

# ESTIMATING EXPECTED HEALTH OPPORTUNITY COSTS IN THE NHS

## (Analysis of 2006/07 Expenditure Data)

### YORK TEAM

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## Summary

This document comprises of two appendices:

### Summary of Appendix 1: Outline of data update, estimation strategy, and results for outcome and expenditure models for 2006/07

#### Starting point: the 2007/08 specification

1. Identify the preferred specification for the outcome and expenditure equation for each programme budget category (PBC) for 2007/08. The outcome and expenditure elasticities generated by these specifications (when estimated at LA-level) are shown in Table 1.

#### Re-estimate the 2007/08 specifications using updated data

2. The 2007/08 specifications were derived using a combination PCT-level data mapped to LA-level and direct LA-level data. Backdate PCT-level data to 2006/07 and put backdated PCT-level data through the appropriate mapper to obtain LA-level data. This will include backdating and mapping:

- the PB expenditure data from 2007/08 to 2006/07
- the raw population, unified weighted population, and MFF estimates used and implied by the resource allocations for 2006/07
- PB specific indices of need (eg infectious diseases, mental health, maternity) from the relevant DH resource allocation exposition books (where possible)
- PB specific disease prevalence rates as extracted from the HSCIC's QOF database.

3. Obtain LA-level statistics for those variables that are reported at this unit of analysis. This will involve backdating LA-level data for 2007/08 to 2006/07. This will include backdating :

- mortality data for 2007/08/09 with data for 2006/07/08
- census-based variables for 2007 with data for 2006 (by appropriate interpolation between 2001 and 2011).

Complications: (i) no data for CKD prevalence for 2006/7 so we use 2007/8 as a proxy; (ii) no age specific practice populations to calculate the denominator for the diabetes (17+) and epilepsy (18+) prevalence rates for 2006/7 so we estimate the relevant practice populations using the proportion of the practice population aged over 17 (or over 18) using 2007/8 data and apply this proportion to the total practice population for 2006/7.

#### Estimation strategy for 2006/07: same as for 2007/08

4. Having backdated all data, use the preferred specification for 2007/08 to re-estimate each outcome and expenditure equation for 2006/07.

5. If this re-estimation produces a result which (a) passes the appropriate statistical tests and (b) generates coefficients in line with theoretical priors, use this result as our preferred result for 2006/07. This rule is applied to cases where the preferred specification for 2007/08 is either IV or OLS. If this re-estimation produces an acceptable result, the resulting elasticity shown in Table 1 has a '--' in the next column.

6. If the re-estimation produces a result which does not pass tests/have coefficients in line with priors, re-estimate the equation having adjusted the specification as suggested by the initial result. So, for example, if the initial estimation implies the presence of weak instruments and one of the instruments is insignificant in the first-stage regression, try re-estimating the equation without the insignificant instrument. And if, for example, one of the regressors in the second-stage regression is insignificant, try re-estimating without it. If this re-estimation produces an acceptable result, the resulting elasticity shown in Table 1 has an 'A' in the next column.
7. If a relatively minor adjustment to the 2007/08 specification does not generate a statistically and theoretically acceptable result, re-derive the IV equation to be estimated (again, this applies to cases where the preferred specification for 2007/08 is either IV or OLS). That is, use OLS with backward stepwise regression to identify relevant covariates to be included in the second-stage regression having forced in the relevant variables throughout. For the outcome equation we force in own programme expenditure, and for the expenditure equation the other programme need variable and the total budget term are forced in throughout the stepwise procedure.
8. Having identified relevant covariates for the second-stage regression, again use stepwise backward regression to identify relevant instruments for the first-stage conditioning on the covariates for the second-stage identified above. In other words, these second-stage covariates are forced in throughout stepwise procedure to identify relevant instruments.
9. Having identified covariates for the second-stage (in 7 above) and instruments for the first-stage (in 8 above), re-estimate the IV specification equation using these two sets of variables. If the endogeneity test suggests that a variable (eg own programme expenditure in the outcome equation) is clearly not endogenous then re-estimate using OLS. If this re-estimation produces an acceptable result, the resulting elasticity shown in Table 1 has a 'B' in the next column.
10. If the above re-estimation approach produces a result which does not pass tests/have coefficients in line with priors, re-estimate the equation having adjusted the specification as suggested by the initial result (for example, if the result fails the misspecification test try adding the squared value of one of the regressors to the specification). If this re-estimation produces an acceptable result, the resulting elasticity shown in Table 1 has a 'C' in the next column.
11. If all of the above approaches fail to produce an acceptable result, consider excluding PCTs with extreme values of expenditure per person. Only explore this option for programmes with small amounts of expenditure and/or mortality. If this re-estimation approach produces an acceptable result, the resulting elasticity shown in Table 1 has a 'D' in the next column.

**Results for 2006/07: elasticities from preferred specifications**

12. The estimation strategy outlined above generated the outcome and expenditure elasticities for 2006/07 shown in Table 1.

**Results for 2006/07: full IV/OLS result for preferred specifications**

13. The full result [IV (second-stage) or OLS] associated with each elasticity reported in Table 1 can be found in Table A3 (for the outcome equations) and Table A4 (for the expenditure equations) in the appendix.

**Results for 2006/07: estimation path to preferred specifications**

14. The full estimation path for each result (starting with the re-estimation of the 2007/08 specification with updated data) can be found in Table A5 (for the outcome equations) and Table A6 (for the expenditure equations) in the appendix.

Table 1 Outcome and expenditure elasticities for 2006/07, 2007/08, 2008/09 and 2009/10

PBC #	PBC description	for 2009/10				for 2008/09				for 2007/08				for 2006/07				for 2005/06				for 2004/05				for 2003/04			
		Outcome elasticity	Re-est. P	Spend elasticity	Re-est. P	Outcome elasticity	Re-est. P	Spend elasticity	Re-est. P	Outcome elasticity	Re-est. P	Spend elasticity	Re-est. P	Outcome elasticity	Re-est. P	Spend elasticity	Re-est. P	Outcome elasticity	Re-est. P	Spend elasticity	Re-est. P	Outcome elasticity	Re-est. P	Spend elasticity	Re-est. P	Outcome elasticity	Re-est. P	Spend elasticity	Re-est. P
1	Infectious diseases	-0.310*	A	0.968***	--	-0.549***	A	147***	--	-0.660**	A	1387***	--	-0.608	A	1051***	A												
2	Cancers and tumours	-0.345***	--	0.502**	A	-0.287***	--	0.784**	--	-0.273***	--	1626***	A	-0.239***	A	1219***	--												
3	Diseases of the blood	n/a		1060***	B	n/a		0.995***	--	n/a		1374***	--	n/a		1037***	--												
4	Endocrine, nutritional, metabolic	-1075**	A	0.708***	--	-1607**	--	0.498***	A	-1491	D	0.455***	--	-1464	A	0.630***	A												
5	Mental health disorders	n/a		0.899***	--	n/a		0.995***	--	n/a		1103***	--	n/a		1143***	--												
6	Learning disability	n/a		0.647**	B	n/a		0.329	--	n/a		0.386	--	n/a		0.410	B												
7	Neurological problems	-1357	C	0.850***	--	-0.304	C	0.897***	--	-0.237*	B	0.733***	A	-0.869*	D	0.382*	A												
8	Vision problems	n/a		0.934***	A	n/a		0.701**	--	n/a		1106***	C	n/a		0.931***	--												
9	Hearing problems	n/a		1273***	C	n/a		1637***	--	n/a		0.951*	A	n/a		0.989**	--												
10	Circulatory problems	-1842***	--	0.494*	--	-1384***	--	1784***	A	-1315***	A	1614***	--	-1404***	--	1578***	--												
11	Respiratory problems	-2.103***	B	0.576***	--	-1671**	--	0.752**	--	-1564***	A	1555***	A	-2.281***	--	1287***	--												
12	Dental problems	n/a		0.765***	B	n/a		0.428**	B	n/a		0.420***	D	n/a		0.835**	C												
13	Gastro-intestinal problems	-1989*	A	0.387*	--	-1146**	A	0.520*	--	-0.837**	--	1490***	A	-1255**	--	1014***	A												
14	Skin problems	n/a		0.890***	D	n/a		0.907***	--	n/a		0.787***	--	n/a		0.701**	A												
15	Musculo-skeletal problems	n/a		0.295	B	n/a		0.738***	C	n/a		0.733***	--	n/a		0.628*	A												
16	Trauma and injuries	0	n/a	1090***	--	0	n/a	1344***	--	-0.638	n/a	1328***	--	0	n/a	0.705***	--												
17	Genito-urinary problems	-2.997	B	0.878***	--	-0.024	C	0.733***	--	-1977	C	1015***	A	-0.588	D	0.988***	A												
18	Maternity and reproductive health	-0.166*	B	0.653***	--	-0.030	A	0.963***	--	-0.057	--	0.563**	--	-0.085	C	0.614**	--												
19	Neonates																												
20	Poisoning and adverse events	n/a		0.658**	--	n/a		2.102***	--	n/a		1674***	A	n/a		1107***	--												
21	Healthy individuals	n/a		1246**	--	n/a		1049	--	n/a		1296**	C	n/a		0.709	B												
22	Social care needs	n/a		0.844	B	n/a		1192*	--	n/a		1669**	C	n/a		1702***	--												
23	Other (includes GMS/FMS)	n/a		0.564***	B	n/a		0.338***	--	n/a		0.553***	--	n/a		0.447***	A												

Notes: (i) see pp1-2 of text for the meaning of the symbols in 're-estimation' columns;

(ii) the 're-estimation' columns for 2009/10 refer to a comparison of the preferred specification for 2009/10 at LA level with the preferred specification for 2008/09 at PCT level.

## **Summary of Appendix 2: Expected health opportunity costs in the NHS (2006/07 results)**

### **Overview**

15. In the second appendix results are presented that reflect the available data for 2006/07 expenditure (this forms Appendix 2.1). In Appendix 2.2, the results are also analysed in terms of how sensitive the results are to two key inputs: i) each of the estimated elasticities and ii) assumptions made in order to overcome data limitations for each PBC (only have mortality outcome data and for only a portion of PBCs). Finally, Appendix 2.3 briefly considers an update regarding data from ONS used to inform burden of disease.

### **Results**

16. Results are presented in two ways as the point estimate of the cost per QALY of marginal activity in the NHS, or alternatively expressed as the expected QALY health opportunity cost for £10,000,000 expenditure.

Table 2 Probabilistic results for 2006/07 expenditure compared to previously generated results

<b>2006/07</b>	<b>Point estimate (deterministic)</b>	<b>Point estimate (probabilistic)</b>	<b>5th percentile</b>	<b>95th percentile</b>
<b>Cost per QALY</b>	£6,844	£6,838	£5,139	£9,878
<b>Health opportunity costs of £10mn (QALYs)</b>	1,461	1,462	1,012	1,946
<b>2007/08</b>	<b>Point estimate (deterministic)</b>	<b>Point estimate (probabilistic)</b>	<b>5th percentile</b>	<b>95th percentile</b>
<b>Cost per QALY</b>	£9,747	£9,765	£7,689	£13,043
<b>Health opportunity costs of £10mn (QALYs)</b>	1,026	1,024	767	1,301
<b>2008/09</b>	<b>Point estimate (deterministic)</b>	<b>Point estimate (probabilistic)</b>	<b>5th percentile</b>	<b>95th percentile</b>
<b>Cost per QALY</b>	£12,960	£13,271	£8,390	£32,881
<b>Health opportunity costs of £10mn (QALYs)</b>	772	754	304	1,192
<b>2009/10</b>	<b>Point estimate (deterministic)</b>	<b>Point estimate (probabilistic)</b>	<b>5th percentile</b>	<b>95th percentile</b>
<b>Cost per QALY</b>	£9,887	£9,920	£6,802	£17,296
<b>Health opportunity costs of £10mn (QALYs)</b>	1,011	1,008	578	1,470

It can be seen from Table 2 that the expected health opportunity costs of a change in expenditure have increased slightly between 2007/08 and 2006/07 and so the cost per QALY ratio has fallen. From Table 2 it is hard to conclude that there is a significant change in the health opportunity costs of £10mn expenditure, since there is a great deal of overlap between the 90% confidence intervals of the years shown.

Figure 1 Results illustrating uncertainty for 2006/07 and previously generated results – cost per QALY

