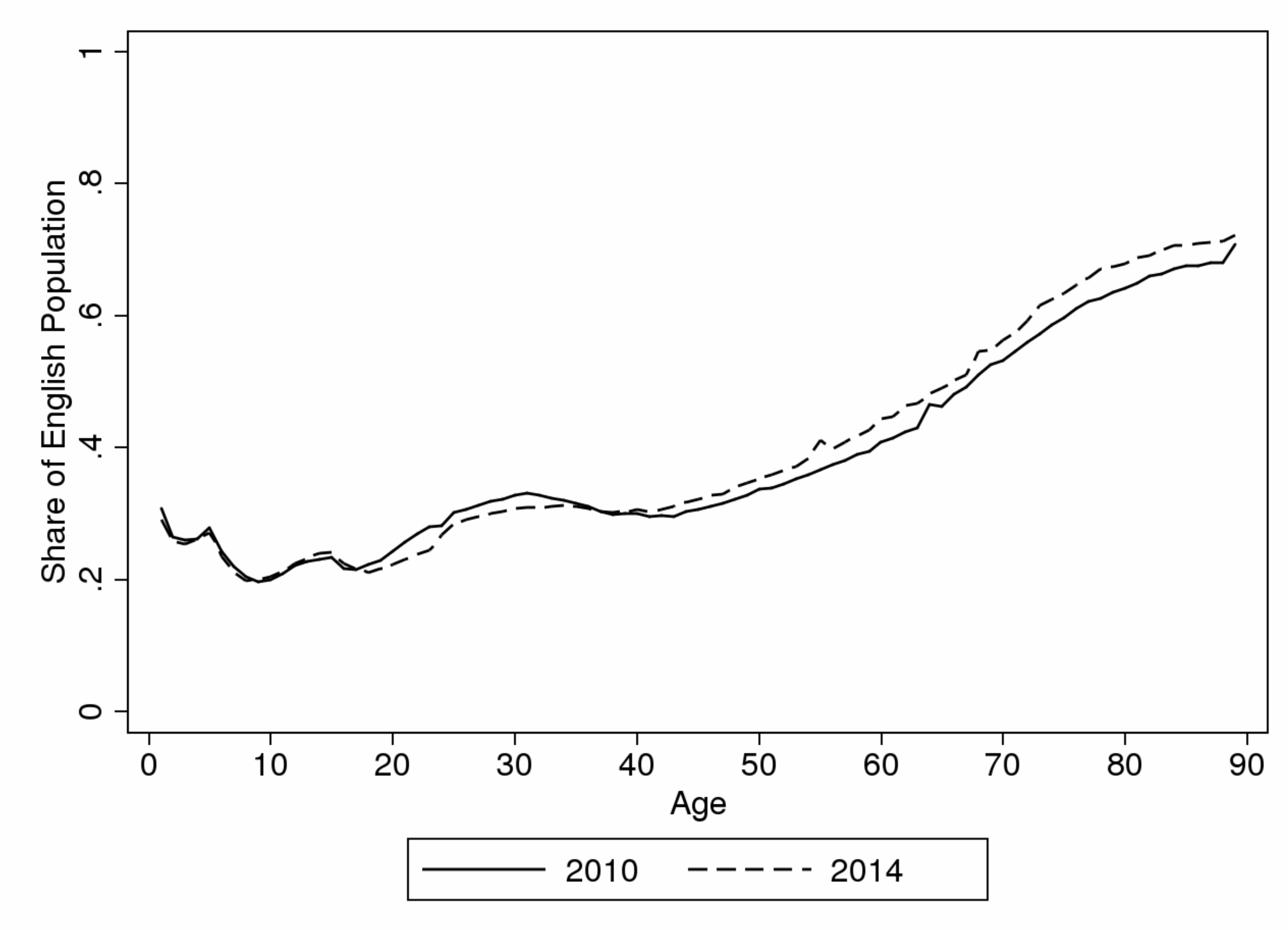
Figure 1: UK public health spending, per capita (2014 dollars) and as a percentage of GDP, 1997-98 to 2013-14



