Web Appendices - **The impact of NHS resource allocation policy on health inequalities in England 2001-2011 A longitudinal ecological study**

Appendix 1. The parameters used to determine mortality amenable to healthcare.

The NHS Information Centre defines deaths considered amenable to health care as those from the following causes for the specific age groups stated. Deaths are classified by underlying cause of death, registered in the respective calendar years and analysed collectively.

Intestinal infections (ICD-10 A00-A09, ICD-9 001-009, ages 0-14 years;
Tuberculosis (ICD-10 A15-A19, B90; ICD-9 010-018, 137), ages 0-74 years;
Other infectious diseases (diptheria, tetanus, poliomyelitis) (ICD-10 A36, A35, A80; ICD-9 032, 037, 045), ages 0-74 years;
Whooping cough (ICD-10 A37, ICD-9 033), ages 0-14 years;
Septicaemia (ICD-10 A40-A41, ICD-9 038), ages 0-74 years;
Measles (ICD-10 B05, ICD-9 055), ages 1-14 years;
Malignant neoplasm of colon and rectum (ICD-10 C18-C21, ICD-9 153-154), ages 0-74 years;
Malignant neoplasm of skin (ICD-10 C44, ICD-9 173), ages 0-74 years;
Malignant neoplasm of female breast (ICD-10 C50, ICD-9 174), ages 0-74 years;
Malignant neoplasm of cervix uteri (ICD-10 C53, ICD-9 180), ages 0-74 years;
Malignant neoplasm of unspecified part of the uterus and body of the uterus (ICD-10 C54-C55, ICD-9 179, 182), ages 0-44 years;
Malignant neoplasm of testis (ICD-10 C62, ICD-9 186), 0-74 years;
Hodgkin's disease (ICD-10 C81, ICD-9 201), ages 0-74 years;
Leukaemia (ICD-10 C91-C95, ICD-9 204-208), ages 0-44 years;
Diseases of the thyroid (ICD-10 E00-E07, ICD-9 240-246), ages 0-74 years;
Diabetes mellitus (ICD-10 E10-E14, ICD-9 250), ages 0-49 years;
Epilepsy (ICD-10 G40-G41, ICD-9 345), 0-74 years;
Chronic rheumatic heart disease (ICD-10 I05-I09, ICD-9 393-398), ages 0-74 years;
Hypertensive disease (ICD-10 I10-I13, I15 ; ICD-9 401-405), ages 0-74 years;
Ischaemic heart disease (ICD-10 I20-I25, ICD-9 410-414), ages 0-74 years;
Cerebrovascular disease (ICD-10 I60-I69, ICD-9 430-438), ages 0-74 years;
All respiratory diseases (excl. pneumonia, influenza and asthma) (ICD-10 J00-J09, J20-J44, J47-J99; ICD-9 460-479, 488-492, 494-519), ages 1-14 years;
Influenza (ICD-10 J10-J11, ICD-9 487), ages 0-74 years;
Pneumonia (ICD-10 J12-J18, ICD-9 480-486), ages 0-74 years;
Asthma (ICD-10 J45-J46, ICD-9 493), ages 0-44 years;
Peptic ulcer (ICD-10 K25-K27, ICD-9 531-533), ages 0-74 years;
Appendicitis (ICD-10 K35-K38, ICD-9 540-543), ages 0-74 years;
Abdominal hernia (ICD-10 K40-K46, ICD-9 550-553), ages 0-74 years;
Cholelithiasis & cholecystitis (ICD-10 K80-K81, ICD-9 574-575.1), ages 0-74 years;
Nephritis and nephrosis (ICD-10 N00-N07, N17-N19, N25-N27; ICD-9 580-589), ages 0-74 years;
Benign prostatic hyperplasia (ICD-10 N40, ICD-9 600), ages 0-74 years;
Maternal deaths (ICD-10 O00-O99, ICD-9 630-676), ages 0-74 years;
Congenital cardiovascular anomalies (ICD-10 Q20-Q28, ICD-9 745-747), ages 0-74 years;
Perinatal deaths (all causes excl. stillbirths), ages 0-6 days;
Misadventures to patients during surgical and medical care (ICD-10 Y60-Y69, Y83-Y84; ICD-9 E870-E876, E878-E879), ages 0-74 years.