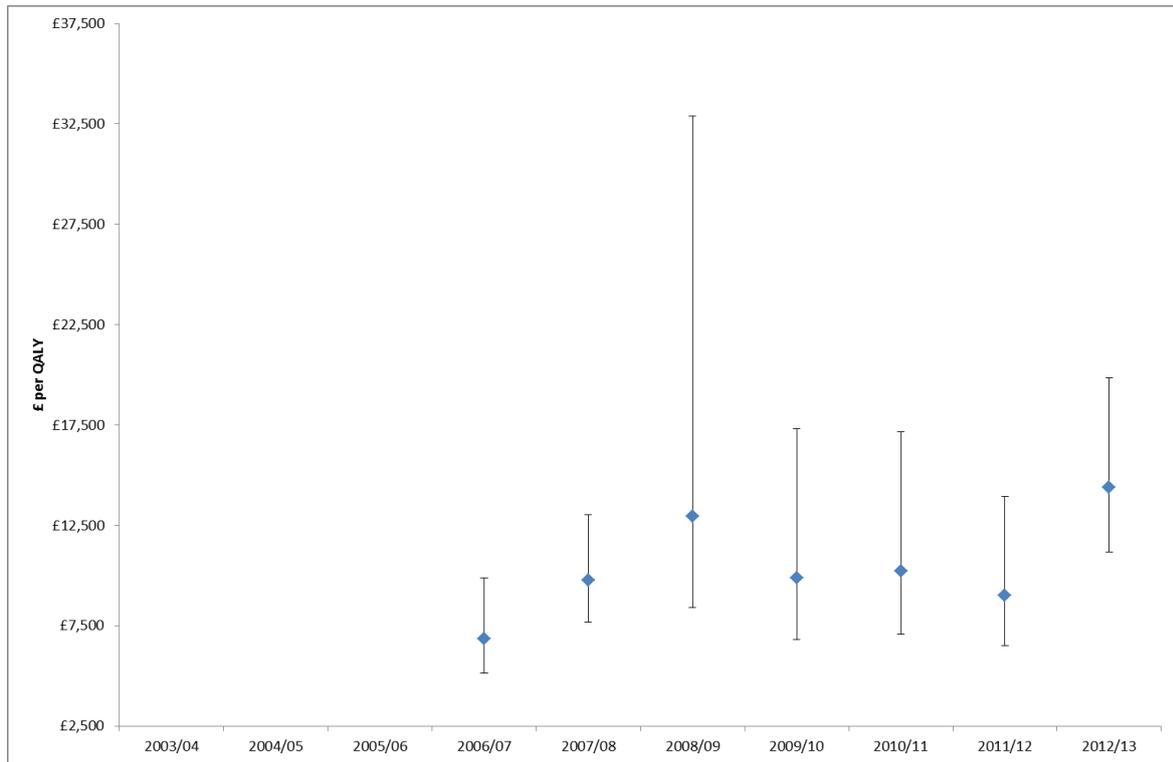
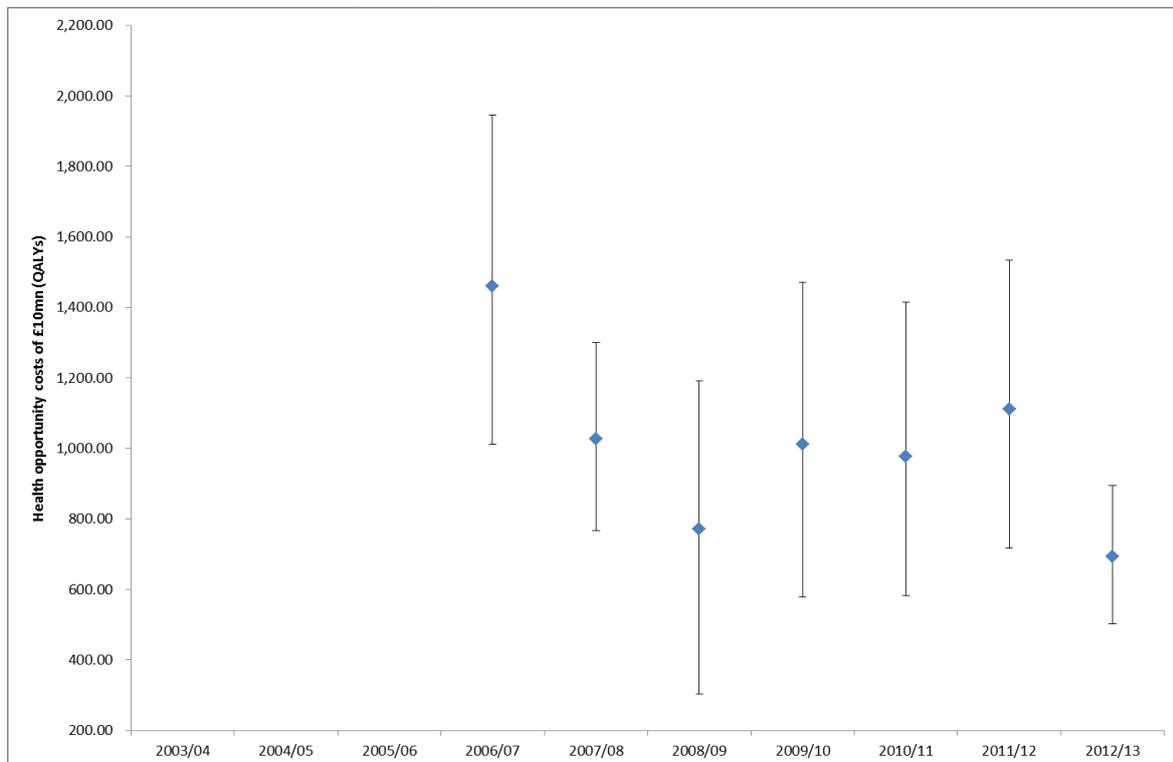


Figure 2 Results illustrating uncertainty for 2006/07 and previously generated results – Health opportunity costs of £10mn (QALYs)



17. It can also be seen from Figures 1 and 2 that while the confidence interval is far from symmetrically distributed around the point estimate of the cost per QALY ratio in Figure 1 (where uncertainty is reflected in the denominator), when expressed as health opportunity costs per £10mn then the distribution of uncertainty is much more symmetric in Figure 2 (uncertainty is reflected in the numerator).

### **Sensitivity analysis**

18. Appendix 2.2 details three sensitivity analyses that were performed. The first two concerned the elasticities that were econometrically estimated for each of the PBCs. In the first case each of the estimated PBC outcome elasticities are varied by +/- 1 standard error. Then, the difference between the two resulting opportunity costs is presented. When this is larger, this implies that the overall resulting estimate of health opportunity costs is more sensitive to the outcome elasticity under consideration. The same procedure is then carried out for each of the PBC expenditure elasticities. The results of these sensitivity analyses are reported in Tables 3 and 4, with analysis and interpretation found in Appendix 2.2.

Table 3 Sensitivity of results to estimated outcome elasticities

	Change in spend	Change in QALY death + QALY alive	Implied PBC cost per QALY (£)	Difference in health opportunity costs between +1 SE and -1 SE in PBC outcome elasticity	% difference in health opportunity costs between +1 SE and -1 SE in PBC outcome elasticity	Importance of PBC (rank)	Importance of PBC (rank) 2007/08	Importance of PBC (rank) 2008/09
2 Cancer	£ 820,970.01	45	£ 18,273.98	45	3.10%	6	5	6
10 Circulatory	£ 1,588,312.24	273	£ 5,823.96	143	9.80%	2	3	4
11 Respiratory	£ 690,639.33	533	£ 1,295.46	446	30.54%	1	1	2
13 Gastro-intestinal	£ 612,928.90	84	£ 7,290.71	101	6.92%	4	4	5
1 Infectious diseases	£ 180,931.63	15	£ 12,275.48	23	1.55%	7	8	7
4 Endocrine	£ 190,678.78	92	£ 2,078.60	127	8.67%	3	2	3
7 Neurological	£ 174,112.62	76	£ 2,301.18	89	6.10%	5	6	1
17 Genito-urinary	£ 562,018.59	5	£ 116,616.35	12	0.81%	8	7	8
16 Trauma & injuries*	£ 333,047.95	0	N/A	-	-	-	-	-
18+19 Maternity & neonates*	£ 358,545.97	0	£ 4,613,479.53	0	0.03%	9	9	9
3 Disorders of Blood	£ 141,805.04	35	£ 4,053.46	-	-	-	-	-
5 Mental Health	£ 1,569,616.08	190	£ 8,254.65	-	-	-	-	-
6 Learning Disability	£ 163,497.98	3	£ 65,320.04	-	-	-	-	-
8 Problems of Vision	£ 207,091.49	11	£ 18,951.38	-	-	-	-	-
9 Problems of Hearing	£ 50,669.02	21	£ 2,407.59	-	-	-	-	-
12 Dental problems	£ 357,594.65	20	£ 17,863.94	-	-	-	-	-
14 Skin	£ 163,637.55	4	£ 44,709.25	-	-	-	-	-
15 Musculo skeletal	£ 345,653.04	52	£ 6,620.05	-	-	-	-	-
20 Poisoning and AE	£ 133,205.94	3	£ 45,750.52	-	-	-	-	-
21 Healthy Individuals	£ 156,979.01	1	£ 200,069.12	-	-	-	-	-
22 Social Care Needs	£ 425,101.04	0	N/A	-	-	-	-	-
23 Other	£ 772,963.14	0	N/A	-	-	-	-	-
Total:		1,461						

Table 4 Sensitivity of overall results to estimated spend elasticities

	Change in spend	Change in QALY death + QALY alive	Implied PBC cost per QALY (£)	Difference in health opportunity costs between +1 SE and -1 SE in PBC spend elasticity	% difference in health opportunity costs between +1 SE and -1 SE in PBC spend elasticity	Importance of PBC (rank)	Importance of PBC (rank) 2007/08	Importance of PBC (rank) 2008/09
2 Cancer	£ 820,970.01	45	£ 18,273.98	45	3.11%	8	8	11
10 Circulatory	£ 1,588,312.24	273	£ 5,823.96	45	3.09%	9	2	2
11 Respiratory	£ 690,639.33	533	£ 1,295.46	169	11.57%	1	1	1
13 Gastro-intestinal	£ 612,928.90	84	£ 7,290.71	11	0.76%	18	12	13
1 Infectious diseases	£ 180,931.63	15	£ 12,275.48	10	0.69%	19	21	19
4 Endocrine	£ 190,678.78	92	£ 2,078.60	30	2.02%	12	10	3
7 Neurological	£ 174,112.62	76	£ 2,301.18	49	3.33%	6	19	18
17 Genito-urinary	£ 562,018.59	5	£ 116,616.35	53	3.64%	4	11	6
16 Trauma & injuries*	£ 333,047.95	0	N/A	46	3.13%	7	6	8
18+19 Maternity & neonates*	£ 358,545.97	0	£ 4,613,479.53	59	4.06%	2	5	4
3 Disorders of Blood	£ 141,805.04	35	£ 4,053.46	9	0.62%	20	18	22
5 Mental Health	£ 1,569,616.08	190	£ 8,254.65	14	0.96%	15	20	12
6 Learning Disability	£ 163,497.98	3	£ 65,320.04	51	3.49%	5	7	10
8 Problems of Vision	£ 207,091.49	11	£ 18,951.38	14	0.94%	16	15	17
9 Problems of Hearing	£ 50,669.02	21	£ 2,407.59	13	0.86%	17	13	20
12 Dental problems	£ 357,594.65	20	£ 17,863.94	30	2.07%	11	14	14
14 Skin	£ 163,637.55	4	£ 44,709.25	14	0.98%	14	16	16
15 Musculo skeletal	£ 345,653.04	52	£ 6,620.05	1	0.09%	22	22	21
20 Poisoning and AE	£ 133,205.94	3	£ 45,750.52	9	0.61%	21	17	15
21 Healthy Individuals	£ 156,979.01	1	£ 200,069.12	27	1.85%	13	9	5
22 Social Care Needs	£ 425,101.04	0	N/A	36	2.44%	10	3	7
23 Other	£ 772,963.14	0	N/A	57	3.87%	3	4	9
Total:		1,461						

19. Following these two sensitivity analyses, a third is performed with a different emphasis, which analyses the sensitivity of the overall health opportunity cost estimate to two key assumptions:

*Surrogacy*- we are required to make an assumption about how the effect on mortality for PBCs with a mortality indicator can be used as a *surrogate* for the effect that expenditure has on morbidity (or health-related quality of life) in those PBCs.

*Extrapolation*- We are required to make an assumption about how the estimated effects on mortality found for PBCs with a mortality indicator can be *extrapolated* to the effect that expenditure has on mortality for those PBCs that do not have a mortality indicator.

In order to assess the impact of these assumptions on the overall results for the NHS, we evaluate the health effects of £10mn spending at the margin in the NHS when either:

- a) For PBCs with a mortality indicator: no surrogacy assumption, therefore expenditure has no effect on morbidity
- b) For PBCs without a mortality indicator: assume no health effects at all, neither on mortality (extrapolation assumption) nor morbidity (surrogacy assumption)

The results are found here in Table 5. Interpretation and analysis is found in Appendix 2.2.

Table 5 Sensitivity of overall results to surrogacy and extrapolation assumptions

	Change in spend	Change in QALY death	Change in QALY alive	Health opportunity costs sensitivity to mortality/morbidity assumption (%)	Importance of PBC (rank)	Importance of PBC (rank) 2007/08	Importance of PBC (rank) 2008/09
2 Cancer	£ 820,970.01	42	3	-0.22%	15	14	14
10 Circulatory	£ 1,588,312.24	186	87	-5.93%	4	3	5
11 Respiratory	£ 690,639.33	18	515	-35.23%	1	1	1
13 Gastro-intestinal	£ 612,928.90	31	53	-3.64%	6	5	6
1 Infectious diseases	£ 180,931.63	3	12	-0.83%	11	10	10
4 Endocrine	£ 190,678.78	5	87	-5.94%	3	4	4
7 Neurological	£ 174,112.62	3	72	-4.95%	5	7	3
17 Genito-urinary	£ 562,018.59	1	4	-0.26%	13	11	18
16 Trauma & injuries*	£ 333,047.95	0	0	0.00%	-	-	-
18+19 Maternity & neonates*	£ 358,545.97	0	0	0.00%	19	19	19
3 Disorders of Blood	£ 141,805.04	2	33	-2.39%	8	8	9
5 Mental Health	£ 1,569,616.08	17	174	-13.01%	2	2	2
6 Learning Disability	£ 163,497.98	0	2	-0.17%	17	17	15
8 Problems of Vision	£ 207,091.49	0	10	-0.75%	12	12	12
9 Problems of Hearing	£ 50,669.02	0	21	-1.44%	9	9	8
12 Dental problems	£ 357,594.65	0	20	-1.37%	10	13	11
14 Skin	£ 163,637.55	1	2	-0.25%	14	16	13
15 Musculo skeletal	£ 345,653.04	3	50	-3.57%	7	6	7
20 Poisoning and AE	£ 133,205.94	0	2	-0.20%	16	15	16
21 Healthy Individuals	£ 156,979.01	0	1	-0.05%	18	18	17
22 Social Care Needs	£ 425,101.04	0	0	0.00%	-	-	-
23 Other	£ 772,963.14	0	0	0.00%	-	-	-
Total:		313	1,148				
Total change in QALY death + QALY alive			1,461				

## **Appendix 1: Outline of data update, estimation strategy, and results for outcome and expenditure models for 2006/07**

### **Starting point: the 2007/08 specification**

20. Identify the preferred specification for the outcome and expenditure equation for each programme budget category (PBC) for 2007/08. The outcome and expenditure elasticities generated by these specifications (when estimated at LA-level) are shown in Table A1.

### **Re-estimate the 2007/08 specifications using updated data**

21. The 2007/08 specifications were derived using a combination PCT-level data mapped to LA-level and direct LA-level data. Backdate PCT-level data to 2006/07 and put backdated PCT-level data through the appropriate mapper to obtain LA-level data. This will include backdating and mapping:

- the PB expenditure data from 2007/08 to 2006/07
- the raw population, unified weighted population, and MFF estimates used and implied by the resource allocations for 2006/07
- PB specific indices of need (eg infectious diseases, mental health, maternity) from the relevant DH resource allocation exposition books (where possible)
- PB specific disease prevalence rates as extracted from the HSCIC's QOF database.

22. Obtain LA-level statistics for those variables that are reported at this unit of analysis. This will involve backdating LA-level data for 2007/08 to 2006/07. This will include backdating :

- mortality data for 2007/08/09 with data for 2006/07/08
- census-based variables for 2007 with data for 2006 (by appropriate interpolation between 2001 and 2011).

Complications: (i) no data for CKD prevalence for 2006/7 so we use 2007/8 as a proxy; (ii) no age specific practice populations to calculate the denominator for the diabetes (17+) and epilepsy (18+) prevalence rates for 2006/7 so we estimate the relevant practice populations using the proportion of the practice population aged over 17 (or over 18) using 2007/8 data and apply this proportion to the total practice population for 2006/7.

### **Estimation strategy for 2006/07: same as for 2007/08**

23. Having backdated all data, use the preferred specification for 2007/08 to re-estimate each outcome and expenditure equation for 2006/07.

24. If this re-estimation produces a result which (a) passes the appropriate statistical tests and (b) generates coefficients in line with theoretical priors, use this result as our preferred result for 2006/07. This rule is applied to cases where the preferred specification for 2007/08 is either IV or OLS. If this re-estimation produces an acceptable result, the resulting elasticity shown in Table A1 has a '--' in the next column.

25. If the re-estimation produces a result which does not pass tests/have coefficients in line with priors, re-estimate the equation having adjusted the specification as suggested by the initial result. So, for example, if the initial estimation implies the presence of weak instruments and one of the

instruments is insignificant in the first-stage regression, try re-estimating the equation without the insignificant instrument. And if, for example, one of the regressors in the second-stage regression is insignificant, try re-estimating without it. If this re-estimation produces an acceptable result, the resulting elasticity shown in Table A1 has an 'A' in the next column.