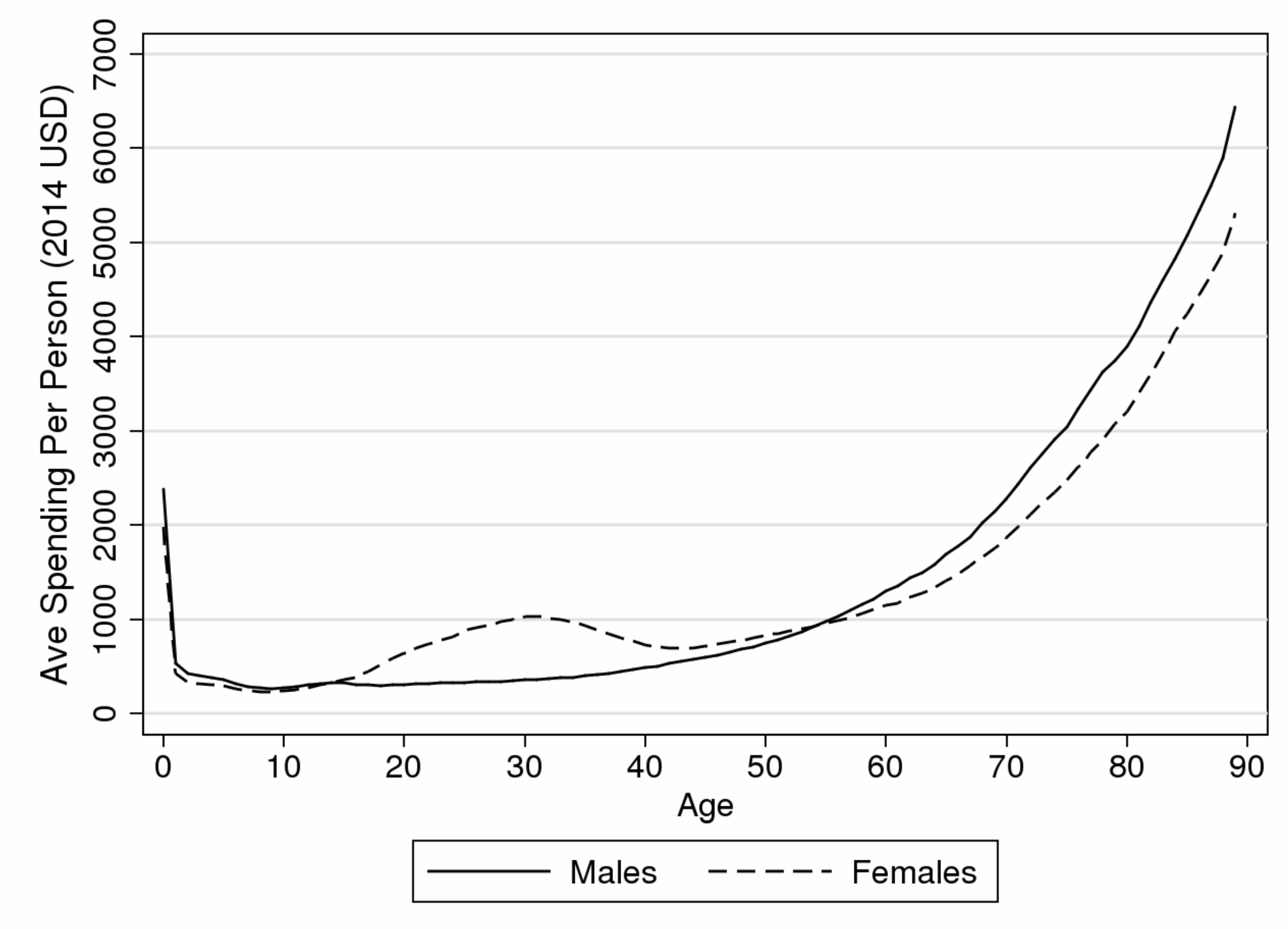
Notes and sources: Nominal health spending data from HM Treasury Public Expenditure Statistical Analyses. Real spending refers to 2014 prices, and uses the ONS household total expenditure implied price deflator. Prices are converted from pounds to dollars using an exchange rate of 1.58. GDP from the Office for Budget Responsibility, Economic and Fiscal Outlook March 2015.

