THE UNIVERSITY *of York*

CHE
Centre For Health Economics

# Measuring Change in Health Care Equity Using Small Area Administrative Data – Evidence from the English NHS 2001-8

CHE Research Paper 67

# Measuring change in health care equity using small area administrative data – evidence from the English NHS 2001-8

[1]Richard Cookson
[2]Mauro Laudicella
[3]Paolo Li Donni

[1]Centre for Health Economics, University of York, UK
[2]Healthcare Management Group, Imperial College Business School, UK
[3]Department of Economics, Finance and Business, University of Palermo, Italy

October 2011

## Background to series

CHE Discussion Papers (DPs) began publication in 1983 as a means of making current research material more widely available to health economists and other potential users. So as to speed up the dissemination process, papers were originally published by CHE and distributed by post to a worldwide readership.

The CHE Research Paper series takes over that function and provides access to current research output via web-based publication, although hard copy will continue to be available (but subject to charge).

## Acknowledgements

This is a draft working paper which has not completed the full academic peer review process required for publication in an academic journal. This study arises from research project SDO/164/2007 funded by the UK Department of Health NIHR SDO research programme and managed by the Department of Health PRP Health Reform Evaluation Programme. The project was entitled "Effects of health reform on health care inequalities". The views and opinions expressed in this paper are those of the authors and do not necessarily reflect those of the SDO programme, NIHR, NHS or the Department of Health. Hospital episode statistics data, QOF data and GP practice attribution data were provided by the NHS Health and Social Care Information Centre, on license from the Department of Health. Mid-year population estimates were provided by the ONS. Earlier versions of this paper were presented at the UK Health Economists' Study Group meeting at the London School of Economics in January 2010, and at the UK Joint Health Services Research and Service Delivery and Organisation Network Annual Conference in Liverpool in June 2011. For useful comments and discussions, we would like to thank Sara Allin, Bob Fleetcroft, Roy Carr-Hill, Mark Dusheiko, Craig Goldsmith, Hugh Gravelle, Azim Lakhani, Steven Lindsay, James Nelson-Smith, Andrew Street, Nicholas Watson and three anonymous reviewers of our draft final report to the Department of Health and an earlier version of this paper. We would also like to thank Mark Dusheiko from the University of York Centre for Health Economics for facilitating access to the HES, QOF and GP practice attribution data used in this project, and the Northern and Yorkshire Public Health Observatory for facilitating access to population data.

## Disclaimer



## Further copies

Copies of this paper are freely available to download from the CHE website www.york.ac.uk/che/publications/ Access to downloaded material is provided on the understanding that it is intended for personal use. Copies of downloaded papers may be distributed to third-parties subject to the proviso that the CHE publication source is properly acknowledged and that such distribution is not subject to any payment.

Printed copies are available on request at a charge of £5.00 per copy. Please contact the CHE Publications Office, email che-pub@york.ac.uk, telephone 01904 321458 for further details.

Centre for Health Economics
Alcuin College
University of York
York, UK
www.york.ac.uk/che

## Abstract

This study developed a method for measuring change in socio-economic equity in health care utilisation using small area level administrative data. Our method provides more detailed information on utilisation than survey data but only examines socio-economic differences between neighbourhoods rather than individuals. The context was the English NHS from 2001 to 2008, a period of accelerated expenditure growth and pro-competition reform. Hospital records for all adults receiving non-emergency hospital care in the English NHS from 2001 to 2008 were aggregated to 32,482 English small areas with mean population about 1,500 and combined with other small area administrative data. Regression models of utilisation were used to examine year-on-year change in the small area association between deprivation and utilisation, allowing for population size, age-sex composition and disease prevalence including (from 2003-8) cancer, chronic kidney disease, coronary heart disease, diabetes, epilepsy, hypertension, hypothyroidism, stroke, transient ischaemic attack and (from 2006-8) atrial fibrillation, chronic obstructive pulmonary disease, obesity and heart failure. There was no substantial change in small area associations between deprivation and utilisation for outpatient visits, hip replacement, senile cataract, gastroscopy or coronary revascularisation, though overall non-emergency inpatient admissions rose slightly faster in more deprived areas than elsewhere. Associations between deprivation and disease prevalence changed little during the period, indicating that observed need did not grow faster in more deprived areas than elsewhere. We conclude that there was no substantial deterioration in socio-economic equity in health care utilisation in the English NHS from 2001 to 2008, and if anything, there may have been a slight improvement.

## Introduction

Equity in health care is a topic of ongoing importance in all health systems (AHRQ, 2009; O'Donnell et al., 2008). Evidence of socio-economic inequity in the utilisation of non-emergency specialist care relative to need has been found even in high income countries with universal and comprehensive health programmes like the English National Health Service (NHS) (Dixon et al., 2007; Morris et al., 2005; van Doorslaer et al., 2006). This is often interpreted as indicating broader socio-economic inequity of access to health care, since utilisation of non-emergency specialist care is potentially sensitive to all of the important financial and non-financial access barriers that people may face in navigating their way through the health system.

Much of this evidence is cross sectional, and much methodological development has centred on improving the accuracy and cross country comparability of equity measures (O'Donnell et al., 2008; van Doorslaer et al., 2006). However, health service policy makers and managers need better methods for detecting change in health care equity (equity “movies”) as well as better methods for measuring levels of health care equity (equity “snapshots”).

Most research on equity in health care utilisation uses survey data rather than administrative data (O'Donnell et al., 2008). The main advantage of survey data is that it allows conclusions to be drawn about inequity in utilisation between individuals, and not just inequity in utilisation between small area populations (or “neighbourhoods”, for short). This is because survey data contains information about individuals who have not used health care, as well as those who have. However, survey data has at least two important disadvantages (Bilheimer & Klein, 2010). First, surveys only include small numbers of sample members using specific procedures, so equity analyses are typically restricted to general utilisation indicators such as the probability of receiving any form of specialist care. Second, surveys have difficulty selecting representative samples of extremely disadvantaged and advantaged population subgroups. By contrast, administrative data can include large numbers using specific procedures and can provide information on the whole population.

So in this study we developed methods for measuring change in health care equity using small area administrative data, as a complement to conventional methods using individual level survey data. Our main challenge was to allow convincingly for change in small area health care need, in order to distinguish change in equity from appropriate change in health care utilisation due to change in need (Gravelle et al., 2006) We did this by using primary care data to construct time varying small area indicators of disease prevalence including (from 2003-8) cancer, chronic kidney disease, coronary heart disease, diabetes, epilepsy, hypertension, hypothyroidism, stroke, transient ischaemic attack and (from 2006-8) atrial fibrillation, chronic obstructive pulmonary disease, obesity and heart failure. We used this data to allow for need in regression models of the utilisation of specialist care, and to check whether health care need grew more rapidly (or more slowly) in deprived neighbourhoods than elsewhere. We could not measure severity of disease, and so probably under-estimated need for specialist health care in deprived areas. This means our method could not accurately measure the *level* of health care equity in cross section data. However, it could accurately measure *change* in health care equity in time series data, on the reasonable assumption that trends in unobserved need run parallel between population subgroups. Our discussion section provides arguments and evidence to support this key assumption of parallel trends in need.

The context of our study was the English NHS from financial years 2001/2 to 2008/9 (in England, the financial year runs from April to March). This was a period of accelerated public expenditure growth on health care throughout and pro-competition reform from 2006. Real annual NHS expenditure growth averaged 6.56% from 1999/00 to 2010/11 compared with 3.48% from 1950/51 to 1999/00 (Appleby et al., 2009). Reforms include a sustained target-driven reduction in hospital waiting times from 2001 (Propper et al., 2008, 2010), a pay for performance scheme in primary care from 2004 (Roland, 2004) and increased hospital choice and competition from 2006 (Department of Health, 2003). When Prime Minister Tony Blair was promoting his NHS reforms in the early 2000s, he claimed that the resulting increase in capacity and choice would enhance equity for poorer patients (Blair, 2003; Department of Health, 2003). This claim was supported by Julian Le Grand, Tony Blair’s senior policy adviser from 2003-5, who highlighted evidence that socio-economic inequities in specialist care existed prior to the reforms (Dixon & Le Grand, 2006; Dixon et al., 2007). In contrast, critics argued that the new emphasis on choice, competition and independent sector provision of publicly funded hospital care would undermine socio-economic equity (Appleby et al., 2003; Barr et al., 2008; Oliver & Evans, 2005; Tudor-Hart, 2006). Our study only measured change in equity and did not identify which factors caused which changes. Nevertheless, it is of considerable policy interest to find out what actually happened to socio-economic equity in the utilisation of hospital care in the English NHS during this period: did things get better (as Prime Minister Blair predicted) or worse (as his critics predicted) or stay about the same?