26. If a relatively minor adjustment to the 2007/08 specification does not generate a statistically and theoretically acceptable result, re-derive the IV equation to be estimated (again, this applies to cases where the preferred specification for 2007/08 is either IV or OLS). That is, use OLS with backward stepwise regression to identify relevant covariates to be included in the second-stage regression having forced in the relevant variables throughout. For the outcome equation we force in own programme expenditure, and for the expenditure equation the other programme need variable and the total budget term are forced in throughout the stepwise procedure.

27. Having identified relevant covariates for the second-stage regression, again use stepwise backward regression to identify relevant instruments for the first-stage conditioning on the covariates for the second-stage identified above. In other words, these second-stage covariates are forced in throughout stepwise procedure to identify relevant instruments.

28. Having identified covariates for the second-stage (in 7 above) and instruments for the first-stage (in 8 above), re-estimate the IV specification equation using these two sets of variables. If the endogeneity test suggests that a variable (eg own programme expenditure in the outcome equation) is clearly not endogenous then re-estimate using OLS. If this re-estimation produces an acceptable result, the resulting elasticity shown in Table A1 has a 'B' in the next column.

29. If the above re-estimation approach produces a result which does not pass tests/have coefficients in line with priors, re-estimate the equation having adjusted the specification as suggested by the initial result (for example, if the result fails the misspecification test try adding the squared value of one of the regressors to the specification). If this re-estimation produces an acceptable result, the resulting elasticity shown in Table A1 has a 'C' in the next column.

30. If all of the above approaches fail to produce an acceptable result, consider excluding PCTs with extreme values of expenditure per person. Only explore this option for programmes with small amounts of expenditure and/or mortality. If this re-estimation approach produces an acceptable result, the resulting elasticity shown in Table A1 has a 'D' in the next column.

**Results for 2006/07: elasticities from preferred specifications**

31. The estimation strategy outlined above generated the outcome and expenditure elasticities for 2006/07 shown in Table A1.

**Results for 2006/07: full IV/OLS result for preferred specifications**

32. The full result [IV (second-stage) or OLS] associated with each elasticity reported in Table A1 can be found in Table A4 (for the outcome equations) and Table A5 (for the expenditure equations) in the appendix.

**Results for 2006/07: estimation path to preferred specifications**

33. The full estimation path for each result (starting with the re-estimation of the 2007/08 specification with updated data) can be found in Table A6 (for the outcome equations) and Table A7 (for the expenditure equations) in the appendix.

Table A1 Outcome and expenditure elasticities for 2006/07, 2007/08, 2008/09 and 2009/10

PBC #	PBC description	for 2009/10				for 2008/09				for 2007/08				for 2006/07				for 2005/06				for 2004/05				for 2003/04			
		Outcome elasticity	Re-est. P	Spend elasticity	Re-est. P	Outcome elasticity	Re-est. P	Spend elasticity	Re-est. P	Outcome elasticity	Re-est. P	Spend elasticity	Re-est. P	Outcome elasticity	Re-est. P	Spend elasticity	Re-est. P	Outcome elasticity	Re-est. P	Spend elasticity	Re-est. P	Outcome elasticity	Re-est. P	Spend elasticity	Re-est. P	Outcome elasticity	Re-est. P	Spend elasticity	Re-est. P
1	Infectious diseases	-0.310*	A	0.968***	--	-0.549***	A	147***	--	-0.660**	A	1387***	--	-0.608	A	1051***	A												
2	Cancers and tumours	-0.345***	--	0.502**	A	-0.287***	--	0.784**	--	-0.273***	--	1626***	A	-0.239***	A	1219***	--												
3	Diseases of the blood	n/a		1060***	B	n/a		0.995***	--	n/a		1374***	--	n/a		1037***	--												
4	Endocrine, nutritional, metabolic	-1075**	A	0.708***	--	-1607**	--	0.498***	A	-1491	D	0.455***	--	-1464	A	0.630***	A												
5	Mental health disorders	n/a		0.899***	--	n/a		0.995***	--	n/a		1103***	--	n/a		1143***	--												
6	Learning disability	n/a		0.647**	B	n/a		0.329	--	n/a		0.386	--	n/a		0.410	B												
7	Neurological problems	-1357	C	0.850***	--	-0.304	C	0.897***	--	-0.237*	B	0.733***	A	-0.869*	D	0.382*	A												
8	Vision problems	n/a		0.934***	A	n/a		0.701**	--	n/a		1106***	C	n/a		0.931***	--												
9	Hearing problems	n/a		1273***	C	n/a		1637***	--	n/a		0.951*	A	n/a		0.989**	--												
10	Circulatory problems	-1842***	--	0.494*	--	-1384***	--	1784***	A	-1315***	A	1614***	--	-1404***	--	1578***	--												
11	Respiratory problems	-2.103***	B	0.576***	--	-1671**	--	0.752**	--	-1564***	A	1555***	A	-2.281***	--	1287***	--												
12	Dental problems	n/a		0.765***	B	n/a		0.428**	B	n/a		0.420***	D	n/a		0.835**	C												
13	Gastro-intestinal problems	-1989*	A	0.387*	--	-1146**	A	0.520*	--	-0.837**	--	1490***	A	-1255**	--	1014***	A												
14	Skin problems	n/a		0.890***	D	n/a		0.907***	--	n/a		0.787***	--	n/a		0.701***	A												
15	Musculo-skeletal problems	n/a		0.295	B	n/a		0.738***	C	n/a		0.733***	--	n/a		0.628*	A												
16	Trauma and injuries	0	n/a	1090***	--	0	n/a	1344***	--	-0.638	n/a	1328***	--	0	n/a	0.705***	--												
17	Genito-urinary problems	-2.997	B	0.878***	--	-0.024	C	0.733***	--	-1977	C	1015***	A	-0.588	D	0.988***	A												
18	Maternity and reproductive health	-0.166*	B	0.653***	--	-0.030	A	0.963***	--	-0.057	--	0.563**	--	-0.085	C	0.614**	--												
19	Neonates																												
20	Poisoning and adverse events	n/a		0.658**	--	n/a		2.102***	--	n/a		1674***	A	n/a		1107***	--												
21	Healthy individuals	n/a		1246**	--	n/a		1049	--	n/a		1296**	C	n/a		0.709	B												
22	Social care needs	n/a		0.844	B	n/a		1192*	--	n/a		1669**	C	n/a		1702***	--												
23	Other (includes GMS/FMS)	n/a		0.564***	B	n/a		0.338***	--	n/a		0.553***	--	n/a		0.447***	A												

Notes: (i) see pp1-2 of text for the meaning of the symbols in 're-estimation' columns;

(ii) the 're-estimation' columns for 2009/10 refer to a comparison of the preferred specification for 2009/10 at LA level with the preferred specification for 2008/09 at PCT level.

## **Part A Overview of results by PBC**

### **Infectious diseases**

34. Outcome: Re-estimation of the 2007/08 specification using updated data reveals an invalid instrument set (Table A6). Dropping the invalid instrument (proportion of population in white ethnic group) and re-estimating generates an acceptable result, both statistically and in line with priors (see Table A4 and Table A6).

35. Expenditure: Re-estimation of the 2007/08 specification using updated data generates a reasonable result but fails the reset test (see Table A7). Adding two regressors has little impact on the coefficient on total budget but this specification now passes the reset test (see Table A5 and Table A7).

### **Cancer and tumours**

36. Outcome: Re-estimation of the 2007/08 specification with updated data reveals an invalid instrument set (Table A6) but the addition of 'need squared' as a regressor generates an acceptable result (see Table A4 and Table A6).

37. Expenditure: Re-estimation of the 2007/08 specification generates an acceptable result (see Table A5 and Table A7).

### **Blood disorders**

38. Expenditure: Re-estimation of the 2007/08 specification generates an acceptable result (see Table A5 and Table A7).

### **Endocrine, nutritional and metabolic**

39. Outcome: Re-estimation of the 2007/08 specification using updated data reveals a weak instrument set (Table 5). Replacing the 'professional occupations' regressor with the diabetes prevalence rate, and replacing the 'permanently sick' instrument with 'lone parents' generates a more acceptable result (see Table A4 and Table A6).

40. Expenditure: The 2007/08 specification has a couple of statistically insignificant regressors (Table A7) and re-estimation without these generates the result shown in Table A5 and Table A7.

### **Mental health disorders**

41. Expenditure: The 2007/08 specification generates an acceptable result (Table A5 and Table A7).

### **Learning disability**

42. Expenditure: The 2007/08 specification generates a poor result (fails reset test and no significant coefficients). Re-derivation suggests that 'other need' is not endogenous so we prefer the OLS equivalent of the re-derived model (see Table A5 and Table A7).

### **Neurological problems**

43. Outcome: The 2007/08 specification generates a poor result with a positive coefficient on expenditure (see Table A6). Re-derivation generates an OK result in some ways but the coefficient on expenditure is still positive (Table A6). Excluding those LAs with expenditure per head outside the 10<sup>th</sup> and 90<sup>th</sup> percentiles generates a negative coefficient on expenditure but the instrument set a little on the weak side (Table A6). Tweaking the regressor and instrument sets generates a more reasonable result (significant coefficient on spend, stronger instrument set) and this result can be found in Table A4 and A6.

44. Expenditure: The 2007/08 specification generates the result shown in Table A7. Re-estimation without the insignificant regressor ('permanently sick') suggests that 'other need' is not endogenous (Table A7). Re-estimation of the same specification using OLS generates the acceptable result shown in Table A5 and Table A7.

### **Problems of vision**

45. Expenditure: The 2007/08 specification generates an acceptable result (Table A5 and Table A7).

### **Problems of hearing**

46. Expenditure: The 2007/08 specification generates an acceptable result (Table A5 and Table A7).

### **Circulatory problems**

47. Outcome: The 2007/08 specification generates an acceptable result (Table A4 and Table A6).

48. Expenditure: The 2007/08 specification generates an acceptable result (Table A5 and Table A7).

### **Respiratory problems**

49. Outcome: The 2007/08 specification generates an acceptable result (Table A4 and Table A6).

50. Expenditure: The 2007/08 specification generates an acceptable (Table A5 and Table A7).

### **Dental problems**

51. Expenditure: The 2007/08 specification generates a poor result with a significant positive coefficient on 'other need' (see Table A7). Re-estimation adjusting the exclusions to reflect the 5<sup>th</sup> and 95<sup>th</sup> percentiles for spend in 2006/7 still generates a poor result (Table A7). Re-derivation of an IV specification (without sample restrictions) still generates a significant coefficient on 'other need' but this variable is not endogenous (Table A7). Re-estimation using OLS and the addition of a couple of further regressors generates a reasonable result albeit with a hint of mis-specification at the 10% level (Tables A5 and A7).

### **Gastro-intestinal problems**

52. Outcome: The 2007/08 specification produces an acceptable result (see Table A4 and Table A6).

53. Expenditure: The 2007/08 specification indicates an invalid instrument set (Table A7) but dropping the problematic instrument and re-estimating generates an acceptable result (Table A5 and Table A7).

### **Skin problems**

54. Expenditure: The 2007/08 specification generates an acceptable result but the IMD variable is insignificant (Table A7). Re-estimation without this reveals that the 'professional occupations' variable wants to enter the specification and, when this specification is estimated, the 'no car' variable becomes insignificant. Dropping this variable generates the result shown in Tables A5 and A7.

### **Musculo-Skeletal system**

55. Expenditure: The 2007/08 specification generates a significant positive coefficient on 'other need' (Table A7). If the two insignificant regressors are dropped and the 'professional occupations' variable is added then we obtain an acceptable result (see Table A5 and Table A7).

### **Trauma and injuries**

56. Outcome: Re-estimation of the 2007/08 specification generates a poor result (Table A7). Re-derivation still using the trauma SMR as the dependent variable offers no improvement (Table A7) and an equally disappointing result is obtained re-deriving with skull fracture SMR as the dependent variable (Table A7). Note that we were also unable to obtain a plausible outcome specification for this PBC using PCT-level data for this year.

57. Expenditure: The 2007/08 specification generates an OK result (Table A5 and Table A7).

### **Genito-urinary system**

58. Outcome: The 2007/08 specification generates an OK result but the instruments are far too weak (see Table A6). Re-derivation of an IV specification also generates a poor result (eg positive coefficient on expenditure) but re-estimation excluding those LAs with expenditure outside the 5<sup>th</sup> and 95<sup>th</sup> percentiles generates a more acceptable result (Table A6). However, the endogeneity test reveals that expenditure is not endogenous in this specification so we re-estimate using OLS (see Table A4 and A6).

59. Expenditure: The 2007/08 specification generates a plausible result but there is some evidence of mis-specification (Table A7). The addition of one further regressor (long-term unemployed) remedies the mis-specification issue and the coefficient on the regressor is significant and with the anticipated sign (Table A5 and Table A7).

### **Maternity/Neonates**

60. Outcome: The 2007/08 specification generates a positive coefficient on expenditure in the outcome equation (Table A6). Re-derivation still produces a positive coefficient on expenditure and an invalid instrument set (Table A6). Small adjustments to both the instrument and regressor sets generate a more plausible model (see Table A4 and A6). Although the endogeneity test statistic is not significant at the 10% level, we retain the IV result as the OLS equivalent also generates a positive coefficient on expenditure.

61. Expenditure: The 2007/08 specification generates an acceptable result (see Table A5 and Table A7).

### **Poisoning**

62. Expenditure: The 2007/08 specification generates an acceptable result (Table A5 and Table A7).

### **Healthy Individuals**

63. Expenditure: All regressors are insignificant if we apply the 2007/08 specification to 2006/07 data (see Table A7). Re-derivation generates a plausible result (Table A7) but this suggests that 'other need' is not endogenous. OLS estimation of the re-derived specification generates the result shown in Table A5 and Table A7.

### **Social Care**

64. Expenditure: The 2007/08 specification generates an OK result but there is little evidence to suggest that the 'other need' variable is endogenous (Table A7). Re-estimation using OLS generates the result shown in Table A5 and Table A7. [Note that the sample restriction to LAs with expenditure per head of between £15 and £75 is the same as that employed for 2007/08. This is necessary because there is a large number of 'outliers'].

### **GMS/PMS**

65. Expenditure: The 2007/08 specification generates a mostly OK result but there is some evidence of mis-specification (Table A7). The addition of two more regressors remedies this issue and the coefficients on the two are significant and with the expected signs (see Table A5 and Table A7).

**All PBCs: Comparing specifications for 2006/07 and 2007/08**

66. Table A2 summarises whether the preferred specification for each equation is the same as for the previous year ('pass') or, if not, why the previous year's specification is not suitable. For example, this might be because the previous specification does not 'pass' the appropriate statistical tests when estimated on updated data. It could also be because the estimated coefficients are incompatible with our prior beliefs about their sign and significance. For example, one of our priors is that, for the outcome equation, health care expenditure should not have a negative marginal effect on mortality and another is that, in the expenditure equation, budget should have a positive marginal effect on PBC expenditure. In a small number of cases, the previous specification might 'fail' on both statistical tests and on priors.