Figure 2: Share of the national population using NHS hospital services, 2010/11 and 2014/15



Notes and sources: Authors' calculations using HES and the ONS annual mid-year population estimates. For each year, this shows the proportion of the national population who are admitted (at least once) to an NHS hospital to receive treatment that can be costed under the Payment by Results framework.

Figure 3: Average hospital spending by age and gender (2010/11 - 2014/15)



Notes and sources: Authors' calculations using HES data and the ONS national mid-year population estimates. Expenditure estimates are a weighted average of one-year hospital expenditure between 2010/11 and 2014/15. Annual population numbers are used as weights. We account for individuals with zero expenditure by weighting expenditure estimates by the proportion of individuals of each age and sex who are observed in hospital in a given year.

Table 1: Mean medical spending (patients only), by age and deprivation quintile

	Under 25			25 - 64			Over 65		
Deprivation quintile	All	Men	Women	All	Men	Women	All	Men	Women
Everyone	1,731	1,649	1,809	2,371	2,444	2,319	4,738	4,986	4,521
Least	1,560	1,541	1,970	2,101	2,148	2,067	4,146	4,368	3,939
2	1,595	1,553	2,064	2,201	2,247	2,169	4,422	4,656	4,212
3	1,693	1,619	2,233	2,343	2,419	2,291	4,716	4,958	3,709
4	1,798	1,695	2,416	2,483	2,572	2,422	5,125	5,417	4,885
Most	1,905	1,778	2,607	2,647	2,747	2,575	5,605	5,947	5,321

Notes: All figures in 2014 US Dollars. Estimates show expenditures for a single financial year. Estimates are a weighted average over all years between 2010/11 and 2014/15. Annual patient numbers are used as weights for each year. The sample includes only individuals with positive expenditure in a given year. Deprivation distibution is defined using the income dimension of the 2004 ONS Index of Multiple Deprivation.

Table 2: Mean medical spending, by age, population spending quintile and gender

	Under 25			25 - 64			Over 65		
	All	Men	Women	All	Men	Women	All	Men	Women
All	437	400	475	776	667	884	2,021	2,787	1,402
Bottom	0	0	0	0	0	0	0	0	0
Fourth	0	0	0	0	0	0	0	0	0
Third	0	0	0	10	0	21	240	264	221
Second	202	185	219	277	210	344	1,080	1,238	952
Top	2,204	2,027	2,388	3,801	3,362	4,232	11,851	12,900	11,001

Notes: All figures in 2014 US Dollars. Estimates show expenditures for a single financial year. Estimates are a weighted average over all years between 2010/11 and 2014/15. Annual patient numbers are used as weights for each year. The sample includes individuals with zero expenditures in a given financial year, using ONS mid-year population estimates to estimate the non-hospital population.

Table 3: Mean medical spending, by age, patient spending quintile and gender

	Under 25			25 - 64			Over 65		
	All	Men	Women	All	Men	Women	All	Men	Women
All	1,731	1649	1,809	2,371	2,444	2,319	4,738	4,986	4,521
Bottom	187	183	190	181	174	186	194	197	192
Fourth	361	346	375	364	345	377	439	409	464
Third	705	651	757	764	699	810	1,202	1,262	1,149
Second	1,458	1,332	1,579	1,909	1,688	2,063	3,560	3,752	3,392
Top	5,949	5,741	6,151	8,642	9,321	8,168	18,257	19,229	17,410

Notes: All figures in 2014 US Dollars. Estimates show expenditures for a single financial year. Estimates are a weighted average over all years between 2010/11 and 2014/15. Annual patient numbers are used as weights for each year. The sample includes only individuals with positive expenditure in a given year.