## Data

Our research question was whether there was any change between 2001 and 2008 in small area socio-economic equity in the utilisation of specialist care relative to need in the English NHS. Our small areas were 32,382 English Lower Layer Super Output Areas (LSOAs) with mean population about 1,500. These are stable, similar sized and residentially homogenous geographical units designed by the Neighbourhood Statistics Service, which supports UK government policy on social exclusion and neighbourhood renewal (Office for National Statistics, 2006). We examined change in the association between small area deprivation and utilisation of non-emergency outpatient and inpatient hospital care, allowing for observable change in need.

### Outcome variables – non-emergency outpatient and inpatient hospital utilisation

Neighbourhood utilisation counts were extracted from Hospital Episode Statistics for England (Information Centre for Health and Social Care, 2009b). Our data included all NHS funded hospital care, including care provided by independent sector hospitals. We did not examine privately funded care, which makes up about 20% of total health expenditure in the UK – falling slightly during the 2000s from 20.7% in 2001 to 17.6% in 2008 (OECD, 2010). Our indicator of overall inpatient utilisation counted the number of continuous inpatient spells for adults age 18 or over admitted for non-emergency inpatient acute hospital care in the English NHS in financial years 2001/2 to 2008/9. Our indicator of overall outpatient utilisation counted the number of individuals age 18 or over who attended at least one outpatient visit in each financial year 2004/5 to 2008/9, including visits in community settings as well as hospital settings and including visits to professions allied to medicine as well as medical specialists. We also examined four specific non-emergency inpatient procedures: primary hip replacement, senile cataract surgery, gastroscopy (diagnostic endoscopic examination of the upper gastrointestinal tract) and coronary revascularisation (including both coronary artery bypass grafting and percutaneous coronary intervention). For gastrosopy we included all adults age 18 or over, whereas for the other procedures we focused on adults age 45 or over as younger patients are rare and atypical. Our basket of specific inpatient procedures represented a broad spectrum of hospital care – including high and low cost care, day case and residential care, secondary and tertiary care, diagnostic and therapeutic care – across four different clinical specialities (orthopaedics, ophthalmology, gastroenterology and cardiothoracic surgery). Hip replacement (Cookson et al., 2007; Judge et al., 2010; Milner et al., 2004; Propper et al., 2005) and coronary revascularisation (Quatromoni & Jones, 2008) are commonly used as indicators of health care equity, and both were cited by Prime Minister Blair's adviser Julian Le Grand (Le Grand, 2006) during the reform period as significant examples of health care inequity in the NHS. Hip replacement, senile cataract and coronary revascularisation were all important targets of the NHS reforms, with initially high waiting times that fell substantially during the reform period (Propper et al., 2010; Propper et al., 2006). Examining gastroscopy allowed us to check whether equity trends differed for a low cost diagnostic procedure, as opposed to relatively high cost treatments. Finally, all four indicators are high volume procedures with tens of thousands performed each year – hundreds of thousands in the case of gastroscopy – making it possible to detect statistically significant change over time.

### Neighbourhood deprivation variables

Neighbourhood deprivation was measured using the time-varying income deprivation domain of the English Economic Deprivation Index (EDI) 2008, which indicates the proportion of individuals aged 0 to 60 living in households receiving low income benefits (Noble et al., 2009). This index provides the most up-to-date picture of neighbourhood deprivation in the light of changing economic circumstances, does not include any health variables that might introduce circularity into the modelling, and is easy to interpret. We used other time-fixed deprivation indices in sensitivity analysis.

### Need variables

Annual estimates of neighbourhood population size and age-sex composition were obtained from the Office for National Statistics (Office for National Statistics, 2009). We also estimated neighbourhood disease prevalence using administrative data from the UK's primary care pay-for-performance scheme, the "Quality and Outcomes Framework" (Information Centre for Health and Social Care, 2009c; Roland, 2004). We attributed family practice data to neighbourhoods using the Attribution Data Set (Information Centre for Health and Social Care, 2009a), which contains information on the number of patients in each family practice resident in each neighbourhood. Most of the prevalence data starts from 2003/4 onwards and refers to all age populations (see Appendix Table A1).

### Supply variables

We used two sets of supply variables: indicators of urbanization from the Office for National Statistics, and indicators of NHS administrative area for resource allocation purposes (152 Primary Care Trusts fixed at 2006 boundaries).

## Methods

### Graphical analysis of equity trends by deprivation group

To illustrate year-by-year trends in socio-economic utilisation patterns, we presented time series charts showing need standardised utilisation rates per 100,000 general population by interval deprivation group and year. To illustrate change between the first and last year, we presented social gradient charts comparing the two years using need standardised utilisation ratios which share a common scale independent of growth in average utilisation rates. This deprivation group approach provides a clearer picture of change over time than concentration curves summarizing the entire socio-economic distribution, since concentration curves for different years appear close together and are hard to tell apart.

We used four interval deprivation groups with an increasing proportion of individuals living in households receiving low income benefits: (1) 0-10%, (2) 10-20%, (3) 20%-30% and (4) 30% or above. Since the distribution of the EDI score was left-skewed, this generated unequally sized groups comprising about 57%, 22%, 12% and 9% of small areas respectively. The size and composition of these groups varied slightly from year to year due to changing national and local economic circumstances (see Appendix Table A2). Our two most deprived groups approximately corresponded to the two most deprived tenths of neighbourhoods in England. In sensitivity analysis we also split our deprivation indices into quantile groups.

We standardised utilisation for observed demographic and disease prevalence need variables using the regression-based indirect standardization methods developed by the ECuity group (O'Donnell et al., 2008). These methods allow appropriately for correlation between "need" and "non-need" variables such as deprivation and supply variables. We computed standardised utilisation ratios as observed utilisation divided by need expected utilisation, and standardised utilisation rates as the standardised utilisation ratio times the national mean utilisation rate. We used linear regression models for standardisation, since predictions from non-linear models are influenced by the value fixed for the "non-need" variables (O'Donnell et al., 2008). The linear regression standard errors may be biased due to the non-normal distribution of the procedure-specific counts, so we computed confidence intervals around standardised utilisation ratios using stratified bootstrap simulation of both numerator and denominator with 1,000 replications.

### Statistical tests for change in equity

We tested for change in the neighbourhood association between utilisation and income deprivation using regression models of utilisation with year-deprivation interactions to measure change from the baseline year. In this analysis we treated income deprivation as a continuous variable on a scale of 0 to 100. This is more general than the categorical approach in our graphical analysis, as it takes account of the full socio-economic distribution and avoids the potential selection biases associated with arbitrarily defined groups. We used linear models to examine absolute inequality (i.e. absolute differences in utilisation between more and less deprived neighbourhoods), and log-linear and generalized linear models to examine relative inequality (i.e. proportional differences in utilisation between more and less deprived neighbourhoods). Since theoretical disagreement is possible on whether to use a "relative" or "absolute" inequality concept, we presented the most statistically appropriate model given the data and then conducted sensitivity analysis. We thus presented linear models for overall indicators and negative binomial count data models for the procedure-specific indicators exhibiting excess zeros and over-dispersion. We used three models to examine how results change with the addition of different covariates: a base model with population size and age-sex fractions only; a base/needs model adding disease prevalence variables; and a full model adding supply variables. All models were estimated using Stata 11 and use cluster robust standard errors to allow for correlation within small areas over time.

## Results

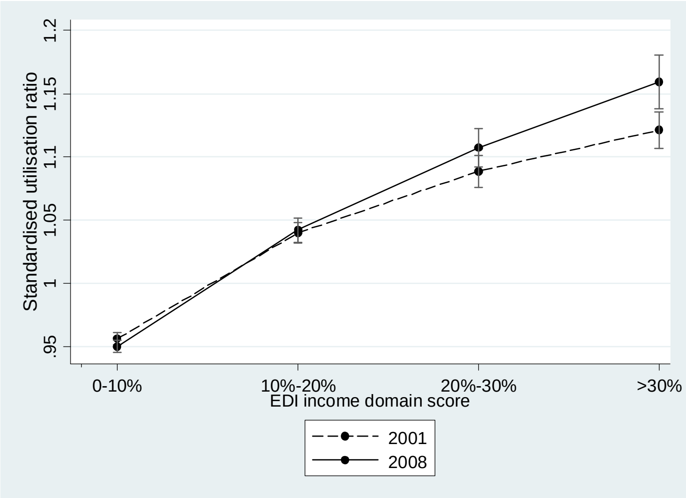
### Graphical analysis of equity trends by deprivation group

Figure 1 shows general equity trends in hospital elective and outpatient admissions. The right hand panels compare all eight years in terms of deprivation gaps, showing standardised utilisation rates per 100,000 by the four deprivation groups. Over time, utilisation changed approximately in parallel across all four groups. In cross section, however, standardised utilisation was higher in more deprived groups, suggesting we under-estimated need in deprived areas (see discussion section).