67. Finally, Table A3 reports the number times where the preferred specification for 2006/07 is OLS and this is the same/similar specification as was preferred for the previous year (i.e., we do not re-derive the OLS specification).

Table A2 Nature of failure of previous year's specification when applied to the following year's data

PBC #	PBC Title	2009/10 Outcome	2009/10 Expenditure	2008/09 Outcome	2008/09 Expenditure	2007/08 Outcome	2007/08 Expenditure	2006/07 Outcome	2006/07 Expenditure	2005/06 Outcome	2005/06 Expenditure	2004/05 Outcome	2004/05 Expenditure	2003/04 Outcome	2003/04 Expenditure
1	Infectious diseases	Tests		Tests		Tests		Tests	Tests						
2	Cancers and tumours		Prior (A)				Prior (A)	Tests							
3	Diseases of the blood	n/a	Prior (A)	n/a		n/a		n/a							
4	Endocrine, nutritional, metabolic	Tests			Prior (A)	Tests, prior		Tests	Prior (C)						
5	Mental health disorders	n/a		n/a		n/a		n/a							
6	Learning disability	n/a	Tests	n/a		n/a		n/a	Test, prior(A, C)						
7	Neurological problems	Prior		Tests		Prior	Tests	Tests, prior	Test, prior(C)						
8	Vision problems	n/a	Priors (A, C)	n/a		n/a	Tests	n/a							
9	Hearing problems	n/a	Priors (A, C)	n/a		n/a	Prior [B]	n/a							
10	Circulatory problems				Prior (A)	Tests									
11	Respiratory problems	Tests				Tests	Prior (A)								
12	Dental problems	n/a	Tests	n/a	Test, prior (B, C)	n/a	Test, prior [B]	n/a	Prior (C)						
13	Gastro-intestinal problems	Tests					Prior (A)		Tests						
14	Skin problems	n/a	Tests	n/a		n/a		n/a	Prior (C)						
15	Musculo-skeletal problems	n/a	Prior (A)	n/a	Prior (A)	n/a		n/a	Prior (B)						
16	Trauma and injuries	n/a		n/a		n/a		n/a							
17	Genito-urinary problems	Prior		Prior		Prior	Prior [C]	Tests	Tests						
18	Maternity and reproductive health	Tests		Prior				Prior							
19	Neonates														
20	Poisoning and adverse events	n/a		n/a		n/a	Prior (A)	n/a							
21	Healthy individuals	n/a		n/a		n/a	Prior [A, C]	n/a	Prior(A, B, C)						
22	Social care needs	n/a	Prior (C)	n/a		n/a	Prior [C]	n/a							
23	Other (includes GMS/PMS)	n/a	Priors (A, C)	n/a		n/a		n/a	Tests						
Totals	Pass (= blank cell)	n=2	n=12	n=5	n=18	n=3	n=11	n=3	n=11						
	Tests	n=5	n=3	n=2	n=0	n=3	n=2	n=4	n=4						
	Prior (negative coefficient on expenditure)	n=2		n=2		n=2		n=1							
	Tests and priors	n=0	n=0		n=1	n=1	n=1	n=1	n=2						
	Prior (A: 'significant', +ve coefficient on budget)		n=3		n=3		n=4								
	Prior (B: no significant +ve coefficient on o/need)		n=0				n=1		n=1						
	Prior (C: other coefficients significant)		n=1				n=2		n=3						
	Priors (A, C)		n=3				n=1		n=1						

Notes: (i) here, 'previous year' relates to the next year temporally (ie we are working backwards); and  
(ii) a 'pass' is recorded if the only change is to drop an insignificant regressor (will be recorded as an 'A' in Table 1) and/or if an IV specification is re-estimated using OLS.

Table A3 OLS specification for previous year and current year

Number of times preferred specification is OLS and the same/similar OLS specification as in the previous year		2008/09	2007/08	2006/07	2005/06	2004/05	2003/04
Outcome equation	(maximum n=10)	n=1	n=1	n=0			
Expenditure equation	(maximum n=22)	n=11	n=12	n=12			

## APPENDIX

### Part B Preferred specifications for outcome and expenditure models for 2006/07

In this section, Tables A4 and A5 provide details of our preferred specification for each outcome and expenditure model by PBC for 2006/07.

Table A4 Preferred outcome specifications for 2006/07

	(1) PBC 1 infectious 2006/7 spend	(2) PBC 2 cancer 2006/7 spend	(3) PBC 4 endocrine 2006/7 spend	(4) PBC 7 neurological 2006/7 spend	(5) PBC 10 circulatory 2006/7 spend	(6) PBC 11 respiratory 2006/7 spend	(7) PBC 13 gastro 2006/7 spend	(8) PBC 17 genito-urinary 2006/7 spend	(9) PBC 1819 mat/neonates 2006/7 spend mortality rate 2006/7/8
	SYLLR 2006/7/8 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 06	SYLLR 2006/7/8 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 06	SYLLR 2006/7/8 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 06	SYLLR 2006/7/8 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 06	SYLLR 2006/7/8 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 06	SYLLR 2006/7/8 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 06	SYLLR 2006/7/8 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 06	SYLLR 2006/7/8 outcome model instrument spend weighted OLS LA-level actual mortality actual census 06 re-derived	SYLLR 2006/7/8 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 06 re-derived
VARIABLES	07/08 revised	07/08 revised	07/08 revised+	re-derived++	07/08 specification	07/08 specification	07/08 specification	5%/95% OLS	re-derived+
ILAg1_67	-0.608 [0.402]								
ILAhivneedph	0.478*** [0.142]								
ILAhivneedph2	0.114 [0.076]								
ILAIMD_2007EXEXPBOOK	0.519*** [0.113]		0.765*** [0.178]	0.307*** [0.082]					0.292 [0.191]
ILAg2_67netpopheadOHP		-0.239*** [0.083]							
ILANeedCARAN67		0.914*** [0.085]			2.296*** [0.282]	2.781** [1.106]	4.015*** [0.782]		0.917** [0.435]
ILANeedCARAN672		0.955*** [0.280]							
ILAg4_67OHP			-1.464 [0.976]						
ILADIAPREV0607			1.233*** [0.428]						
ILAg7_67OHP				-0.869* [0.494]					
LPOPPUCAR06				1.492*** [0.371]				-2.849** [1.157]	
ILAg10_67netpopheadOHP					-1.404***				

LPROFOCCU06						[0.218]			
						-0.508***			
						[0.140]			
ILAg11_67netpopheadOHP									
LPERMSICK06									
LPERMSICK06SQ									
ILAg13_67netpopheadOHP									
ILAg17_67netpopheadOHP									
LNQUAL17406									
LWHITEEG06									
ILAg1819_67OHP									
LBORNEXEU06									
LHHNOCAR06									
LPC74LTUN06									
Constant	2.248**	6.052***	8.080*	7.442***	10.621***	18.286***	8.505***	-2.020	
	[0.944]	[0.364]	[4.157]	[2.483]	[1.006]	[5.109]	[2.703]	[2.908]	
Observations	148	150	136	117	150	150	149	135	149
Endogeneity test statistic	1.915	8.416	2.828	2.516	35.080	24.628	6.928		0.824
Endogeneity p-value	0.166	0.004	0.093	0.113	0.000	0.000	0.008		0.364
Kleibergen-Paap LM test statistic	9.043	19.866	7.931	16.288	35.077	6.770	10.318		14.757
Kleibergen-Paap p-value	0.003	0.000	0.005	0.001	0.000	0.009	0.001		0.001
Kleibergen-Paap F statistic	15.331	16.380	9.502	7.767	30.494	12.140	15.426		9.216
Pesaran-Taylor reset statistic	0.248	0.358	0.044	0.615	0.039	1.756	0.054		1.239
Pesaran-Taylor p-value	0.618	0.550	0.834	0.433	0.843	0.185	0.817		0.266
Hansen-Sargan test statistic		1.457		0.005	0.624				2.628
Hansen-Sargan p-value		0.227		0.998	0.430				0.105
R-squared								0.222	
Ramsey reset F statistic								0.752	
Probability > F								0.523	

Robust standard errors in brackets

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Table A5 Preferred expenditure specifications for 2006/07

	(1) PBC 1 infectious 2006/7 spend SYLLR 2006/7/8 spend model instrument n/a weighted OLS  LA-level actual mortality actual census 06 07/08 spec revised	(2) PBC 2 cancer 2006/7 spend SYLLR 2006/7/8 spend model instrument o/need weighted IV second stage GMM2S  LA-level actual mortality actual census 06 07/08 specification	(3) PBC 3 blood 2006/7 spend SYLLR 2006/7/8 spend model instrument n/a weighted OLS  LA-level actual mortality actual census 06 07/08 specification	(4) PBC 4 endocrine 2006/7 spend SYLLR 2006/7/8 spend model instrument n/a weighted OLS  LA-level actual mortality actual census 06 07/08 revised	(5) PBC 5 mental health 2006/7 spend SYLLR 2006/7/8 spend model instrument n/a weighted OLS  LA-level actual mortality actual census 06 07/08 specification	(6) PBC 6 LDisability 2006/07 spend SYLLR 2006/7/8 spend model instrument n/a weighted OLS  LA-level actual mortality actual census 06 re-derived OLS	(7) PBC 7 neurological 2006/07 spend SYLLR 2006/7/8 spend model instrument n/a weighted OLS  LA-level actual mortality actual census 06 7/8 revised OLS	(8) PBC 8 vision 2006/7 spend SYLLR 2006/7/8 spend model instrument o/need weighted IV second stage GMM2S  LA-level actual mortality actual census 06 07/08 specification	(9) PBC 9 hearing 2006/7 spend SYLLR 2006/7/8 spend model instrument n/a weighted OLS  LA-level actual mortality actual census 06 07/08 revised
ILAgall_67netpopheadOHP	1.051*** [0.258]	1.219*** [0.263]	1.037*** [0.330]	0.630*** [0.168]	1.143*** [0.204]	0.410 [0.488]	0.382* [0.220]	0.931*** [0.329]	0.989** [0.458]
ILAhivneedph	0.364*** [0.040]								
ISYLLRacExlandP678	-0.043 [0.288]								
ILAhivneedph2	0.165*** [0.026]								
LPROFOCCU06	0.647* [0.346]	-0.527*** [0.102]				-0.762*** [0.243]			-0.607** [0.254]
LNQUAL17406	0.357 [0.364]			0.185** [0.078]				0.803*** [0.126]	
ISYLLRacExCancer678		-0.751*** [0.204]							
ISYLLRallcause678			-0.648** [0.321]		-0.397*** [0.124]	-0.561* [0.330]		-0.664** [0.273]	-0.079 [0.313]
LLONEPARH06			0.565*** [0.194]						
ISYLLRacExDIA678				0.051 [0.137]					
ILAmhneedindexpp					0.560*** [0.148]				
LPOPPUCAR06					-0.837*** [0.118]				
LBORNEXEU06						0.279*** [0.083]			
LWHITEEG06						0.838*** [0.303]			
ILAepiprev0607							0.417*** [0.102]		
ISYLLRacExEPI678							0.119 [0.159]		
Constant	-3.116 [2.237]	-0.773 [1.188]	0.769 [2.461]	-1.014 [1.017]	-2.637 [1.850]	4.214* [2.513]	2.561* [1.334]	1.677 [1.537]	-5.653** [2.581]
Observations	148	150	150	150	150	150	150	150	150

R-squared	0.698		0.162	0.371	0.739	0.111	0.283		0.253
Ramsey reset F statistic	1.801		0.305	0.553	1.380	0.238	0.219		0.601
Probability > F	0.150		0.822	0.647	0.252	0.870	0.883		0.615
Endogeneity test statistic		12.742						1.869	
Endogeneity p-value		0.000						0.172	
Hansen-Sargan test statistic		0.194						0.037	
Hansen-Sargan p-value		0.660						0.848	
Kleibergen-Paap LM test statistic		33.956						34.857	
Kleibergen-Paap p-value		0.000						0.000	
Kleibergen-Paap F statistic		46.177						74.593	
Pesaran-Taylor reset statistic		0.014						0.007	
Pesaran-Taylor p-value		0.906						0.931	

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Robust standard errors in brackets

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Table A5 continued Preferred expenditure specifications for 2006/07

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	PBC 10 circulatory 2006/7 spend	PBC 11 respiratory 2006/7 spend	PBC 12 dental 2006/7 spend	PBC 13 gastro 2006/7 spend	PBC 14 skin problems 2006/7 spend	PBC 15 musculo-skeletal 2006/7 spend	PBC 16 trauma 2006/7 spend	PBC 17 genito- 2006/7 spend	PBC 1819 mat/neonates 2006/07 spend infant mort rate 2006/07/08 spend model spend exogenous weighted OLS	PBC 20 poisoning 2006/7 spend
	SYLLR 2006/7/8 spend model instrument o/need weighted IV second stage GMM2S LA-level actual mortality actual census 06 07/08 specification	SYLLR 2006/7/8 spend model instrument o/need weighted IV second stage GMM2S LA-level actual mortality actual census 06 07/08 specification	SYLLR 2006/7/8 spend model instrument n/a weighted OLS LA-level actual mortality actual census 07 re-derived OLS	SYLLR 2006/7/8 spend model instrument o/need weighted IV second stage GMM2S LA-level actual mortality actual census 06 07/08 revised	SYLLR 2006/7/8 spend model instrument n/a weighted OLS LA-level actual mortality actual census 06 07/08 revised	SYLLR 2006/7/8 spend model instrument n/a weighted OLS LA-level actual mortality actual census 06 07/08 specification	SYLLR 2006/7/8 spend model instrument n/a weighted OLS LA-level actual mortality actual census 06 07/08 specification	SYLLR 2006/7/8 spend model instrument n/a weighted OLS LA-level actual mortality actual census 06 07/08 revised	SYLLR 2006/7/8 spend model instrument n/a weighted OLS LA-level actual mortality actual census 06 07/08 specification	SYLLR 2006/7/8 spend model instrument spend weighted IV second stage GMM2S LA-level real mortality actual census 06 07/08 revised
VARIABLES										
ILAgall_67netpopheadOHP	1.578*** [0.270]	1.287*** [0.221]	0.835** [0.392]	1.014*** [0.210]	0.701*** [0.249]	0.628** [0.246]	0.705*** [0.233]	0.988*** [0.242]	0.614** [0.245]	1.107*** [0.300]
ISYLLRallcause678			0.628 [0.382]		-0.124 [0.155]	0.341 [0.224]	0.273 [0.210]		0.167 [0.177]	-0.667*** [0.237]
LPERMSICK06			-0.375 [0.284]							
LLONEPARH06			-2.097 [1.704]							
LLONEPARH06SQ			-0.480 [0.324]							
LWHITEEG06			0.734** [0.302]							
ISYLLRacExCirc678	-1.203*** [0.247]									
LNQUAL17406	0.553*** [0.093]	0.273*** [0.093]		0.402*** [0.079]						0.133 [0.122]
ISYLLRacExResp678		-0.262 [0.221]								
ISYLLRacExGast678				-0.363 [0.224]						
LPROFOCCU06					-0.287*** [0.100]	-0.504*** [0.182]				
LPC74LTUN06						-0.475*** [0.106]		0.147* [0.076]		
LWORKAGRI06							0.080*** [0.026]			
ISYLLRacExrenal678								-0.229 [0.184]		
ILAmatneedindexpp									0.561*** [0.123]	
Constant	1.221 [1.349]	-3.159*** [1.195]	-9.116 [5.559]	-0.291 [1.014]	-1.325 [1.338]	-5.128*** [1.863]	-2.329** [1.041]	-0.867 [1.298]	-1.203 [1.307]	-1.069 [1.571]
Observations	150	150	150	150	150	150	150	150	150	150
Endogeneity test statistic	26.058	7.261		4.381						11.024
Endogeneity p-value	0.000	0.007		0.036						0.001