Appendix 2. Model Formula

Model equation:

Equation 1: $Mortality_{i,t} = \beta_1 Allocation_{i,t} + \beta_2 GDHI_{i,t} + \beta_3 UNEMP_{i,t} + IMDQ_i \times Allocation_{i,t} + \mu_i + t + \varepsilon_{i,t}$

Where *i* is the English Local authority area and *t* is the year. $Mortality_{i,t}$ $Allocation_{i,t}$, $GDHI_{i,t}$ and $UNEMP_{i,t}$ are the mortality rate, NHS allocation, GDHI and unemployment rate in local authority i in year t. $IMDQ_i$ is the quintile of deprivation of local authority i. μ is a set of local authority dummy variables, and *t* is an annual time-trend.

Model equation for relative change.

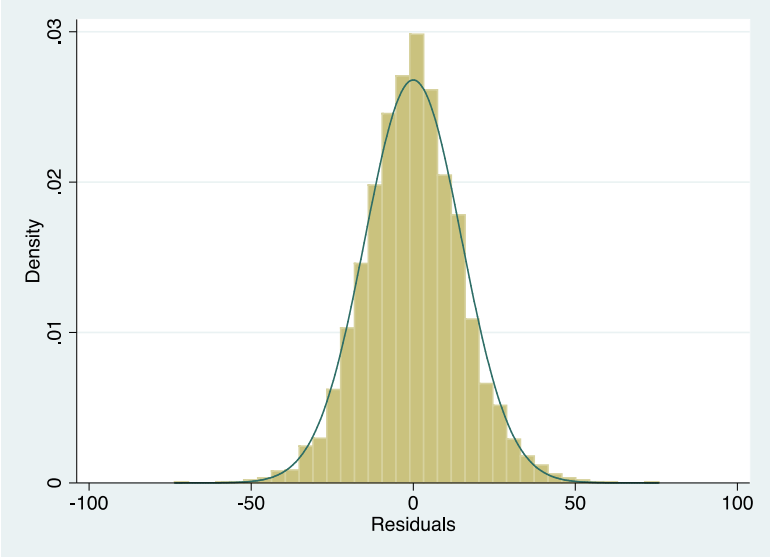
Equation 2: $\ln(Mortality)_{i,t} = \beta_1 \ln(Allocation)_{i,t} + \beta_2 GDHI_{i,t} + \beta_3 UNEMP_{i,t} + \mu_i + t + + \varepsilon_{i,t}$

Appendix 3. Regression diagnostics.