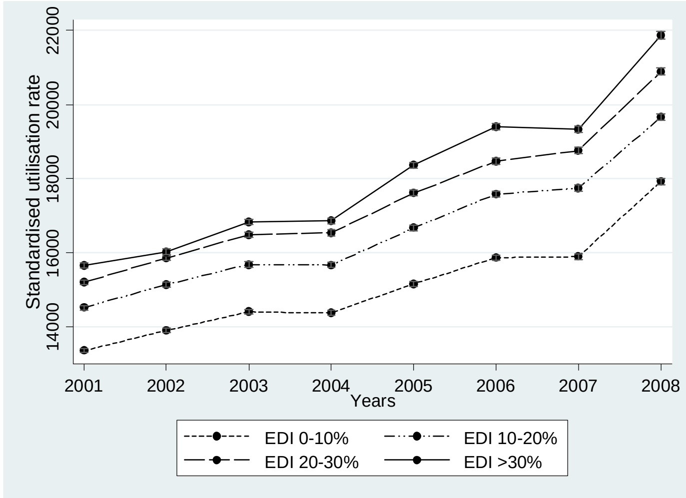
The left hand panels compare the first and last years in terms of deprivation gradients, showing how standardised utilisation ratios vary by the four deprivation groups. Deprivation was increasing as we move rightwards on the horizontal axis. There was no sign of any change in the social gradient in outpatient visits between 2004/5 and 2008/9. However, for inpatient admissions standardised utilisation ratios in the two most deprived groups appeared slightly higher in 2008/9 than 2001/2. In 2001/2, standardised utilisation was respectively 17.2% and 13.8% higher in the two most deprived groups compared with the least deprived group, whereas by 2008/9 standardised utilisation was respectively 22.0% and 16.5% higher. This suggests that inpatient admissions grew slightly faster relative to need in the two most deprived groups compared with the least deprived group.

Figure 2 shows equity trends in our four specific inpatient procedures. In each case, standardised utilisation rates changed approximately in parallel across deprivation groups. In cross section, rates of both observed and standardised utilisation were higher in deprived areas for cataract surgery, gastroscopy and revascularisation, but lower for hip replacement. Appendix Table A1 reports the observed utilisation rates.

## Non-emergency inpatient admissions

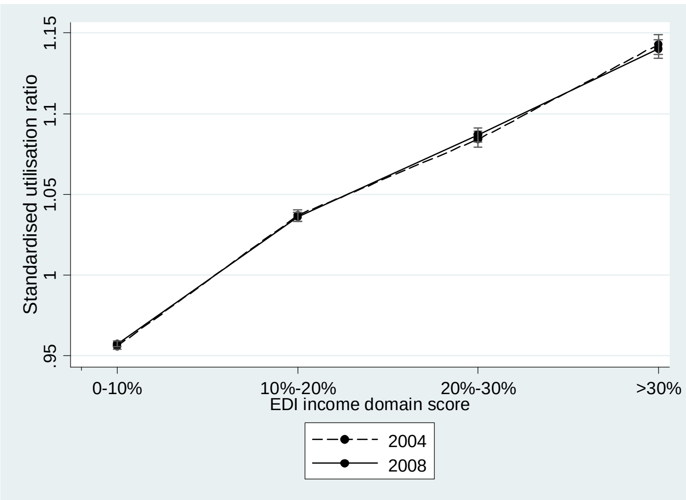



2001 versus 2008

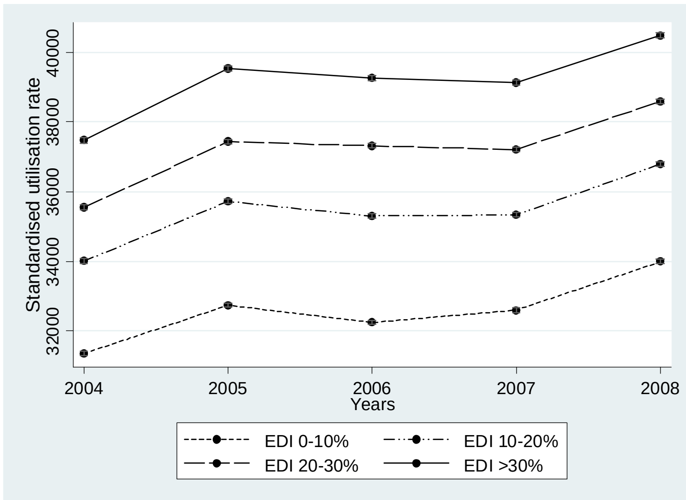



Year-by-year trends
(utilisation rate per 100,000)

## Outpatient visits




2004 versus 2008




Year-by-year trends
(utilisation rate per 100,000)

**Figure 1: Overall trends in non-emergency inpatient admissions and outpatient visits**

**Notes to Figure 1:**

1. Year-specific linear regression models were used to standardise utilisation for population size, age-sex fractions and disease prevalence.
2. The first year for outpatient visits was 2004, as this was the earliest year for which acceptably complete outpatient data are available in England.
3. EDI is the neighbourhood level Economic Deprivation Index indicating the proportion of individuals living in low-income households.

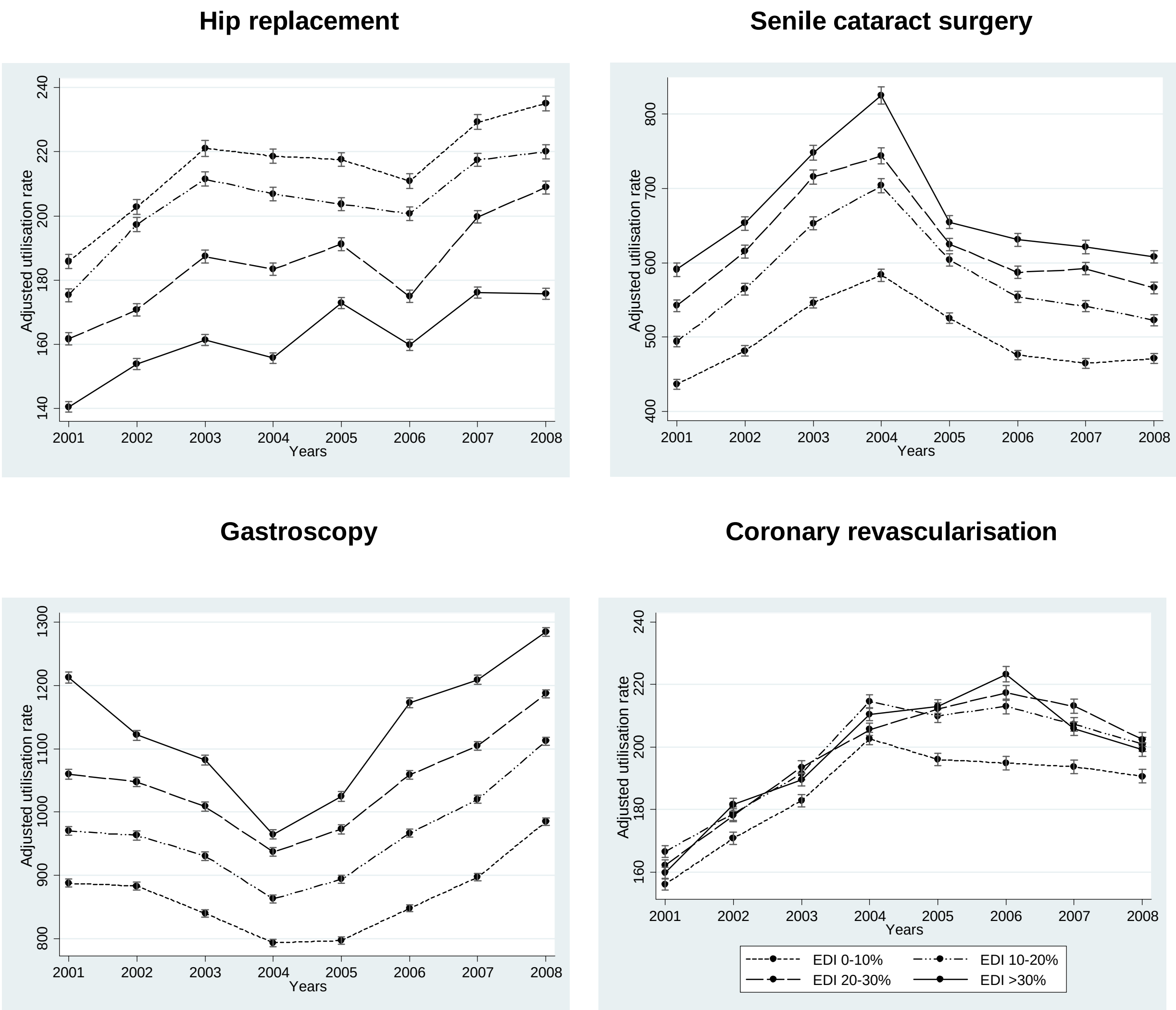



**Figure 2: Trends in four specific hospital inpatient procedures (Standardised utilisation rate per 100,000)**

**Notes to Figure 2:**

1. Year-specific linear regression models were used to indirectly standardise utilisation for population size and age-sex fractions.
2. EDI is the neighbourhood level Economic Deprivation Index indicating the proportion of individuals living in low-income households.