Hansen-Sargan test statistic	0.158	0.478								1.866
Hansen-Sargan p-value	0.691	0.489								0.172
Kleibergen-Paap LM test statistic	27.832	34.096	29.551							35.141
Kleibergen-Paap p-value	0.000	0.000	0.000							0.000
Kleibergen-Paap F statistic	33.179	56.202	85.706							59.640
Pesaran-Taylor reset statistic	0.140	0.314	0.004							0.024
Pesaran-Taylor p-value	0.708	0.575	0.949							0.876
R-squared			0.343	0.286	0.277	0.230	0.358	0.391		
Ramsey reset F statistic			2.275	1.670	0.503	0.759	1.568	1.269		
Probability > F			0.083	0.176	0.681	0.519	0.200	0.287		

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Robust standard errors in brackets

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Table A5 continued Preferred expenditure specifications for 2006/07

	(1)	(2)	(3)
	PBC 21	PBC 22	PBC 23a
	HI	social care	GMS
	2006/7 spend	2006/07 spend	2006/7 spend
	SYLLR 2006/7/8	SYLLR 2006/7/8	SYLLR 2006/7/8
	spend model	spend model	spend model
	spend exogenous	spend exogenous	instrument n/a
	weighted	weighted	weighted
	OLS	OLS	OLS
	LA-level	LA-level	LA-level
	actual mortality	actual mortality	actual mortality
	actual census 07	actual census 06	actual census 06
VARIABLES	re-derived	07/08 specification	07/08 specification
ILAgall_67netpopheadOHP	0.709	1.702***	0.447***
	[0.432]	[0.489]	[0.112]
ISYLLRallcause678	-0.318	-0.817*	0.056
	[0.471]	[0.429]	[0.082]
LPOPPUCAR06	-2.104***		
	[0.681]		
LBORNEXEU06	-0.190***		
	[0.072]		
LNQUAL17406	0.903**		
	[0.394]		
LWORKAGRI06			0.051***
			[0.010]
LWHITEEG06			-0.225***
			[0.049]
Constant	-4.143	-3.938*	1.621***
	[3.699]	[2.367]	[0.452]
Observations	150	103	145
R-squared	0.134	0.102	0.367
Ramsey reset F statistic	1.695	0.312	0.757
Probability > F	0.171	0.817	0.520

Robust standard errors in brackets

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

**APPENDIX**

**Part C Estimation path to preferred specifications for outcome and expenditure models for 2006/07**

In this section, Tables A6 and A7 provide details of the estimation path to our preferred specifications for each outcome and expenditure model by PBC for 2006/07. For each PBC, we first estimate the model for 2006/07 using our preferred specification for 2007/08. If this specification fails to meet either the necessary statistical tests or our prior beliefs about the sign/size/significance of coefficients, then the specification is adjusted in line with our estimation strategy outlined on pp2-3 and the model is re-estimated. This process continues until we identify a specification that meets our priors and passes the relevant statistical tests. The final, preferred specification for each PBC for 2006/07 is also shown here, along with the results associated with the estimation of selected intermediate specifications.

Table A6 Estimation path to preferred outcome specifications for 2006/07

	(1) PBC 1 infectious 2006/7 spend SYLLR 2006/7/8 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 06 07/08 specification	(2) PBC 1 infectious 2006/7 spend SYLLR 2006/7/8 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 06 07/08 revised	(3) PBC 2 cancer 2006/7 spend SYLLR 2006/7/8 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 06 07/08 specification	(4) PBC 2 cancer 2006/7 spend SYLLR 2006/7/8 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 06 07/08 revised	(5) PBC 4 endocrine 2006/7 spend SYLLR 2006/7/8 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 06 07/08 specification	(6) PBC 4 endocrine 2006/7 spend SYLLR 2006/7/8 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 06 07/08 revised	(7) PBC 4 endocrine 2006/7 spend SYLLR 2006/7/8 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 06 07/08 revised+	(8) PBC 7 neurological 2006/7 spend SYLLR 2006/7/8 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 06 07/08 specification	(9) PBC 7 neurological 2006/7 spend SYLLR 2006/7/8 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 06 re-derived	(10) PBC 7 neurological 2006/7 spend SYLLR 2006/7/8 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 06 re-derived+	(11) PBC 7 neurological 2006/7 spend SYLLR 2006/7/8 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 06 re-derived++	
ILAg1_67	-0.997*** [0.371]	-0.608 [0.402]										
ILAhivneedph	0.613*** [0.132]	0.478*** [0.142]										
ILAhivneedph2	0.181** [0.072]	0.114 [0.076]										
ILAIMd_2007exexpobook	0.616*** [0.109]	0.519*** [0.113]			0.650*** [0.240]	0.747*** [0.168]	0.765*** [0.178]					0.307*** [0.082]
ILAg2_67netpopheadOHP			-0.263*** [0.092]	-0.239*** [0.083]								
ILANeedCARAN67			0.945*** [0.099]	0.914*** [0.085]				0.332 [0.600]				
ILANeedCARAN672				0.955***								

				[0.280]								
ILag4_67OHP					-0.655	-1.492*	-1.464					
					[1.819]	[0.898]	[0.976]					
LPROFOCCU06					-0.479	-0.624***						
					[0.350]	[0.233]						
ILAdiaprev0607								1.233***				
								[0.428]				
ILag7_67OHP									0.890	0.241	-0.185	-0.869*
									[0.609]	[0.270]	[0.441]	[0.494]
LPOPPUCAR06										0.726***	1.263***	1.492***
										[0.281]	[0.363]	[0.371]
LPC74LTUN06										0.327***	0.299***	
										[0.086]	[0.087]	
Constant	3.087***	2.248**	6.174***	6.052***	1.119	3.652	8.080*	-2.056	3.625**	6.403***	7.442***	
	[0.897]	[0.944]	[0.405]	[0.364]	[5.493]	[2.652]	[4.157]	[2.438]	[1.633]	[2.291]	[2.483]	
Observations	148	148	150	150	136	136	136	149	149	117	117	
Endogeneity test statistic	4.644	1.915	7.384	8.416	0.167	4.017	2.828	3.855	1.048	0.053	2.516	
Endogeneity p-value	0.031	0.166	0.007	0.004	0.683	0.045	0.093	0.050	0.306	0.818	0.113	
Hansen-Sargan test statistic	3.158		3.215	1.457				0.139	2.898	2.462	0.005	
Hansen-Sargan p-value	0.076		0.073	0.227				0.933	0.408	0.482	0.998	
Kleibergen-Paap LM test statistic	10.235	9.043	19.716	19.866	3.876	10.362	7.931	11.250	23.930	18.215	16.288	
Kleibergen-Paap p-value	0.006	0.003	0.000	0.000	0.049	0.006	0.005	0.010	0.000	0.001	0.001	
Kleibergen-Paap F statistic	8.180	15.331	15.719	16.380	3.995	6.238	9.502	5.146	11.239	6.283	7.767	
Pesaran-Taylor reset statistic	0.256	0.248	2.463	0.358	0.004	0.109	0.044	0.003	0.134	1.015	0.615	
Pesaran-Taylor p-value	0.613	0.618	0.117	0.550	0.950	0.741	0.834	0.957	0.714	0.314	0.433	

Robust standard errors in brackets

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Table A6 continued Estimation path to preferred outcome specifications for 2006/07

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	PBC 10	PBC 11	PBC 13	PBC 16	PBC 16	PBC 16	PBC 17	PBC 17
	circulatory	respiratory	gastro	trauma	trauma	trauma	genito-urinary	genito-urinary
	2006/7 spend	2006/7 spend	2006/7 spend	2006/7 spend	2006/7 spend	2006/7 spend	2006/7 spend	2006/7 spend
	SYLLR 2006/7/8	SYLLR 2006/7/8	SYLLR 2006/7/8	SMR 2006/7/8	SMR 2006/7/8	SMR 2006/7/8	SYLLR 2006/7/8	SYLLR 2006/7/8
	outcome model	outcome model	outcome model	outcome model	outcome model	outcome model	outcome model	outcome model
	instrument spend	instrument spend	instrument spend	instrument spend	instrument spend	instrument spend	instrument spend	instrument spend
	weighted	weighted	weighted	weighted	weighted	weighted	weighted	weighted
	IV second stage	IV second stage	IV second stage	IV second stage	IV second stage	IV second stage	IV second stage	IV second stage
	GMM2S	GMM2S	GMM2S	GMM2S	GMM2S	GMM2S	GMM2S	GMM2S
	LA-level	LA-level	LA-level	LA-level	LA-level	LA-level	LA-level	LA-level
	actual mortality	actual mortality	actual mortality	actual mortality	actual mortality	actual mortality	actual mortality	actual mortality
	actual census 06	actual census 06	actual census 06	actual census 06	actual census 06	actual census 06	actual census 06	actual census 06
VARIABLES	07/08 specification	07/08 specification	07/08 specification	07/08 specification	trauma: re-derived	skull: re-derived	07/08 specification	re-derived
ILAg11_67netpopheadOHP		-2.281*** [0.801]						
ILAneedCARAN67	2.296*** [0.282]	2.781** [1.106]	4.015*** [0.782]	0.884 [1.323]	2.155*** [0.775]	1.531*** [0.574]	8.392** [4.242]	
LPERMSICK06		2.745** [1.385]						
LPERMSICK06SQ		0.285 [0.203]						
ILAg10_67netpopheadOHP	-1.404*** [0.218]							
LPROFOCCU06	-0.508*** [0.140]							
ILAg13_67netpopheadOHP			-1.255** [0.632]					
ILAg16_67OHP				0.518 [0.704]	0.651 [0.463]	0.709* [0.399]		
LPC74LTUN06				0.025 [0.304]				
LLONEPARH06					-0.566** [0.226]	-0.593** [0.238]		
LLONEPENH06					-1.624*** [0.386]	-1.685*** [0.429]		
LOWNOCC06					0.402* [0.232]			
LPOPPUCAR06						0.753** [0.348]		-2.691*** [1.028]
ILAg17_67OHP							-5.747 [3.731]	0.230 [0.635]
LBORNEXEU06							0.351** [0.153]	
LNQUAL17406								1.969*** [0.491]
LWHITEEG06								-0.910* [0.505]
Constant	10.621*** [1.006]	18.286*** [5.109]	8.505*** [2.703]	-1.311 [1.682]	-6.603*** [2.181]	-5.639** [2.216]	24.544 [15.860]	-5.323 [3.359]

Observations	150	150	149	150	150	150	150	150
Endogeneity test statistic	35.080	24.628	6.928	0.624	1.979	2.830	9.050	0.177
Endogeneity p-value	0.000	0.000	0.008	0.430	0.159	0.093	0.003	0.674
Hansen-Sargan test statistic	0.624			0.001	0.123	0.518	0.092	0.042
Hansen-Sargan p-value	0.430			0.969	0.940	0.772	0.762	0.838
Kleibergen-Paap LM test statistic	35.077	6.770	10.318	3.288	11.845	15.792	3.364	18.139
Kleibergen-Paap p-value	0.000	0.009	0.001	0.193	0.008	0.001	0.186	0.000
Kleibergen-Paap F statistic	30.494	12.140	15.426	1.672	4.154	5.472	1.849	18.505
Pesaran-Taylor reset statistic	0.039	1.756	0.054	0.001	0.998	1.607	0.141	1.261
Pesaran-Taylor p-value	0.843	0.185	0.817	0.973	0.318	0.205	0.707	0.261

Robust standard errors in brackets

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Table A6 continued Estimation path to preferred outcome specifications for 2006/07

	(1)	(2)	(3)	(4)	(5)
	PBC 17	PBC 17	PBC 1819	PBC 1819	PBC 1819
	genito-urinary	genito-urinary	mat/neonates	mat/neonates	mat/neonates
	2006/7 spend	2006/7 spend	2006/7 spend	2006/7 spend	2006/7 spend
	SYLLR 2006/7/8	SYLLR 2006/7/8	infant mort rate	infant mort rate	infant mort rate
	outcome model	outcome model	2006/07/08	2006/07/08	2006/07/08
	instrument spend	instrument n/a	outcome model	outcome model	outcome model
	weighted	weighted	spend exogenous	instrument spend	instrument spend
	IV second stage	OLS	weighted	weighted	weighted
	GMM2S		OLS	IV second stage	IV second stage
	LA-level	LA-level	LA-level	LA-level	LA-level
	actual mortality	actual mortality	actual mortality	actual mortality	actual mortality
	actual census 06	actual census 06	actual census 06	actual census 06	actual census 06
VARIABLES	re-derived 5%/95%	re-derived 5/95% OLS	07/08 specification	re-derived	re-derived+
ILAg17_67OHP	-0.109 [0.861]				
LNQUAL17406	2.021*** [0.519]	2.140*** [0.524]			
LPOPPUCAR06	-2.897*** [1.077]	-2.849** [1.157]			
LWHITEEG06	-0.900* [0.510]	-0.973* [0.557]			
ILAg17_67netpopheadOHP		-0.588 [0.428]			
ILAg1819_67netpopheadOHP			0.106 [0.065]		
ILAneedCARAN67			1.200*** [0.295]	1.432*** [0.305]	0.917** [0.435]
LBORNEXEU06			0.117*** [0.040]	0.141*** [0.039]	0.120*** [0.039]
LHHNOCAR06			-0.612*** [0.125]	-0.650*** [0.121]	-0.708*** [0.140]
LPC74LTUN06			0.558*** [0.103]	0.558*** [0.113]	0.489*** [0.125]
ILAg1819_67OHP				0.019 [0.206]	-0.085 [0.205]
ILAIMD_2007exexpobook					0.292 [0.191]
Constant	-4.294 [4.127]	-2.020 [2.908]	2.598*** [0.489]	2.965** [1.170]	2.104 [1.481]
Observations	135	135	149	149	149
R-squared		0.222	0.458		
Endogeneity test statistic	0.431			0.209	0.824
Endogeneity p-value	0.511			0.648	0.364
Hansen-Sargan test statistic	0.014			11.528	2.628
Hansen-Sargan p-value	0.905			0.003	0.105
Kleibergen-Paap LM test statistic	26.687			16.172	14.757