Table 4: Correlation of medical spending in year t with spending in year t+1, t+2 and t+3, by age and gender

	All			Males			Females		
Spending in year:	t+1	t+2	t+3	t+1	t+2	t+3	t+1	t+2	t+3
Under 25	0.32	0.22	0.17	0.33	0.22	0.17	0.32	0.22	0.18
25 - 64	0.31	0.21	0.17	0.32	0.20	0.16	0.30	0.21	0.17
Over 65	0.26	0.14	0.10	0.26	0.13	0.09	0.25	0.14	0.10
Log spending in year:	t+1	t+2	t+3	t+1	t+2	t+3	t+1	t+2	t+3
Under 25	0.36	0.25	0.20	0.35	0.25	0.20	0.36	0.25	0.21
25 - 64	0.38	0.27	0.24	0.41	0.30	0.26	0.37	0.26	0.22
Over 65s	0.41	0.27	0.21	0.41	0.26	0.19	0.41	0.28	0.22

Notes: Displayed estimates are correlation coefficients. Estimates are a weighted average over all years between 2010/11 and 2014/15, using annual patient numbers as weights for each financial year. Individuals who die in year t are excluded from analysis in subsequent years. The sample includes individuals with zero expenditures in a given financial year, using ONS mid-year population estimates to estimate the non-hospital population.

Table 5: Transition matrices for hospital spending from year t to year t+1 and t+2, by age and spending group

Spending group	Year t+1		Year t+2	
Year t	Zero	Positive	Zero	Positive
		Under 25		
Zero	67.1	32.9	60.8	39.2
Positive	48.5	51.5	58.0	42.0
		25 - 64		
Zero	63.7	36.3	56.0	44.0
Positive	38.4	61.6	46.4	53.6
		Over 65		
Zero	60.9	39.1	53.1	46.9
Positive	24.3	75.7	31.5	68.5

Notes: The table shows the percentage of individuals, by age-spending group in year t, in each age-spending group in years t+1 and t+2. Estimates are a weighted average over all years between 2010/11 and 2014/15, using annual patient numbers as weights for each financial year. The sample includes individuals with zero expenditures in a given financial year, using ONS mid-year population estimates to estimate the non-hospital population. Individuals who die in hospital in year t are excluded from analysis in subsequent years.

Table 6: The percentage of the population in the top quintile of spending in year t who remain in the top 20% of spenders in year t+1 and t+2, by age

	% of top quintile in year t who remain in the top quintile:	
	Year t+1	Year t+2
Under 25	67.1	60.7
25 - 64	63.7	56.0
Over 65	60.9	49.5

Notes: The table shows the percentage those in the top quintile of spenders in year t who remain in the top 20

Table 7: Transition matrices for patients with positive hospital spending in year t and year t+1, by age

Spending group			Year t+1			
Year t	Bottom	2	3	4	Top	Zero
			Under 25			
Bottom	13.6	8.0	6.7	5.8	6.4	59.4
2	12.5	10.0	9.4	7.4	7.7	53.1
3	11.0	10.6	14.0	10.3	10.3	43.8
4	8.9	8.5	12.6	13.4	12.6	44.1
Top	8.8	7.5	10.2	11.5	21.6	40.3
			25 - 64			
Bottom	16.4	9.8	8.5	7.8	6.8	50.6
2	14.0	12.3	11.6	10.3	9.0	42.7
3	11.5	12.3	15.9	14.0	13.0	33.3
4	9.5	9.5	13.5	16.7	15.5	35.3
Top	8.8	8.5	11.8	15.0	26.0	29.9
			Over 65			
Bottom	24.7	14.0	11.0	9.5	7.7	33.1
2	17.7	19.1	14.9	12.7	10.3	25.3
3	12.5	16.1	20.3	16.8	13.1	21.2
4	10.2	12.6	17.4	21.6	18.7	19.5
Top	8.2	9.7	12.4	17.6	30.2	21.9

Notes: The table shows the percentage of patients in each t+1 spending group, by year t positive spending quintile. Estimates are a weighted average over all years between 2010/11 and 2014/15, using annual patient numbers as weights for each financial year. The sample only includes individuals with positive hospital expenditure in year t. Individuals who die in hospital in year t are excluded from analysis in subsequent years.