## Statistical tests for change in equity

Table 1 presents modelled associations between income deprivation and utilisation, allowing for need, showing the baseline association in 2001/2 and change between 2001/2 and 2008/9. There was no significant change in the deprivation-utilisation association for hip replacement, gastroscopy or revascularisation in any of the models, or in sensitivity analysis using linear models. There was a small change for outpatient visits in the base model allowing for population size, age and sex only, but this disappeared after allowing for disease prevalence. There was also a small change for cataract surgery, but deprivation-year coefficients for previous years were not significant and showed no systematic pattern of change during the 2000s (full regression tables available from the authors on request).

**Table 1: Modelled associations between income deprivation and utilisation, showing baseline association and difference in 2008/9**

| | Base model | Base/Needs model | Full model |
|---|---|---|---|
| **All Elective (OLS model)** | | | |
| Deprivation effect in 2001 | 1.184 (1.115 to 1.254) | 0.625 (0.547 to 0.704) | 0.758 (0.684 to 0.831) |
| Difference in 2008 | 0.623 (0.516 to 0.731) | 0.652 (0.541 to 0.763) | 0.530 (0.422 to 0.639) |
| **All Outpatient (OLS model)** | | | |
| Deprivation effect in 2004 | 2.536 (2.463 to 2.609) | 1.964 (1.885 to 2.043) | 1.738 (1.666 to 1.809) |
| Difference in 2008 | 0.069 (0.010 to 0.128) | 0.032 (-0.031 to 0.095) | -0.026 (-0.088 to 0.035) |
| **Hip replacement (negative binomial model)** | | | |
| Deprivation effect in 2001 (rate ratio) | 0.992 (0.991 to 0.993) | 0.994 (0.993 to 0.995) | 0.995 (0.994 to 0.997) |
| Difference in 2008 (rate ratio) | 1.002 (1.000 to 1.003) | 1.001 (0.999 to 1.003) | 1.001 (0.999 to 1.002) |
| **Senile Cataract (negative binomial model)** | | | |
| Deprivation effect in 2001 (rate ratio) | 1.011 (1.009 to 1.012) | 1.012 (1.01 to 1.013) | 1.010 (1.008 to 1.011) |
| Difference in 2008 (rate ratio) | 0.998 (0.996 to 1.000) | 0.997 (0.995 to 0.999) | 0.994 (0.993 to 0.996) |
| **Gastroscopy (negative binomial model)** | | | |
| Deprivation effect in 2001 (rate ratio) | 1.014 (1.014 to 1.015) | 1.01 (1.009 to 1.010) | 1.011 (1.010 to 1.011) |
| Difference in 2008 (rate ratio) | 1.000 (0.999 to 1.001) | 1.001 (1.000 to 1.001) | 1.000 (1.000 to 1.001) |
| **Revascularisation (negative binomial model)** | | | |
| Deprivation effect in 2001 (rate ratio) | 1.005 (1.004 to 1.007) | 1.004 (1.003 to 1.005) | 1.003 (1.002 to 1.004) |
| Difference in 2008 (rate ratio) | 1.001 (0.999 to 1.003) | 1.001 (1.000 to 1.003) | 1.001 (0.999 to 1.003) |

**Notes to Table 1:**
1. All coefficients are shown with 95% confidence intervals in brackets.
2. In the OLS models of general utilisation, the deprivation effect shows the additional number of admissions or visits associated with a one percentage point increase in income deprivation, and the difference in 2008 shows the difference in 2008 compared with baseline (2001 for inpatient admissions and 2004 for outpatient visits).
3. In the negative binomial models of procedure-specific utilisation, the deprivation effect shows the proportionate change in utilisation associated with a one percentage point increase in income deprivation, and the difference in 2008 shows the direction of any difference in this association in 2008 compared with 2001.
4. The base model controls for population, age-sex fractions and year only; the base/needs model adds disease prevalence covariates; and the full model adds supply variables (urbanization and NHS administrative area).

There was however a small but significant and systematic increase in the positive deprivation-utilisation association for all non-emergency inpatient admissions, in all three models and in sensitivity analysis using log-linear models of proportional utilisation. Deprivation-year coefficients for previous years were gradually increasing, confirming that this was a systematic change throughout the 2000s rather than a temporary change in 2008/9. To interpret the magnitude of the increase, we can consider the effect of a ten percentage point increase in income deprivation – enough to shift a small area into a higher interval deprivation group (0-10%, 10-20%, 20-30% and 30%+). At baseline in 2001/2, the linear deprivation coefficient of 0.758 in the full model means that a ten percentage point increase in deprivation is associated with an additional 7.58 admissions, or 4.77% of mean neighbourhood admissions in 2001/2 (159). The corresponding deprivation-year coefficient in 2008/9 of 0.530 implies that by 2008/9 the coefficient had risen to 1.288 (0.758 + 0.530). This means that in 2008/9 a ten percentage point increase in deprivation was associated with an additional 12.88 admissions or 5.03% of mean neighbourhood admissions in 2008/9 (256).

## Discussion

### Main findings

Allowing for need, we found no substantial change in the neighbourhood level association between income deprivation and hospital utilisation for either general or procedure-specific indicators. Rates of non-emergency inpatient admission increased slightly faster in more deprived areas than elsewhere between 2001/2 and 2008/9, without a corresponding increase in need for health services as measured by observed disease prevalence. However, there was no significant and systematic change in neighbourhood level socio-economic utilisation patterns for outpatient visits (data only from 2004/5), hip replacement, senile cataract, gastroscopy or revascularisation.

### Trends in average utilisation

Average utilisation trends are not the focus of this paper, as our aim is to test for differences in utilisation trends by socio-economic group. Nevertheless, we can offer the following speculations about the average trends. Average utilisation showed a gradual increase over time in both our summary indicators of utilisation, all elective inpatient admissions and all outpatient visits. This was as expected, given the accelerated expenditure growth during the period. However, three of our specific indicators diverged in interesting respects from the general upward trend. First, cataract surgery had a major peak in 2004, changing from sharply rising to sharply falling. This may reflect a large volume of "catch up" activity in the early 2000s in order to meet waiting time targets, followed by reduced activity thereafter. Following the publication of Action on Cataracts in 2000 (NHS Executive, 2000), the substantial rise in activity in the early 2000s gave rise to concerns about possible over-treatment (Black et al., 2009). Second, gastroscopy had a major trough in 2004, changing from sharply falling to sharply rising. This may reflect publication of guidance on dyspepsia in 2004 by the National Institute for Health and Clinical Excellence, which encouraged GPs to refer patients over 55 for endoscopy when symptoms persist despite Helicobacter pylori testing and acid suppression therapy (NICE, 2004). Prior to this guidance, gastroscopy rates may have been falling due to pressure on theatre time to meet waiting time targets for surgery. Finally, elective coronary revascularisation rose sharply from 2001/2 but then flattened from 2004/5. This rise followed the publication of the National Service Framework for coronary heart disease in 2000 (Department of Health, 2000) and significant investment to increase PCI rates and reduce historically long waiting times for CABG. The plateau from 2004/5 may reflect the shift in clinical practice towards immediate stenting rather than thrombolysis following emergency admission for acute myocardial infarction (Keeley et al., 2003), since our data focused on non-emergency revascularisation.

### Cross sectional findings

In cross section, neighbourhood deprivation was generally associated with higher inpatient hospital utilisation, except in the interesting case of hip replacement to which we return below. This suggests our demographic and disease prevalence variables generally under-estimated need for inpatient hospital services in deprived neighbourhoods. This may be because unobserved disease severity is higher in deprived areas – due to issues such as cumulative material and psycho-social stresses to health over the life course, unhealthy lifestyle behaviour, limited preventive care seeking behaviour, and under-supply of primary care – and disease prevalence may be under-diagnosed. For these reasons, we cannot accurately measure the *level* of socio-economic equity relative to need in cross section.

In relation to inpatient hospital utilisation, our cross sectional findings are consistent with other studies in England and other high income countries (Asada & Kephart, 2007; Gravelle et al., 2003; van Doorslaer et al., 2006). Unlike our study, however, previous studies have often found lower need adjusted utilisation of specialist medical care (McGrail, 2008; van Doorslaer et al., 2004; van Doorslaer et al., 2006). One reason for this apparent discrepancy may be that previous studies have focused on visits to medical specialists, whereas the present study includes outpatient visits in community-based clinics run by nurses and professions allied to medicine.

Like our study, previous studies of hip replacement in the English NHS have found that both observed and need standardised rates of hip replacement are lower in deprived areas (Cookson et al., 2007; Judge et al., 2010). This negative deprivation-utilisation association for hip replacement is commonly attributed to demand factors such as less proactive care seeking behaviour and lower willingness and fitness for surgery among deprived groups compared with affluent groups (Judge et al., 2010). However, it is not known why hip replacement differs in this respect from other inpatient procedures such as senile cataract, gastroscopy and coronary revascularisation. Proactive care seeking behaviour may be particularly important for hip replacement, since morbidity from osteoarthritis is intermittent and the care seeking pathway often requires multiple appearances at health services. Willingness and fitness for surgery may also be particularly important, since there is considerable clinical uncertainty about the appropriate time to move from medical management to surgery.