Kleibergen-Paap p-value	0.000			0.001	0.001
Kleibergen-Paap F statistic	20.824			7.251	9.216
Pesaran-Taylor reset statistic	0.642			0.108	1.239
Pesaran-Taylor p-value	0.423			0.743	0.266
Ramsey reset F statistic		0.752	2.047		
Probability > F		0.523	0.110		

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Robust standard errors in brackets

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Table A7 Estimation path to preferred expenditure specifications for 2006/07

	(1) PBC 1 infectious 2006/7 spend SYLLR 2006/7/8 spend model  instrument n/a weighted OLS  LA-level actual mortality actual census 06 07/08 specification	(2) PBC 1 infectious 2006/7 spend SYLLR 2006/7/8 spend model  instrument n/a weighted OLS  LA-level actual mortality actual census 06 07/08 spec revised	(3) PBC 2 cancer 2006/7 spend SYLLR 2006/7/8 spend model instrument o/need weighted IV second stage GMM2S LA-level actual mortality actual census 06 07/08 specification	(4) PBC 3 blood 2006/7 spend SYLLR 2006/7/8 spend model  instrument n/a weighted OLS  LA-level actual mortality actual census 06 07/08 specification	(5) PBC 4 endocrine 2006/7 spend SYLLR 2006/7/8 spend model  instrument n/a weighted OLS  LA-level actual mortality actual census 06 07/08 specification	(6) PBC 4 endocrine 2006/7 spend SYLLR 2006/7/8 spend model  instrument n/a weighted OLS 07/08 revised	(7) PBC 5 mental health 2006/7 spend SYLLR 2006/7/8 spend model  instrument n/a weighted OLS  LA-level actual mortality actual census 06 07/08 specification	(8) PBC 6 LDisability 2006/7 spend SYLLR 2006/7/8 spend model  instrument n/a weighted OLS  LA-level actual mortality actual census 06 07/08 specification	(9) PBC 6 LDisability 2006/7 spend SYLLR 2006/7/8 spend model  instrument n/a weighted OLS re-derived OLS	(10) PBC 7 neurological 2006/7 spend SYLLR 2006/7/8 spend model instrument o/need weighted IV second stage GMM2S LA-level actual mortality actual census 06 07/08 specification	(11) PBC 7 neurological 2006/7 spend SYLLR 2006/7/8 spend model instrument o/need weighted IV second stage GMM2S LA-level actual mortality actual census 06 07/08 revised
ILAgall_67netpopheadOHP	0.952*** [0.257]	1.051*** [0.258]	1.219*** [0.263]	1.037*** [0.330]	0.638*** [0.177]	0.630*** [0.168]	1.143*** [0.204]	0.046 [0.431]	0.410 [0.488]	0.370 (0.291)	0.359 (0.285)
ILAhivneedph	0.381*** [0.026]	0.364*** [0.040]									
ISYLLRacExlandP678	-0.293 [0.217]	-0.043 [0.288]									
ILAhivneedph2	0.175*** [0.024]	0.165*** [0.026]									
LPROFOCCU06		0.647* [0.346]	-0.527*** [0.102]					-0.428 [0.267]	-0.762*** [0.243]		
LNQUAL17406		0.357 [0.364]			0.147 [0.502]	0.185** [0.078]					
ISYLLRacExCancer678			-0.751*** [0.204]								
ISYLLRallcause678				-0.648** [0.321]			-0.397*** [0.124]	-0.242 [0.333]	-0.561* [0.330]		
LLONEPARH06				0.565*** [0.194]							
LNQUAL17406SQ					0.007 [0.174]						
ILAdiaprev0607					0.134 [0.132]						
ISYLLRacExDIA678					0.046 [0.138]	0.051 [0.137]					
ILAmhneedindexpp							0.560*** [0.148]				
LPOPPUCAR06							-0.837*** [0.118]				
ILAneedCARAN672								1.497 [2.154]			
LBORNEXEU06									0.279*** [0.083]		
LWHITEEG06									0.838*** [0.303]		

ISYLLRacExEPI678										0.131 (0.297)	0.152 (0.229)
ILAepiprev0607										0.412*** (0.116)	0.422*** (0.101)
LPERMSICK06										0.009 (0.126)	
Constant	-2.175* [1.141]	-3.116 [2.237]	-0.773 [1.188]	0.769 [2.461]	-0.681 [1.295]	-1.014 [1.017]	-2.637 [1.850]	4.405 [2.671]	4.214* [2.513]	2.573 (2.141)	2.549* (1.353)
Observations	148	148	150	150	150	150	150	150	150	150	150
R-squared	0.687	0.698		0.162	0.375	0.371	0.739	0.042	0.111		
Ramsey reset F statistic	3.803	1.801		0.305	0.658	0.553	1.380	2.368	0.238		
Probability > F	0.012	0.150		0.822	0.579	0.647	0.252	0.073	0.870		
Endogeneity test statistic			12.742							0.028	0.075
Endogeneity p-value			0.000							0.868	0.785
Hansen-Sargan test statistic			0.194							0.916	0.812
Hansen-Sargan p-value			0.660							0.339	0.368
Kleibergen-Paap LM test statistic			33.956							19.850	34.367
Kleibergen-Paap p-value			0.000							0.000	0.000
Kleibergen-Paap F statistic			46.177							32.375	106.146
Pesaran-Taylor reset statistic			0.014							0.095	0.085
Pesaran-Taylor p-value			0.906							0.758	0.771

Robust standard errors in brackets

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Table A7 continued Estimation path to preferred expenditure specifications for 2006/07

	(1) PBC 7 neurological 2006/7 spend SYLLR 2006/7/8 spend model instrument n/a weighted OLS LA-level actual mortality actual census 06	(2) PBC 8 vision 2006/7 spend SYLLR 2006/7/8 spend model instrument o/need weighted IV second stage GMM2S LA-level actual mortality actual census 06 07/08	(3) PBC 9 hearing 2006/7 spend SYLLR 2006/7/8 spend model instrument n/a weighted OLS LA-level actual mortality actual census 06 07/08 revised	(4) PBC 10 circulatory 2006/7 spend SYLLR 2006/7/8 spend model instrument o/need weighted IV second stage GMM2S LA-level actual mortality actual census 06 07/08	(5) PBC 11 respiratory 2006/7 spend SYLLR 2006/7/8 spend model instrument o/need weighted IV second stage GMM2S LA-level actual mortality actual census 06 07/08	(6) PBC 12 dental 2006/7 spend SYLLR 2006/7/8 spend model instrument n/a weighted OLS LA-level actual mortality actual census 07 07/08	(7) PBC 12 dental 2006/7 spend SYLLR 2006/7/8 spend model instrument n/a weighted OLS LA-level actual mortality actual census 07 07/08 revised	(8) PBC 12 dental 2006/7 spend SYLLR 2006/7/8 spend model instrument o/need weighted IV second stage GMM2S LA-level actual mortality actual census 06 re-derived+	(9) PBC 12 dental 2006/7 spend SYLLR 2006/7/8 spend model instrument n/a weighted OLS LA-level actual mortality actual census 07 re-derived OLS	(10) PBC 13 gastro 2006/7 spend SYLLR 2006/7/8 spend model instrument o/need weighted IV second stage GMM2S LA-level actual mortality actual census 06 07/08	(11) PBC 13 gastro 2006/7 spend SYLLR 2006/7/8 spend model instrument o/need weighted IV second stage GMM2S LA-level actual mortality actual census 06 07/08 revised
VARIABLES	7/8 revised OLS	specification	07/08 revised	specification	specification	specification	07/08 revised	re-derived+	re-derived OLS	specification	07/08 revised
ILAgall_67netpopheadOHP	0.382* [0.220]	0.931*** [0.329]	0.989** [0.458]	1.578*** [0.270]	1.287*** [0.221]	-0.120 [0.198]	0.319 [0.227]	0.351 [0.329]	0.835** [0.392]	1.216*** [0.216]	1.014*** [0.210]
ILAepiprev0607	0.417*** [0.102]										
ISYLLRacExEPI678	0.119 [0.159]										
ISYLLRallcause678		-0.664** [0.273]	-0.079 [0.313]			0.752*** [0.235]	0.369 [0.245]	0.663** [0.278]	0.628 [0.382]		
LNQUAL17406		0.803*** [0.126]		0.553*** [0.093]	0.273*** [0.093]	0.037 [0.103]	0.089 [0.098]			0.450*** [0.079]	0.402*** [0.079]
LPROFOCCU06			-0.607** [0.254]								
ISYLLRacExCirc678				-1.203*** [0.247]							
ISYLLRacExResp678					-0.262 [0.221]						
LLONEPARH06						-0.120 [0.150]	0.017 [0.147]		-2.097 [1.704]		
LWHITEEG06								0.418** [0.191]	0.734** [0.302]		
LPERMSICK06									-0.375 [0.284]		
LLONEPARH06SQ									-0.480 [0.324]		
ISYLLRacExGast678										-0.669*** [0.208]	-0.363 [0.224]
Constant	2.561* [1.334]	1.677 [1.537]	-5.653** [2.581]	1.221 [1.349]	-3.159*** [1.195]	-0.006 [1.628]	-0.443 [1.568]	-2.587** [1.041]	-9.116 [5.559]	0.177 [1.048]	-0.291 [1.014]
Observations	150	150	150	150	150	123	135	150	150	150	150
R-squared	0.283		0.253			0.346	0.330		0.343		
Ramsey reset F statistic	0.219		0.601			0.149	1.846		2.275		
Probability > F	0.883		0.615			0.930	0.142		0.083		
Endogeneity test statistic		1.869		26.058	7.261			1.348		10.278	4.381

Endogeneity p-value	0.172	0.000	0.007	0.246	0.001	0.036
Hansen-Sargan test statistic	0.037	0.158	0.478	2.130	6.662	
Hansen-Sargan p-value	0.848	0.691	0.489	0.546	0.010	
Kleibergen-Paap LM test statistic	34.857	27.832	34.096	34.236	36.978	29.551
Kleibergen-Paap p-value	0.000	0.000	0.000	0.000	0.000	0.000
Kleibergen-Paap F statistic	74.593	33.179	56.202	55.222	68.427	85.706
Pesaran-Taylor reset statistic	0.007	0.140	0.314	0.064	0.010	0.004
Pesaran-Taylor p-value	0.931	0.708	0.575	0.801	0.919	0.949

Robust standard errors in brackets

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Table A7 continued Estimation path to preferred expenditure specifications for 2006/07

	(1) PBC 14	(2) PBC 14	(3) PBC 14	(4) PBC 15 musculo- skeletal	(5) PBC 15 musculo- skeletal	(6) PBC 16	(7) PBC 17	(8) PBC 17	(9) PBC 1819	(10) PBC 20
	skin problems 2006/7 spend	skin problems 2006/7 spend	skin problems 2006/7 spend	skin problems 2006/7 spend	skin problems 2006/7 spend	trauma 2006/7 spend	genito- 2006/7 spend	genito- 2006/7 spend	mat/neonates 2006/7 spend infant mort rate 2006/07/08 spend model	poisoning 2006/7 spend
	SYLLR 2006/7/8 spend model	SYLLR 2006/7/8 spend model	SYLLR 2006/7/8 spend model	SYLLR 2006/7/8 spend model	SYLLR 2006/7/8 spend model	SYLLR 2006/7/8 spend model	SYLLR 2006/7/8 spend model	SYLLR 2006/7/8 spend model		SYLLR 2006/7/8 spend model instrument spend weighted IV second stage GMM2S
	instrument n/a weighted OLS	instrument n/a weighted OLS	instrument n/a weighted OLS	instrument n/a weighted OLS	instrument n/a weighted OLS	instrument n/a weighted OLS	instrument n/a weighted OLS	instrument n/a weighted OLS	spend exogenous weighted OLS	
	LA-level actual mortality actual census 06 07/08 specification	LA-level actual mortality actual census 06 07/08 revised	LA-level actual mortality actual census 06 07/08 revised	LA-level actual mortality actual census 06 07/08 specification	LA-level actual mortality actual census 06 07/08 revised	LA-level actual mortality actual census 06 07/08 specification	LA-level real mortality actual census 06 07/08 revised			
VARIABLES										
ILAgall_67netpopheadOHP	0.786*** [0.271]	0.744*** [0.258]	0.701*** [0.249]	0.466 [0.298]	0.628** [0.246]	0.705*** [0.233]	1.035*** [0.244]	0.988*** [0.242]	0.614** [0.245]	1.107*** [0.300]
ISYLLRallcause678	0.065 [0.183]	-0.038 [0.179]	-0.124 [0.155]	0.541** [0.229]	0.341 [0.224]	0.273 [0.210]			0.167 [0.177]	-0.667*** [0.237]
ILAimd_2007exexpobook	0.151 [0.131]									
LHHNOCAR06	-0.199** [0.094]	-0.051 [0.070]								
LPROFOCCU06		-0.251** [0.109]	-0.287*** [0.100]		-0.504*** [0.182]					
LPC74LTUN06				-0.386*** [0.115]	-0.475*** [0.106]			0.147* [0.076]		
LPOPPUCAR06				0.469 [0.334]						
LNQUAL17406				0.206 [0.195]						0.133 [0.122]
LWORKAGRI06						0.080*** [0.026]				
ISYLLRacExrenal678							-0.015 [0.158]	-0.229 [0.184]		
ILAmatneedindexpp									0.561*** [0.123]	
Constant	-3.465** [1.530]	-2.185 [1.643]	-1.325 [1.338]	-2.809 [2.504]	-5.128*** [1.863]	-2.329** [1.041]	-3.143*** [1.134]	-0.867 [1.298]	-1.203 [1.307]	-1.069 [1.571]
Observations	150	150	150	150	150	150	150	150	150	150
R-squared	0.275	0.289	0.286	0.289	0.277	0.230	0.340	0.358	0.391	
Ramsey reset F statistic	1.993	1.769	1.670	0.439	0.503	0.759	3.053	1.568	1.269	
Probability > F	0.118	0.156	0.176	0.726	0.681	0.519	0.031	0.200	0.287	
Endogeneity test statistic										11.024
Endogeneity p-value										0.001
Hansen-Sargan test statistic										1.866

Hansen-Sargan p-value	0.172
Kleibergen-Paap LM test statistic	35.141
Kleibergen-Paap p-value	0.000
Kleibergen-Paap F statistic	59.640
Pesaran-Taylor reset statistic	0.024
Pesaran-Taylor p-value	0.876

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Robust standard errors in brackets

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Table A7 continued Estimation path to preferred expenditure specifications for 2006/07