2. Checking normality assumption for equation 1.

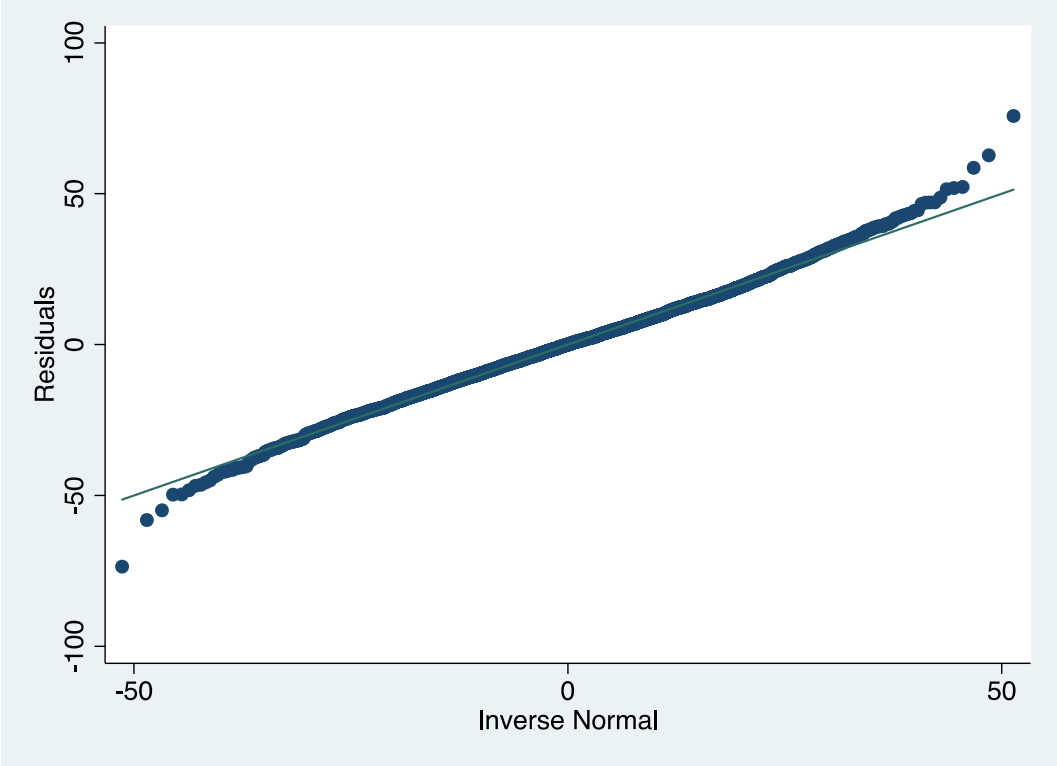
First we check the normality assumptions of the residuals from our model.

Figure 1 . Checking normality of residuals -- histogram of residuals



The residuals appear normally distributed,. This is confirmed by plotting the quantiles of the residuals against the quantiles of the normal distribution (see below)

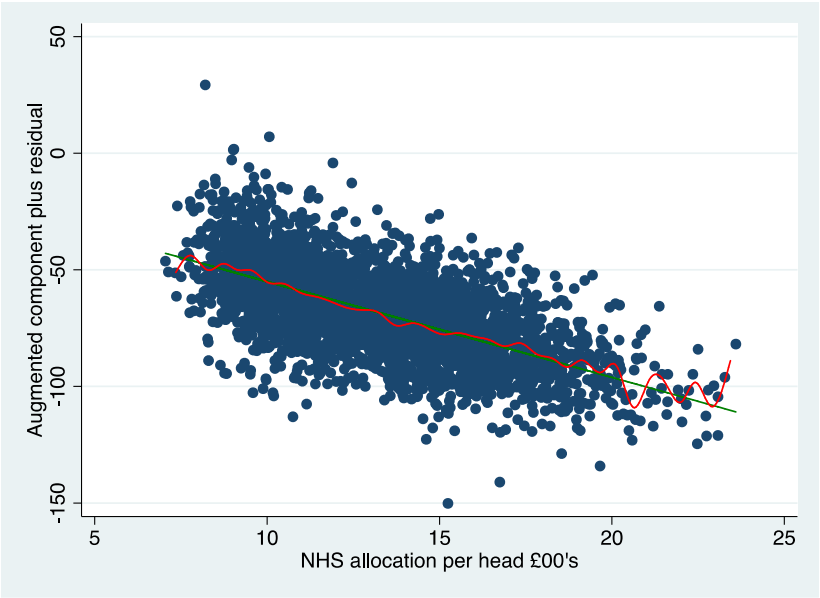
Figure 2 . Checking normality of residuals -- Quantiles of residuals against quantiles of normal distribution