## Change in equity and the assumption of parallel trends in need

As explained above, we cannot draw conclusions about the *level* of inequity relative to need, because some aspects of need remain unobserved. However, we can draw conclusions about *change* in equity relative to need if we are prepared to assume that unobserved need for inpatient and outpatient hospital services did not increase more rapidly in deprived groups than elsewhere during the 2000s. Three main factors influence trends in unobserved need for hospital services:

1. Change in utilisation of health care
2. Change in medical technology
3. Change in underlying social determinants of health

Non-parallel changes in the utilisation of health care could potentially drive non-parallel changes in the need for health care in future years. But that is not what we observed for hospital inpatient and outpatient services: utilisation ran approximately parallel between deprivation groups. And in relation to primary care, studies suggest that if anything primary care quality improved faster in deprived areas than elsewhere during the 2000s (Doran et al., 2008). So there was no sign of any relative deterioration in the utilisation of either primary or secondary care in deprived areas of a kind that might be expected to drive a relative increase in unobserved need for hospital services in subsequent years. Medical innovation is unlikely to drive differential socio-economic trends in need within high income countries, even though innovation may be socio-economically skewed on a global scale by differential disease patterns between high and low income countries. Finally, underlying social determinants of health may evolve differentially between socio-economic groups over a period of decades, but are unlikely to change substantially over a few years.

An important challenge to this latter argument is the possibility that unobserved need may have grown faster in deprived areas due to non-parallel trends in lifestyle behaviour such as diet, physical exercise and smoking. However, Table 1 offers some evidence to defend our assumption against this challenge. We observed prevalence of a battery of conditions sensitive to lifestyle behaviour including (from 2003-8) cancer, chronic kidney disease, coronary heart disease, diabetes, epilepsy, hypertension, hypothyroidism, stroke, transient ischaemic attack and (from 2006-8) atrial fibrillation, chronic obstructive pulmonary disease, obesity and heart failure. The addition of these covariates substantially reduced the deprivation-utilisation association for inpatient admissions and outpatient visits, suggesting as expected that observed need is generally greater in deprived areas. However, these covariates had little impact on the year-deprivation interaction terms indicating change in the deprivation-utilisation association. This suggests that the relationship between observed need and deprivation did not change much over time. So even if there was a relative worsening of unhealthy lifestyle behaviour in deprived neighbourhoods during this period, this did not have a short term effect on increased disease prevalence and need for specialist health care during the period of this study.

Table 2 offers further evidence. It shows associations between disease prevalence and deprivation by year, after allowing for age and sex. Most of the associations were positive, with rate ratios between 1.001 and 1.016, so that a ten percentage point increase in EDI score is associated with a 1% to 16% increase in disease prevalence. However, the associations did not change much over time. This shows that trends in observed disease prevalence were approximately parallel between deprivation groups during this period. We cannot of course directly measure unobserved aspects of need, in particular disease severity. However, if disease severity increased faster in deprived areas than elsewhere, one would expect this also to show up in the disease prevalence figures.

We therefore conclude that there was no substantial deterioration in small area socio-economic equity in health care in the English NHS from 2001 to 2008. Small area equity may even have improved slightly, with slightly faster growth in non-emergency hospital utilisation relative to need in deprived areas.

**Table 2: Small area associations between disease prevalence and deprivation by year, after allowing for age and sex**

| | **Atrial fibrillation** | **Cancer** | **Chronic kidney disease (*)** |
|---|---|---|---|
| 2003 | N/A | 0.996 (0.995 to 0.996) | 0.997 (0.996 to 0.997) |
| 2004 | N/A | 0.995 (0.995 to 0.996) | 0.997 (0.996 to 0.997) |
| 2005 | N/A | 0.995 (0.995 to 0.996) | 0.997 (0.997 to 0.998) |
| 2006 | 0.996 (0.996 to 0.997) | 0.995 (0.995 to 0.996) | 0.998 (0.997 to 0.998) |
| 2007 | 0.997 (0.996 to 0.997) | 0.996 (0.995 to 0.996) | 1.000 (0.999 to 1.000) |
| 2008 | 0.997 (0.997 to 0.998) | 0.996 (0.995 to 0.996) | 1.000 (1.000 to 1.001) |
| | **Chronic obstructive pulmonary disease** | **Coronary heart disease** | **Diabetes (*)** |
| 2003 | N/A | 1.006 (1.005 to 1.006) | 1.007 (1.006 to 1.007) |
| 2004 | N/A | 1.005 (1.005 to 1.006) | 1.007 (1.007 to 1.007) |
| 2005 | N/A | 1.005 (1.005 to 1.006) | 1.007 (1.007 to 1.007) |
| 2006 | 1.015 (1.015 to 1.016) | 1.006 (1.006 to 1.006) | 1.007 (1.007 to 1.007) |
| 2007 | 1.015 (1.015 to 1.016) | 1.006 (1.006 to 1.007) | 1.007 (1.007 to 1.008) |
| 2008 | 1.016 (1.015 to 1.016) | 1.006 (1.006 to 1.007) | 1.008 (1.007 to 1.008) |
| | **Epilepsy (*)** | **Heart failure** | **Hypertension** |
| 2003 | 1.006 (1.006 to 1.006) | N/A | 1.000 (1.000 to 1.001) |
| 2004 | 1.006 (1.006 to 1.006) | N/A | 1.001 (1.000 to 1.001) |
| 2005 | 1.006 (1.006 to 1.007) | N/A | 1.001 (1.001 to 1.001) |
| 2006 | 1.007 (1.007 to 1.007) | 1.004 (1.004 to 1.005) | 1.002 (1.002 to 1.002) |
| 2007 | 1.007 (1.007 to 1.008) | 1.005 (1.004 to 1.005) | 1.003 (1.003 to 1.003) |
| 2008 | 1.008 (1.007 to 1.008) | 1.005 (1.005 to 1.006) | 1.003 (1.003 to 1.003) |
| | **Hypothyroidism** | **Obesity (*)** | **Stroke and transient ischaemic attack** |
| 2003 | 0.997 (0.996 to 0.997) | N/A | 1.001 (1.001 to 1.001) |
| 2004 | 0.996 (0.996 to 0.997) | N/A | 1.001 (1.000 to 1.001) |
| 2005 | 0.997 (0.996 to 0.997) | N/A | 1.001 (1.000 to 1.001) |
| 2006 | 0.998 (0.998 to 0.998) | 1.010 (1.010 to 1.010) | 1.002 (1.001 to 1.002) |
| 2007 | 0.998 (0.998 to 0.999) | 1.010 (1.010 to 1.011) | 1.002 (1.002 to 1.003) |
| 2008 | 0.999 (0.999 to 0.999) | 1.011 (1.011 to 1.011) | 1.003 (1.002 to 1.003) |

**Notes to Table 2:**

1. Estimated rate ratios with 95% confidence intervals in brackets.
2. These rate ratios can be interpreted as the proportionate change in disease prevalence associated with a one percentage point increase in income deprivation.
3. Estimates are from separate GLM regression models of disease prevalence in each year, with income deprivation and age-sex fractions as covariates.
4. N/A means data not available for this year.

## Strengths and limitations

Strengths our study included (1) the ability to examine change in specific high volume procedures as well as general utilisation of specialist care, (2) the use of data on the entire population rather than a potentially unrepresentative sample, (3) the analysis of year-on-year change in utilisation to check whether changes were systematic or due to selection of atypical endpoint years, and (4) the use of primary care disease prevalence data to measure change in population health need.

Our study also had important limitations. First, this was an ecological study and we can only draw firm conclusions about change in neighbourhood level equity, not individual level equity. In 2005, the mean English small area population was 1,554 and 99% had populations smaller than 2,375; falling to 1,173 and 1,818 respectively if we focus on adults age 20 or over. These are small populations, and English neighbourhoods are segregated by socio-economic status. So if there were a substantial change in individual level equity one would expect this to show up as a change in neighbourhood level equity. Nevertheless, there is considerable individual level heterogeneity in socio-economic status within small areas: not all socio-economically disadvantaged individuals live in low income neighbourhoods, and *vice versa.* Second, data on privately funded hospital care were not available. Privately funded hospital use made up a small and declining share of total hospital activity in England during the period, due to falling NHS waiting times. This shift in demand may have disproportionately increased NHS utilisation in affluent areas, which other things equal would show up as a worsening of equity on our measure. This reinforces our conclusion that if anything equity was improving during this period. Third, our data contained coding errors which may have varied systematically between hospitals with different coding practices. This cannot bias our estimates for general indicators of hospital utilisation, which captured all activity irrespective of coding, though is a potential issue for the procedure-specific indicators. However, any such bias was likely small as there is no reason to suppose that change in hospital coding practices was systematically and substantially related to the deprivation mix of hospital patient intake. Fourth, there was substantially incomplete reporting of hospital utilisation data for Independent Sector (IS) providers treating NHS funded patients from 2003/4 to 2005/6. This missing data could in theory obscure disproportionate rises in IS activity in affluent neighbourhoods in those years. However, only a small proportion of total NHS hospital utilisation data was missing (see Appendix Table A3). Furthermore, IS patients were not much more likely to live in affluent areas than other NHS patients: one study found mean area deprivation of IS patients was only 1.56 percentage points lower (Mason et al., 2010).