Table 8: Transition matrices for patients with positive hospital spending in year t and year t+2, by age

Spending group	Year t+2					
Year t	Bottom	2	3	4	Top	Zero
Under 25						
Bottom	9.5	6.7	6.0	4.8	5.1	67.8
2	9.0	8.0	7.8	6.1	5.7	63.4
3	8.7	8.6	10.7	8.3	7.2	56.4
4	7.9	7.7	10.4	10.3	9.3	54.4
Top	7.4	6.7	9.1	10.2	18.8	47.7
25 - 64						
Bottom	12.6	8.8	8.0	7.2	6.5	56.9
2	11.4	10.6	10.3	8.8	7.8	51.1
3	10.2	10.8	13.5	11.7	10.2	43.6
4	8.5	8.9	12.0	14.1	12.9	43.5
Top	7.7	8.0	10.7	13.7	21.4	38.5
Over 65						
Bottom	20.0	13.3	11.2	10.1	9.0	36.5
2	15.3	16.2	13.9	12.4	11.0	31.2
3	12.0	14.7	17.1	15.4	13.2	27.7
4	10.1	12.2	15.5	18.1	16.6	27.5
Top	7.8	9.1	11.1	14.6	22.0	35.5

Notes: The table shows the percentage of patients in each t+2 spending group, by year t positive spending quintile. Estimates are a weighted average over all years between 2010/11 and 2014/15, using annual patient numbers as weights for each financial year. The sample only includes individuals with positive hospital expenditure in year t. Individuals who die in hospital are excluded from analysis in subsequent years.

Table 9: Measures of the concentration of medical spending across the national population, by age

	Medical spending averaged over		
	1 year	2 years	3 years
Under 25			
Gini coefficient on medical spending	0.89	0.85	0.81
Percentage spent by top 1% of spenders	32.9%	27.1%	24.3%
Percentage spent by top 10% of spenders	81.3%	57.4%	40.0%
25 - 64			
Gini coefficient on medical spending	0.90	0.85	0.82
Percentage spent by top 1% of spenders	31.5%	25.1%	22.1%
Percentage spent by top 10% of spenders	82.8%	58.7%	40.7%
Over 65			
Gini coefficient on medical spending	0.86	0.81	0.77
Percentage spent by top 1% of spenders	21.9%	16.2%	13.7%
Percentage spent by top 10% of spenders	77.3%	52.2%	35.3%

Notes: Estimates are a weighted average over all years between 2010/11 and 2014/15, using annual patient numbers as weights for each financial year. The sample only includes individuals with positive hospital expenditure in year t. The sample includes individuals with zero expenditures in a given financial year, using ONS mid-year population estimates to estimate the non-hospital population.

Table 10: Measures of the concentration of medical spending across patients, by age

	Medical spending averaged over		
	1 year	2 years	3 years
Under 25			
Gini coefficient on medical spending	0.65	0.65	0.65
Percentage spent by top 1% of spenders	19.59%	15.10%	11.11%
Percentage spent by top 10% of spenders	52.43%	41.91%	31.56%
25 - 64			
Gini coefficient on medical spending	0.70	0.69	0.68
Percentage spent by top 1% of spenders	17.31%	13.20%	9.67%
Percentage spent by top 10% of spenders	51.91%	45.70%	34.86%
Over 65			
Gini coefficient on medical spending	0.72	0.68	0.66
Percentage spent by top 1% of spenders	13.29%	9.10%	6.26%
Percentage spent by top 10% of spenders	56.13%	45.13%	34.20%

Notes: Estimates are a weighted average over all years between 2010/11 and 2014/15, using annual patient numbers as weights for each financial year. The sample only includes individuals with positive hospital expenditure in year t