2. Testing linearity assumptions.

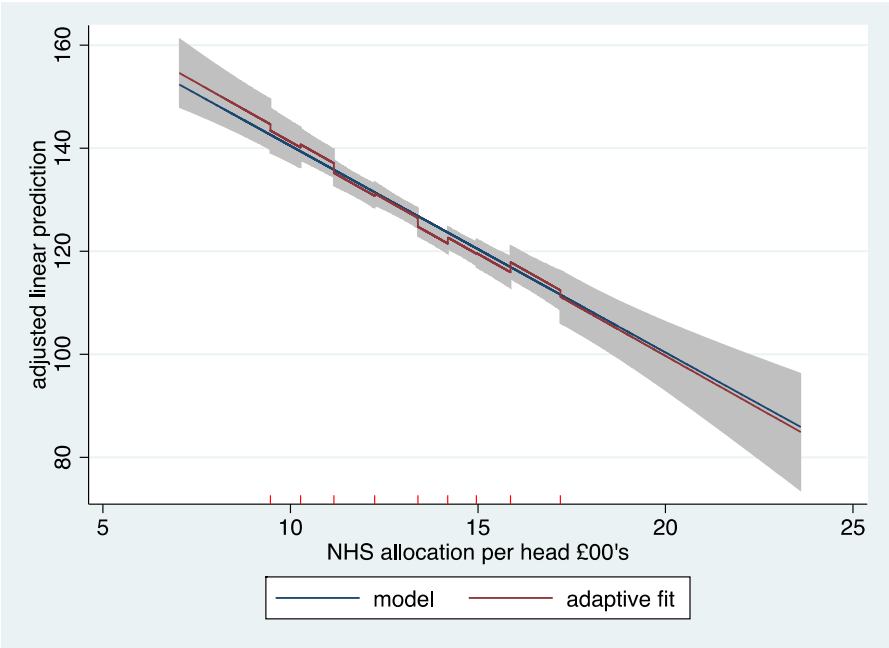
The linearity assumption is assessed using an augmented component plus residual plot (acrplot) with a median spline. In the plot below the smoothed line is close to the ordinary regression line, and the entire pattern seems pretty uniform, indicating that assuming a linear relationship is reasonable.

Figure 3. Augmented component plus residual pot – showing linear relationship between NHS allocation and decline in mortality amenable to healthcare (Male mortality in most deprived 20% of areas 2001 -2011)



The linearity assumption can be further tested by categorizing the main exposure variable into bins, refitting the model including dummy variables for the bins, and then performing a joint Wald test for the added parameters[1]. A significant test result indicates that the linearity assumption is violated.

Figure 4. linear predictions from the base model and the adaptive fit (with NHS allocation categorised into bins) against the predictor with all other variables set to their mean. (Male mortality in most deprived 20% of areas 2001 -2011).



Nonlinearity test (Joint Wald test): p= 0.1634

Appendix 4– Alternative specifications.

Table 1. The absolute reduction in under 75 year old deaths from causes amenable to healthcare 2001-2011 associated with the absolute increase in the allocation of increased NHS funds. ***Adjusted for separate linear trends for each LA.***

	% decrease in mortality amenable to health for each 10% increase in NHS funds allocated **[95%CI]**		
Women	0.88	1.55	0.22
R^2 =0.68			
Men	2.38	3.35	1.41
R^2 =0.78			

Notes: 95% confidence intervals in brackets based on robust standard errors. Model based on equation 1 in appendix 1. Model adjusted for LA, annual trend, separate trends in each LA, annual unemployment rate and annual average household income per head (GDHI) for each LA.

Table 2. The percentage reduction in under 75 year old deaths from causes amenable to healthcare 2001-2011 associated with the percentage increase in the allocation of increased NHS funds. ***Adjusted for separate linear trends for each LA.***

	% decrease in mortality amenable to health for each 10% increase in NHS funds allocated **[95%CI]**		
Women	1.05	1.96	0.14
R^2 =0.64			
Men	1.86	2.79	0.93
R^2 =0.74			

Notes: 95% confidence intervals in brackets based on robust standard errors. Model based on equation 2 in appendix 1. Model adjusted for LA, annual trend, separate trends in each LA, annual unemployment rate and annual average household income per head (GDHI) for each LA.

Table 3. The reduction in potential years of life lost from causes amenable to healthcare 2003-2011 associated with allocation of increased NHS funds.