## Policy implications

Together with the findings of previous studies, our findings suggest there was little change over the last two decades in socio-economic equity in the delivery of health care in the English NHS. Small area studies of hospital utilisation in the English NHS from 1991 to 2001 found no change in socio-economic equity in coronary revascularisation and a small reduction for hip replacement (Cookson et al., 2007; Cookson et al., 2010). Patient level studies of the English NHS from the late 1990s to the mid 2000s using small area deprivation measures found little change in socio-economic variations in hospital waiting times (Cooper et al., 2009) or in proportions of patients receiving preferred treatments colorectal, breast and lung cancer (Raine et al., 2010). This was despite substantial variations in spending growth between the 1990s and 2000s, and the introduction of major pro-competition health reforms in both decades. This suggests that socio-economic inequity in utilisation of health care in the English NHS may reflect slow changing demand factors relating to patient care-seeking behaviour, rather than supply factors that respond to short term changes in NHS spending growth and reform.

## References

AHRQ. (2009). *National healthcare disparities report*, 2009. Agency for Healthcare Research and Quality.

Appleby J, Crawford R, Emmerson C. (2009). How cold will it be? Prospects for NHS funding: 2011–17. London: Kings Fund.

Appleby J, Harrison A, Devlin N. (2003). *What is the real cost of more patient choice?* London: Kings Fund.

Asada Y, Kephart G. (2007). Equity in health services use and intensity of use in Canada. *BMC Health Services Research,* 7.

Barr DA, Fenton L, Blane D. (2008). The claim for patient choice and equity. *Journal of Medical Ethics* 34:271-274.

Bilheimer LT, Klein RJ. (2010). Data and measurement issues in the analysis of health disparities. *Health Serv Res* 45;1489-1507.

Black N, Browne J, van der Meulen J, Jamieson L, Copley L, Lewsey J. (2009). Is there overutilisation of cataract surgery in England? *Br J Ophthalmol* 93:13-17.

Blair T. (2003) We must not waste this precious period of power. Speech given at South Camden Community College, 23 January 2003.

Cookson R, Dusheiko M, Hardman G. (2007). Socioeconomic inequality in small area use of elective total hip replacement in the English National Health Service in 1991 and 2001. *J Health Serv Res Policy* 12;Suppl 1;S1-10-17.

Cookson R, Dusheiko M, Hardman G, Martin S. (2010). Competition and inequality: evidence from the English National Health Service 1991-2001. *Journal of Public Administration Research and Theory* 20:I181-I205.

Cooper Z, McGuire A, Jones S, Le Grand J. (2009). Equity, waiting times, and NHS reforms: retrospective study. *BMJ* 339:b3264.

Department of Health. (2000). Coronary heart disease: national service framework for coronary heart disease - modern standards and service models. London: Department of Health.

Department of Health. (2003). Building on the best: choice, responsiveness and equity in the NHS. London: HMSO.

Dixon A, Le Grand J. (2006). Is greater patient choice consistent with equity? The case of the English NHS. *J Health Serv Res Policy* 11:162-166.

Dixon A, Le Grand J, Henderson J, Murray R, Poteliakhoff E. (2007). Is the British National Health Service equitable? The evidence on socioeconomic differences in utilization. *J Health Serv Res Policy* 12:104-109.

Doran T, Fullwood C, Kontopantelis E, Reeves D. (2008). Effect of financial incentives on inequalities in the delivery of primary clinical care in England: analysis of clinical activity indicators for the quality and outcomes framework. *Lancet* 372:728-736.

Gravelle H, Morris S, Sutton M. (2006). Economic studies of equity in the consumption of health care. In A. Jones (Ed.), *Elgar Companion to Health Economics* pp. 193-204): Edward Elgar.

Gravelle H, Sutton M, Morris S, Windmeijer F, Leyland A, Dibben C, et al. (2003). Modelling supply and demand influences on the use of health care: implications for deriving a needs-based capitation formula. *Health Economics* 12;985-1004.

Information Centre for Health and Social Care. (2009a). *Attribution data set*. Leeds: Information Centre for Health and Social Care.

Information Centre for Health and Social Care. (2009b). *Hospital Episode Statistics*. Leeds: Information Centre for Health and Social Care.

Information Centre for Health and Social Care. (2009c). Quality and Outcomes Framework Achievement Data 2008/09. Leeds: Information Centre for Health and Social Care.

Judge A, Welton NJ, Sandhu J, Ben-Shlomo Y. (2010). Equity in access to total joint replacement of the hip and knee in England: cross sectional study. *British Medical Journal* 341.

Keeley EC, Boura JA, Grines CL. (2003). Primary angioplasty versus intravenous thrombolytic therapy for acute myocardial infarction: a quantitative review of 23 randomised trials. *Lancet* 361:13-20.

Le Grand J. (2006). Equality and choice in public services. *Social Research* 73:695-710.

Mason A, Street A, Verzulli R. (2010). Private sector treatment centres are treating less complex patients than the NHS. *J R Soc Med* 103:322-331.

McGrail K. (2008). Income-related Inequities: cross-sectional analyses of the use of Medicare services in British Columbia in 1992 and 2002. *Open Medicine* 2:3-10.

Milner PC, Payne JN, Stanfield RC, Lewis PA, Jennison C, Saul C. (2004). Inequalities in accessing hip joint replacement for people in need. *European Journal of Public Health* 14:58-62.

Morris S, Sutton M, Gravelle H. (2005). Inequity and inequality in the use of health care in England: an empirical investigation. *Social Science & Medicine* 60:1251-1266.

NHS Executive. (2000). *Action on cataracts: good practice guidance*. London: Department of Health.

NICE. (2004). *Clinical guideline 17: Dyspepsia - Management of dyspepsia in adults in primary care*. London: NICE.

Noble M, McClennan D, Whitworth A. (2009). *Tracking neighbourhoods: the English Economic Deprivation Indices* 2008. London.

O'Donnell O, van Doorslaer EV, Wagstaff A, Lindelow M. (2008). *Analyzing health equity using household survey data : a guide to techniques and their implementation*. Washington, D.C.: World Bank.

OECD. (2010). *OECD Health 2010: selected data*. Organisation for Economic Cooperation and Development.

Office for National Statistics. (2006). *Neighbourhood statistics service annual report to Ministers* 2005/06.

Office for National Statistics. (2009). Methodology note on production of super output area population estimates.

Oliver A, Evans JG. (2005). The paradox of promoting choice in a collectivist system. *Journal of Medical Ethics* 31:187-187.

Propper C, Eachus J, Chan P, Pearson N, Smith GD. (2005). Access to health care resources in the UK: the case of care for arthritis. *Health Econ* 14:391-406.

Propper C, Sutton M, Whitnal, C, Windmeijer F. (2008). Did 'targets and terror' reduce waiting times in England for hospital care? *B E Journal of Economic Analysis & Policy* 8.

Propper C, Sutton M, Whitnall C, Windmeijer F. (2010). Incentives and targets in hospital care: Evidence from a natural experiment. *Journal of Public Economics* 94:318-335.

Propper C, Wilson D, Burgess S. (2006). Extending choice in English health care: The implications of the economic evidence. *Journal of Social Policy* 35:537-557.

Quatromoni J, Jones R. (2008). Inequalities in socio-economic status and invasive procedures for coronary heart disease: a comparison between the USA and the UK. *International Journal of Clinical Practice* 62:1910-1919.

Raine R, Wong W, Scholes S, Ashton C, Obichere A, Ambler G. (2010). Social variations in access to hospital care for patients with colorectal, breast, and lung cancer between 1999 and 2006: retrospective analysis of hospital episode statistics. *British Medical Journal* 340.

Roland M. (2004). Linking physicians' pay to the quality of care--a major experiment in the United kingdom. *N Engl J Med* 351:1448-1454.

Tudor-Hart J. (2006). *The political economy of health care : a clinical perspective*. Bristol: Policy Press.

van Doorslaer E, Koolman X, Jones AM. (2004). Explaining income-related inequalities in doctor utilisation in Europe. *Health Economics* 13:629-647.

van Doorslaer E, Masseria C, Koolman X, Grp, O.H.E.R. (2006). Inequalities in access to medical care by income in developed countries. *Canadian Medical Association Journal* 174:177-183.