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	PBC 21	PBC 21	PBC 21	PBC 22	PBC 22	PBC 23a	PBC 23a
	HI	HI	HI	social care	social care	GMS	GMS
	2006/7 spend	2006/7 spend	2006/7 spend	2006/7 spend	2006/7 spend	2006/7 spend	2006/7 spend
	SYLLR 2006/7/8	SYLLR 2006/7/8	SYLLR 2006/7/8	SYLLR 2006/7/8	SYLLR 2006/7/8	SYLLR 2006/7/8	SYLLR 2006/7/8
	spend model	spend model	spend model	spend model	spend model	spend model	spend model
	spend exogenous	instrument spend	spend exogenous	instrument spend	spend exogenous	instrument n/a	instrument n/a
	weighted	weighted	weighted	weighted	weighted	weighted	weighted
	OLS	IV second stage	OLS	IV second stage	OLS	OLS	OLS
	LA-level	LA-level	LA-level	LA-level	LA-level	LA-level	LA-level
	actual mortality	real mortality	actual mortality	real mortality	actual mortality	actual mortality	actual mortality
	actual census 06	actual census 06	actual census 07	actual census 06	actual census 06	actual census 06	actual census 06
VARIABLES	07/08 specification	re-derived	re-derived OLS	07/08 specification	OLS	07/08 specification	07/08 specification
ILAgall_67netpopheadOHP	0.812	0.990*	0.709	1.997***	1.702***	0.424***	0.447***
	[0.519]	[0.548]	[0.432]	[0.654]	[0.489]	[0.129]	[0.112]
LNQUAL17406	0.398	1.091**	0.903**				
	[0.326]	[0.478]	[0.394]				
ISYLLRallcause678	-0.085	-0.627	-0.318	-1.027*	-0.817*	0.003	0.056
	[0.531]	[0.738]	[0.471]	[0.551]	[0.429]	[0.094]	[0.082]
LWHITEEG06	0.507						-0.225***
	[0.330]						[0.049]
LLONEPENH06	-0.775						
	[0.530]						
LPOPPUCAR06		-2.361***	-2.104***				
		[0.665]	[0.681]				
LBORNEXEU06		-0.189***	-0.190***				
		[0.071]	[0.072]				
LWORKAGRI06							0.051***
							[0.010]
Constant	-3.116	-4.630	-4.143	-4.780**	-3.938*	1.885***	1.621***
	[3.711]	[3.310]	[3.699]	[2.311]	[2.367]	[0.502]	[0.452]
Observations	150	150	150	103	103	145	145
R-squared	0.102		0.134		0.102	0.262	0.367
Ramsey reset F statistic	1.353		1.695		0.312	3.587	0.757
Probability > F	0.260		0.171		0.817	0.015	0.520
Endogeneity test statistic		0.643		0.078			
Endogeneity p-value		0.422		0.780			
Hansen-Sargan test statistic		0.647		5.544			
Hansen-Sargan p-value		0.886		0.136			
Kleibergen-Paap LM test statistic		29.393		24.762			
Kleibergen-Paap p-value		0.000		0.000			
Kleibergen-Paap F statistic		23.169		25.408			
Pesaran-Taylor reset statistic		0.020		0.072			
Pesaran-Taylor p-value		0.886		0.788			

Robust standard errors in brackets

\*\*\* p&lt;0.01, \*\* p&lt;0.05, \* p&lt;0.1

## Appendix 2: Expected health opportunity costs in the NHS (2006/07 results)

### Overview

68. In the second appendix results are presented that reflect the available data for 2006/07 expenditure (this forms Appendix 2.1). In Appendix 2.2, the results are also analysed in terms of how sensitive the results are to two key inputs: i) each of the estimated elasticities and ii) assumptions made in order to overcome data limitations for each PBC (only have mortality outcome data and for only a portion of PBCs). Finally, Appendix 2.3 briefly considers an update regarding data from ONS used to inform burden of disease.

### Appendix 2.1 Results

69. Results are presented in two ways as the point estimate of the cost per QALY of marginal activity in the NHS, or alternatively expressed as the expected QALY health opportunity cost for £10,000,000 expenditure.

Table A8 Deterministic results for 2006/07 compared to previously generated results

Year	2006/07	2007/08	2008/09	2009/10
Cost per QALY	£6,844	£9,747	£12,960	£9,887
Health opportunity costs of £10mn (QALYs)	1,461	1,026	772	1,011

70. It can be seen from Table A8 that the expected health opportunity costs of a given level of expenditure have increased between 2007/08 and 2006/07 and so the cost per QALY ratio has decreased. The associated uncertainty with each of these results is presented in Table A9 and figures A1 and A2 below.

Table A9 Probabilistic results for 2006/07 compared to previously generated results

<b>2006/07</b>	<b>Point estimate (deterministic)</b>	<b>Point estimate (probabilistic)</b>	<b>5th percentile</b>	<b>95th percentile</b>
<b>Cost per QALY</b>	£6,844	£6,838	£5,139	£9,878
<b>Health opportunity costs of £10mn (QALYs)</b>	1,461	1,462	1,012	1,946
<b>2007/08</b>	<b>Point estimate (deterministic)</b>	<b>Point estimate (probabilistic)</b>	<b>5th percentile</b>	<b>95th percentile</b>
<b>Cost per QALY</b>	£9,747	£9,765	£7,689	£13,043
<b>Health opportunity costs of £10mn (QALYs)</b>	1,026	1,024	767	1,301
<b>2008/09</b>	<b>Point estimate (deterministic)</b>	<b>Point estimate (probabilistic)</b>	<b>5th percentile</b>	<b>95th percentile</b>
<b>Cost per QALY</b>	£12,960	£13,271	£8,390	£32,881
<b>Health opportunity costs of £10mn (QALYs)</b>	772	754	304	1,192
<b>2009/10</b>	<b>Point estimate (deterministic)</b>	<b>Point estimate (probabilistic)</b>	<b>5th percentile</b>	<b>95th percentile</b>
<b>Cost per QALY</b>	£9,887	£9,920	£6,802	£17,296
<b>Health opportunity costs of £10mn (QALYs)</b>	1,011	1,008	578	1,470

It can be seen from Table A9 that the expected health opportunity costs of a change in expenditure have increased slightly between 2007/08 and 2006/07 and so the cost per QALY ratio has fallen. From Table A9 it is hard to conclude that there is a significant change in the health opportunity costs of £10mn expenditure, since there is a great deal of overlap between the 90% confidence intervals of the years shown.

Figure A1 Results illustrating uncertainty for 2006/07 and previously generated results – cost per QALY

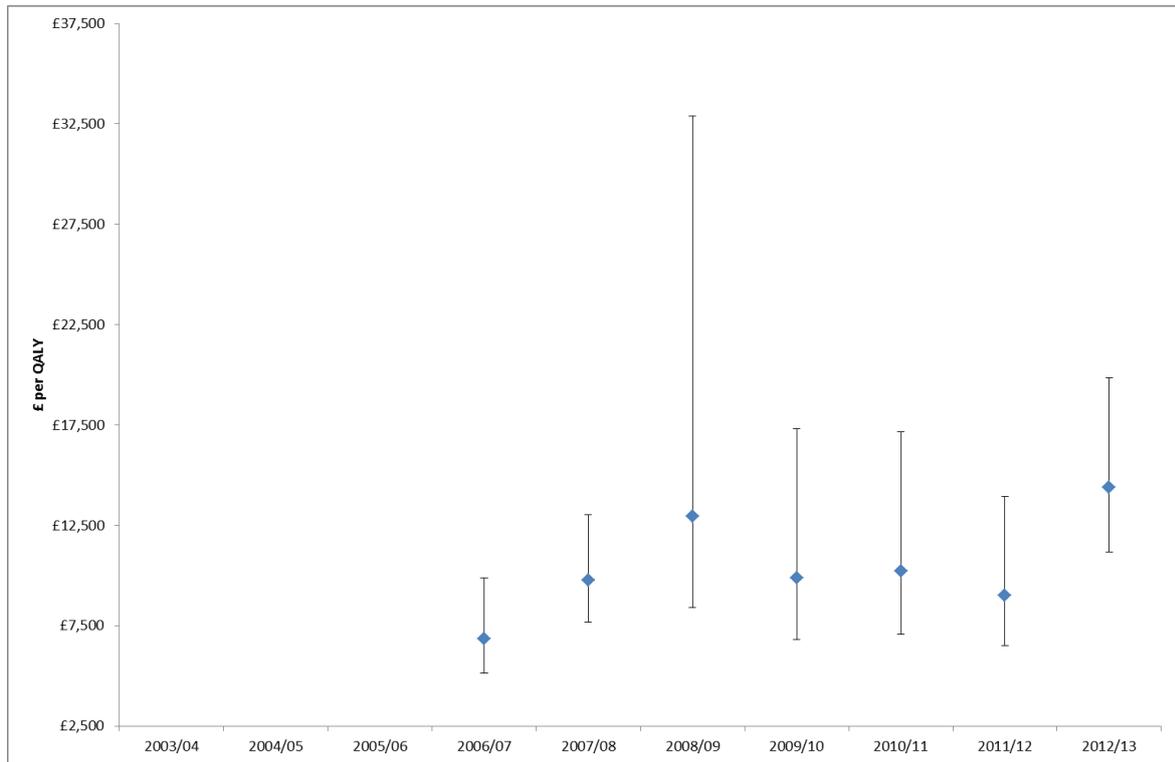
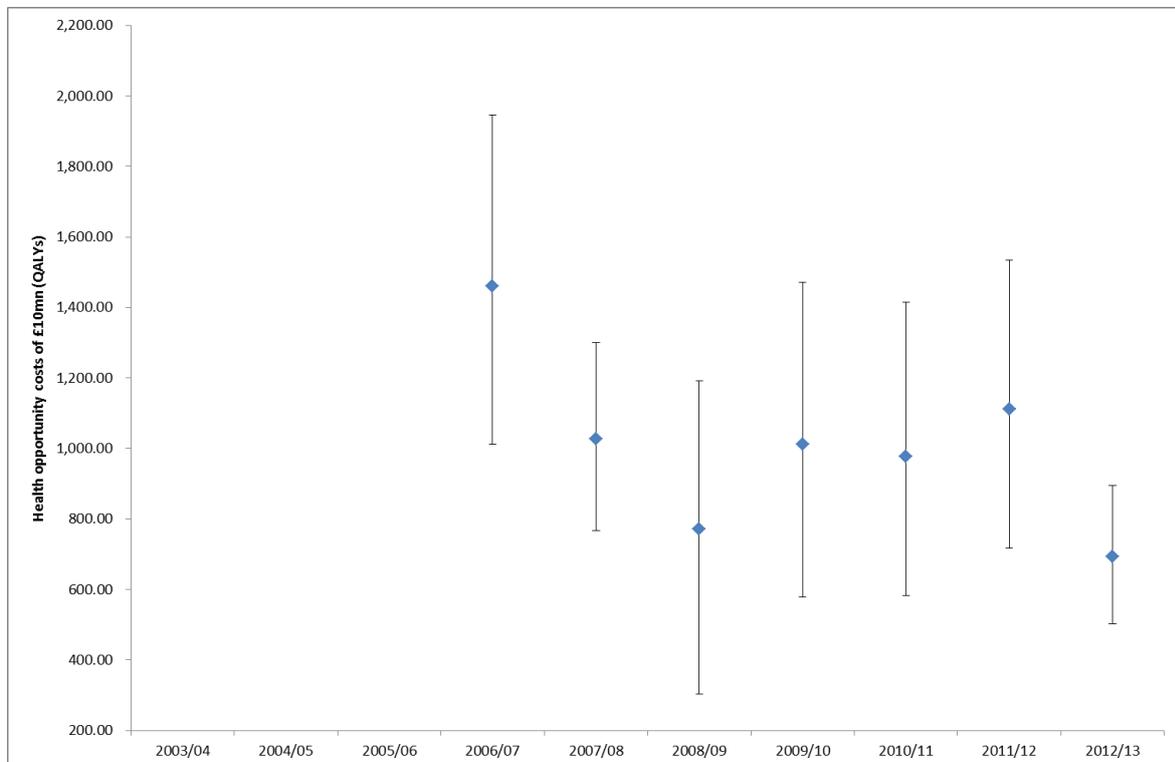


Figure A2 Results illustrating uncertainty for 2006/07 and previously generated results – Health opportunity costs of £10mn (QALYs)



71. It can also be seen from Figures A1 and A2 that while the confidence interval is far from symmetrically distributed around the point estimate of the cost per QALY ratio in Figure A1 (where uncertainty is reflected in the denominator), when expressed as health opportunity costs per £10mn then the distribution of uncertainty is much more symmetric in Figure A2 (uncertainty is reflected in the numerator).

72. It is also possible to generate implied cost per QALY ratio results for each individual PBC. If taken at face values then these results would have important policy implications, for example to divest from one PBC, perhaps maternity and neonates (PBCs 18 and 19), and to invest in another, for example respiratory (PBC 11). There are good reasons why this should not happen, namely potential 'spillovers' between PBCs and the assumption of proportionality between the effect of changes in expenditure on the QALY burden disease and the estimated proportionate effect on the mortality burden, which may be more appropriate for some PBCs than others. In Table A10, we consider how cost per QALY ratios for specific PBCs vary over time.

Table A10 Implied PBC cost per QALY ratios over time

	Implied PBC cost per QALY (£) 2006/07	Implied PBC cost per QALY (£) 2007/08	Implied PBC cost per QALY (£) 2008/09
2 Cancer	£ 18,273.98	£ 17,640.20	£ 17,594.59
10 Circulatory	£ 5,823.96	£ 6,571.01	£ 6,665.70
11 Respiratory	£ 1,295.46	£ 1,971.96	£ 2,151.60
13 Gastro-intestinal	£ 7,290.71	£ 11,292.57	£ 8,602.65
1 Infectious diseases	£ 12,275.48	£ 12,886.90	£ 19,030.88
4 Endocrine	£ 2,078.60	£ 2,198.46	£ 2,270.96
7 Neurological	£ 2,301.18	£ 9,165.34	£ 7,504.74
17 Genito-urinary	£ 116,616.35	£ 33,836.19	£ 2,978,823.26
16 Trauma & injuries*	N/A	N/A	N/A
18+19 Maternity & neonates*	£ 4,613,479.53	£ 6,260,414.86	£ 12,313,490.13
3 Disorders of Blood	£ 4,053.46	£ 5,977.55	£ 8,676.28
5 Mental Health	£ 8,254.65	£ 11,278.69	£ 17,250.44
6 Learning Disability	£ 65,320.04	£ 92,084.50	£ 137,944.35
8 Problems of Vision	£ 18,951.38	£ 27,118.28	£ 42,138.55
9 Problems of Hearing	£ 2,407.59	£ 3,935.06	£ 5,753.54
12 Dental problems	£ 17,863.94	£ 25,722.64	£ 39,088.10
14 Skin	£ 44,709.25	£ 60,419.56	£ 92,974.01
15 Musculo skeletal	£ 6,620.05	£ 9,469.74	£ 14,382.87
20 Poisoning and AE	£ 45,750.52	£ 62,464.12	£ 104,500.87
21 Healthy Individuals	£ 200,069.12	£ 294,658.13	£ 484,677.80
22 Social Care Needs	N/A	N/A	N/A
23 Other	N/A	N/A	N/A

73. The results in Table A10 for each PBC are largely driven by two key variables: each PBC's estimated outcome elasticity and the changing burden of disease for PBCs. Expenditure elasticities only affect PBCs without a mortality signal through the mortality elasticity used for extrapolation,

which depends upon expenditure elasticities. As a result, the variations observed in Table A10 reflect variations that can be seen in the elasticities found in Table A1.