	Decrease in potential years of life lost from causes amenable to health care per 100,000 population for each £10 million of additional NHS funds allocated					
Level of deprivation	Male	**[95%CI]**		Female	**[95%CI]**	
Most affluent LAs (Quintile 1)	27.2	0.6	53.7	7.9	-13.1	29
Quintile 2	16	-10.9	42.9	-4.3	-25.6	16.9
Quintile 3	-4.5	-31	21.9	-11.1	-34.5	12.2
Quintile 4	-36	-62.1	-10	-13.2	-35.2	8.7
Most deprived LAs (Quintile 5)	-63.7	-89.5	-37.9	-39.7	-62.2	-17.1

Notes: 95% confidence intervals in brackets based on robust standard errors. Model based on equation 1 in appendix 1. Model adjusted for LA, annual trend, annual unemployment rate and annual average household income per head (GDHI) for each LA.

Table 4. Change in under 75 year old deaths from causes NOT amenable to healthcare 2001-2010 associated with increased NHS funds. (no associations are significant)

	Decrease in under 75 deaths amenable to health care for each £1 million of additional NHS funds. [95%CI]		
Women	0.59	-0.05	1.23
R^2 =0.17			
Men	0.95	-0.2	2.09
R^2 =0.36			

Notes: 95% confidence intervals in brackets based on robust standard errors. Model based on equation 2 in appendix 1. Model adjusted for LA, annual trend, annual unemployment rate and annual average household income per head (GDHI) for each LA.

Table 5. Comparing the effect of change in NHS allocation on (1) causes amenable to healthcare –including Ischaemic Heart Disease and (2) causes amenable to health care excluding Ischaemic Heart Disease, 2001-2011 – standardised coefficients – all variables have been standardised to z-scores to enable comparisons in effect sizes.

(1) Causes amenable to healthcare –**including** Ischaemic Heart Disease	**Decrease in mortality in standard deviations for each standard deviation of additional NHS funds.**					
Level of deprivation	Male	**[95%CI]**		Female	**[95%CI]**	
Most affluent LAs (Quintile 1)	0	-0.08	0.09	0.03	-0.03	0.09
Quintile 2	-0.03	-0.12	0.05	0	-0.05	0.06
Quintile 3	-0.15	-0.23	-0.08	-0.07	-0.13	-0.02
Quintile 4	-0.23	-0.31	-0.15	-0.1	-0.15	-0.04
Most deprived LAs (Quintile 5)	-0.32	-0.39	-0.25	-0.14	-0.2	-0.09
(2) Causes amenable to healthcare –**excluding** Ischaemic Heart Disease	**Decrease in mortality in standard deviations for each standard deviation of additional NHS funds.**					
Level of deprivation	Male	**[95%CI]**		Female	**[95%CI]**	
Most affluent LAs (Quintile 1)	-0.09	-0.23	0.04	-0.03	-0.15	0.08
Quintile 2	-0.09	-0.23	0.04	-0.04	-0.16	0.07
Quintile 3	-0.14	-0.26	-0.02	-0.11	-0.22	0.01
Quintile 4	-0.22	-0.33	-0.1	-0.1	-0.2	-0.01
Most deprived LAs (Quintile 5)	-0.32	-0.44	-0.21	-0.17	-0.27	-0.07

Table 6. Comparing the effect of change in NHS allocation causes amenable to health care excluding Ischaemic Heart Disease and Stroke, 2001-2011 – standardised coefficients – all variables have been standardised to z-scores to enable comparisons in effect sizes.