# Appendix: Further details of data and coding procedures

## Hospital Episode Statistics

The national Hospital Episode Statistics (HES) database covers all patients admitted to hospital in the English NHS and all patients admitted to an outpatient visit. Anonymous records were extracted by financial year and summed to the patient's small area of residence. Observations were excluded if there were missing data fields for small area or age, which occurred in a very small proportion of cases (fewer than half of 1%), or if there were duplicate records. For inpatient activity, hospital episode records were linked in the form of Continuous Inpatient Spells that include patient transfers between different consultants within the same hospital and across different hospitals until final discharge home. This enabled us to count total hospital admissions more appropriately, by avoiding double counting when the patient care pathway involves several episodes of care before final discharge home.

***Coding of Independent Sector (IS) activity***

We included data on Independent Sector (IS) providers of NHS hospital care, including IS providers under local contracts as well as Independent Sector Treatment Centres (ISTCs) under national contracts. IS activity reporting was substantially incomplete in the early years of the ISTC programme from 2003/4 to 2005/6. During those three years, we had to drop respectively 29%, 76% and 28% of IS activity data due to missing codes. However, this dropped data made up respectively only 0.1, 0.24 and 0.12 of one percent of total NHS non-emergency inpatient activity. For all non-emergency admissions, IS activity made up 0.08% of activity in 2004/5, rising to 0.31% in 2005/6, 1.12% in 2006/7, 1.42% in 2007/8 and 2.17% in 2008/9 (see Table A3 for details). Coding of IS activity has improved since 2006/7, and according to the NHS Information Centre (NHS Information Centre 2009) data validity in 2008/9 for the primary procedure OPCS code used to identify hip replacement, cataract, gastroscopy and revascularization activity was 87.94% in ISTCs compared with 94.43% in NHS Trusts.

*All elective (non-emergency) acute hospital inpatient admissions* - All elective inpatient admissions were extracted for individuals aged 18 and over in financial years 2001/2 through 2008/9. We focus on elective admissions to acute NHS Hospital Trusts and independent sector providers, excluding admissions to Primary Care Trusts and mental health care trusts.

*Outpatient visits* - Outpatient visits were extracted from the HES outpatient database for individuals aged 18 and over in financial years 2004/5 to 2008/9. Outpatient data collection began on an experimental basis in 2003/4 and acceptably complete data were reported in HES from 2004/5 onwards, though data quality continued to improve throughout the period of this study. We exclude multiple visits by the same individual in the same year, and we also exclude appointments which the individual did not attend since this does not represent beneficial utilisation of health care and we want our indicator to be sensitive to potential changes in barriers to attendance. The outpatient database includes secondary care appointments not only in hospitals but also in community settings (such as health centres, residential care homes and the patient's own home), and under the care not only of medical doctors but also professions allied to medicine (such as chiropodists, dieticians and physiotherapists) and other health professionals (such as nurses and midwives). As with our inpatient admissions indicator, we excluded outpatient visits in mental health specialities in order to focus as closely as possible on outpatient visits relating to acute hospital care. Data quality in the outpatient dataset did not allow a more refined selection of outpatient activity relating to acute hospital care only.

*Elective primary hip replacement surgery* –Primary hip replacement admissions were extracted for patients aged 45 and over. These patients represent the vast majority of people in need of elective hip replacement, and focusing on this age group limits heterogeneity in need for this procedure. Elective primary total prosthetic replacement of the hip joint was identified under OPCS-4 codes W37.1, W38.1 and W39.1 as reported under the main operation. These OPCS-4 codes represent the three main variants of this procedure – "using cement", "not using cement", and "not elsewhere classified". To keep the interpretation as clean and simple as possible we aim to avoid heterogeneity in the type of procedure. We therefore exclude patients coming for revisions or conversions of previous hip operations.

*Elective senile cataract surgery* - Elective senile cataract surgery admissions were extracted for patients aged 45 and over. These patients were identified by OPCS-4 codes C71, C72, C74, C75 reported in their main operation and ICD-10 codes H25 and R69 in their primary diagnosis. The H25 code explicitly identifies a diagnosis of senile cataract, while the R69 code covers "unknown and unspecified" causes of morbidity and is mostly reported by independent sector providers together with the relevant OPCS-4 codes. The R69 code helps us to identify cataract surgery activity by these providers that would otherwise be excluded due to incomplete coding.

*Diagnostic gastroscopy* **-** Inpatient elective admissions involving a diagnostic endoscopic examination of the upper gastrointestinal tract (oesophagus, stomach and duodenum) were extracted for patients aged 18 and over. These patients were identified by OPCS-4 code G45 reported in their primary procedure, as our aim was to focus on patients admitted for diagnostic gastroscopy rather than patients admitted for some other procedure who were then subsequently referred for gastroscopy as part of further investigations carried out at a later stage of their spell in hospital.

*Elective coronary revascularisation* - Coronary revascularisation consists of percutaneous coronary intervention (PCI) and coronary artery bypass grafting (CABG). Elective revascularisation admissions were extracted for patients age 45 and over. Patients were identified using OPCS-4 codes K40-K46, K49-50 and K75 reported under the main operation.

## ONS Mid-Year Population Estimates

For each year, data on small area population size and age-sex structure in 5 year age groups were obtained from ONS mid-year population estimates. Utilisation rates are calculated by dividing utilisation counts by mid-year population estimates for the appropriate age groups, and expressing as rates per 100,000 general population.

## Neighbourhood Deprivation Variables

The Economic Deprivation Index (EDI) 2008 was produced by the Social Disadvantage Research Centre at the University of Oxford for the Department of Communities and Local Government (DCLG), and is published on the DCLG website. The EDI income deprivation index indicates the proportion of the LSOA population aged from 0 to 60 who were living in households receiving one of two out-of-work means-tested benefits: Income Support (IS) or income-based Job Seekers Allowance (JSA-IB). The index is based on ONS mid-year population estimates and benefit claims data from the Department of Work and Pensions. In sensitivity analysis we also use two time-fixed indices from the Index of Multiple Deprivation 2004, both of which measure small area deprivation in the population census year of 2001 – the all age income deprivation index and the index of income deprivation affecting older people. These three deprivation indices are all highly correlated with one another. The EDI index covers each year from 1999 to 2005, and for years 2006, 2007 and 2008 we use the 2005 values.

Analyses conducted using English area deprivation indices developed in the 1990s, such as the Townsend and Carstairs indices, typically categorize areas into fourths or fifths of the index. However, since our EDI index is on a cardinal scale – a simple proportion from 0 to 100 – we prefer to categorize areas into groups using an interval split that exploits this additional information. This interval split makes it easier to compare the graphical analysis with our more general statistical analysis, which treats EDI as a continuous cardinal variable on a scale of 0 to 100. It also gives more information about trends at the more deprived end of the distribution, since our two more deprived interval groups are approximately the most deprived two tenths of areas. It is worth taking an in-depth look at the more deprived end of the spectrum, because (i) there are particular equity concerns about the most severely disadvantaged "sink estate" areas of England and (ii) sharp falls in utilisation emerge at this point in the deprivation gradient for both hip replacement and coronary revascularization (unlike the other indicators, which show a smooth gradient across deprivation fifths).

## QOF Data on Disease Prevalence

Estimates of disease prevalence at GP practice level are obtained from Quality and Outcomes Framework (QOF) disease registers submitted to the national Quality Management and Analysis System (QMAS). This data covers more than 99% of GP practices in England. The data show the proportion of individuals registered to each GP practice who are recorded as having the disease in question. We attribute this to small area level using the Attribution Dataset of patient registration addresses within GP practices. We assume that neighbourhood prevalence is a weighted sum of the prevalence in each GP practice serving that neighbourhood, with weights proportional to the number of neighbourhood residents registered with each GP practice. Both the QOF data and attribution data were obtained from the NHS Information Centre.

### Geoconvert Matching of Small Areas to Primary Care Trusts

Small areas are mapped to 152 PCTs locked at 2006 boundary configurations using the “Geoconvert” online geography matching and conversion tool (http://geoconvert.mimas.ac.uk/). Small areas intersecting with two PCTs are attributed to the PCT with the largest portion of the LSOA’s territory. From 1 October 2006, 303 PCTs merged into 152 PCTs.