### **Appendix 2.2 Sensitivity analysis**

74. Appendix 2.2 details three sensitivity analyses that were performed. The first two concerned the elasticities that were econometrically estimated for each of the PBCs. In the first case each of the estimated PBC outcome elasticities are varied by +/- 1 standard error. Then, the difference between the two resulting opportunity costs is presented. When this is larger, this implies that the overall resulting estimate of health opportunity costs is more sensitive to the outcome elasticity under consideration. The same procedure is then carried out for each of the PBC expenditure elasticities. The results of these sensitivity analyses are reported in Tables A11 and A12.

Table A11 Sensitivity of results to estimated outcome elasticities

		Change in spend	Change in QALY death + QALY alive	Implied PBC cost per QALY (£)	Difference in health opportunity costs between +1 SE and -1 SE in PBC outcome elasticity	% difference in health opportunity costs between +1 SE and -1 SE in PBC outcome elasticity	Importance of PBC (rank)	Importance of PBC (rank) 2007/08	Importance of PBC (rank) 2008/09
2	Cancer	£ 820,970.01	45	£ 18,273.98	45	3.10%	6	5	6
10	Circulatory	£ 1,588,312.24	273	£ 5,823.96	143	9.80%	2	3	4
11	Respiratory	£ 690,639.33	533	£ 1,295.46	446	30.54%	1	1	2
13	Gastro-intestinal	£ 612,928.90	84	£ 7,290.71	101	6.92%	4	4	5
1	Infectious diseases	£ 180,931.63	15	£ 12,275.48	23	1.55%	7	8	7
4	Endocrine	£ 190,678.78	92	£ 2,078.60	127	8.67%	3	2	3
7	Neurological	£ 174,112.62	76	£ 2,301.18	89	6.10%	5	6	1
17	Genito-urinary	£ 562,018.59	5	£ 116,616.35	12	0.81%	8	7	8
16	Trauma & injuries*	£ 333,047.95	0	N/A	-	-	-	-	-
18+19	Maternity & neonates*	£ 358,545.97	0	£ 4,613,479.53	0	0.03%	9	9	9
3	Disorders of Blood	£ 141,805.04	35	£ 4,053.46	-	-	-	-	-
5	Mental Health	£ 1,569,616.08	190	£ 8,254.65	-	-	-	-	-
6	Learning Disability	£ 163,497.98	3	£ 65,320.04	-	-	-	-	-
8	Problems of Vision	£ 207,091.49	11	£ 18,951.38	-	-	-	-	-
9	Problems of Hearing	£ 50,669.02	21	£ 2,407.59	-	-	-	-	-
12	Dental problems	£ 357,594.65	20	£ 17,863.94	-	-	-	-	-
14	Skin	£ 163,637.55	4	£ 44,709.25	-	-	-	-	-
15	Musculo skeletal	£ 345,653.04	52	£ 6,620.05	-	-	-	-	-
20	Poisoning and AE	£ 133,205.94	3	£ 45,750.52	-	-	-	-	-
21	Healthy Individuals	£ 156,979.01	1	£ 200,069.12	-	-	-	-	-
22	Social Care Needs	£ 425,101.04	0	N/A	-	-	-	-	-
23	Other	£ 772,963.14	0	N/A	-	-	-	-	-
Total:			1,461						

Table A12 Sensitivity of overall results to estimated spend elasticities

	Change in spend	Change in QALY death + QALY alive	Implied PBC cost per QALY (£)	Difference in health opportunity costs between +1 SE and -1 SE in PBC spend elasticity	% difference in health opportunity costs between +1 SE and -1 SE in PBC spend elasticity	Importance of PBC (rank)	Importance of PBC (rank) 2007/08	Importance of PBC (rank) 2008/09
2 Cancer	£ 820,970.01	45	£ 18,273.98	45	3.11%	8	8	11
10 Circulatory	£ 1,588,312.24	273	£ 5,823.96	45	3.09%	9	2	2
11 Respiratory	£ 690,639.33	533	£ 1,295.46	169	11.57%	1	1	1
13 Gastro-intestinal	£ 612,928.90	84	£ 7,290.71	11	0.76%	18	12	13
1 Infectious diseases	£ 180,931.63	15	£ 12,275.48	10	0.69%	19	21	19
4 Endocrine	£ 190,678.78	92	£ 2,078.60	30	2.02%	12	10	3
7 Neurological	£ 174,112.62	76	£ 2,301.18	49	3.33%	6	19	18
17 Genito-urinary	£ 562,018.59	5	£ 116,616.35	53	3.64%	4	11	6
16 Trauma & injuries*	£ 333,047.95	0	N/A	46	3.13%	7	6	8
18+19 Maternity & neonates*	£ 358,545.97	0	£ 4,613,479.53	59	4.06%	2	5	4
3 Disorders of Blood	£ 141,805.04	35	£ 4,053.46	9	0.62%	20	18	22
5 Mental Health	£ 1,569,616.08	190	£ 8,254.65	14	0.96%	15	20	12
6 Learning Disability	£ 163,497.98	3	£ 65,320.04	51	3.49%	5	7	10
8 Problems of Vision	£ 207,091.49	11	£ 18,951.38	14	0.94%	16	15	17
9 Problems of Hearing	£ 50,669.02	21	£ 2,407.59	13	0.86%	17	13	20
12 Dental problems	£ 357,594.65	20	£ 17,863.94	30	2.07%	11	14	14
14 Skin	£ 163,637.55	4	£ 44,709.25	14	0.98%	14	16	16
15 Musculo skeletal	£ 345,653.04	52	£ 6,620.05	1	0.09%	22	22	21
20 Poisoning and AE	£ 133,205.94	3	£ 45,750.52	9	0.61%	21	17	15
21 Healthy Individuals	£ 156,979.01	1	£ 200,069.12	27	1.85%	13	9	5
22 Social Care Needs	£ 425,101.04	0	N/A	36	2.44%	10	3	7
23 Other	£ 772,963.14	0	N/A	57	3.87%	3	4	9
Total:		1,461						

75. Generally, the results display varying degrees of sensitivity to estimated elasticities depending upon the PBC under consideration. In general, but not always, the results are more sensitive to specific PBC outcome elasticities than to specific PBC spend elasticities. Looking first at Table A12, the difference between the overall health opportunity cost when the spend elasticity is increased by one standard error compared to the result when the standard error is reduced by one standard error represents more than 10% for PBC 11 (respiratory). Switching to look at Table A11 it can be seen that the most important PBC in terms of outcome elasticity sensitivity is PBC 11: respiratory, as it is when spend elasticity is considered.

76. Following these two sensitivity analyses, a third is performed with a different emphasis, which analyses the sensitivity of the overall health opportunity cost estimate to two key assumptions:

*Surrogacy*- we are required to make an assumption about how the effect on mortality for PBCs with a mortality indicator can be used as a *surrogate* for the effect that expenditure has on morbidity (or health-related quality of life) in those PBCs.

*Extrapolation*- We are required to make an assumption about how the estimated effects on mortality found for PBCs with a mortality indicator can be *extrapolated* to the effect that expenditure has on mortality for those PBCs that do not have a mortality indicator.

In order to assess the impact of these assumptions on the overall results for the NHS, we evaluate the health effects of £10mn spending at the margin in the NHS when either:

- a) For PBCs with a mortality indicator: no surrogacy assumption, therefore expenditure has no effect on morbidity
- b) For PBCs without a mortality indicator: assume no health effects at all, neither on mortality (extrapolation assumption) nor morbidity (surrogacy assumption)

The results are found here in Table A13.

Table A13 Sensitivity of overall results to surrogacy and extrapolation assumptions

		Change in spend	Change in QALY death	Change in QALY alive	Health opportunity costs sensitivity to mortality/morbidity assumption (%)	Importance of PBC (rank)	Importance of PBC (rank) 2007/08	Importance of PBC (rank) 2008/09
2	Cancer	£ 820,970.01	42	3	-0.22%	15	14	14
10	Circulatory	£ 1,588,312.24	186	87	-5.93%	4	3	5
11	Respiratory	£ 690,639.33	18	515	-35.23%	1	1	1
13	Gastro-intestinal	£ 612,928.90	31	53	-3.64%	6	5	6
1	Infectious diseases	£ 180,931.63	3	12	-0.83%	11	10	10
4	Endocrine	£ 190,678.78	5	87	-5.94%	3	4	4
7	Neurological	£ 174,112.62	3	72	-4.95%	5	7	3
17	Genito-urinary	£ 562,018.59	1	4	-0.26%	13	11	18
16	Trauma & injuries*	£ 333,047.95	0	0	0.00%	-	-	-
18+19	Maternity & neonates*	£ 358,545.97	0	0	0.00%	19	19	19
3	Disorders of Blood	£ 141,805.04	2	33	-2.39%	8	8	9
5	Mental Health	£ 1,569,616.08	17	174	-13.01%	2	2	2
6	Learning Disability	£ 163,497.98	0	2	-0.17%	17	17	15
8	Problems of Vision	£ 207,091.49	0	10	-0.75%	12	12	12
9	Problems of Hearing	£ 50,669.02	0	21	-1.44%	9	9	8
12	Dental problems	£ 357,594.65	0	20	-1.37%	10	13	11
14	Skin	£ 163,637.55	1	2	-0.25%	14	16	13
15	Musculo skeletal	£ 345,653.04	3	50	-3.57%	7	6	7
20	Poisoning and AE	£ 133,205.94	0	2	-0.20%	16	15	16
21	Healthy Individuals	£ 156,979.01	0	1	-0.05%	18	18	17
22	Social Care Needs	£ 425,101.04	0	0	0.00%	-	-	-
23	Other	£ 772,963.14	0	0	0.00%	-	-	-
Total:			313	1,148				
Total change in QALY death + QALY alive				1,461				

77. It can be seen that the surrogacy assumption is especially impactful for PBC 11 (respiratory). Extrapolation and surrogacy is particularly important for PBC 5 (mental health).

### **Appendix 2.3 Outline of ONS data update for 2006/07**

78. The calculation of net YLL by PBC relies on two crucial inputs. The first is data on deaths within each PBC and the age of death, which is then compared to the benchmark of the second input, PBC life expectancy. Each death can then be translated into a number of years of life lost (YLL) if death occurred before the life expectancy and years of life gained (YLG) when the death occurred after the life expectancy. The difference between YLL and YLG gives net YLL, which is an input into the calculation of results. PBC life expectancy itself has to be calculated and relies on data provided by national life tables.

Table A14 Net YLL for 2006-2008, 2007-2009, 2008-2010 and 2009-2011 using LE for each PBC

**2006-2008**

<b>PBC</b>	<b>GP LE (M)</b>	<b>GP LE (F)</b>	<b>PBC LE (M)</b>	<b>PBC LE (F)</b>	<b>All deaths</b>	<b>Net YLL</b>
<b>1</b>	79.6	83.6	79.6	83.6	6,958	36,379
<b>2</b>	83.0	84.7	83.0	84.7	130,810	1,347,324
<b>4</b>	81.0	84.7	81.0	84.7	6,765	50,933
<b>7</b>	79.6	83.3	79.6	83.3	15,353	92,710
<b>10</b>	83.0	86.5	83.0	86.5	159,852	808,850
<b>11</b>	80.3	84.0	80.3	84.0	65,446	61,007
<b>13</b>	80.6	84.5	80.6	84.5	24,147	226,380
<b>17</b>	83.5	85.6	83.5	85.6	10,624	16,669
<b>18+19</b>	78.7	83.1	78.7	83.1	226	16,801

**2007-2009**

<b>PBC</b>	<b>GP LE (M)</b>	<b>GP LE (F)</b>	<b>PBC LE (M)</b>	<b>PBC LE (F)</b>	<b>All deaths</b>	<b>Net YLL</b>
<b>1</b>	79.8	83.8	79.8	83.8	6,288	38,835
<b>2</b>	83.2	84.9	83.2	84.9	131,372	1,355,804
<b>4</b>	81.2	84.9	81.2	84.9	6,762	51,857
<b>7</b>	79.9	83.5	79.9	83.5	16,076	91,442
<b>10</b>	83.2	86.6	83.2	86.6	155,222	785,989
<b>11</b>	80.5	84.2	80.5	84.2	65,026	73,441
<b>13</b>	80.8	84.7	80.8	84.7	23,920	227,224
<b>17</b>	83.7	85.7	83.7	85.7	11,015	15,310
<b>18+19</b>	79.0	83.2	79.0	83.2	255	18,899

**2008-2010**

<b>PBC</b>	<b>GP LE (M)</b>	<b>GP LE (F)</b>	<b>PBC LE (M)</b>	<b>PBC LE (F)</b>	<b>All deaths</b>	<b>Net YLL</b>
<b>1</b>	81.2	84.8	80.1	84.0	5,262	44,445
<b>2</b>	81.2	84.8	83.4	85.1	131,945	1,199,680
<b>4</b>	81.2	84.8	81.4	85.1	6,763	49,504
<b>7</b>	81.2	84.8	80.1	83.7	16,771	111,501
<b>10</b>	81.2	84.8	83.4	86.8	151,443	459,945
<b>11</b>	81.2	84.8	80.7	84.4	64,449	112,633
<b>13</b>	81.2	84.8	81.0	84.9	23,898	231,757
<b>17</b>	81.2	84.8	83.9	85.9	11,345	4,085
<b>18+19</b>	81.2	84.8	79.3	83.5	265	20,332

**2009-2011**

<b>PBC</b>	<b>GP LE (M)</b>	<b>GP LE (F)</b>	<b>PBC LE (M)</b>	<b>PBC LE (F)</b>	<b>All deaths</b>	<b>Net YLL</b>
<b>1</b>	80.5	84.3	80.5	84.3	4,907	38,814
<b>2</b>	83.7	85.4	83.7	85.4	132,656	1,395,819
<b>4</b>	81.7	85.4	81.7	85.4	6,477	51,079
<b>7</b>	80.5	84.0	80.5	84.0	17,113	93,164
<b>10</b>	83.6	87.1	83.6	87.1	142,567	768,320
<b>11</b>	81.1	84.7	81.1	84.7	63,088	101,927
<b>13</b>	81.4	85.2	81.4	85.2	23,499	235,041
<b>17</b>	84.1	86.2	84.1	86.2	10,600	16,230
<b>18+19</b>	79.7	83.8	79.7	83.8	252	18,895

## Appendix 2.4 Calculation of elasticity for extrapolation and overall NHS mortality elasticities

84. Whilst we have estimated outcome elasticities for PBCs 2, 10, 11, 13, 1, 4, 7, 17 and 18+19, we can also use these to generate an overall to compare with a vast body of literature that estimates the elasticity of all-cause mortality with respect to health care expenditure (Andrews et al., 2016 report an elasticity for 2005/6 English NHS as 0.71). It is worth noting that direct comparison is not possible, since there are substantial methodological differences across publications. An important consideration is that all-cause models may find it harder to detect signal rather than noise, which may cancel out signal, compared to an approach that uses disease-specific models to estimate the effect of expenditure on mortality. The results for an overall mortality elasticity are presented below in Table A15.

Table A15 Estimated overall elasticities

	Elasticity comparable to all-cause model results
2009/10	0.94
2008/9	0.80
2007/8	1.27
2006/7	1.50