(2) Causes amenable to healthcare –**excluding** Ischaemic Heart Disease **and** Stroke	**Decrease in mortality in standard deviations for each standard deviation of additional NHS funds.**					
Level of deprivation	Male	**[95%CI]**		Female	**[95%CI]**	
Most affluent LAs (Quintile 1)	-0.1	-0.23	0.04	-0.04	-0.19	0.1
Quintile 2	-0.04	-0.16	0.09	-0.04	-0.18	0.09
Quintile 3	-0.05	-0.17	0.06	-0.07	-0.21	0.06
Quintile 4	-0.12	-0.23	-0.01	-0.09	-0.21	0.03
Most deprived LAs (Quintile 5)	-0.21	-0.33	-0.09	-0.12	-0.24	0.01

Note: The outcome of causes amenable to healthcare –excluding Ischaemic Heart Disease and Stroke has been estimated by taking the difference between the directly standardised rates for mortality from causes amenable to healthcare – excluding Ischaemic Heart Disease (provided by the NHSIC) and the under 75 directly standardised mortality rate for stroke in each area.

Table 7. Controlling for the effect of additional interventions in Spearhead Areas. The reduction in under 75 year old deaths from causes amenable to healthcare 2001-2011 associated with allocation of increased NHS funds with controls for separate trend in Spearhead and non-spearhead areas.

	Decrease in rates of under 75 deaths amenable to health care per 100,000 population for each £10 million of additional NHS funds allocated					
Level of deprivation	Male	**[95%CI]**		Female	**[95%CI]**	
Most affluent LAs (Quintile 1)	-0.3	-1.3	0.8	0.3	-0.5	1
Quintile 2	-0.7	-1.8	0.3	-0.1	-0.8	0.6
Quintile 3	-2.1	-3	-1.2	-0.9	-1.6	-0.3
Quintile 4	-2.5	-3.6	-1.5	-1.1	-1.7	-0.4
Most deprived LAs (Quintile 5)	-3	-4.2	-1.9	-1.4	-2.1	-0.6
R^2 =0.74				R^2 =0.62		

Notes: 95% confidence intervals in brackets based on robust standard errors. Model based on equation 1 in appendix 2. Model adjusted for LA, annual trend, trend in Spearhead Areas, annual unemployment rate and annual average household income per head (GDHI) for each LA. Number of local authorities = 324.

Appendix 5. Calculating the reduction in mortality amenable to healthcare in deprived areas from regression estimates.

From the model above we found that each £10 million additional NHS funding in deprived areas was associated with a reduction in 4.0 male deaths and 1.8 female deaths amenable to healthcare per 100,000 population. There was no significant association in the most affluent areas. NHS funding in deprived areas increased by £864 per head of population, our model indicates that this would account for a reduction in mortality of 35 male deaths per 100,000 population:
= ((864*100000)/10000000)*4.0=35

Similarly the confidence intervals are calculated from the confidence intervals of the model coefficients.
UCL= ((864*100000)/10000000)*4.9=42
LCL=((864*100000)/10000000)*3.1=27

Appendix 6. Associations between economic variables and mortality outcomes from each models.

1. Change in mortality associated with each £100 million increase in GDHI per 100,000 population.

	Decrease in mortality for each £100 million increase in GDHI per 100,000 population					
Outcome	Male	**[95%CI]**		Female	**[95%CI]**	
Mortality under 75 amenable to healthcare	-2.15	-4.24	-0.05	-0.57	-1.86	0.71
Years of life lost amenable to healthcare	-71.6	-116.63	-26.57	-17.06	-52.17	18.05
Mortality under 75 NOT amenable to healthcare	-4	-6.16	-1.85	-2.82	-4.28	-1.35

2. Change in mortality associated with each 1% increase in unemployment

	Increase in mortality for each 1000 unemployed claimants per 100,000 population					
Outcome	Male	**[95%CI]**		Female	**[95%CI]**	
Mortality under 75 amenable to healthcare	1.83	0.96	2.69	-0.1	-1.35	1.15
Years of life lost amenable to healthcare	20.51	0.95	40.08	-34.34	-73.85	5.17
Mortality under 75 NOT amenable to healthcare	0.26	-0.62	1.15	-3.46	-5.05	-1.87

1 Jann B. *NLCHECK: Stata module to check linearity assumption after model estimation*. 2008. http://econpapers.repec.org/software/bocbocode/s456968.htm (accessed 18 Mar2014).