**Table A1: Observed Utilisation Rates by Year and Deprivation**

| | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|
| **Hip replacement rate per 100,000** | | | | | | | | |
| All | 178 | 195 | 212 | 209 | 210 | 203 | 221 | 230 |
| Deprived small areas (EDI > 20%) | 157 | 171 | 179 | 173 | 177 | 164 | 187 | 185 |
| Non deprived small areas | 183 | 200 | 218 | 216 | 216 | 209 | 227 | 238 |
| **Senile cataract rate per 100,000** | | | | | | | | |
| All | 471 | 523 | 597 | 637 | 558 | 510 | 500 | 504 |
| Deprived small areas (EDI > 20%) | 584 | 632 | 720 | 739 | 615 | 579 | 569 | 542 |
| Non deprived small areas | 446 | 501 | 573 | 618 | 549 | 499 | 488 | 498 |
| **Gastroscopy rate per 100,000** | | | | | | | | |
| All | 948 | 935 | 894 | 836 | 852 | 917 | 966 | 1062 |
| Deprived small areas (EDI > 20%) | 1136 | 1097 | 1039 | 938 | 959 | 1060 | 1107 | 1191 |
| Non deprived small areas | 902 | 897 | 861 | 814 | 831 | 888 | 937 | 1036 |
| **Revascularisation rate per 100,000** | | | | | | | | |
| All | 159 | 174 | 186 | 206 | 202 | 202 | 199 | 197 |
| Deprived small areas (EDI > 20%) | 178 | 196 | 209 | 229 | 228 | 227 | 222 | 216 |
| Non deprived small areas | 155 | 169 | 182 | 202 | 197 | 198 | 195 | 194 |
| **All elective inpatient admissions rate per 100,000** | | | | | | | | |
| All | 13,959 | 14,521 | 15,063 | 15,055 | 15,958 | 16,737 | 16,818 | 18,863 |
| Deprived small areas (EDI > 20%) | 15,334 | 15,926 | 16,524 | 16,494 | 17,426 | 18,140 | 18,356 | 20,434 |
| Non deprived small areas | 13,620 | 14,191 | 14,725 | 14,749 | 15,662 | 16,453 | 16,507 | 18,544 |
| **All outpatient appointments rate per 100,000** | | | | | | | | |
| All | N/A | N/A | N/A | 32,790 | 34,329 | 33,900 | 34,105 | 35,506 |
| Deprived small areas (EDI > 20%) | N/A | N/A | N/A | 36,015 | 37,510 | 37,188 | 37,033 | 38,192 |
| Non deprived small areas | N/A | N/A | N/A | 32,103 | 33,686 | 33,234 | 33,512 | 34,961 |

**Notes to Table A1:**

1. For all elective, all outpatient and gastroscopy we use populations aged 18 and over; for all other procedures we use populations aged 45 and over.
2. Our inpatient data includes multiple admissions for the same patient in the same year, whereas our outpatient data counts each patient only once.
3. Acceptably complete outpatient HES data is not available before 2004/5.
4. Deprived small areas are those in which 20% or more of individuals are living in households receiving low income benefits.

**Table A2: Small Area Mean Values of Deprivation and Control Variables by Year**

| | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|
| **Deprivation variables** | | | | | | | | |
| EDI income deprivation (small area mean) | 11.9% | 11.5% | 11.4% | 10.9% | 10.7% | 10.7% | 10.7% | 10.7% |
| Four deprivation groups of small areas defined by intervals of EDI (proportion of small areas in each group) | | | | | | | | |
| Group 1: EDI income deprivation = 0-10% | 57% | 58% | 58% | 60% | 60% | 60% | 60% | 60% |
| Group 2: EDI income deprivation = 10%-20% | 22% | 22% | 22% | 22% | 22% | 22% | 22% | 22% |
| Group 3: EDI income deprivation = 20%-30% | 12% | 12% | 12% | 11% | 11% | 11% | 11% | 11% |
| Group 4: EDI income deprivation > 30% | 9% | 9% | 8% | 7% | 7% | 7% | 7% | 7% |
| All | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| **Disease prevalence variables (small area mean)** | | | | | | | | |
| Atrial fibrillation | N/A | N/A | N/A | N/A | N/A | 1.3% | 1.3% | 1.4% |
| Cancer | N/A | N/A | N/A | 0.5% | 0.7% | 0.9% | 1.1% | 1.3% |
| Chronic kidney disease | N/A | N/A | N/A | N/A | N/A | 2.4% | 3.0% | 3.2% |
| Chronic obstructive pulmonary disease | N/A | N/A | N/A | 1.4% | 1.4% | 1.4% | 1.5% | 1.5% |
| Coronary heart disease | N/A | N/A | N/A | 3.6% | 3.6% | 3.6% | 3.5% | 3.5% |
| Diabetes | N/A | N/A | N/A | 3.3% | 3.5% | 3.6% | 3.9% | 4.1% |
| Epilepsy | N/A | N/A | N/A | 0.6% | 0.6% | 0.6% | 0.6% | 0.6% |
| Heart failure | N/A | N/A | N/A | N/A | N/A | 0.8% | 0.8% | 0.7% |
| Hypertension | N/A | N/A | N/A | 11.3% | 11.9% | 12.5% | 12.9% | 13.2% |
| Hypothyroidism | N/A | N/A | N/A | 2.2% | 2.4% | 2.6% | 2.7% | 2.9% |
| Obesity | N/A | N/A | N/A | N/A | N/A | 7.4% | 7.6% | 8.1% |
| Stroke and transient ischaemic attack | N/A | N/A | N/A | 1.5% | 1.6% | 1.6% | 1.6% | 1.7% |
| **Rurality variables (proportion of small areas)** | | | | | | | | |
| Villages, hamlets and isolated dwellings | 9.1% | 9.1% | 9.1% | 9.1% | 9.1% | 9.1% | 9.1% | 9.1% |
| Small towns and fringe areas | 9.5% | 9.5% | 9.5% | 9.5% | 9.5% | 9.5% | 9.5% | 9.5% |
| Urban settlements with population > 10,000 | 81.4% | 81.4% | 81.4% | 81.4% | 81.4% | 81.4% | 81.4% | 81.4% |
| All | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |

**Notes to Table A2:**

1. EDI income deprivation is the proportion of individuals aged under 60 living in households receiving low income benefits, from the Economic Deprivation Index 2008. The EDI data series stops in 2005, so fixed 2005 values are used for 2006, 2007 and 2008.
2. N/A means data not available for that year.
3. All disease prevalence variables use all age practice list size as the population denominator. However, the four variables denoted (*) use age specific disease registers in the population numerator. Diabetes prevalence is based on patients aged 17 and over; epilepsy and chronic kidney disease is based on patients aged 18 and over; and obesity prevalence is based on patients aged 16 and over.

**Table A3: Total Inpatient Admissions by Year Comparing NHS and Independent Sector Activity**

| | | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | Average (all years) |
|---|---|---|---|---|---|---|---|---|---|---|
| **all outpatient visits** | Total NHS | N/A | N/A | N/A | 12,396,090 | 13,115,410 | 13,062,610 | 13,276,500 | 13,935,270 | 13,157,176 |
| **all elective inpatient admissions** | Total NHS | 5,181,858 | 5,418,148 | 5,649,347 | 5,680,005 | 6,082,163 | 6,430,688 | 6,515,212 | 7,371,928 | 6,041,169 |
| | IS | 0 | 0 | 1,078 | 4,293 | 18,980 | 72,307 | 92,416 | 159,881 | 43,619 |
| | IS as % Total NHS | 0.00% | 0.00% | 0.02% | 0.08% | 0.31% | 1.12% | 1.42% | 2.17% | 0.64% |
| **hip replacement** | Total NHS | 34,829 | 38,472 | 42,192 | 42,119 | 42,774 | 42,135 | 46,079 | 51,316 | 42,490 |
| | IS | 0 | 0 | 398 | 1,140 | 1,183 | 1,790 | 3,942 | 6,127 | 1,823 |
| | IS as % Total NHS | 0.00% | 0.00% | 0.94% | 2.71% | 2.77% | 4.25% | 8.55% | 11.94% | 3.89% |
| **senile cataract** | Total NHS | 92,022 | 103,257 | 118,950 | 129,591 | 113,592 | 106,454 | 104,076 | 105,192 | 109,142 |
| | IS | 0 | 0 | 0 | 5,493 | 3,991 | 7,012 | 6,200 | 5,564 | 3,533 |
| | IS as % Total NHS | 0.00% | 0.00% | 0.00% | 4.24% | 3.51% | 6.59% | 5.96% | 5.29% | 3.20% |
| **gastroscopy** | Total NHS | 351,904 | 349,050 | 335,459 | 315,603 | 325,249 | 353,699 | 374,196 | 419,858 | 353,127 |
| | IS | 0 | 0 | 7 | 12 | 745 | 3,662 | 6,054 | 9,132 | 2,452 |
| | IS as % Total NHS | 0.00% | 0.00% | 0.00% | 0.00% | 0.23% | 1.04% | 1.62% | 2.18% | 0.63% |
| **coronary revascularization** | Total NHS | 31,130 | 34,333 | 37,080 | 41,468 | 40,972 | 41,652 | 41,484 | 47,481 | 39,450 |
| | IS | 0 | 0 | 309 | 49 | 13 | 1 | 69 | 155 | 75 |
| | IS as % Total NHS | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |

**Notes to Table A3:**

1. Independent sector activity includes some locally commissioned activity as well as nationally commissioned activity from the Independent Sector Treatment Centre programme.
2. It is not possible to compare NHS and independent sector activity for outpatient visits, since the Hospital Episode Statistics outpatient dataset does not code independent sector activity.